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THE ALBERTA OIL SANDS

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prepared by

Energy and Natural Resources

Energy Resources Conservation Board

Alberta Oil Sands Technology and Research Authority

Alberta

ENERGY AND NATURAL RESOURCES

TABLE OF CONTENTS

THE ALBERTA OIL SANDS – A BRIEF DESCRIPTION

The oil sands deposits of Alberta, as shown on Figure 1, are found in four principal and several minor deposits in an area covering some 19,000 square miles of northern and eastern Alberta. The four principal deposits are Athabasca, Cold Lake, Peace River and Wabasca.

The largest deposit, the 12,000 square mile Athabasca Oil Sands, is covered by an overburden of muskeg, glacial till, sandstones and shales ranging in depth from zero to 2,000 feet. Approximately one half million acres are overlain by 150 feet or less of overburden and are suitable for surface mining. The in-place reserves of bitumen in the surface mining area are estimated at 74 billion barrels, with the balance of the deposit having reserves of 552 billion barrels, for a total of 626 billion barrels.

The Cold Lake, Peace River and Wabasca deposits are deep deposits with overburden ranging in depth from 250 to 3,000 feet, which does not permit recovery by surface mining. The combined in-place reserves of these deep deposits are estimated at 326 billion barrels of bitumen.

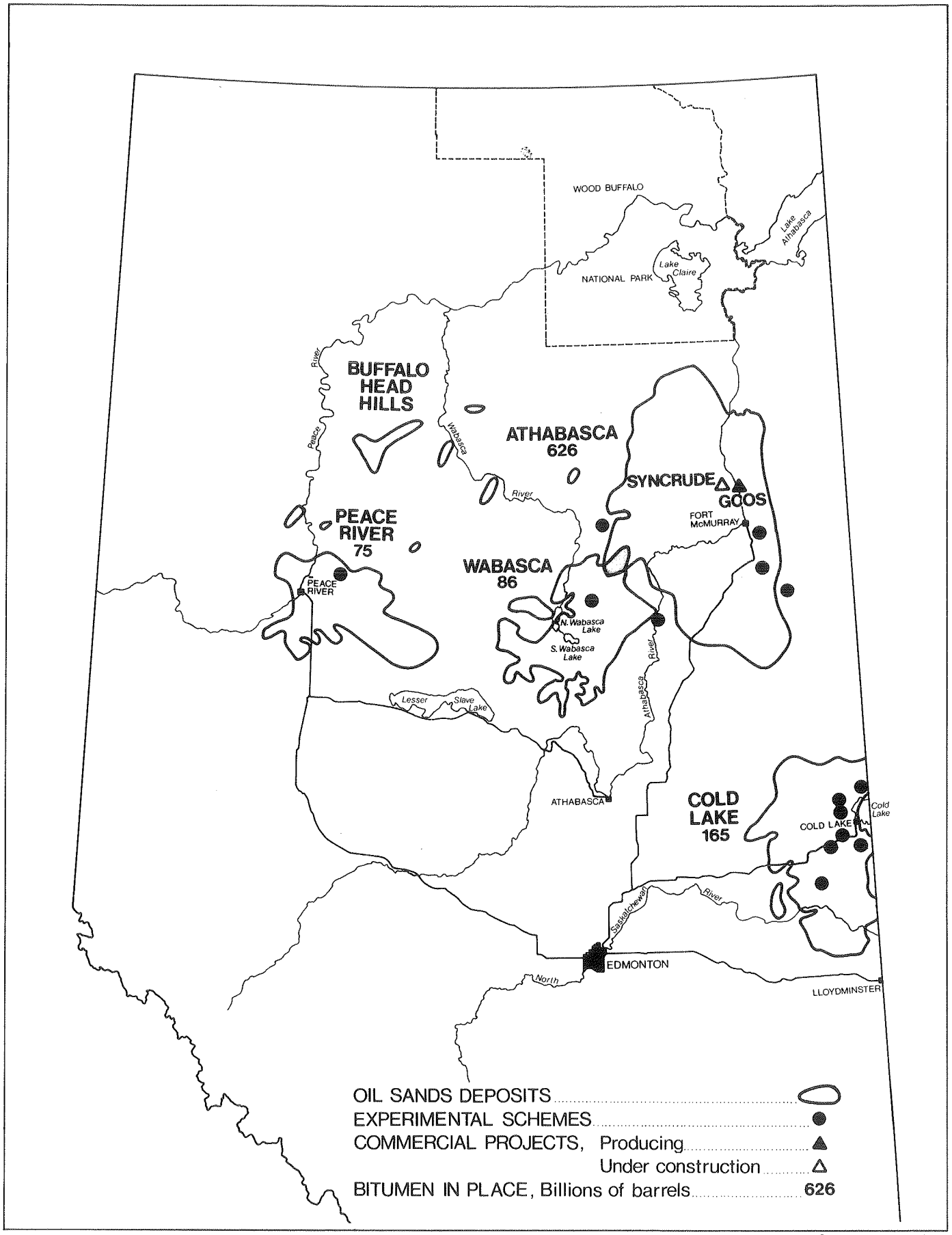
The total proved in-place reserves of crude bitumen in the Alberta Oil Sands are approximately 953 billion barrels. However, because only the surface mining method is currently economically feasible, and since this method cannot recover all the in-place bitumen, the present estimate of recoverable bitumen is only 38 billion barrels. This will produce 26.5 billion barrels of synthetic crude oil. If economically viable "in-situ" methods are developed, the Alberta Oil Sands may ultimately yield 250-300 billion barrels of synthetic crude oil as compared to Alberta's proved conventional crude oil reserves of seven billion barrels and proved world reserves of 632.3 billion barrels.

COMMERCIAL DEVELOPMENT OF THE OIL SANDS

The existence of the Oil Sands was first reported about 200 years ago. The Geological Survey of Canada initiated a detailed survey in 1882 and the first exploratory well was drilled in the late 1890's.

In the subsequent years a number of attempts were made to extract and upgrade crude bitumen from the oil sands deposits. In 1929 oil separated from Athabasca oil sand was used for road paving experiments in the City of Edmonton. In 1930 International Bitumen Company became the first company to exploit the sands commercially. Abasand Oils Ltd. constructed a 250 ton per day separation plant in 1936 and in 1937 a 400 ton per day plant.

The Alberta Research Council, since its founding in 1919, has conducted many studies and experiments to develop a commercial process for extracting the bitumen from the sands. These experiments, under the direction of Dr. Karl Clark, resulted in the development of a hot water extraction process which was proved technically feasible in 1948-49. At the present time, the only commercial plant operating and utilizing this process is that of Great Canadian Oil Sands Ltd. near Fort McMurray, which produces approximately 50,000 barrels per day of synthetic crude oil. Syncrude Canada Ltd. is constructing a 125,000 barrel per day plant near Mildred Lake which will commence production in 1978.



Source: E.R.C.B.

FIGURE 1 **OIL SANDS DEPOSITS AND LOCATIONS OF EXPERIMENTAL SCHEMES AND COMMERCIAL PROJECTS**

Great Canadian Oil Sands Ltd.

History

Great Canadian Oil Sands Ltd., controlled by Sun Oil Co., originally applied to the Alberta Government in 1960 for approval of its plan to produce 31,500 barrels per day of synthetic crude oil. Approval was granted in 1962, the limit was subsequently increased and GCOS now has approval to produce 65,000 barrels per day. Construction began in 1965 and the plant commenced production in September of 1967. The plant, when initially constructed, had a capital cost of $235 million. Capital investment by 1975 had increased to $389 million. Employment now stands at 1,600 with a payroll of approximately $40 million.

Description

The GCOS process involves removal of overburden, mining, extraction and upgrading of the bitumen to produce synthetic crude oil.

The mining operation uses three giant bucket wheel excavators and one smaller bucket wheel. The newest and largest bucket wheel weighs about 1,900 tons and features a 41 foot diameter wheel on the end of a long boom. The other two large excavators weigh about 1,800 tons and have 33 foot bucket wheels. The mined sand is transported to the extraction plant by a series of conveyor belts, up to six feet in width.

Crude bitumen extraction is accomplished by mixing the sand with hot water and a small amount of caustic soda. By means of separation cells, the crude bitumen is drawn off, deaerated, mixed with diluent and then centrifuged. The resulting product is stored prior to upgrading. Upgrading is based on delayed coking and fractionating techniques.

The tailings stream at Great Canadian is delivered to the tailings pond at the rate of 24,000 gallons per minute. The pond is surrounded by a dike 210 feet high and three miles in circumference made from the coarse fraction of the tailings sand.

The initial production of the plant in 1967 averaged 1,200 barrels per day. This has been increased until, at present, GCOS has reached a sustained production level of approximately 50,000 barrels per day. However, due to a combination of factors, including technical problems requiring major modifications to various areas of the plant, GCOS, by 1975, had an accumulated deficit of $79 million and reported a profit in only one year, 1974.

Syncrude Canada Ltd.

History

The Syncrude Athabasca project began in the late 1950's and in 1962 Syncrude first applied to the Alberta Oil and Gas Conservation Board for permission to build a plant capable of producing 100,000 barrels per day of synthetic crude oil. This was refused because of Alberta's policy of assuring conventional oil supplies a sufficiently large maket. Syncrude's second application in 1968 was again delayed due to perceived uncertainties related to the Prudhoe Bay, Alaska discoveries. In 1969, Syncrude received permission to proceed and in 1972 Alberta authorized production of 125,000 barrels of synthetic crude oil per day.

GCOS PROCESS

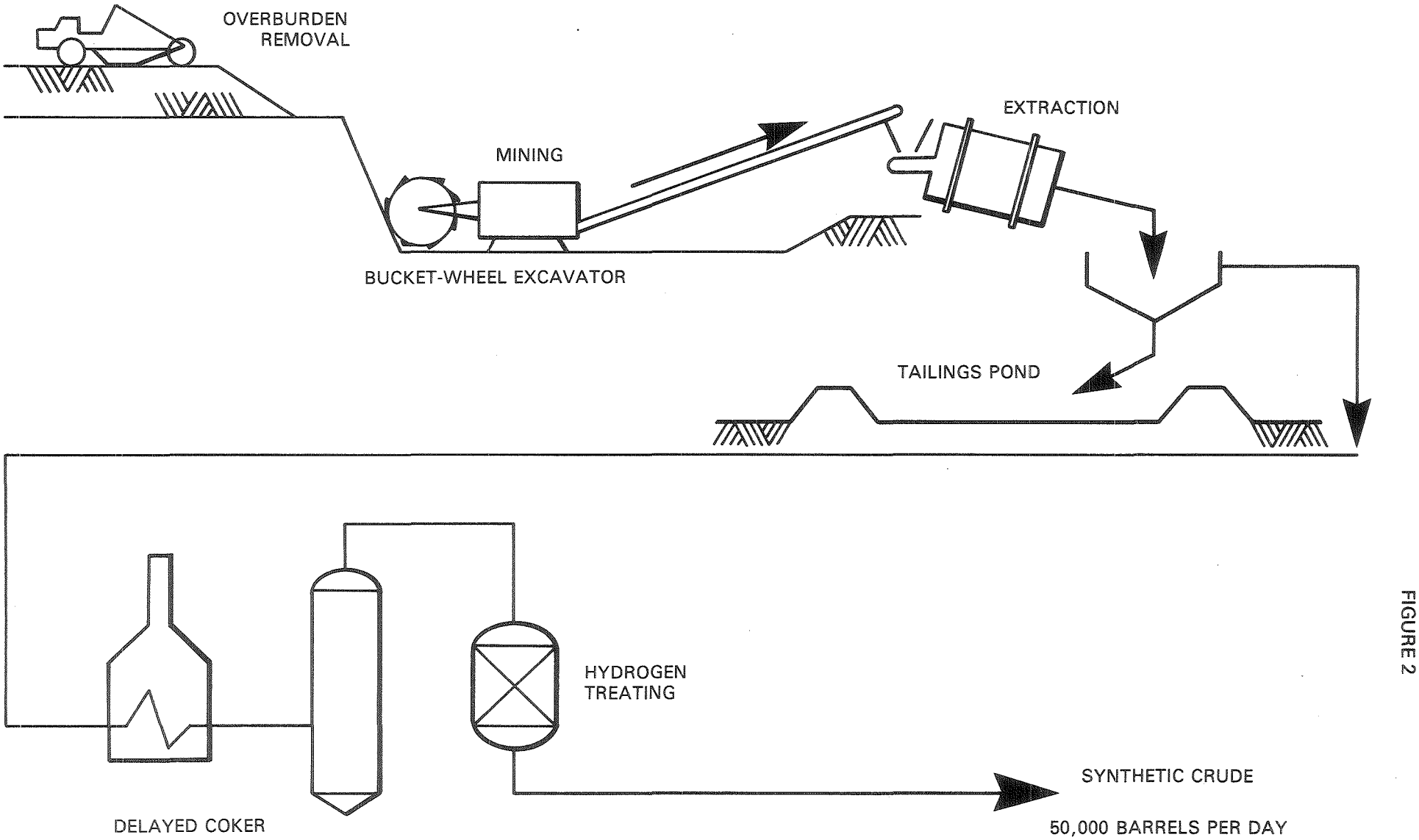


FIGURE 2

Description

The Syncrude project will consist of three distinct but closely related operations: mining, extraction and upgrading.

The mining operation has two phases. The first is the removal of the overburden, the surface layer of muskeg and lean or oil-poor sand which lies on top of the oil sands. This will be done with large draglines equipped with buckets capable of holding 80 to 90 cubic yards of material. The same draglines are used to mine the oil sand once it is exposed. Following the initial opening of the mine and after sufficient oil sand has been excavated to expose the underlying shale, the overburden will be cast directly into the mined-out area. This is the first step in land reclamation.

Following the mining of the oil sand it will be loaded onto a conveyor belt system which will deliver it to the extraction plant. Here it will be mixed with hot water and steam to form an air-saturated slurry. This slurry is pumped into extraction cells where aerated bitumen, which rises to the top in the form of a water and solids laden froth, will be skimmed off. The bitumen froth is then treated to remove remaining water and solids and is then fed to the primary conversion units in the initial upgrading step.

During upgrading the bitumen is "cracked" and separated into two streams: naphtha and gas oil. Each stream will be individually scrubbed to remove sulphur and treated with hydrogen. When blended together these two streams will result in a low-sulphur specification synthetic crude oil which will be piped to Edmonton for refining and subsequent transportation to markets.

Ownership

The 1974 withdrawal of Atlantic Richfield Canada Ltd. from the original Syncrude joint venture meant the full financial weight of the massive project rested on the three remaining participants: Canada-Cities Service, Ltd., Gulf Oil Canada Limited and Imperial Oil Limited. These companies announced that, unless a new investor was found, the project would be postponed or possibly abandoned altogether.

In response, three governments indicated their intentions of investing a total of $600 million in the Syncrude project: $300 million from the federal government for a 15 per cent interest, $200 million from Alberta for 10 per cent and $100 million from Ontario for five per cent.

The three remaining oil companies agreed to increase their participation to make up the remaining funding. Imperial Oil, in total, committed $625 million for an interest of 31¼ per cent; Cities Service agreed to spend $440 million for a 22 per cent share and Gulf Oil Canada bought 16¾ per cent for $335 million.

On April 30, 1976 the six participants signed the agreements that provided for the equity participation in the project by the three governments, the Alberta Government's Joint Venture Share of the profits, the granting of an option to Alberta Energy Company to acquire a five to 20 per cent interest in the Project, and the construction and operation of the Utilities Plant and the product pipeline by the Alberta Energy Company.

FIGURE 3 **SYNCRUDE OWNERSHIP**

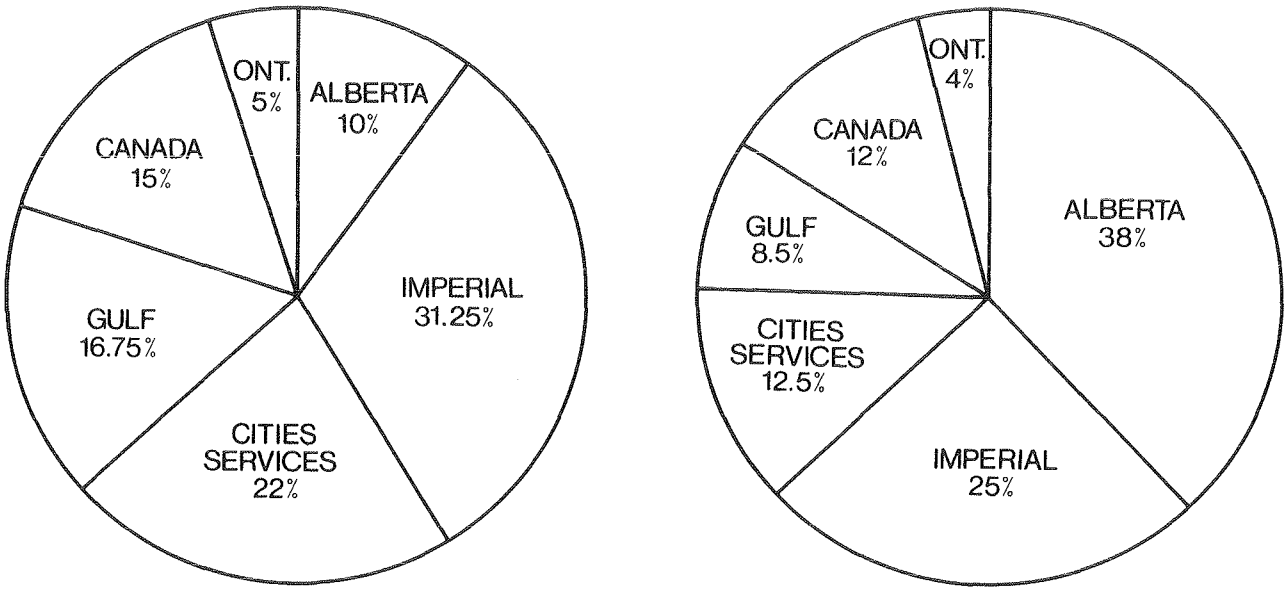
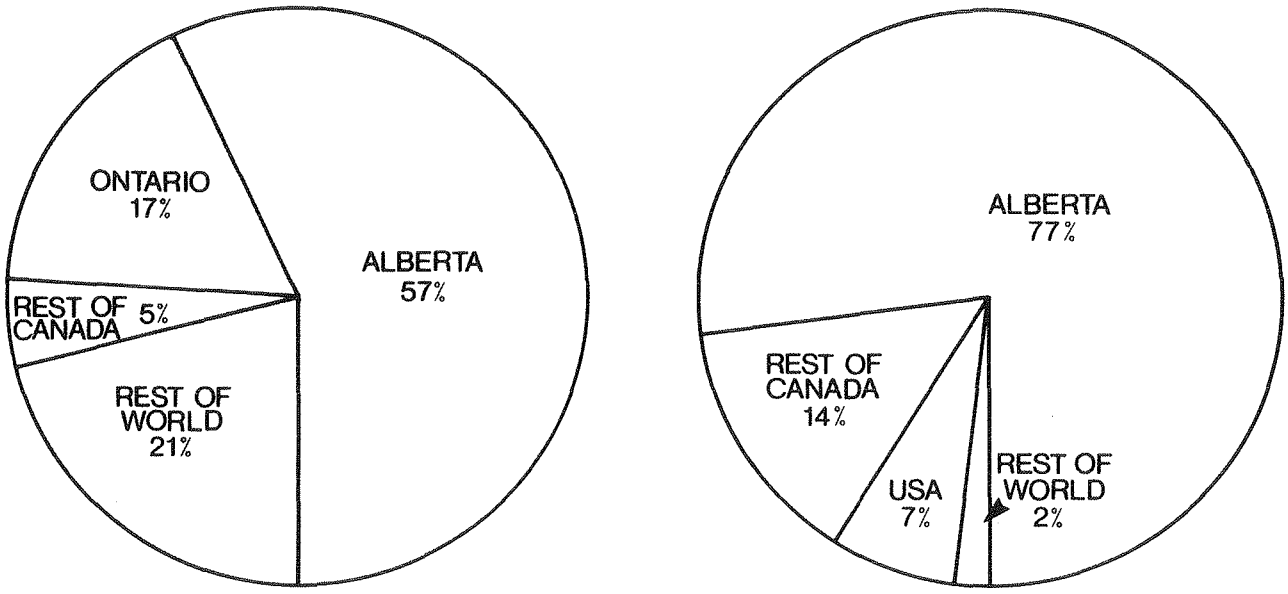


FIGURE 4 **SYNCRUDE'S SOURCES OF MANPOWER AND MATERIAL**



Source Syncrude

Labour Agreements

Because it is essential that the development of the Alberta Oil Sands proceed in an orderly fashion, The Alberta Labour Act, was amended in 1974, to permit the negotiation of collective agreements between the principal contractors engaged to construct oil sands plants and the construction trade unions.

This amendment permitted the parties responsible for construction of oil sands plants to establish collective agreements that would have the effect of providing labour stability until the completion of the project.

Under the provisions of this amendment, Syncrude's managing contractor, Canadian Bechtel Limited, has entered into Site Agreements (no strike no lock out) with the construction trades.

SYNCRUDE PROCESS

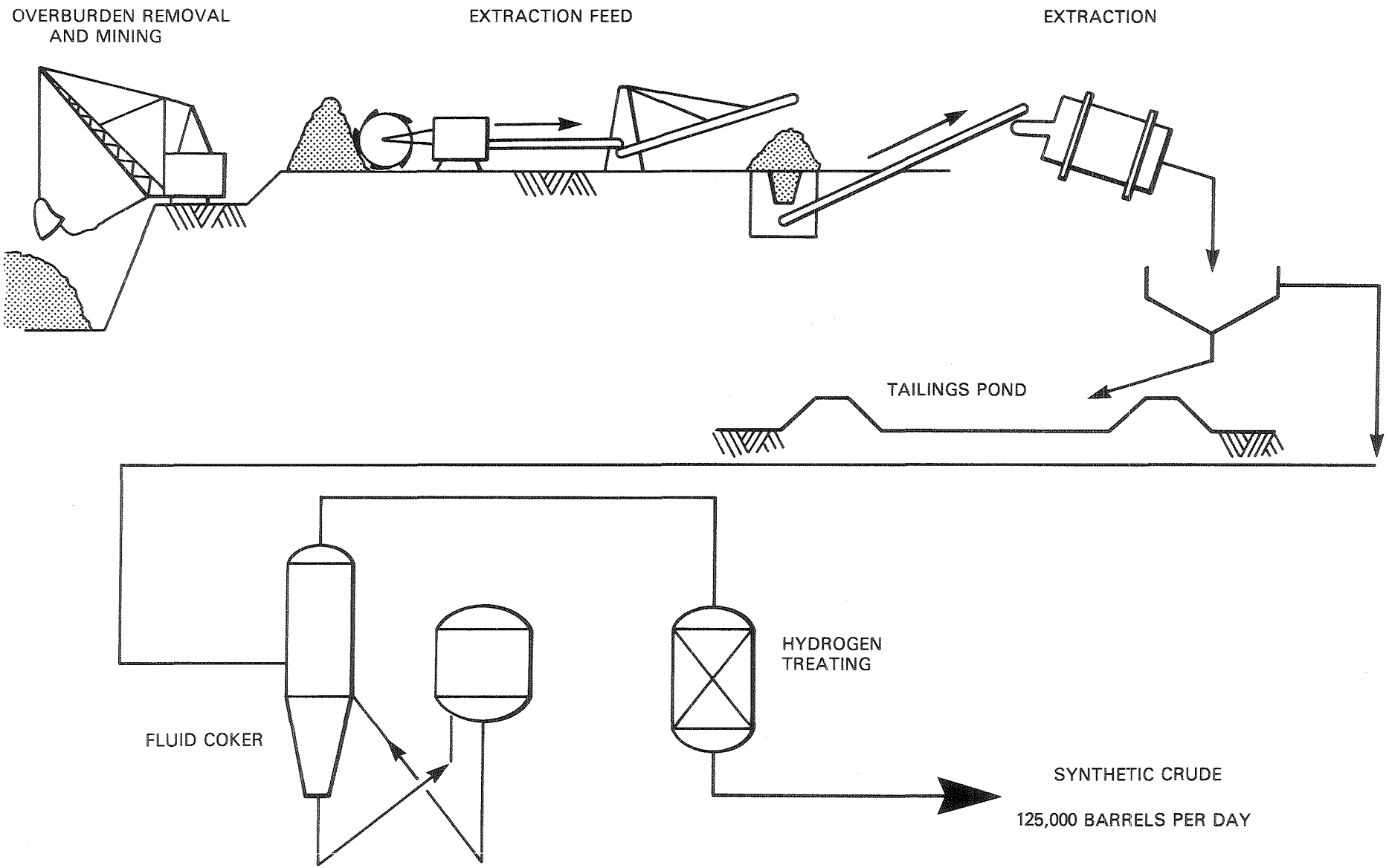


FIGURE 5

EXPERIMENTAL WORK

In addition to the on-going research undertaken by Great Canadian and Syncrude a number of other oil companies have been making significant research expenditures into oil sands mining and crude bitumen recovery and upgrading.

For example, since 1964 Imperial Oil Limited has spent about $35 million on research and a 5,000 barrel per day "in-situ" pilot plant project at Cold Lake, 140 miles northeast of Edmonton, using steam injection to reduce viscosity.

Shell Canada Ltd. has recently undertaken considerable research into "in-situ" steam injection tests and has reportedly invested $23 million in experimental work to date. If the results of the latest program warrant further research, the company plans to undertake an expanded injection and production well program over three years at a cost of $15 million or more. According to the Alberta Energy Resources Conservation Board, if the latter program is successful, it could lead to an application to the Alberta Board by Shell about the middle of the next decade for a permit to remove bitumen by "in-situ" techniques.

Amoco Canada Petroleum Company Limited has been involved since the late 1950's with "in-situ" recovery methods including field testing its COFCAW process (Combination of Forward Combustion and Waterflooding). Amoco employs a patented hydofrac process followed by injection of air (to initiate and maintain underground combustion) and water.

A number of other companies, including Texaco Canada Limited, Petrofina Canada Ltd., British Petroleum Company Ltd., Chevron Standard Limited, Norcen Energy Resources Ltd., and Great Plains Development Company of Canada Ltd. have been, or are presently, active in oil sands recovery research.

AOSTRA Research Programs

The Alberta Government in 1974 created the Alberta Oil Sands Technology and Research Authority (AOSTRA) to support both laboratory and field research, mainly in the area of "in-situ" recovery processes. AOSTRA has recently announced a $130 million research program covering the financing of five field experiments to test advanced "in-situ" oil recovery concepts.

Three large scale projects will be carried out in the Cold Lake, Athabasca and Peace River deposits. In addition two exploratory concepts will be tested in the Athabasca deposit, on a smaller scale.

Peace River Deposit

In this deposit a field research project will be carried out in partnership with Shell Canada. The test will involve cyclic pressurization and depressurization of the deposit with steam, and if successful will represent a significant advance in steam displacement technology. The proposed process has the potential of producing a high oil recovery. The Peace River deposit is well suited to the process due to the presence of an underlying zone of high water saturation which will provide an initial path for the steam as it moves between wells. The extension of the process to other deposits will require artificial methods of developing inter-well communication. The Authority is committing $29 million to carry out its share of Phase I of this project. Phase I is expected to be completed in December, 1979.

Athabasca Deposit

In this deposit a field research project will be carried out in partnership with Amoco Canada Petroleum. The test will employ underground combustion to provide heat to reduce bitumen viscosity, followed by water to drive the bitumen to the surface. If the high temperatures can be successfully handled, the process will yield an excellent energy balance and should be applicable to the widest variety of deposits. The Authority is committing $23 million to carry out its share of Phase I of this project. Phase I is expected to be completed in December, 1980.

Cold Lake Deposit

In this deposit a field research project will be carried out in partnership with BP Canada, and will test a combination of steam and combustion as a recovery mechanism. It has the potential of providing a high rate of oil production and also a high overall oil recovery from the deposit. This combination recovery method is particularly suited for the characteristics of the Cold Lake deposit. The Authority is committing $8.5 million to carry out its share of Phase I of this project. Phase I is expected to be complete in December, 1984.

Exploratory Program on Fracturing (Athabasca Deposit)

This program will be carried out in partnership with Numac Oil and Gas. Most of the current "in-situ" processes depend on the presence or establishment of pre-communications between wells and it is imperative that a reliable method of establishing this communication be developed. Current technology does not allow reliable methods of establishing horizontal communication below a depth of approximately 500 feet of overburden. In an effort to extend this technology, the Authority will fund an extensive field study of fracturing, on the applicant's lease. If fractures can be successfully obtained and controlled, the test will be expanded to evaluate a recovery method developed at the Alberta Research Council. The Authority is committing approximately $1 million to carry out Phase I of the program. Numac is providing 25% of the financing, and the Authority and Numac are seeking another company to complete the industrial financing.

Shallow Deposit Program (Athabasca Deposit)

This test will be carried out in conjunction with the applicant, In-Situ Research and Engineering (an Alberta consulting firm). High pressure steam, which is to be used in some of the existing and proposed pilots, cannot be safely used in the shallow deposits (200-500 feet of overburden). The applicant has developed a heating process which can be safely used at shallow depths, and if successful it will increase the amount of oil producible by the "in-situ" method. The Authority has earmarked up to $3 million to carry out a field test, contingent on the successful completion of laboratory tests. Negotiations are taking place with an industrial partner to provide the company's share of the financing.

Environmental Programs

A considerable amount of oil sands environmental research is currently being planned and conducted by both government and industry. On-going research is carried out by both GCOS and Syncrude relative to their own operations. One phase of this research has resulted in revegetation

programs undertaken by both companies on land that was disturbed by construction activities. The industry has also formed the Oil Sands Environmental Study group with representation from all the lease-holders in the Athabasca Oil Sands. This group is primarily concerned with environmental programs with regional significance.

In addition to continuing monitoring and research programs of the Alberta and Federal Environment Departments, Alberta And Canada, in February, 1975, signed an agreement to provide $40 million over 10 years for environmental research in the Oil Sands Area. This program, called the Alberta Oil Sands Environmental Research Program (AOSERP), includes research dealing with the effects of oil sands development on air, land, water and the inhabitants of each – birds, insects, plant life, mammals, fish and man. The research is directed to the practical solution of environmental and social problems resulting from oil sands development and the provision of scientific data for use of government, industry and the public. One of AOSERP's main goals is to aid in fulfilling the commitment to restore the area to a biologically productive state, as good or better than that before mining commenced.

FORT McMURRAY

Fort McMurray is located 275 miles northeast of Edmonton. The town and immediate surrounding area are serviced by Highway 63, the Northern Alberta Railway and regularly scheduled airlines. Fort McMurray is the transhipment centre for the river barge system down the Athabasca, serving Fort Chipewyan, Uranium City, and smaller outposts along the river and lakeshores.

Early History

Fort McMurray's history spans more than a century and has always been associated with the development of natural resources and transportation.

Peter Pond, a fur trapper and explorer visited the confluence of the Athabasca and Clearwater Rivers in 1778. Twelve years later in 1790, the North West Company established a trading post on the present site of Fort McMurray calling it the "Fort of the Forks".

The post served the area until 1840 when a smallpox epidemic forced abandonment. In 1870 a new trading post was built and named after J.D. McMurray, a Hudson's Bay Company trader.

By the year 1900, the population had reached 300 and the town was enjoying its role as a major transportation and trading centre. The potential of the oil sands was becoming evident at this time, and a number of claims were made along the Athabasca River north of the town.

In 1930 the Research Council of Alberta developed an experimental hot water oil sands extraction plant at Waterways. In 1936 the next step was taken and Abasand Oil built its commercial extraction plant on a site adjacent to the Horse River.

The Second World War brought 3,000 American troops to Fort McMurray. In the years following Fort McMurray's wartime boom, the population decreased from a high of nearly 4,000 to 900. It was not until Great Canadian Oil Sands applied to the Oil and Gas Conservation Board in 1960 that things started to move again.

Recent History

With the award to GCOS of Lease 86, approximately 20 miles from town, serious growth started to take place. By 1961, 1,200 people were living in Fort McMurray. The pressures of development led, in 1962, to an application for New Town Status, which was granted in 1963.

In 1966, with a growing population and 2,500 permanent residents, the first neighborhood subdivision was developed. In the same year, Highway 63 was completed as an all-weather road link with Edmonton.

By 1968 the population had doubled to 5,943.

By 1971 it was apparent that future development would be required outside the Lower Townsite. In 1973, Athabasca Realty Company began development in a new subdivision, Thickwood Heights, northwest of the town.

With the Energy Resources Conservation Board's approval of Syncrude's construction plans in 1973, additional pressure for residential development mounted, with the population of the town now 9,500. Alberta Housing Corporation, as agents for the town, began residential subdivision development of Beacon Hill, and development of the Gregoire Mobile Home Park.

Syncrude commenced construction of its oil extraction plant in 1974. This necessitated an acceleration in the rate of residential development in all areas of Fort McMurray.

Fort McMurray has now grown to more than 17,000 people and estimates indicate that it will increase to approximately 30,000 by 1978, when the Syncrude plant starts operation.

The town features a relatively broad range of public and commercial facilities although the capacities of these facilities, as happens in most rapidly growing communities, are currently lagging behind the requirements of the expanding population. Those services and facilities which do exist are modern and of a good quality.

In 1974, Alberta established the office of the Commissioner of the Northeast Alberta Region to co-ordinate the orderly development and supply of the support and related services that must accompany development in the Oil Sands Area.

Education

Four new elementary schools, each accommodating 525 students, have recently opened and more schools are being planned.

A new, combined, 750-student composite high school has also been completed.

Keyano College offers trade, technical and academic courses at introductory and advanced levels. Extension and evening courses range from automotive mechanics to wine-making, upholstery repair to cake decorating.

In addition to the regular programs offered by these institutions, special academic upgrading courses for natives being hired for the Syncrude operating phase will be established in support of Syncrudes's policy of maximizing the hiring and training of native people.

Athabasca University, through live and packaged courses, offers introductory University courses in Fort McMurray. The live courses will utilize local intructors and the facilities of Keyano College.

Health Facilities

Fort McMurray General Hospital has recently expanded to 56 beds and is now in the second phase of a program to increase its size to 150 beds, with attendant facilities, by 1980.

Recreation

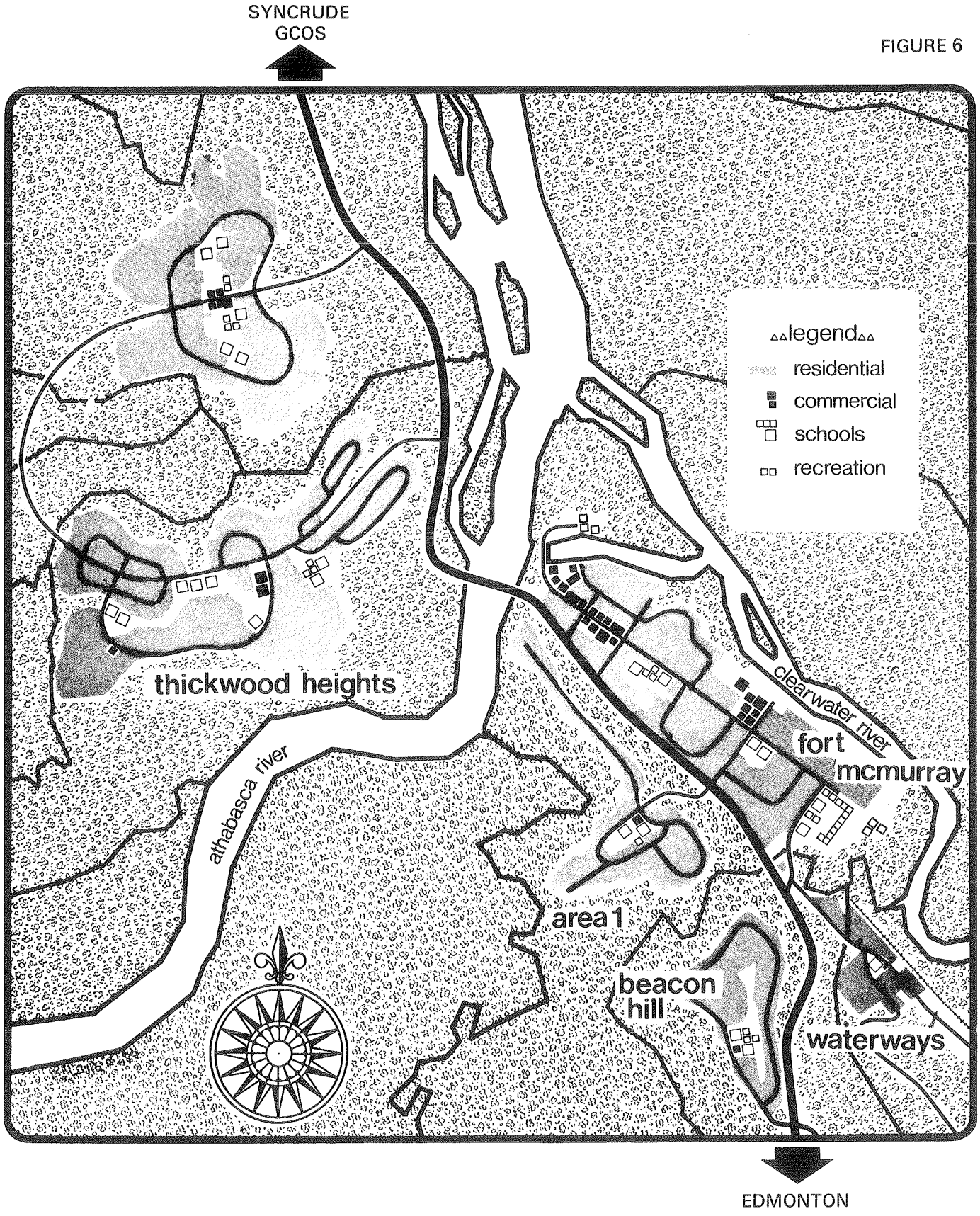
Nearby, there are excellent opportunities for fishing, hunting, camping, boating, snowmobiling and exploring. The town itself provides many entertainment and sporting facilities, including a modern indoor swimming pool, skating arenas and curling rink. The tennis courts and golf courses are easily accessible. Figure skating and badminton, boxing and basketball clubs are all active as are a number of service clubs. The Art Club, Open Stage Society and Overture Concert Society contribute to the cultural aspects of the community, while the younger residents enjoy organized baseball, hockey, soccer and other sports.

One feature of development at Fort McMurray is unique in that, with few exceptions, the land available for development within the corporate limits is crown land under the jurisdiction of the Alberta Housing Corporation.

Fort McMurray constitutes the largest development ever undertaken by the Alberta Housing Corporation. Between March, 1973, and December 31, 1975 a total of $47 million had been committed for development of land already held in Beacon Hill Subdivision, Gregoire Mobile Home Park, MacKenzie Industrial Park, Thickwood Heights and Area 1, as shown in Figure 6. A.H.C.'s 1976 commitment for development in Fort McMurray is presently $17.9 million.

The actual construction of those areas designated for GCOS and Syncrude workers is carried out by Northward Developments for Syncrude and Athabasca Realty for Great Canadian Oil Sands.

FIGURE 6



FORT McMURRAY

SIGNIFICANCE OF SYNTHETIC CRUDE OIL

Western Canada experienced substantial development of crude oil production in the 20 years following the major discovery at Leduc, near Edmonton, in 1947. However, since the late 1960's, production of conventional crude oil each year has exceeded additions to conventional crude oil reserves. Although some spare production capacity remains as a result of earlier excess capacity, production system improvements and market restraints, the spare capacity will soon disappear. The significance of Alberta and Western Canada, as sources of Canadian crude oil production, is best appreciated by reference to the trends in supply and demand illustrated in Figure 7.

The Canadian demand for crude oil is projected to increase at a considerably lower rate than it has in recent years. The growth is projected to average about 2.0 per cent per year which would result in a demand of about 2.6 million barrels per day by 1995. Over the same period, conventional crude oil productive capacity in Alberta is projected to decline at four to five per cent per year with similar declines likely for Saskatchewan and British Columbia. The additional supplies needed to offset growth in demand and decline in conventional crude oil production must come from frontier areas now being explored, such as the Mackenzie Delta, the Arctic Islands and the Labrador Shelf, and from the oil sands of Alberta and imports. The present and the projected 1995 contributions from these sources, assuming the oil sands projection shown in Figure 7, are compared as follows:

Source	Millions of Barrels per Day 1976	1995
Frontier Areas	6	0.8
Alberta conventional crude oil	1.26	0.4
British Columbia and Saskatchewan conventional crude oil	0.24	0.1
Oil Sands	0.05	0.4
Net imports	0.28	0.9
TOTAL	1.83	2.6

The extent to which Canada must rely on imports can be reduced if exploration and development in the frontier areas and in the established producing areas of Western Canada are more successful than projected, or if a more intensive effort is made to develop the oil sands.

The Great Canadian Oil Sands project is now producing some 50,000 barrels per day of synthetic crude production and with the Syncrude project and expansions projected such production is expected to increase to 160,000 barrels per day by 1980 and 190,000 barrels per day by 1984.

However, even allowing for further anticipated development of the oil sands, it is expected that Canada's domestic supplies will provide only 1.7 million barrels per day in 1995 leaving an import requirement of 0.9 million barrels per day.

The significance of the presently proved oil sands reserves of 26.5 billion barrels is indicated by the fact that they alone would provide Canada's total projected needs for crude oil for 34 years, assuming the demand grows at an annual rate of two per cent per year. The ERCB has estimated that these reserves are adequate to support 20 to 30 plants of 100,000 to 150,000 barrels per day capacity.

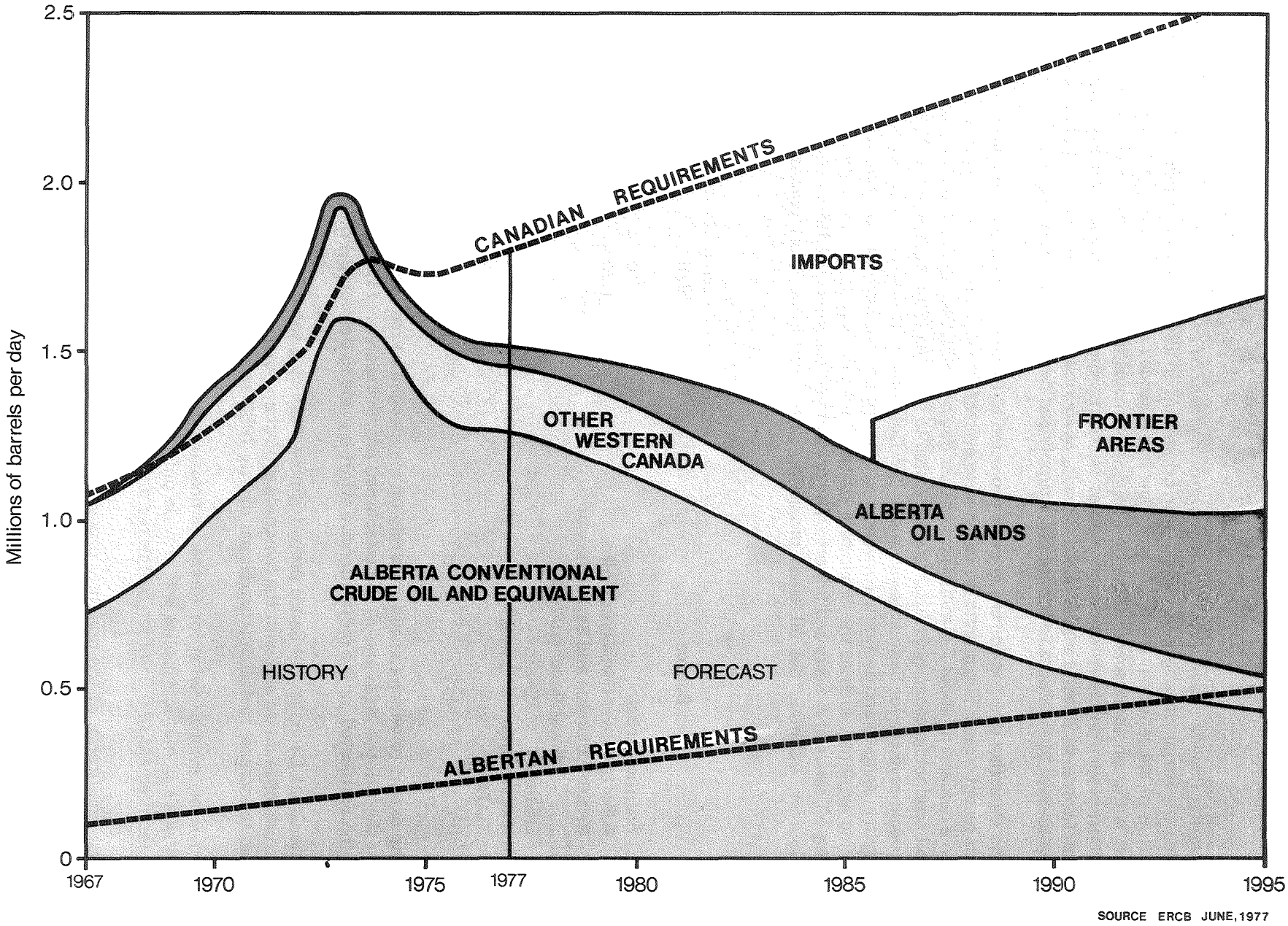


FIGURE 7 **CRUDE OIL PRODUCTION AND REQUIREMENTS – ALBERTA AND CANADA**

THE ROLE OF ALBERTA GOVERNMENT DEPARTMENTS AND AGENCIES

Alberta Energy and Natural Resources

The department is responsible for the management of Alberta's energy, mineral and forest resources, and public lands for the benefit of Albertans.

Syncrude Equity Division of Alberta Energy and Natural Resources

The division manages Alberta's 10 per cent equity participation in the Syncrude project, negotiates agreements on behalf of Alberta and provides management liaison between Syncrude and the Alberta government.

Alberta Oil Sands Technology and Research Authority

In 1974, the Alberta government created a crown corporation (AOSTRA) to develop the technology needed to establish a commercial "in-situ" method for recovery of bitumen from the Alberta Oil Sands. A fund of $146 million is administered by AOSTRA to achieve the purpose of the Oil Sands Technology and Research Authority Act. AOSTRA is working jointly with industry, universities, individual inventory and research institutions to develop the technology needed to achieve its objectives. On March 31, 1977, $42 million had been committed to approved research projects.

The Energy Resources Conservation Board

The ERCB has as some of its main functions the appraisal of reserves and productive capacity for energy and energy resources and the requirements for these both within and outside Alberta, and is to ensure orderly development and environment conservation in areas involving energy and energy resources. The Board is funded 40 per cent by industry and 60 per cent by the government and reports to the Executive Council through the Minister of Energy and Natural Resources.

Alberta Petroleum Marketing Commission

APMC is the petroleum marketing agency of the Alberta government and may acquire, sell or exchange petroleum in Alberta, act as an agent or broker in connection with a purchase, sale or exchange of petroleum in Alberta, and develop and operate storage facilities and related pipelines.

Alberta Environment

This Alberta department sets and monitors environmental standards related to water, air and land quality in Alberta.

Alberta Oil Sands Environmental Research Program

AOSERP is a 10-year, $40 million dollar, provincial/federal research program, jointly funded to assess the effects of oil sands development on air, land and water, and the inhabitants of each.

Alberta Federal and Intergovernmental Affairs

The coordination of programs with other governments, federal or provincial, is the function of this Alberta department.