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ATHABASCA TAR SANDS STUDY

Interim Report

on

ENVIRONMENTAL CONSTRAINTS AND RESEARCH PRIORITIES

for

MINING/HOT WATER EXTRACTION TECHNOLOGY

Prepared for:

The Alberta Department of Environment

Prepared by:

Harold V. Page, P.Eng.

On behalf of:

Intercontinental Engineering of
Alberta Ltd.

4 Aug 72

ABSTRACT OF RECOMMENDATIONS AND RESEARCH PRIORITIES

1. Determine the location and capacity of natural drainage basins (if any) within the mineable area which could be dedicated to the storage of tailings without detriment to the environment.

2. In future the storage of tailings in dyked ponds on the banks of the Athabasca River should be prohibited.

3. Establish a coordinated research program to progressively alleviate the tailings problem.

4. Commence large scale field tests to simulate reclamation techniques.

5. Remove all existing restrictions on available information which is required for environmental planning.

6. Utilize the existing operation on Lease 86 to generate additional data required for environmental planning.

7. Prepare a regional plan for permissable industrial development based upon environmental considerations - with particular regard to human ecology.

8. Future applications for development should be required to demonstrate significant contributions to environmental protection.

9. Financial incentives should be provided to stimulate research and development in Alberta, by Canadians, to resolve the potential environmental problems - notably those involving tailings accumulation and reclamation.

10. Authorize the Alberta Research Council to coordinate technological research required for environmental protection and improvement.

11. Authorize a study of meteorological conditions affecting the Bituminous Sands Area.

12. Initiate groundwater measurements to monitor subterranean conditions.

13. Expand the existing program of sampling and analyzing the Athabasca River.

STATUS OF THE STUDY

The objective of this report is to present to the Alberta Department of Environment the principal preliminary observations and recommendations which result from the Project Team's work on the initial phases of the Study.

On a budget basis the Study is approximately 60% complete. The work to date has been confined to determining what safeguards will be required to protect the environment against the possible proliferation of mining and hot water extraction plants in the Alberta Bituminous Sands Area.

Subsequent phases of the Study, scheduled for the ensuing five to eight months, will examine the possible future technological developments and their relative effects on the environment. This will permit recommendations regarding the ecological factors which should influence future recovery methods.

TERMS OF REFERENCE

In order to properly interpret this Progress Report, one should appreciate the terms of reference prescribed for the Study.

On 6 March 72 the Department of Environment selected Intercontinental Engineering of Alberta Ltd. as the successful competitor to conduct the Study. The selection was based upon the Company's formal submission which has provided the guidelines for executing the project.

The scope of the Study had been set forth in the Alberta Department of Environment's memorandum dated 2 December 71 (refer to Exhibit 1).

A formal contract was signed on 28 April 72 defining the respective responsibilities of the two parties.

Several aspects of these two documents are worthy of special note:

- the total cost of the Study is not to exceed $150,000.
- the geographical area involved in the Study is that designated as the Bituminous Sands Area.
- the area to be studied excludes G.C.O.S. Lease 86 and Syncrude Lease 17, except as required to clarify or interpret baseline data.
- the Client is to supply "baseline data" - i.e. existing technical information on current emissions, and ecological information on the current status of vegetation and wildlife.

PROJECT ORGANIZATION

In accordance with the formal agreement, Intercontinental Engineering of Alberta Ltd. provides Project Management for the Study. The corporate principals include three Canadian companies, viz:

Angus, Butler Engineering Ltd.,
Wright Engineers Ltd.,
Intercontinental Engineering Ltd.

These corporations supply extensive experience in technical and environmental studies. They are represented by the following senior executives:

Percy M. Butler (President),
Ian L.M. Walker,
Peter F. O'Sullivan,
Fred R. Dorward.

For the purpose of conducting the Study, Intercontinental Engineering of Alberta Ltd. organized a Project Team comprising Canadian consultants having complementary expertise in the required disciplines. Exhibit 2 lists the participating consultants and their respective functions.

STUDY OBJECTIVES AND PHILOSOPHY

On 25 April 72 the Project Team met with the Conservation and Utilization Committee which was designated as the advisory body to the Client. On this occasion, the general concept of the project was reviewed and it was recognized that its general parameters were such that it would be essentially a Pilot Study.

For any given recovery technology a definitive environmental study would co-relate the answers to several basic questions viz:

- what are the undesirable emissions (liquids, vapours, and solids)? - i.e. the technical baseline data.
- what are the meteorological, hydrological, and terrain conditions which determine the migration of the emissions?
- what human habitat, vegetation and wildlife exists in the affected region? - i.e. the ecological baseline data.
- what are their respective sensitivities to the emissions?

The nature of any study is influenced by the data available as inputs. At an early stage in the conduct of this Study it became apparent that considerable effort was required to obtain quantitative data beyond the published literature. To some extent this is understandable because the tar sands industry is unique and much of its technology is quite new.

It is common practise, especially in industry, to conduct a Pilot Study to determine the order-of-magnitude of potential problems or preliminary plans. This serves to identify the critical areas and the type of information required to progress subsequently to more definitive conclusions. This approach is well suited to our Tar Sands Study. We have analyzed and co-related the data acquired up to mid-July and tested its adequacy to supply answers to the foregoing basic questions. As would be expected there are significant gaps in the available information, which preclude a quantitative treatment of the total subject at this time.

INFORMATION AVAILABLE

A substantial quantity of technical baseline data pertaining especially to the G.C.O.S. design stack emissions was received from the Client on July 19th. This is being reviewed to determine its possible contribution to more definitive projections of future air quality. The conclusions will be incorporated into the final report at a later date.

We appreciate that the Government is often under considerable pressure by Industry to "classify" information supplied by the latter. Although recognizing that some situations may justify secrecy, we submit that an effective program of environmental planning will ultimately require the examination of all pertinent data and much more extensive monitoring than is now done. This is particularly true for the complex and essential task of prescribing ecological safeguards for the orderly future development of the Alberta tar sands industry. In some instances the Government should contemplate incentives to encourage the generation by Industry of new technology or information which contributes to environmental planning. For example research grants might be appropriate for some studies on tailings disposal and reclamation. Another example might involve tax incentives for core hole drilling which helps to better define subterranean features. An important condition of any contemplated incentive program should require unrestricted Government use of the data thus generated. It is axiomatic that the availability of information is essential to enable Albertans and other Canadians to optimize their career opportunities in this new industry.

The Study has also served to confirm the lack of ecological baseline data. The Government has taken prompt action to initiate a modified Canada Land Inventory for the mineable region of the Bituminous Sands Area. Since it has been estimated that several months will be required to complete this survey, a portion of our Study budget has been deferred into 1973.

One of the Client's objectives is to integrate the results of this Study into the Government's total program to regulate the development of this unique resource. This concept is inherent in the "total system approach" which is evolving through the Conservation and Utilization Committee. One of the immediate benefits of this inter-departmental coordination is the recognition of the need for a regional plan which would project population and community growth beyond Syncrude. We recognize that our Study is expected to provide inputs for the industrial planning which must complement the regional plan. We would suggest that the Provincial Planning Branch should begin to project new community concepts which relate to human ecology.

THE IMPACT OF TECHNOLOGY ON ENVIRONMENTAL PLANNING

The technology used for developing the tar sands determines the impact on the environment. For the purpose of our Study the existing technology can be classified into three industrial entities, viz:

- bitumen production,
- bitumen upgrading,
- power and utilities.

The final report will cover all three of these industrial entities, however, the current report is confined primarily to the environmental impact of bitumen production by the mining/hot water extraction technology since this poses the most urgent research demands.

The present commercial method for separating the bitumen from the Alberta Bituminous Sands involves four inter-dependent steps, viz:

- stripping the overburden (including the lean sand),
- excavating and transporting the bituminous sands,
- hot water extraction of the bitumen,
- disposal of the tailings comprising a mixture of spent sand, clay, water and unextracted bitumen.

Both the existing G.C.O.S. plant and the government authorized Syncrude project employ this basic mining/hot water extraction technology. It is our opinion that this recovery method will continue to be technically and economically feasible wherever the overburden depth is less than 120 feet and the thickness of tar sand is greater than the thickness of overburden. These basic parameters serve to define the mineable portion of

the Bituminous Sands Area. The mineable area comprises approximately 430,000 acres representing 6% of the total Bituminous Sands Area.

Exhibit 3 is a map showing the location of the tar sands which underlay 200 feet or less of overburden.

CONSTRAINTS AND RESEARCH PRIORITIES FOR MINING/HOT WATER EXTRACTION

The participating consultants comprising our Project Team have studied the available data from which they have identified the principal environmental constraints on the proliferation of the mining/hot water extraction technology. They have prepared recommendations to guide the government in establishing short term precautions relating to these constraints. They have also identified additional research required to provide progressively more sophisticated planning, and have suggested priorities for this research. Copies of the individual consultants' reports are appended.

The following comments provide a composite of the principal observations and priority recommendations derived from the appended reports. Readers who are interested in specific topics should refer to the appended documents.

The disposal of tailings from the hot water extraction process represents the most imminent environmental constraint to the future expansion of this recovery method. Typical of tar sands operations, the quantities of material involved are enormous. The tailings comprise the clean sand, water, suspended mineral fines and the unrecovered bitumen. The published data for the Syncrude project gives the following composition for the tailings stream:

- solids (i.e. sand plus fines) 185,660 tons per calendar day;

- water - 193,840 tons per calendar day;

- bitumen - 1,850 tons per calendar day (equals 10,430 barrels).

The tailings are pumped as a slurry to a large retention pond. The Syncrude pond will cover an area of 9.3 square miles and will be formed by diverting the natural water course of the Beaver Creek and building retaining dykes to permit utilization of the basin for impounding of the tailings. The Syncrude plan contemplates the impounding of tailings in the retention pond for the first three to four years of operation, after which time it is planned to pump the water into the mined out area.

The limited research which was done on tailings handling prior to building the G.C.O.S. plant contemplated that sufficient settling of the mineral fines would occur in the retention pond to permit re-cycling of the bulk of the water to the extraction process. Approximately four years of operating experience have demonstrated that the degree of settling is limited and consequently the fines which remain in suspension with the water often restrict the re-cycle stream. The net result is a continual accumulation of water in the tailings pond.

Consequently the G.C.O.S. retention pond provided by dyking the escarpment area along the Athabasca River has not provided sufficient temporary capacity relative to the rate of dyke building. The progress of the tar sand mining has not yet reached the stage where tailings can be placed permanently in the mined-out area. As a consequence, G.C.O.S. has advised the Alberta Government of its urgent desire to convert Ruth Lake into a supplementary tailings pond. This application serves to illustrate the magnitude and urgency of the tailings problem.

The appended recommendations contain pertinent references to the environmental implications of this situation both short term and long term. Some of the suggestions include the following:

a) The behavior of the existing G.C.O.S. tailings pond should be examined, for example, to determine what seepage, if any, occurs from the existing tailings pond (Syncrude estimates 5800 g.p.m. of water to "evaporation and percolation").

b) In view of the recent formal request for converting Ruth Lake into a tailings pond an examination should be made of the ecological and hydrological characteristics of that particular drainage regime to ascertain whether its diversion would be adviseable.

c) Co-relate the observations pertaining to tailings seepage and the ecological condition.

d) If diversion is authorized, specifications should be prepared to define design of the new hydraulic channels.

e) Any new dykes which are authorized should be constructed in accordance with the Department of Energy, Mines and Resources, Technical Bulletin TB 145, published in March, 1972.

f) If permission is granted to use Ruth Lake as a supplementary tailings pond, permanent observation wells should be required in the surrounding area to monitor the effect of groundwater properties and level.

Unless some tangible environmental problems can be identified from the available data or short term research it would seem reasonable to permit the use of Ruth Lake for tailings storage under prescribed conditions such as those already suggested. This might be done as a pilot program to generate quantitative data which would permit more sophisticated control of future projects.

Regulations should be introduced to prevent the construction of any more tailings ponds involving the dyked sections in the immediate vicinity of the Athabasca River. The possibility of overflow conditions, river or wind errosion of the sand dykes and/or structural failure would result in consequences too serious to justify continuation of this practise.

One of the longer range recommendations presented in Appendix 2A, would involve a comprehensive survey of all of the drainage basins which traverse the mineable area. From the data thus obtained it could be determined which water systems might be safely diverted under prescribed conditions. This in turn would serve to identify what additional water basins might be allocated to tailings storage without undue damage to the environment. Exhibit 4 is a map of the drainage basins in the Bituminous Sands Area.

Such a study would also identify the existing hydrology regimes which should be maintained in their present condition. Mining exclusions could then be defined within prescribed distances of these critical water courses.

It is important to recognize that the overall pattern of surface and groundwater flows will be a basic consideration in preserving or improving the environment. The geology of the tar sands deposit and the established pattern of lease boundaries within the mineable area may not be consistent - from a development priority point of view - with the fundamental ecological consideration of hydrology. Consequently the present practise of individual lease development may have to be modified significantly to permit the establishment of a master development plan for the area based upon environmental considerations. This may also involve some planning of the permissible sequence of lease development. It follows that the appropriate government departments should initiate the basic studies at the earliest opportunity in order to insure that regional plans are available in time to properly assess development proposals and if possible, to guide their preparation.

Appendix 1 deals with the extent of the mineable area which could be disturbed at any given time assuming a proliferation of open pit mines at a projected capacity of one million barrles per day of product equivalent. Calculations indicate that under such conditions a total area of 19,800 acres (i.e. 31 square miles) would be the minimum required for the existing technology. These calculations assumed that deforestration

for overburden drainage would proceed the mining by two years and also that the time lag between mining and reclamation would be six years. It is recommended that this ratio of disturbed land to productive capacity should be used as a tentative limit pending improved technology.

The subject of ultimate land reclamation is an important long term consideration for which research studies should be commenced as soon as possible to develop policy guidelines for tailings disposal and mining plans. The current program of testing small vegetation growth on the face of the existing G.C.O.S. dykes will no doubt prove helpful in alleviating the specific problem of wind errosion. Much more extensive studies will be required, however, to determine the total vegetation including reforestration which would be possible and desirable in a mined-out area which has been backfilled with tailings. Such research will require consideration of the ultimate disposition of the mineral fines and unrecovered bitumen. Obviously the water content of the backfilled area and its effect on the total groundwater system will also be significant. The pH of the back-filled regions may also be important. Several of the appended reports provide more specific suggestions on this complex subject. Since the determination of satisfactory solutions will require extended periods of study and experimentation it is important that such programs be initiated at an early stage. In order to provide logical direction for reclamation studies it is desirable to have a master plan for the ultimate optimum land utilization and hopefully this will be provided by the modified Canada Land Inventory which was recently initiated.

The ecological baseline data currently being generated should also provide useful information on the most desirable soil conditions for preferred vegetation and the related wildlife. For example, the possibility of supporting renewable forest resources on reclaimed land should be considered. The suggestion to stockpile muskeg for later use in reclaiming is not adviseable since this would create other environmental problems. The distribution of muskeg throughout the Bituminous Sands Area is shown in Exhibit 5. The existing sand dunes may offer useful clues on reclamation, these are shown on the map attached as Exhibit 6. Both of these maps were prepared by the Alberta Research Council.

The environmental considerations related to human habitat will require more definitive treatise including the development of a regional plan for community development and the related infrastructure. The Fort McMurray General Plan 1972, just issued by the Department of Municipal Affairs, is an excellent document which provides guidelines for the expansion of the Town of Fort McMurray to include the population increase expected to result from the Syncrude project. This research should be extended to determine the optimum municipal developments related to additional plants beyond Syncrude. Appendix 6 deals with this subject from the point of view of Climatology. As an initial suggestion it proposes consideration of the Birch Mountain region for a regional community if one or more should prove necessary. Our preliminary recommendations reflect only environmental considerations and these must of course be integrated with other factors such as:

a) possible planning limitations to the ultimate population capacity for the existing Town of Fort McMurray;

b) acceptable commuting distances to plant locations;

c) transportation facilities.

The overall plan for human habitat must include studious consideration of the native population which is currently concentrated in the Fort McKay settlement.

Although our specific study on air quality is not yet completed, the report by Western Research and Development Ltd. suggests that seven additional Syncrude style plants might be accommodated within the southern half of the mineable region without any further effect upon air quality beyond that approved by the Syncrude permit. This preliminary conclusion, however, is based upon the diffusion characteristics estimated for the Syncrude application. One of the principal recommendations would involve a more advanced meteorological survey to permit more reliable determination of the year round diffusion capabilities of the atmosphere.

The prevalence of ice fog in winter months represents a unique local condition apparently caused by the large exposed surface of hot tailings water and the meteorological conditions in the Athabasca valley. This phenomenon poses an additional possible constraint to the future construction of additional hot water extraction plants. Apart from the

reduced visibility caused in the immediate area by the ice fog, additional impacts upon the environment could result from an abnormal saturation of the atmosphere with water vapour thereby affecting the capacity to disperse airborne contaminants. As recommended in the appended report by Geoscience Research Associates Ltd., additional studies should be conducted to permit quantifying this factor.

Appendix 2 contains recommendations for more extensive monitoring of the Athabasca River and suggests the locations for sampling stations.

Appendix 2B presents specific recommendations for groundwater studies.

TIME SCHEDULE FOR RESEARCH

Within the mineable area the estimated reserves calculated as synthetic crude product approximate 30 to 40 billion barrels. The permit for the existing G.C.O.S. plant authorizes an annual production of 16 million barrels. The Syncrude permit authorizes an additional 46 million barrels of product per year.

The estimated mineable bitumen reserves will support many more recovery plants having the capacity of the Syncrude facility or greater. Most recognized authorities on the future of the petroleum industry have predicted an escalating market demand for "synthetic fuels" as derived from the tar sands. These projections have been related to the current and future need to supplement the world's supply of conventional crude oil, although it should be recognized that the bitumen resource may ultimately prove to be more valuable as a precursor to other hydrocarbons. The Alberta Energy Resources Conservation Board has estimated that the market demand for synthetic fuels could justify an additional tar sand plant of 150,000 barrels per day capacity each year commencing in 1978 and continuing through 1985 (refer to Exhibit 7). Potential market demand alone, however, should not be used to project the rate of tar sands development. It is our opinion that the availability of design and construction services could be a principal constraint which might require a three year interval between future plants. Financing could be an additional restraint since each plant represents an investment of approxi-

mately 500 million dollars. Another important consideration relates to the need for research and development on improved technologies, especially those which will safeguard the environment.

In summary we would suggest that a schedule be prepared to conduct the recommended research programs assuming that additional extraction plants will be proposed after Syncrude at an initial frequency of three years and that this time interval will reduce to two years as the total product output approaches one million barrels per day.

Respectfully submitted

INTERCONTINENTAL ENGINEERING OF
ALBERTA LTD.

Harold V. Page

Harold V. Page, P. Eng.
Project Director

EXHIBITS

Memorandum regarding request for proposal for consultant to study the effects of eventual multi-plant operation over the extent of the Athabasca Tar Sands.

For the information of interested individuals and agencies, the following is a general concept of the work that is to be carried out within the terms of reference which will be negotiated as a result of this request for qualifications and competence:

(1) Identify the various methods that could be used for oil extraction and their comparative merits with respect to minimum adverse effects on the environment.

(2) In considering the Clarke method of tar sands extraction (or its variations), it will not be necessary to study the effects on the environment within the area in which actual mining and extraction activities take place, but detrimental effects or impact on the otherwise undisturbed surrounding area are to be investigated.

(3) Other recovery methods, such as in situ steam extraction, shall be evaluated in terms of impact or consequences on the immediate as well as the surrounding environment.

(4) Recommendations shall be made with respect to mining, extraction and processing methods and procedures that should be employed to eliminate or minimize adverse effects on the environment.

(5) Recommend constraints to be applied on plant location, plant capacity and number of plants per given area, as may be required to give effect to the above recommendations.

(6) Determine which effects or problems should be given priority in research efforts, the allocation of resources for abatement, and legislation. Investigations should include the recommendations for the establishment of a realistic balance between long and short term effects on the environment. The study should also enable the Government of Alberta to select optimum strategies in the implementation of long term tar sands development policies.

(7) It is suggested that before forwarding a submission either alone or on a consortium basis, consultant carefully assess the degree of expertise necessary, the opportunities of using local talent, and the actual ability to perform the work.

Consultant to advise client of contacts to be made so that prior introductions can be arranged.

E. Kupchanko

Eugene E. Kupchanko, P. Eng.
Director,
Pollution Control Division

EEK/gc

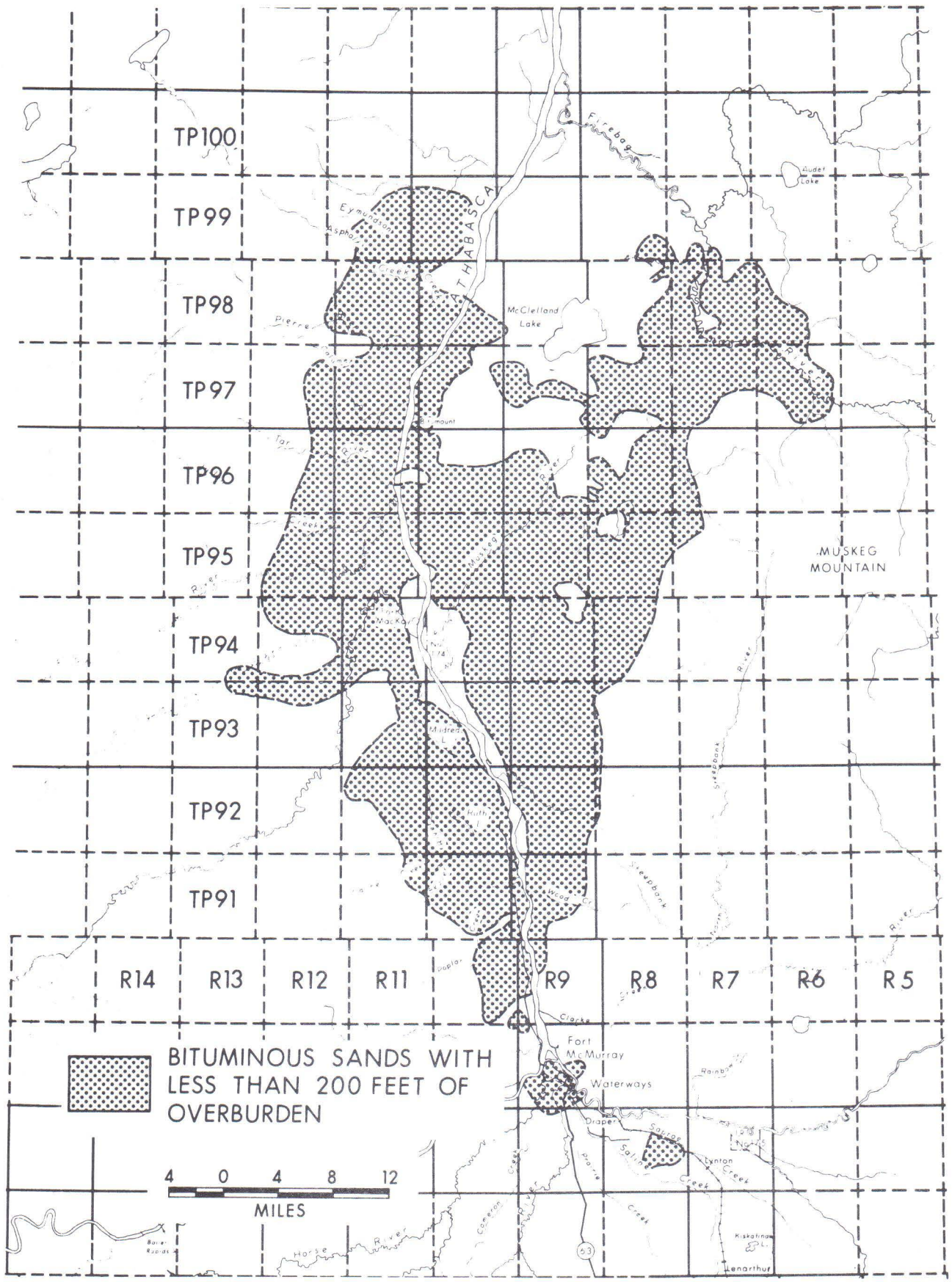
December 2, 1971

EXHIBIT 2

ATHABASCA TAR SANDS STUDY

Project Team Organization for Phase II

Function	Company	Name
Project Director	Hydrocarb Consultants Ltd.	H.V. Page
Water Quality	University of Alberta	P. Bouthillier
"	Research Council of Alberta	C. Neill
"	"	M. Carrigy
Air Quality	Western Research & Development	J. Lukacs
"	"	P. Beauchemin
"	"	D. Leahey
"	"	C. Harvey
Human/Land Ecology	Arctic-MacKenzie Consultants	J. Borger
"	"	P. Otke
Climatology	Geoscience Research Associates	J. Kinisky
Mining Technology	Independent	M. Pearson
"	Wright Engineers Ltd.	R. Palmer
Extraction Technology	Research Council of Alberta	S. Creighton
Upgrading Technology	Independent	C.G. Miller
Utilities Technology	Intercontinental Engineering	I.L.M. Walker
"	"	C.E. Wood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MUSKEG MOUNTAIN
McClelland Lake
Fort McMurray
Waterways
Draper
Lynton
Lenarthur
BITUMINOUS SANDS WITH LESS THAN 200 FEET OF OVERBURDEN
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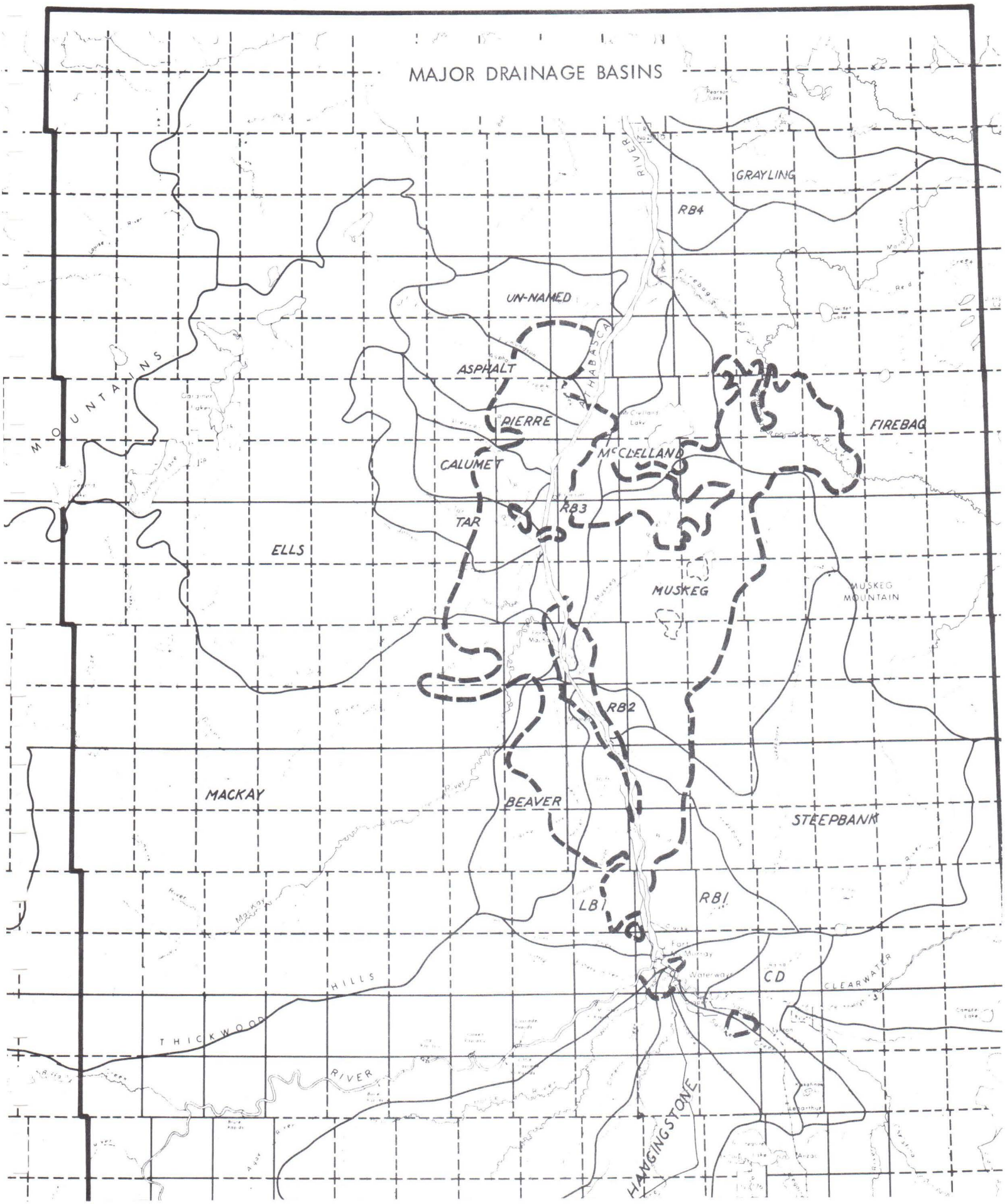
MILES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MUSKEG
MUSKEG MOUNTAIN
RB2
MACKAY
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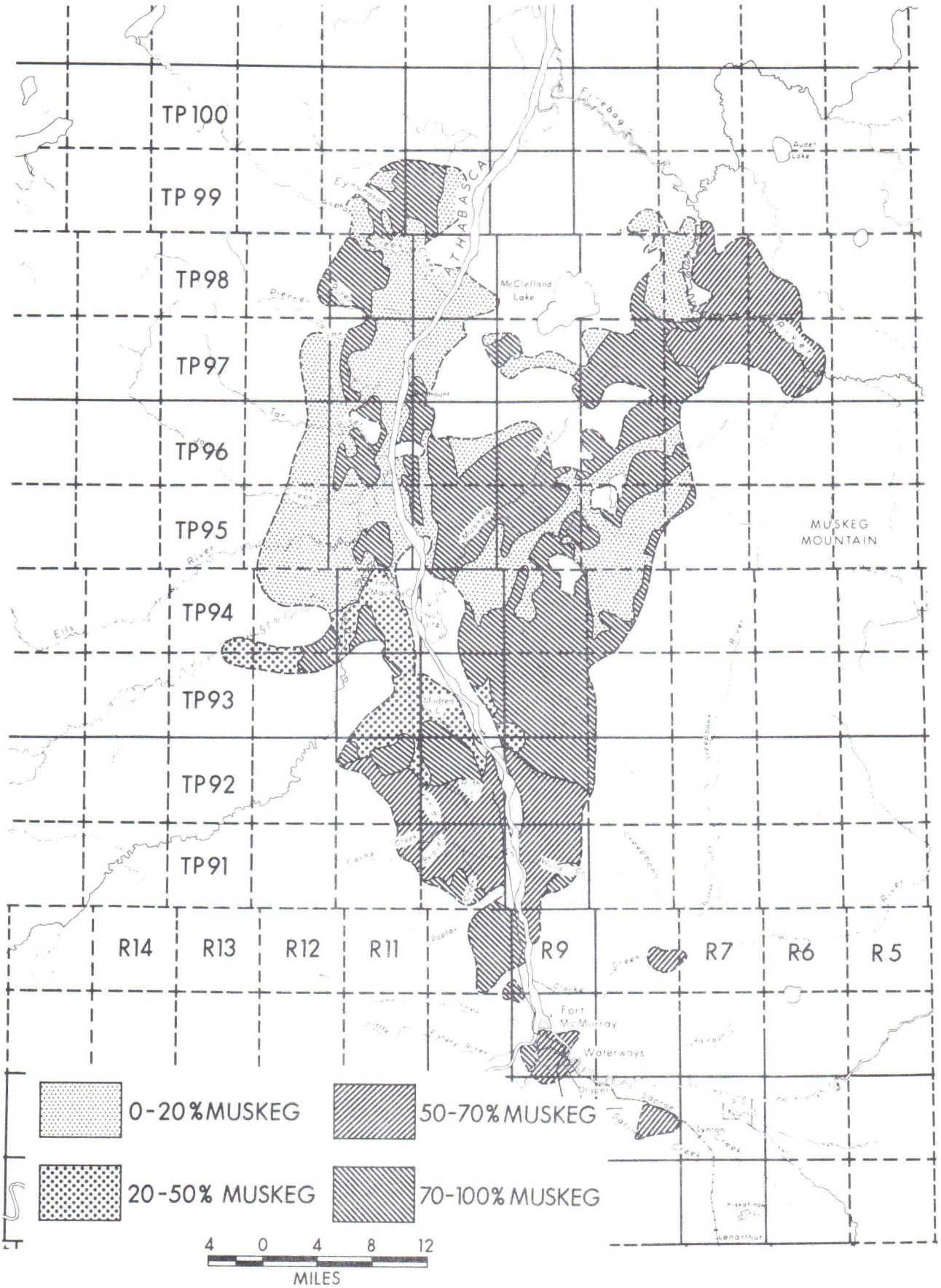
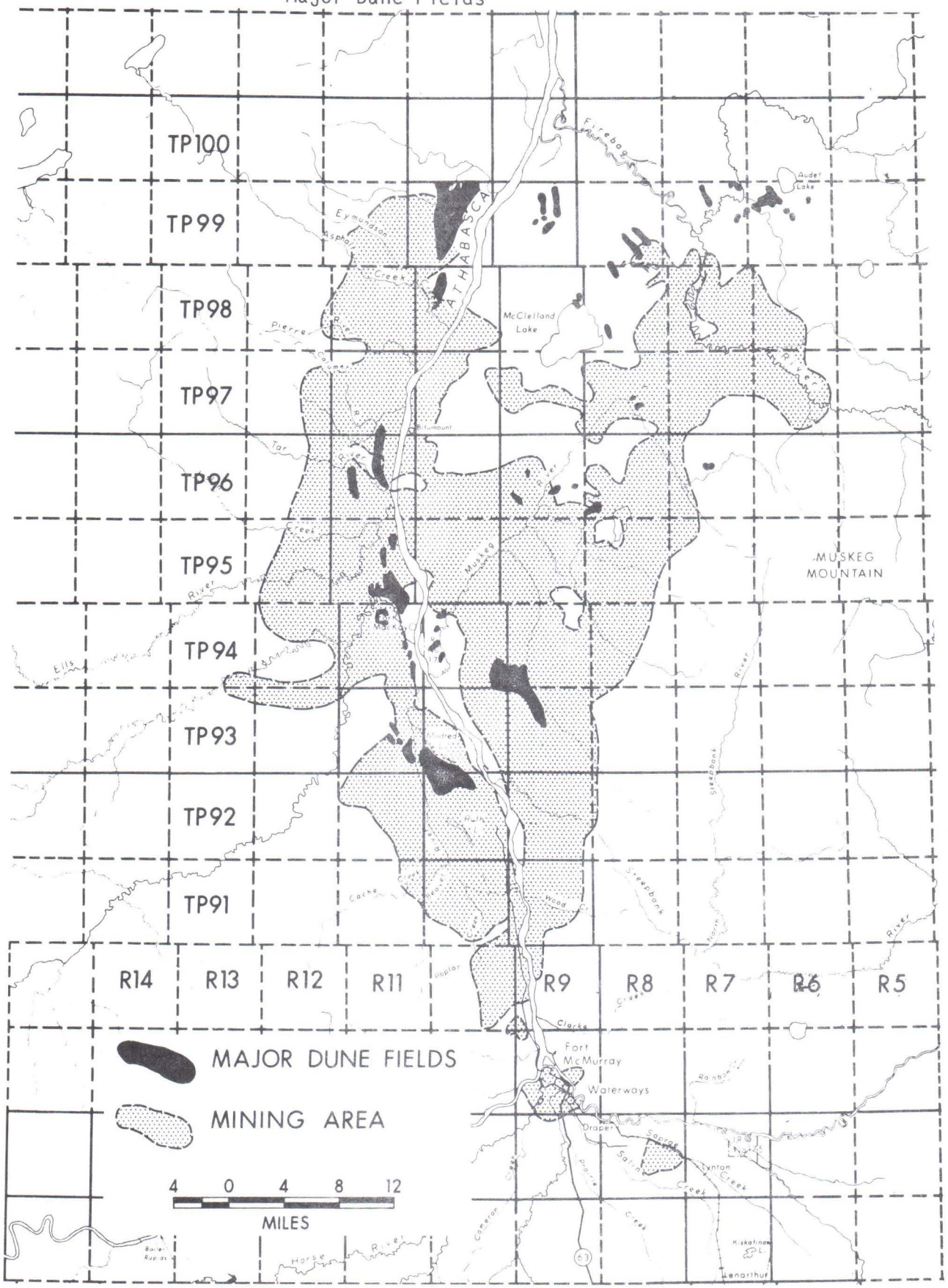
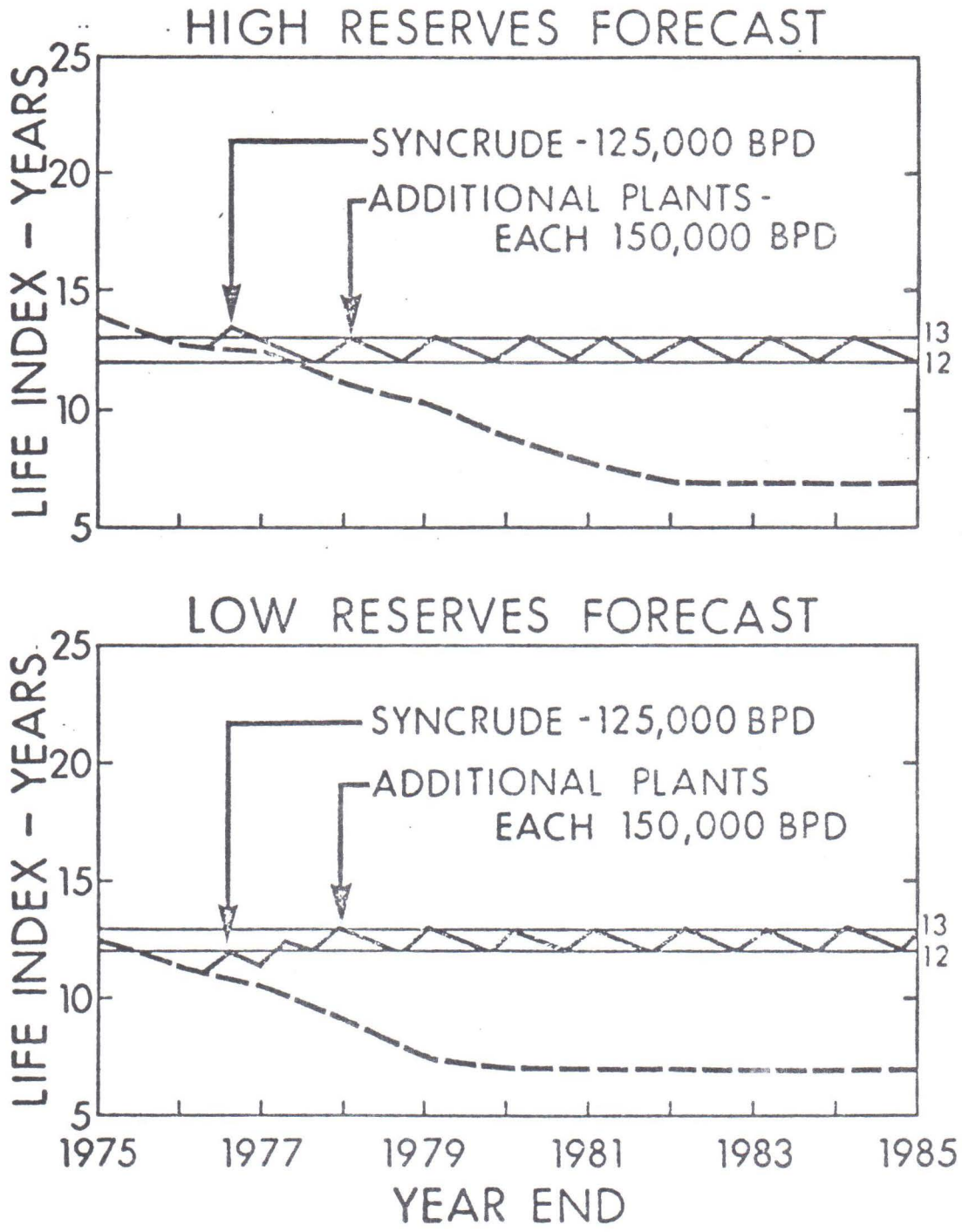
Muskeg Distribution



Major Dune Fields





ADDITIONAL PRODUCTION OF SYNTHETIC CRUDE OIL REQUIRED TO MAINTAIN LIFE INDEX AND MEET FORECAST DEMAND

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