Shell Canada Limited

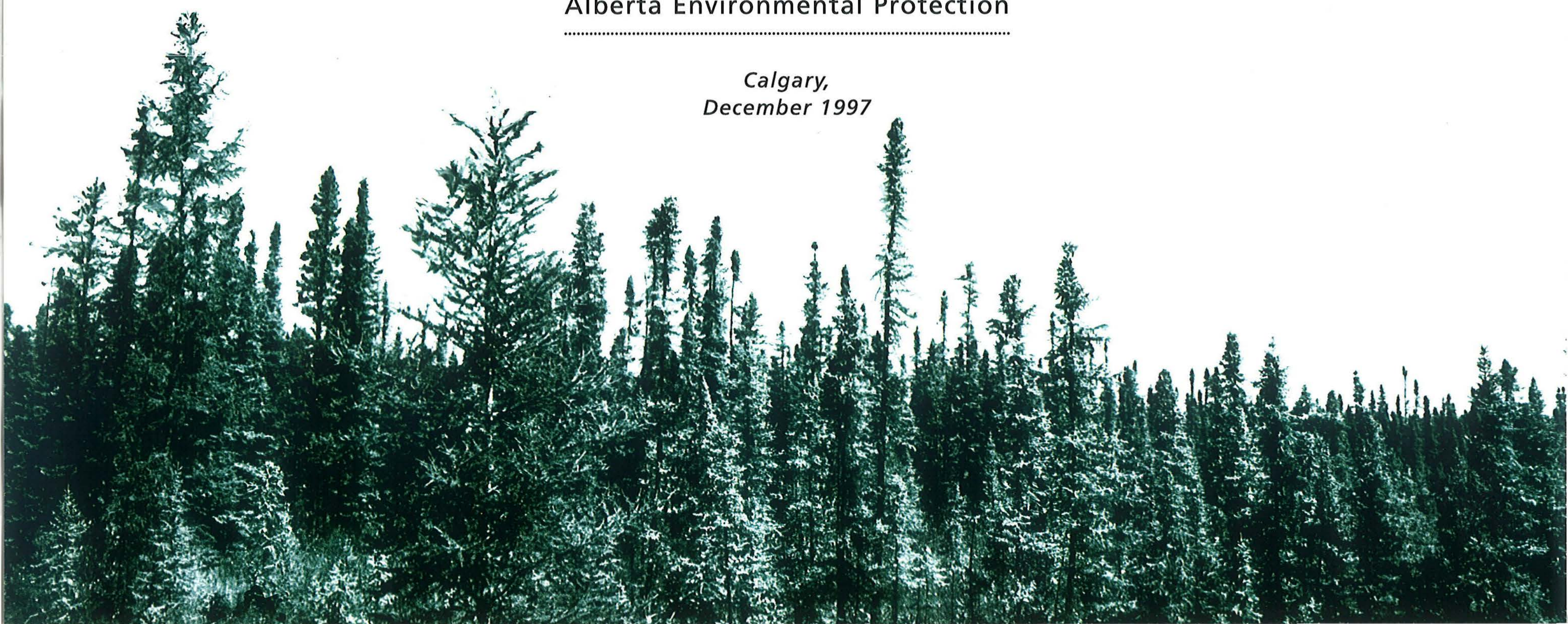
application for the approval of

MUSKEG RIVER MINE PROJECT

Volume 1 • Project Description

submitted to
Alberta Energy and Utilities Board
and to
Alberta Environmental Protection

Calgary,
December 1997



December 19, 1997

Shell Canada Limited

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Dear Sirs:

Re: Application for Approval of Muskeg River Mine Project

Shell Canada Limited hereby applies to:

- The Alberta Energy and Utilities Board, pursuant to the *Energy Resources Conservation Act* and Section 10 of the *Oil Sands Conservation Act* (OSCA), in accordance with the enclosed information, for approval to:
    - construct and operate an oil sands mine and bitumen extraction plant on the western portion of Bituminous Sands Lease No. 7277080T13 (Lease 13) north of Fort McMurray, Alberta. The expected production rate from the project area is 8.7 million m^3/a (55 million bbl/yr) of bitumen, or 23, 850 m^3 (150,000 bbl) per day.
    - receive third-party oil sand material (mined ore or intermediate process streams, such as bitumen froth) at its site for processing.
    - produce and ship oil sand material (mined ore or intermediate process streams, such as bitumen froth) from its site for processing at third-party facilities.
- Alberta Environmental Protection (AEP) for approval:
    - under Section 63 of the *Environmental Protection and Enhancement Act* (EPEA), to develop the Muskeg River Mine Project in accordance with the environmental plans and specific applications described in this application.

- under Section 11 of the *Water Resources Act* (WRA), to construct diversion works and withdraw water from the Athabasca River and other groundwater sources in accordance with specific applications described in this application.

In support of these applications, Shell Canada Limited submits the enclosed documentation entitled *Application for Approval of the Muskeg River Mine Project.* In accordance with the provisions of Division 1 of Part 2 of EPEA and the Terms of Reference issued by Alberta Environmental Protection on November 7, 1997, an environmental impact assessment (EIA) has been prepared. The results of the EIA are reported in the enclosed documentation.

The application consists of the following:

- Volume 1: Project Description, which contains the information required for the EUB application under the *Oil Sands Conservation Act* (OSCA), the AEP 10-year approval application under EPEA, and the AEP application for a water resources permit under the WRA

- Volume 2: Environmental Impact Assessment – Biophysical and Historical Resources, Baseline Conditions

- Volume 3: Environmental Impact Assessment – Biophysical and Historical Resources, Part 1: Impact Assessment and Part 2: Supplements

- Volume 5: Environment Impact Assessment – Socio-Economic Impact Assessment

Volume 4: Environmental Impact Assessment – Biophysical and Historical Resources Cumulative Effects Assessment and Regional Development will be issued in January, 1998.

Shell Canada Limited respectfully submits that its proposed Muskeg River Mine Project is in the public interest, considering the project's social, environmental and economic effects, all of which is described in the enclosed documents. This project is expected to generate 3,000 work years of direct employment in Alberta during design and construction and about 800 new direct long-term jobs throughout the project's operation phase. The undiscounted net social benefits of the Muskeg River Mine are estimated to be $3.8 billion.

Shell's environmental assessment has not revealed any unacceptable environmental effects, provided that the appropriate mitigation and monitoring is undertaken. Shell is committed to the ongoing development of oil sands technology which improves both economic and environmental performance of oil sands operators. Shell is also committed to cooperating with other developers in the region and all stakeholders to promote orderly and efficient development of one of Canada's largest energy resources in an economic and environmentally acceptable manner.

In addition, Shell has conducted an extensive communications program in the Fort McMurray region since early 1997. Shell staff have participated in a variety of community forums and have met regularly with representatives of regulatory agencies, aboriginal groups, local residents, community organizations, special interest groups and the public, to inform them of the company's plans for developing the Muskeg River Mine Project and to obtain their input in developing these plans.

Please direct all communications regarding this application to:

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Regulatory Affairs Manager
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and to counsel

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Respectfully submitted on December 19, 1997.

Yours truly,

SHELL CANADA LIMITED

Neil J. Camarta
Vice President, Oil Sands

PREFACE

APPLICATION FOR APPROVAL OF THE
MUSKEG RIVER MINE PROJECT
VOLUME 1: PROJECT DESCRIPTION

EXECUTIVE SUMMARY

PURPOSE

Shell Canada Limited (Shell) is applying to the Alberta Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) for approval to construct, operate and reclaim a $1.2 billion oil sands mine and processing facilities on the western portion of Oil Sands Lease No. 7277080T13 (Lease 13). Lease 13 is located about 70 km north of Fort McMurray, Alberta and about 500 km northeast of Edmonton.

SCOPE OF PROJECT

Project Facilities

The project, to be known as the Muskeg River Mine Project, involves mining and processing oil sands from the western portion of Lease 13 to produce a diluted bitumen (dilbit) product. The project includes:

- a truck-and-shovel mining operation
- an extraction plant that uses a warm (45°C to 50°C) water-based, caustic-free ore conditioning and extraction process and a conventional centrifuge froth treatment process, coupled with a paraffinic solvent-based product clean-up unit to meet the low solids and water bitumen specification
- a tailings management scheme that uses a tailings settling pond for initial tailings storage, converting to consolidated tailings production and the initiation of in-pit storage after four years
- utilities and infrastructure

Resource Base

Lease 13 covers 20,182 ha (77 sections) and has a potentially mineable bitumen resource of about 800 million m^3 (5 billion bbl). The reserves in the Muskeg River Mine area are assessed at about 200 million m^3 (1.3 billion bbl). The targeted production rate from the project area is 8.7 million m^3/a (55 million bbl/yr) of bitumen, or 23,850 m^3 (150,000 bbl) per day. At this rate, the expected mine life is over 20 years.

Upgrading and Marketing

Bitumen from the Muskeg River Mine will be transported to the Edmonton area via a 610-mm diluted bitumen pipeline. The transportation diluent will be returned to Lease 13 via a 323-mm pipeline. Shell's plan is to build a new upgrader at Scotford, which will produce a range of upgraded refinery feedstocks. The bitumen product will also be suitable for direct-marketing as a bitumen product with low water and solids content.

Shell is also seeking approval to receive third-party oil sands material at its site for processing and to ship this material from its site for processing elsewhere.

Project Schedule

The project schedule is focused on achieving production in 2002. Site preparation will start in early 1999, followed by facility and mine construction through to early 2002. Commissioning and start-up are planned before mid-2002.

PUBLIC CONSULTATION

Shell has conducted an active communications program in the Fort McMurray area since early 1997. A focused effort has been made to work closely with Fort McKay, the community closest to Lease 13, to understand their issues and concerns in order to ensure understanding and mutually acceptable development.

ENVIRONMENTAL IMPACTS

The environmental assessment has not revealed any unacceptable environmental effects, provided that the appropriate mitigation and monitoring are undertaken.

INDUSTRIAL BENEFITS

The design and construction of the project will generate an estimated 3,000 work years of employment in Alberta. About 800 full-time staff will be employed in the Muskeg River Mine operation.

About 60% of the project's $1.2 billion capital cost will accrue directly to the provincial economy. About 80% of the annual $225 million to $300 million operating expenditure will be spent in Alberta.

DEVELOPMENT PROPONENTS

Shell is undertaking this project with The Broken Hill Proprietary Company Limited (BHP), through BHP Diamonds Inc. Shell and BHP are parties to a feasibility agreement for assessing and advancing the development of an oil sands project on Lease 13.

PREFACE

APPLICATION FOR APPROVAL OF THE MUSKEG RIVER MINE PROJECT VOLUME 1: PROJECT DESCRIPTION

GUIDE TO THE APPLICATION

SCOPE

The Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) applications for approval of the Muskeg River Mine Project have been integrated to:

- reduce the amount of duplication, particularly in the area of project descriptions
- make the review of the documents by regulators and the public as efficient as possible

This application is presented in five volumes and contains the necessary information for the approvals listed in Table P-1.

Table P-1: Integrated Application Content Summary

Volume	Title	Guideline	Legislation
Volume 1, Parts 1, 2 and 3	EUB Application	ERCB Guide G-23 September 1991	OSCA Sections 10 and 11
Volume 1, Part 4	AEP 10 Year Approval	AEP Interim Guide to Content February 1994	EPEA Approvals Procedure Regulation 113/93
Volume 1, Part 4	Water Resources Application	Guidelines for Licensing July 1997 Dam & Canal Safety Guidelines December 1991	WRA Section 11 WRA Dam & Canal Safety Regulations 351/78
Volume 2	EIA - Biophysical and Historical Resources Baseline Conditions	EIA Terms of Reference, November 7, 1997 and EPEA Section 47	EPEA Section 46
Volume 3, Parts 1 and 2	EIA - Biophysical and Historical Resources Impact Assessment	EIA Terms of Reference, November 7, 1997 and EPEA Section 47	EPEA Section 46
Volume 4*	EIA - Biophysical and Historical Resources Cumulative Effect Assessment	EIA Terms of Reference, November 7, 1997 and EPEA Section 47	EPEA Section 46
Volume 5	EIA - Socio-Economic Impact Assessment	EIA Terms of Reference, November 7, 1997 and EPEA Section 47	EPEA Section 46
* Note: To be issued in early 1998.			

REGULATORS' INFORMATION REQUIREMENTS

The information requirements of the EUB and AEP, and the location of the required information in Volume 1, are summarized in:

- Table P-2 - for the EUB G-23 requirements
- Table P-3 - for the AEP 10-year approval requirements
- Table P-4 - for the AEP water resources information requirements

The location of the information requirements described in the Final Terms of Reference for the EIA is provided in EIA Volume 2.

Table P-2: EUB Guideline G-23 Information Requirements

EUB Guideline	Information Required	Volume 1 Sections
1.1	Project summary, objectives and approvals requested	Section 1
1.5.1	Act and section under which application is made	Section 1.6
1.5.2	Name and address of Applicant	Section 1.6
1.5.3	Statement of need for and timing of the project	Section 1.1
1.5.4	Scheme description: location, size, scope, schedule, pre-construction, start-up, duration and reasons for proposed schedule	Section 1.1
1.5.5	Description of the regional setting with reference to existing and proposed land use	Section 1.2
1.5.6	Map of surface and subsurface lease holds	Section 1.1
1.5.7	Map of existing developments	Section 1.1
1.5.8	Aerial photo of proposed project facilities	Section 1.3
1.5.9	General description of storage and transportation facilities for dilbit, including pipeline size and ownership	Section 13.2
1.5.10	Proposed rate of production of dilbit over project life	Section 1.1
1.5.11	Description of oil sands owned or leased	Section 1.2
1.5.12	Description of status of negotiations with the free-hold, leasehold and mineral surface rights owners	Section 4.6
1.5.13	Description of proposed energy sources, alternative sources, rates of use, and supply sources	Section 7
1.5.14	Results of public information programs	Section 12
1.5.15	Start and completion dates	Section 15
1.5.16	Name of person responsible for application	Section 1.6
2.1.1	Geological description	Section 2
2.1.2	Evaluation of the reserves within the project area	Section 3
2.1.3	Description of the project layout and mining equipment selected	Section 4
2.1.4	Description of the mine development plans	Section 4
2.1.5	Description of the design, stability analysis, construction method and schedule of pit slopes and discard, including tailings	Sections 4 and 6
2.4.1	Description of the bitumen extraction, utilities, and offsites facilities	Sections 5 and 7
2.4.2	Material and energy balances, including recoveries, water use and energy efficiency	Section 9
2.4.3	Descriptions of products, byproducts and discard generated and their disposition	Sections 4, 5 and 7
2.4.4	Treatment and disposal of surface drainage from the processing plant, product storage and discharge areas	Section 8
2.4.5	Comparison of alternative processes based on recovery, energy efficiency, cost, commercial availability and environmental considerations, and reasons for selecting the proposed process	Section 5
2.4.7	Measurement	Section 9
2.5.1	Electrical facilities and external sources	Section 7
2.5.2	Source, quality and quantity of fuels, electricity or steam obtained from beyond project site	Section 7
2.5.3	Options to eliminate the need for offsite energy resources	Section 7
2.6.1	Description of air and water pollution control and monitoring facilities, including a liquid spill contingency plan	Section 16

Table P-2: EUB Guideline G-23 Information Requirements (cont'd)

EUB Guideline	Information Required	Volume 1 Sections
2.6.2	Description of the water management program including: (a) proposed water source and expected withdrawal; (b) source water quality control; (c) wastewater program; and (d) water balance for the proposed scheme	Sections 8 and 16.4
2.6.3	Surface drainage collection, treatment and disposal	Sections 8 and 16.4
2.6.4	Description of the emission control system	Section 16.3
3.1.1	Summary of project capital and operating costs	Section 14
3.2	Summary of public benefits and costs during construction and operation	Section 11
3.3	Summary of the economic and employment impacts of the project at the regional, provincial and national levels	Section 11

Table P-3: EPEA 10-Year Approval Information Requirements

EPEA Regulation Clause	Information Required	Volume 1 Sections
3(1)a	Name and address of Applicant	Section 1.6
3(1)b	Location, capacity and size of the activity to which the Applicant relates	Section 1.1
3(1)c	Nature of the activity and the change to the activity (amendment, addition or deletion as the case may be)	Section 1.1
3(1)d	Where the Applicant requires an approval from the Energy and Utilities Board, the date of the written decision in respect to the Application	-
3(1)e	An indication of whether an environmental impact assessment report has been required	Section 1.4
3(1)f	Copies of existing approvals that were issued to the Applicant in respect of the activity under this Act or a predecessor of this Act	N/A
3(1)g	Proposed or actual dates for construction commencement, construction completion and commencement of operations	Section 15
3(1)h	List of substances, their sources; the amount of each substance that will be released into the environment as a result of the activity, the change to the activity or amendment, addition, deletion, as the case may be; the method by which the substances will be released; and the steps taken to reduce the amount of the substances released	Section 16
3(1)i	Summary of the environmental monitoring information gathered during the previous approval period	N/A
3(1)j	Summary of the performance of substance release control systems used for the activity during previous approval period	N/A
3(1)k	Justification for the release of substances into the environment as a result of the activity, the change to the activity or the amendment, addition or deletions, as the case may be	Sections 10 and 16
3(1)l	Measures that will be implemented to minimize the amount of waste produced, including a list of the wastes that will or may be produced, their quantities and the method of their final disposition	Section 16
3(1)m	Any impact, including surface disturbance, that may or will result from the activity, the change to the activity or the amendment, addition or deletion, as the case may be	Sections 10 and 16
3(1)n	Confirmation that any emergency response plans required to be filed with the local authority of the Municipality or with Alberta Public Safety Services have been so filed	Section 15.3
3(1)o	Confirmation that there are contingency plans in place to deal with any unforeseen sudden or gradual releases of substances to the environment	Section 15.3
3(1)p	Conservation and reclamation plan for the activity	Section 16.4
3(1)q	Description of the public consultation undertaken or proposed by the Applicant	Section 12
3(1)r	Information required under any other regulation under the Act to be submitted as part of or in support of the Application	Section 16.5
3(1)s	Any other information required by the Director, including information addressed in a standard or guideline pertaining to the activity that is published or adopted by the Department	-

Table P-4: Water Resources Act Information Requirements

Dam Safety Guideline Clause	Information Required	Information, Location and Remarks
1	Key plan showing principal topographic features of the drainage area (watershed) and downstream channel at an appropriate scale	Vol 1, Section 8
2	General plan of tailings pond and adjacent areas at an appropriate contour interval showing location of all appurtenant structures and reference bench marks	Vol 1, Section 6
3	General plan of tailings pond at an appropriate scale showing borrow areas, extent of reservoir, water surface and reservoir capacity curves	Vol 1, Section 6
4	Centerline profile of dykes.	Vol 1, Section 6
5	Typical cross-section(s) of dykes at maximum section.	Vol 1, Section 6
6	Gradation curves of granular filter materials and the base material being protected	Vol 1, Section 6
7	Calculations showing analysis of embankment stability including the effect of rapid drawdown of the reservoir	N/A
8	Details of the hydrologic studies carried out to establish the size of the spillway(s)	N/A
9	Detailed plan of spillway	N/A
10	Detailed plan(s) of outlet works showing locations and dimensions of all valves or sluice gates, intakes, trash racks, outlet towers, gate houses and appurtenant structures	N/A
11	Discharge rating curve for the outlet works	N/A
12	Sub-surface exploration results.	Vol 1, Sections 2, 3 and 6
13	Miscellaneous plans of construction features not covered above such as pilings, fish ladders, flash boards, timber details, radial gates or mechanical operating devices, fuse plug spillways, etc.	N/A
14	Construction specifications	Vol 1, Section 6
15	Proposed construction schedule	Vol 1, Section 6
16	Spillway and outlet model studies	N/A
17	Plans for handling river diversion during construction	N/A
18	Flood inundation maps, flood action plans, and emergency preparedness plans	N/A
19	Instrumentation drawings, reports and reading schedules	-
20	Schedule of first filling of reservoir, operating methodology	Vol 1, Section 6
21	Design reports	-
22	Additional information required at discretion of the Dam Safety Branch	-
Water Diversion Guideline Clause		
1	The application form (WR1) must be completed and signed by the owner or an authorized official of the company	Attached to transmittal letter
2	Plans should be on a material suitable for microfilming, and should have title block which includes: (a) company name (b) drawing number (c) the stamp or seal of a registered professional engineer	Provided in final design
3	A key plan showing the overall project and its location in Alberta.	Vol 1, Section 1.1

Table P-4: Water Resources Act Information Requirements (cont'd)

Water Diversion Guideline Clause	Information Required	Information, Location and Remarks
3 (cont'd)	A general location plan tied to quarter-section lines, including the configuration of the river, meander, location of intake, pumphouse and other associated works (including control structures, spillway, dam location).	Vol 1, Section 8
	Detailed design drawings of the intake and pumphouse (if it is a permanent pumpsite) or diversion works, including the location, elevations and extent of the diversion works.	Provided in final design
	If a sewage treatment plant or lagoon is used, provide plans of the plant and/or lagoon including outfall and discharge channel.	Provided in final design
4	Conceptual plans may be accepted for initial processing on the understanding that construction plans will be forwarded for review (one set of plans will be required for processing).	Will be supplied when appropriate
5	Quantitative analysis of the effect the proposed diversion of water may have on: (a) the source of supply and current water users (b) neighbouring lands and works (c) aquatic habitat (d) the environment in general	Vol 3, Sections E4 and E5
6	Other reports may include: (a) project description (b) construction specifications (c) proposed construction schedule (d) operational strategy(ies)	Vol 1, Sections 8 and 16
7	Written permission must be obtained from the appropriate provincial or municipal authority if the project affects road or road allowance	N/A
8	The appropriate pump specifications are required for the intake pump(s) only, including the rate capacity and expected operating capacity of the pump(s)	Provided in final design
9	The Crown (under Section 4 of the Public Lands Act) claims ownership of the bed and shore of all waterbodies, therefore, a Licence of Occupation (LOC)/easement may be required	Will be obtained when appropriate
10	If permanent works are to be constructed in a water course, approval may be required under the Navigable Waters Protection Act	Will be obtained if applicable

**APPLICATION FOR APPROVAL OF THE MUSKEG RIVER MINE PROJECT
VOLUME 1: PROJECT DESCRIPTION**

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PROJECT APPLIED FOR

Shell Canada Limited (Shell) is applying to the Alberta Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) for approval to construct, operate and reclaim an oil sands mine and processing facilities on the western portion of Oil Sands Lease No. 7277080T13 (Lease 13). Lease 13 is located about 70 km north of Fort McMurray, Alberta (see Figure 1-1) and about 500 km northeast of Edmonton. Fort McKay is the closest community to the project, located roughly adjacent to Lease 13 on the west side of the Athabasca River.

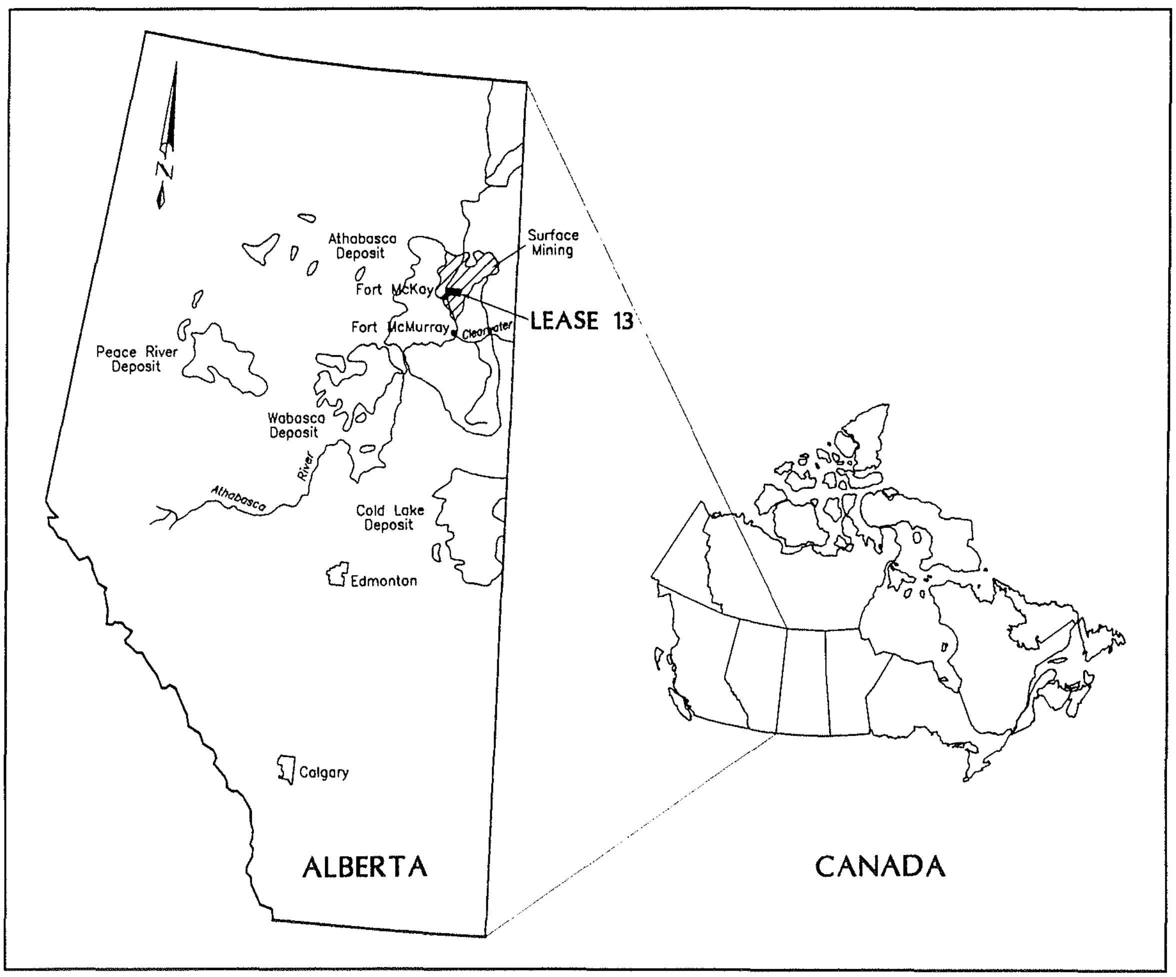


Figure 1-1: Project Location

PROJECT APPLIED FOR (cont'd)

The Muskeg River Mine Project involves mining and processing oil sands from the western portion of Lease 13 to produce a diluted bitumen (dilbit) product. The mine and extraction facilities will be located in the portion of Lease 13 which is east of the Athabasca River and west of the Muskeg River.

Lease 13 covers 20,182 ha (49,872 acres - 77 sections) in Township 95, Ranges 9 and 10, plus a small western portion of Range 8 and an eastern portion of Range 11. Lease 13 has a potentially mineable bitumen resource of about 800 million m^3 (5 billion bbl). The reserves in the area of the Muskeg River Mine are assessed at about 200 million m^3 (1.3 billion bbl). The outline of the Muskeg River Mine Project area is shown in Figure 1-2.

The targeted production rate from the project area is 8.7 million m^3/a (55 million bbl/yr) of bitumen, or 23,850 m^3 (150,000 bbl) per day. At this rate, the expected mine life is over 20 years.

Shell is also requesting approval to receive third-party oil sands material at its site for processing and to ship this oil sands material from its site for processing elsewhere (see Selected Process Scheme in Section 5.2).

ADDITIONAL APPROVALS REQUIRED

Shell is currently evaluating alternative options for the supply of electrical power to the project. As well, consideration is being given to requesting an industrial system exemption under the Electric Utilities Act.

Bitumen product from the Muskeg River Mine will be transported to the Edmonton area via a 610-mm (24-inch) diluted bitumen pipeline. The transportation diluent will be received and returned to Lease 13 via a 323-mm (12-inch) pipeline, to be located in the same pipeline trench as the diluted bitumen line. Shell is proposing to construct a new upgrader at its Scotford refinery site in Fort Saskatchewan to produce a range of upgraded refinery feedstocks to take advantage of the Scotford refinery's existing configuration. The bitumen product will be of an acceptable quality to also allow it to be direct-marketed as a bitumen product with low water and solids content.

Shell will file separate applications for the electrical utilities, transportation and upgrading parts of the project.

DEVELOPMENT SETTING

The Regional Municipality of Wood Buffalo represents a diverse and dynamic development setting. The Muskeg River Mine is located near the community of Fort McKay. A focused effort has been made to work closely with this community to understand their issues, concerns or interests in order to ensure understanding and mutually acceptable development.

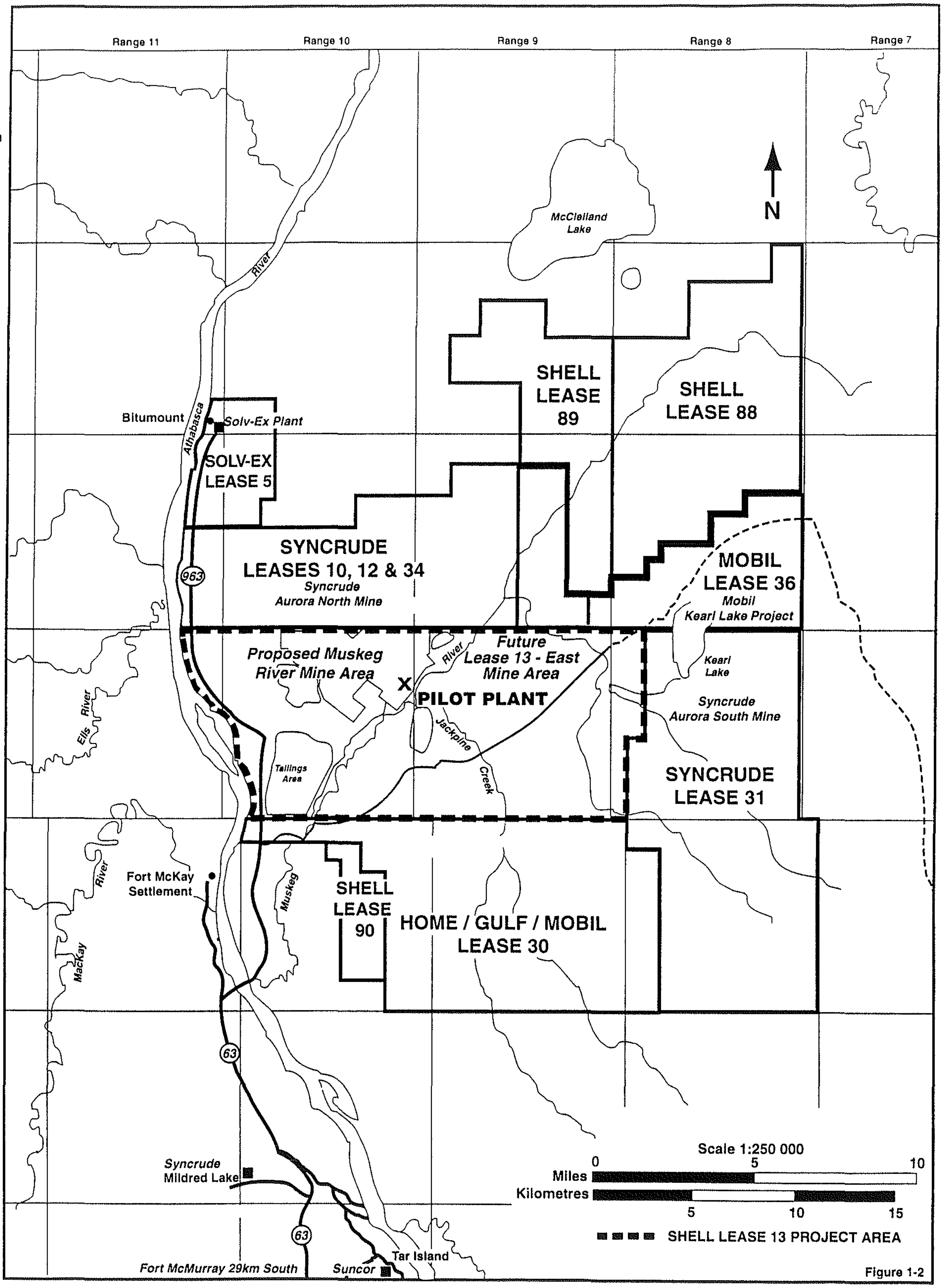


Figure 1-2: Muskeg River Mine Project Area

DEVELOPMENT SETTING (cont'd)

Other regional development factors that have been incorporated into project planning include:

- existing oil sands industry operations, such as:
    - Suncor Energy Inc.'s Tar Island operations
    - Syncrude Canada Ltd.'s Mildred Lake operations
    - the Alberta Northstar Energy (formerly known as AOSTRA) underground test facility (UTF)
    - the Solv-Ex experimental facility
- approved oil sands industry development that are under construction, such as:
    - Suncor's Steepbank Project
    - Syncrude's Aurora Project
- proposed oil sands industry development, such as:
    - Syncrude's Upgrader Project
    - Suncor's Millenium Project
    - Mobil Oil Canada's Kearl Lake Project
    - potential in situ developments
- other mineral lease holders, such as Birch Mountain Resources Ltd.
- the forest industry, including:
    - Alberta Pacific Forest Industries Inc. (Alberta-Pacific)
    - Northland Forest Products Ltd.
- regional transportation and utilities infrastructure
- traditional land uses

SCOPE OF PROJECT

The Muskeg River Mine Project includes:

- a truck-and-shovel mining operation
- a crushing and conveying system to size and transport the material about 600 m to the processing facility

SCOPE OF PROJECT (cont'd)

- an extraction plant that uses a warm (45°C to 50°C) water-based, caustic-free ore conditioning and extraction process and a conventional centrifuge froth treatment process, coupled with a paraffinic solvent-based product clean-up unit to meet the low solids and water bitumen specification

- a tailings management scheme that uses a tailings settling pond for initial tailings storage, converting to consolidated tailings production and the initiation of in-pit storage after four years

- utilities, including:

  - raw water supply through a dedicated Athabasca River intake facility
  - natural-gas-fired process water heating
  - electrical power via connections to the Alberta electrical grid

- a utility service corridor that runs southwest from the plant site to the lease boundary and then west for connections to:

  - the Alberta electrical grid, via two 144 kV tie-lines
  - natural gas supply pipelines
  - communications network and links
  - Highway 63

The water intake line will come from the Athabasca River (see Section 8), and connect with this utility service corridor.

The project facilities are more fully described in Section 1.3.

DEVELOPMENT PROPONENTS

Muskeg River Mine Feasibility Participants

Shell and The Broken Hill Proprietary Company Limited (BHP), through BHP Diamonds Inc., are parties to a feasibility agreement for assessing and advancing the development of an oil sands project on Lease 13. This combination of a world-scale oil company and an international mining organization provides a solid base for an oil sands development. Both companies have:

- a strong history of responsible development of natural resources

- a long-standing practice of public and stakeholder consultation

- a well documented record of safe and environmentally responsible operations

Muskeg River Mine Feasibility Participants (cont'd)

- technology and management expertise
- financial strength

Shell is seeking approvals for developing and operating the Muskeg River Mine. This reflects both Shell and BHP's confidence in the commercial development of Lease 13.

Shell Canada Limited

Shell is one of the largest integrated petroleum companies in Canada with total annual revenues of $5.2 billion and assets of more than $5 billion. It is a major producer of crude oil, natural gas, natural gas liquids and bitumen, and is Canada's largest producer of sulphur. Shell operates three major refineries in Canada with a combined capacity of 44,500 m^3 (280,000 bbl) per day and a national network of 2,100 Shell-brand service stations. Shell employs more than 3,600 people across Canada and has its head office in Calgary, Alberta.

Shell has three major business units:

- Resources - responsible for the exploration, development and production of natural gas and crude oil, including in situ bitumen production
- Oil Products - responsible for refining crude oil and the production, packaging and marketing of petroleum products
- Oil Sands - responsible for developing the Muskeg River Mine Project which includes oil sands mining, bitumen production, transportation and upgrading

Shell's relationships with its international affiliates in the Shell International Group provide valuable technical expertise in areas important to this project. Shell Group has international coal mining expertise through its operations, primarily in Australia. A depth of expertise in refining and upgrading can be accessed to supplement Shell's own strengths in those areas.

The Broken Hill Proprietary Company Limited

BHP is Australia's largest public company. BHP's annual sales exceed $20 billion and its assets total more than $36 billion.

BHP was incorporated in Melbourne in 1885, and began mining silver, lead and zinc at Broken Hill, New South Wales. In its 112-year history, the company has established a record of impressive performance and expansion.

Today, BHP is a leading global resources company with more than 60,000 people employed in operations and offices in 70 countries. BHP is the world's largest non-governmental producer of copper, and the world's second largest

The Broken Hill Proprietary Company Limited (cont'd)

producer of iron ore. Its inventory of high-quality assets and its unique combination of skills make it a significant player in the world's mining, steel and energy industries.

The company consists of eight business units:

- World Minerals
- Ferrous Minerals
- Coal
- Copper
- Integrated Steel
- Steel Products
- Petroleum
- Service Companies, which includes engineering, information technology, insurance, power and transport

Public Consultation

Shell believes in the benefits of public consultation and has conducted an active communications program in the Fort McMurray area since early 1997. Shell staff have participated in a variety of community forums and met regularly with representatives of regulatory agencies, aboriginal groups, local residents, community organizations, special interest groups and the public, to inform them of the company's plans for developing the Muskeg River Mine and to obtain their input in developing these plans. The consultation program is designed to establish trust and build cooperative working relationships. It also enables Shell to benefit from the public's input and knowledge.

For details of Shell's public consultation program, see Section 12.

PROJECT INCENTIVES

Shell has held Lease 13 since 1956 and has advanced developments on several occasions. This involved making major financial commitments which lead to an improved understanding of the resource and its development potential.

The ability to access the significant new reserves of the Athabasca oil sands is attractive because:

- there is no additional cost or risk associated with finding the resource
- the potential to offset declining reserves of conventional oil and gas in the Western Canadian Sedimentary Basin is high

PROJECT INCENTIVES (cont'd)

- the potential for profitable growth opportunities exists as oil sands production becomes an increasingly competitive and secure component of Canada's energy supply

Project Need

The development of the Muskeg River Mine is justified on the basis of sustaining the long-term future of Shell and BHP as profitable, positive contributors to their shareholders, employees, the communities in which they operate, and the Canadian economy. Shell and BHP also believe they can make a substantial contribution to sustainability and advancement of oil sands as a competitive and secure energy supply for Canada's future. The benefits expected from developing the Muskeg River Mine include:

- increasing production over the long term to replace declining conventional reserves and to provide Canada with security of energy supply
- accelerating technological innovation for enhanced cost, recovery and environmental performance as new ideas are brought to the industry
- creating new construction and permanent jobs, sustaining and diversifying the local and regional economy
- encouraging the formation of new businesses, and the continuation of existing businesses to support the project
- providing significant contributions to the corporate, personal and municipal tax base and provincial royalty base
- giving major short and long-term support to the Alberta and Canadian economies, particularly those of Edmonton and Northern Alberta, through project-related expenditures

Prospects for Commercial Viability

The key challenge is to develop a grassroots oil sands project in a commercially viable way. Over the past few years, several positive changes have enhanced the prospect for this commercial viability, including the:

- success of the existing oil sands operators in achieving lower unit operating costs
- evolution of mining and extraction technologies that provide for environmentally responsible development and the potential for further reduction in capital and operating costs

Prospects for Commercial Viability (cont'd)

- government's recognition of the importance of oil sands development through a more certain fiscal regime (see Section 14.1)

Muskeg River Mine Project Viability

In addition to these general factors, which support commercial oil sands development, the Muskeg River Mine Project has two unique advantages:

- Lease 13 is a large resource with high-quality, well-defined orebodies.
- Shell's Scotford refinery in Fort Saskatchewan is designed to exclusively process synthetic crude oil derived from oil sands.

Built in the 1980s, Scotford is one of the newest and most efficient refineries in North America. Shell plans to build a new upgrader next to the Scotford refinery which will process the bitumen produced from the Muskeg River Mine into a range of upgraded refinery feedstocks. Although Scotford currently processes fully upgraded synthetic crude oil, with minor modifications it will also be capable of processing a range of partially upgraded refinery feedstock materials. The Scotford advantage is derived from being able to customize the upgrader to produce feed streams that meet specific refinery capabilities. Costs of upgrading are less than those for producing synthetic crude oil for general sale in the marketplace. The feedstock is upgraded only to the level needed for the specific refinery process, and not beyond.

The development of the Muskeg River Mine Project reinforces the Alberta Chamber of Resources' *National Task Force on Oil Sands Strategies'* conclusions, documented in the report, *The Oil Sands: A New Energy Vision for Canada*, Spring 1995. Key points concerning development include:

- Market Sustainability - The market for oil sands bitumen and upgraded feedstocks will remain. Fossil fuel will continue to provide transportation fuels and chemical feedstocks well into the next century.
- North American Market - Given the reduction in supply costs, the markets for bitumen and upgraded crude are expanding in Canada and the U.S. as these materials replace or displace feedstock from other sources. In the case of the Muskeg River Mine Project, the bitumen will be upgraded and will displace existing feedstocks to Shell's refineries in Scotford, Alberta and Sarnia, Ontario.
- Price Robustness - The oil sands industry is viable at lower commodity prices, as demonstrated by the continuous improvement of existing operators in lowering development and production costs. This is also supported by the presence of an existing established infrastructure.

Muskeg River Mine Project Viability (cont'd)

- Knowledge Driven Industry - The oil sands industry is one of Canada's most successful knowledge-driven industries. With informed, constructive stakeholders and focused industry collaboration, technological development will continue to be a key lever for reducing risk, lowering supply cost and improving environmental performance.

- Wealth Generation - Increased oil sands development will create additional employment opportunities and new wealth for Canada.

- Canadian Energy Future - Bitumen and upgraded oil sands account for over 20% of Canada's total crude production. The oils sands industry will continue to be an integral sustaining part of Canada's future energy security.

INDUSTRIAL BENEFITS

The design and construction of the project will generate an estimated 3,000 work years of employment in Alberta. About 800 full-time staff will be employed in Muskeg River Mine operation.

An estimated $1.2 billion will be spent during construction, 60% of which will accrue directly to the provincial economy. About 80% of the annual $225 million to $300 million operating expenditure will be spent in Alberta.

PROJECT SCHEDULE

The overall project schedule (see Figure 1-3) is focused on achieving production in 2002. This aggressive schedule is motivated by the need to:

- fill the projected market need and provide a secure feedstock for Shell's existing refining assets

- obtain a revenue stream as soon as possible, to offset the significant expenditures required to support Lease 13 development

- use the existing capabilities of Shell's refinery assets to support the efficient development of Lease 13 and enhance the potential for achieving a commercially viable development

This schedule also enables Shell to meet lease tenure obligations of production before 2003.

An assessment of the project development opportunity began in late 1995. Screening and option evaluations took place throughout 1996. The regulatory approval process was initiated in March, 1997, when a Lease 13 project disclosure was released for public review. The focus in 1997 has been on developing the conceptual plan and preliminary engineering design of the

PROJECT SCHEDULE (cont'd)

project, as outlined in this application. Extensive consultation with the regulators, local communities, other key stakeholders and the general public has been instrumental in the development of this definition.

The regulatory review process will proceed in 1998, in parallel with the project's more detailed front-end engineering and design (FEED) work. Approvals are required before full project funding will be provided or detailed engineering initiated.

Site preparation will need to start in early 1999, to be followed by facility and mine construction through to early 2002. Commissioning and start-up are planned before mid-2002.

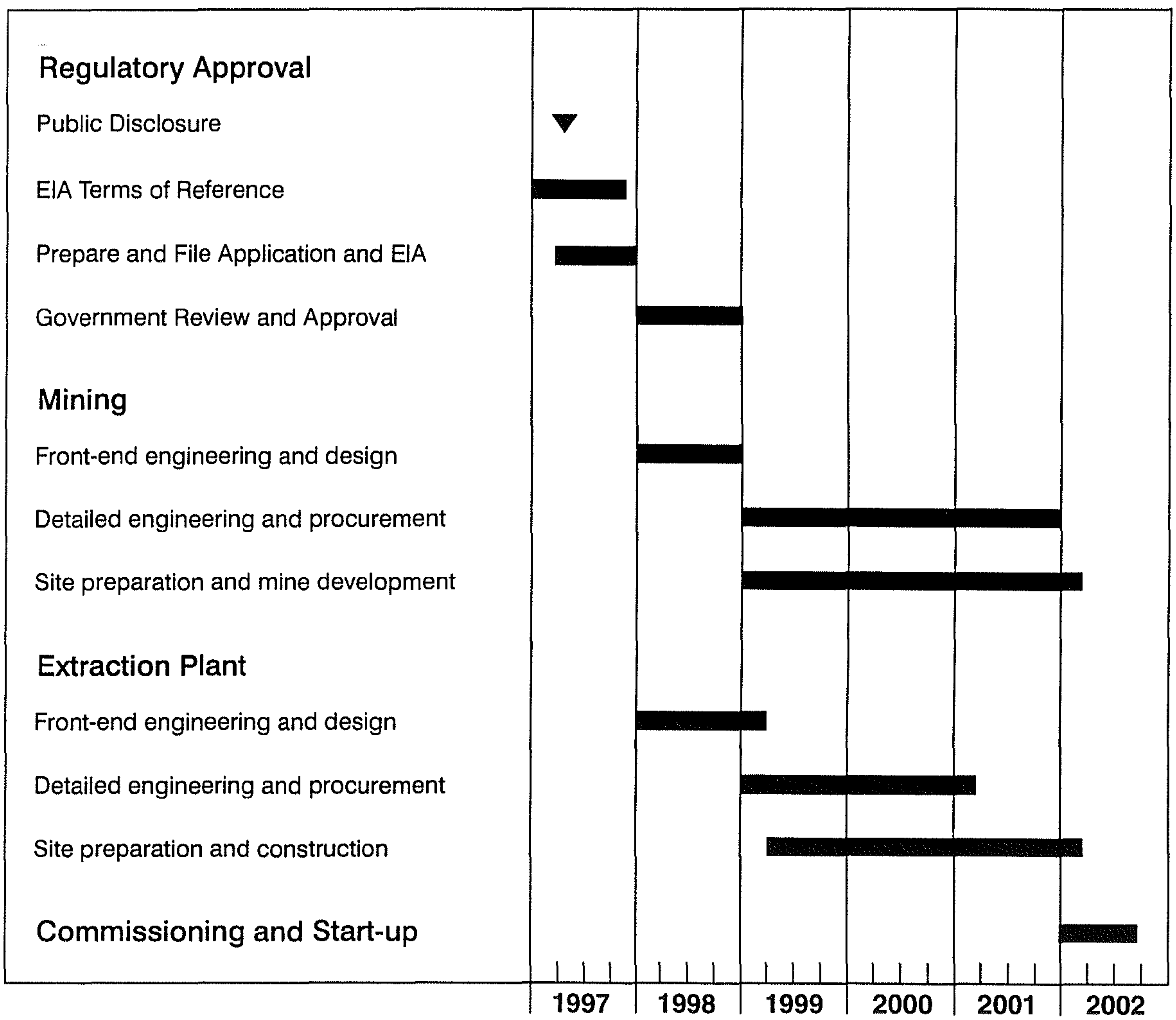


Figure 1-3: Muskeg River Mine Project Summary Schedule

PROJECT APPROVAL DECISION POINTS

The key project approval decision points are:

- receive regulatory approvals and permits before the end of 1998
- receive Shell and BHP Board of Directors' project approval by the end of 1998

From a risk management perspective, full project funding will not be authorized until all major regulatory approvals, permits and licences have been obtained.

SHELL OIL SANDS HOLDINGS

Over the past 50 years, Shell has demonstrated a strong interest in oil sands development in Alberta, in both the Peace River and Athabasca oil sands deposits.

In the Peace River area, Shell holds under lease about 1,600 million m^3 (10 billion bbl) of in-place bitumen and has an operating facility capable of producing up to 1,900 m^3/d (12,000 bbl/d) of bitumen.

In the Athabasca region, Shell's combined lease holdings contain an estimated 1,400 million m^3 (9 billion bbl) of bitumen resource.

LEASE 13 EXPLORATION AND DEVELOPMENT

Shell first explored the Athabasca oil sands in the 1940s and was granted Lease 13 by the Province of Alberta in 1956. Since then, the company has made a significant investment in defining and characterizing the oil sands resource.

Shell began testing production methods on Lease 13 in 1955 and first applied to the Alberta government in 1962 for approval of an in situ project. This application was withdrawn as mining methods evolved and the Great Canadian Oil Sands (now known as Suncor Energy Inc.) project advanced.

After a four-year drilling program, Shell applied for a 15,900 m^3/d (100,000 bbl/d) mining project on Lease 13 in 1974. Although the project did not proceed at that time, between 1974 and 1976, Shell spent more than $25 million acquiring geotechnical data and verifying mining methods through development of a test pit on Lease 13.

In 1978, Lease 13 was renewed for a second term, and one year later the Alsands Project applied to the Energy Resources Conservation Board (ERCB) for approval to develop and produce 21,780 m^3/d (137,000 bbl/d) of synthetic crude oil from the oil sands on Lease 13 and neighbouring leases. The Alsands Project spent over $140 million on regulatory approvals, detailed engineering and site preparation before it was cancelled in 1982 because of rapidly escalating costs, falling crude prices, and an uncertain fiscal framework.

ACQUISITION OF AMERADA HESS LEASES

To support its long-term growth strategy for oil sands development, Shell acquired leases 15, 88, 89 and 90 from Amerada Hess Canada Limited, in 1996.

EXTENSION TO SECOND TERM OF LEASE 13

In late 1996, the Alberta government granted a five-year extension to the second term of Lease 13, enabling Shell to proceed with this major project.

RESOURCE DEFINITION

About 790 exploration wells had been drilled on Lease 13 before 1996. With over 510 exploration wells in the area west of the Muskeg River, Shell has a solid understanding of the resource, to support the planning of a commercial development.

The Lease 13 eastern area, defined as the portion of Lease 13 east of the Muskeg River, is also well defined with over 280 wells. For further information on well data, see Resource Evaluation Methods in Section 3.1. Knowledge gained through future drilling programs will provide further support for future development planning in the east.

In 1996 and 1997, additional drilling and evaluation work helped to establish a detailed geological understanding for the Muskeg River Mine Project area on the western portion of Lease 13. This geological understanding was supported by:

- reviewing, in 1996, all available historical core and geological information acquired since the 1940s, and building on the understanding from this previous work to establish a new geological block model
- conducting a winter field program in 1997 to drill 40 wells. The objective was to correlate with, and validate, the historical information base as well as to define mine boundaries and potential external disposal sites.
- establishing a facies-based geology model in 1997 to enhance understanding of the resource and improve predictive capability

A geological field program is planned for winter 1997 and 1998. The program will start with site preparation in December 1997 and will involve drilling about:

- 130 core holes
- 200 overburden wells
- two pumping test wells for the aquifer
- two piezometer wells

A shallow seismic program will also be conducted.

RESOURCE DEFINITION (cont'd)

The program will provide the necessary definition for the detailed design and mine operating plan.

DEVELOPMENT OF EASTERN PORTION OF LEASE 13

If the economic environment remains favourable, and subject to regulatory approval, Shell intends to further develop the eastern portion of Lease 13. Preliminary analysis has shown that this area can sustain bitumen production rates of up to 30,000 m^3/d (200,000 bbl/d). The nature and timing of development will depend on market conditions and technological progress. Possibly, an expansion could proceed within the next 10 to 15 years. A hypothetical mine plan with a standalone processing facility was developed for the eastern portion of Lease 13 to consider how that development might fit with future regional development. All options to use existing facilities and infrastructure will be assessed during the detailed development planning.

Any development of the eastern portion of Lease 13 would be reviewed with adjacent leaseholders, regulators, local community groups and other stakeholders, and would be subject to the regulatory process applicable at that time.

EXISTING INFRASTRUCTURE

Road Systems

Highway 63 is paved from Fort McMurray to the Peter Lougheed Bridge crossing the Athabasca River. From there, a gravel road extends to the southwest corner of Lease 13. An all-weather gravel road, built and maintained by Shell, referred to as the Lease Traverse Road, crosses Lease 13 from southwest to northeast. A 9 km gravel road connects the Shell test pit and pilot plant location with the Lease Traverse Road. Granular resources are available on Lease 13 (see Regional Geology in Section 2.1).

Utility Corridor

A cleared utility corridor 96 m wide extends along the southern boundary of the lease. The corridor contains an electrical power line and a 25-cm (10-inch) diameter gas line.

MAJOR FACILITIES

SCOPE

The major facilities required for the Muskeg River Mine Project include:

- a truck-and-shovel mining operation
- a crusher and conveying system to size and transport material to the processing facility
- an extraction plant specifically designed to produce a bitumen product with low levels of water and solids content
- a tailings settling pond for initial tailings storage and facilities for consolidated tailings (CT) production and in-pit storage after four years
- utilities and offsites to support production operations

A simplified process schematic is shown in Figure 1-4.

The Muskeg River Mine has entered the front-end engineering and design phase, leading to the level of definition required for detailed design. During the front-end engineering stage in 1998, significant emphasis will be given to further optimizing the project.

Shell's design philosophy is to have a robust and reliable process configuration that takes full advantage of existing oil sand processes and experience, with advances where technically and economically viable. Key criteria for decision making includes:

- product recovery and quality
- environmental performance
- energy efficiency
- safety in construction and operations
- operability
- maintainability
- technical risk
- cost of production

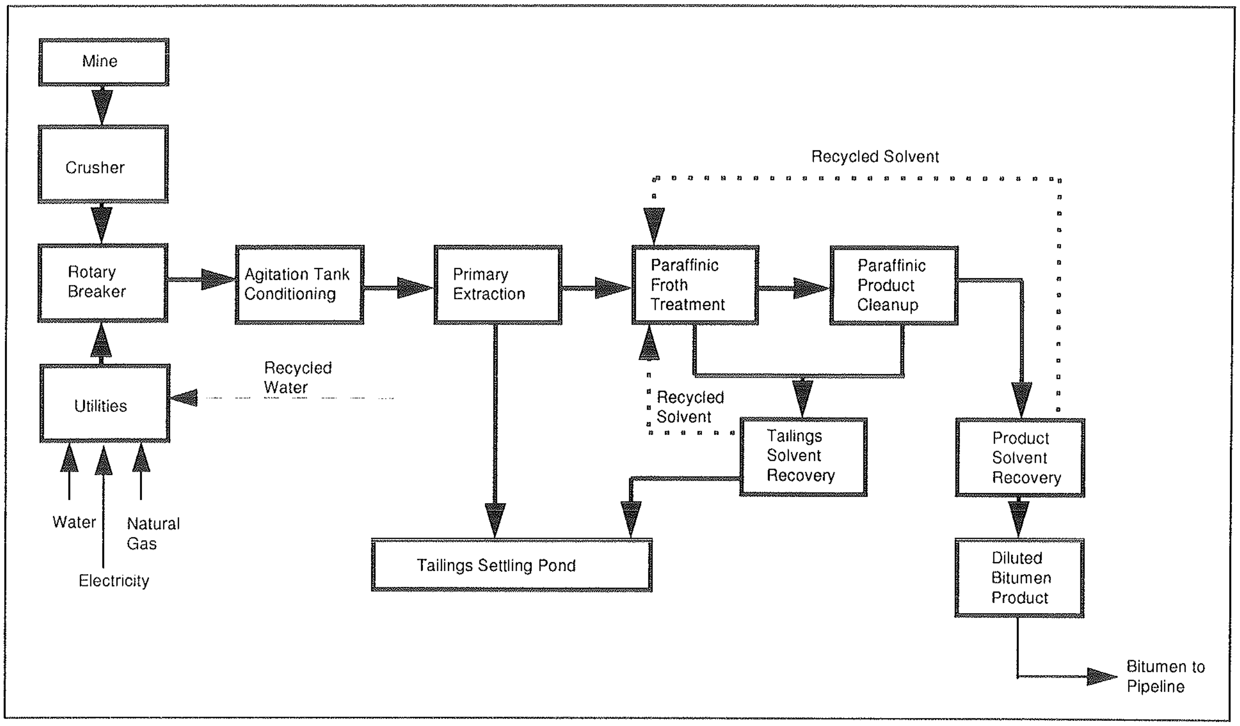


Figure 1-4: Simplified Process Schematic

SITE PREPARATION

In early 1999, subject to regulatory approval, land will be cleared and prepared for facility construction overburden removal and mining.

All merchantable (coniferous and deciduous) timber will be salvaged. Wet areas will be drained, and muskeg and topsoil removed from the initial mine area. Muskeg and topsoil will be stored for reclamation purposes.

Facilities, including a truck dump, in-pit crusher, construction utilities, a temporary office and maintenance shops will be constructed by the end of 2001.

MINING

Pre-stripping of the overburden for the crusher location will begin in late 1999, using trucks and shovels. The overburden will be hauled to external disposal areas or to construct external tailings dykes. Pre-stripping for the initial mine pit will take place in 2001. Oil sand suitable for plant feed will be removed and stockpiled.

MINING (cont'd)

In spring 2002, mining of the oil sands will begin, to support commissioning of the extraction facilities. Standard truck-and-shovel methods, using large-scale equipment, will be used to mine the oil sands.

The oil sands will be removed in mining benches designed to accommodate the size of the equipment used and will incorporate geological and geotechnical considerations. Oil sands feed to the extraction plant will be blended from a number of mining locations. This will minimize the need for blending stockpiles ahead of the extraction process. The mined oil sands will be hauled to a crushing facility located on the mine boundary adjacent to the ore extraction plant. At the crushing facility, crushers will size the oil sands to less than 400 mm (16 inches). The crushed oil sands will then be conveyed about 600 m to the extraction plant.

For further details on the mining process, see Section 4.

EXTRACTION

Oil sands delivered from the mining operation will be further sized and conditioned for the initial phase of bitumen separation (primary extraction).

A rotary breaker (a perforated rotating drum) with hot water addition will be used to further reduce the size of the oil sand for slurry preparation. Agitation conditioning tanks will be used for conditioning the oil sand. Agitation in the tanks will be accomplished either by impeller mixing and pumping or by a pumparound recirculation system. A non-caustic extraction process, operating at temperatures between 45°C and 50°C, will be used.

From the conditioning tank, the conditioned slurry will be pumped into a surge tank before entering a conventional primary bitumen extraction unit.

The bitumen froth from the primary extraction circuit will be fed to the froth treatment process, which is required to produce a clean diluted bitumen product. The coarse sand and fine tailings products from the primary extraction process will be combined and transported as water slurry to the tailings settling pond.

Froth emulsion from the water-based oil sands bitumen extraction process must be treated to produce a bitumen product that is sufficiently free from water and solids to enable it to be upgraded or marketed directly.

The conventional froth treatment process used by the existing operators uses an aromatic (naphtha)-based diluent to reduce viscosity and density, followed by centrifuge separation and diluent recovery via distillation. Although acceptable in meeting the feed requirements for an on-site upgrader, the conventional process can present problems in meeting the water and solids specifications for commercial pipelines.

EXTRACTION (cont'd)

The objective for the Muskeg River Mine Project is to produce a bitumen product that meets broadly accepted pipeline specifications of a 0.5 wt% basic sediment and water content (BS&W). Shell intends to upgrade the material, but wants to leave the direct marketing of bitumen option available by targeting for a premium bitumen product quality. The primary goal is to create a feed that will be optimum for Shell's upgrading options.

The Muskeg River Mine froth treatment process will use a conventional dilution centrifuging froth treatment process, but will add a product clean-up processing unit to provide final removal of ultra-fine solids and residual water. This product clean-up step involves the recently developed paraffinic solvent demulsification (PSD) process, which has been the focus of a joint industry effort through the Canadian Oilsands Network for Research and Development (CONRAD) Extraction Technology Development Group. The difference from the work undertaken through CONRAD is the use of conventional centrifuge technology to remove bulk solids and water, rather than attempting to apply the PSD process directly to a bitumen froth stream.

A key feature of the PSD process is the upgrader feed preconditioning involving the capture of the ultra-fine solids material by a small amount of a heavy, coke-like hydrocarbon material, which can be preferentially removed with the tailings. The result is that the original oil continuous emulsion (water-in-oil) separates into a dilute bitumen phase with BS&W less than 0.1 %.

The bitumen material from froth treatment will be taken to a product solvent recovery unit where the bulk of the paraffinic diluent will be removed to give a diluted bitumen with about 30% diluent by volume for pipeline transportation.

For further details on the extraction process, see Section 5.

TAILINGS

The objectives for the Muskeg River Mine Project are to manage the bitumen extraction plant tailings streams economically and in a way that:

- minimizes out-of-mine impact
- allows for a stable, long-term landscape, consistent with effective reclamation and mine closure planning

In the initial four years of operation, the tailings streams from the extraction process will be pumped to a surface tailings settling pond. Clarified water from the pond will be recycled to the process. Once sufficient mining has occurred to allow for a separate storage area in the mined-out pit to be segregated, the mature fine tailings from the tailings settling pond, in combination with the

TAILINGS (cont'd)

extraction plant streams, will be used to produce consolidated tailings for in-pit disposal.

For further details on tailings, see Section 6.

PILOT PLANT

Shell is currently planning a pilot plant facility on Lease 13 to provide information for front-end engineering and process optimization. The scope of this pilot includes tailings handling. The pilot results, together with the ongoing development work on tailings management by the existing operators, will provide a solid design basis for implementing consolidated tailings for the Muskeg River Mine.

UTILITIES

Shell considers energy management to be a key issue. An efficient and effective energy supply plan requires the definition of energy demand requirements. The project definition, including energy demand requirements for the mine and extraction facilities, will advance to a much more detailed level in 1998, with the completion of front-end engineering and design. A central part of this definition process will be a:

- reduction in energy demand
- optimization of utilities

Technical, economic, commercial and environmental considerations will all be part of this optimization.

The current project design basis requires about 80 MW of electrical power. The plan is to supply this demand from the Alberta electrical grid. Alberta Power Limited (APL) has proposed that two 144 kV power lines from APL's Ruth Lake substation or Beaver Lake substation will be needed to link the Muskeg River Mine to the Alberta electrical grid. Shell is working with APL and other area developers to obtain the most cost-effective grid interconnections. Other options for electrical power supply, including on-site cogeneration of electricity and hot water, are being evaluated.

Extraction process heat will be provided via a combination of natural-gas-fired heaters and packaged utility boilers. This will be optimized through the front-end engineering and design phase in 1998, at which time opportunities to reduce overall energy demands will be pursued.

Natural gas will be supplied through a new pipeline to the Lease 13 site. The commercial arrangements for providing this link are currently being assessed.

UTILITIES (cont'd)

Requirements are estimated to range from 1 million m^3/d in summer to 1.3 million m^3/d in winter (30 to 50 MMSCFD).

Auxiliary Systems

Process water will be provided through a combination of:

- muskeg surface drainage
- basal aquifer depressurization
- raw makeup water from the Athabasca River

Beginning in 2004, water will be recycled from the tailings settling pond to the process. This will reduce the volume of makeup water intake from the Athabasca River. A new water intake facility will be required at the Athabasca River with a pipeline to the extraction plant (see Section 8). For offsites associated with potable water, boiler feed water and sewage, see Water Supply in Section 8.3.

Diesel fuel required for the mine operation is estimated at 65 million litres annually. This will be stored on site in tanks. Options for supply are being assessed.

Nitrogen and instrument and utility air will be supplied by conventional industrial units on site.

Solid waste disposal is currently planned via an on site industrial landfill.

A camp will be developed on site to house workers for the construction period. Plans will be discussed with other area developers to ensure that effective communication is maintained and cooperative opportunities are captured.

Facility Locations

The location of the major project facilities is shown in Figure 1-5. A preliminary plot plan is shown in Figure 1-6.

The placement of mine facilities, including alternative sites for the extraction plant site and tailings location, is discussed in Section 4.

The utility service corridor, with road access, natural gas pipeline, electrical power and communications is required to support the development. This will follow a common corridor north toward the Lease 13 boundary. Access to the plant will be east along the southern lease boundary, then northeast to the plant site. The east-west segment along the lease boundary might also serve other potential access needs, such as future development at Syncrude's Aurora South Mine and Mobil's Kearl Lake Project.

The diluted bitumen product and diluent pipelines will follow a corridor from the plant site southeast to the southern boundary of Lease 13, then generally follow

Facility Locations (cont'd)

the 1986 *Alberta Forestry Athabasca Oil Sands Multiple Use Corridor Study* route. The pipeline routing selection on Lease 13 is discussed in Section 13.2.

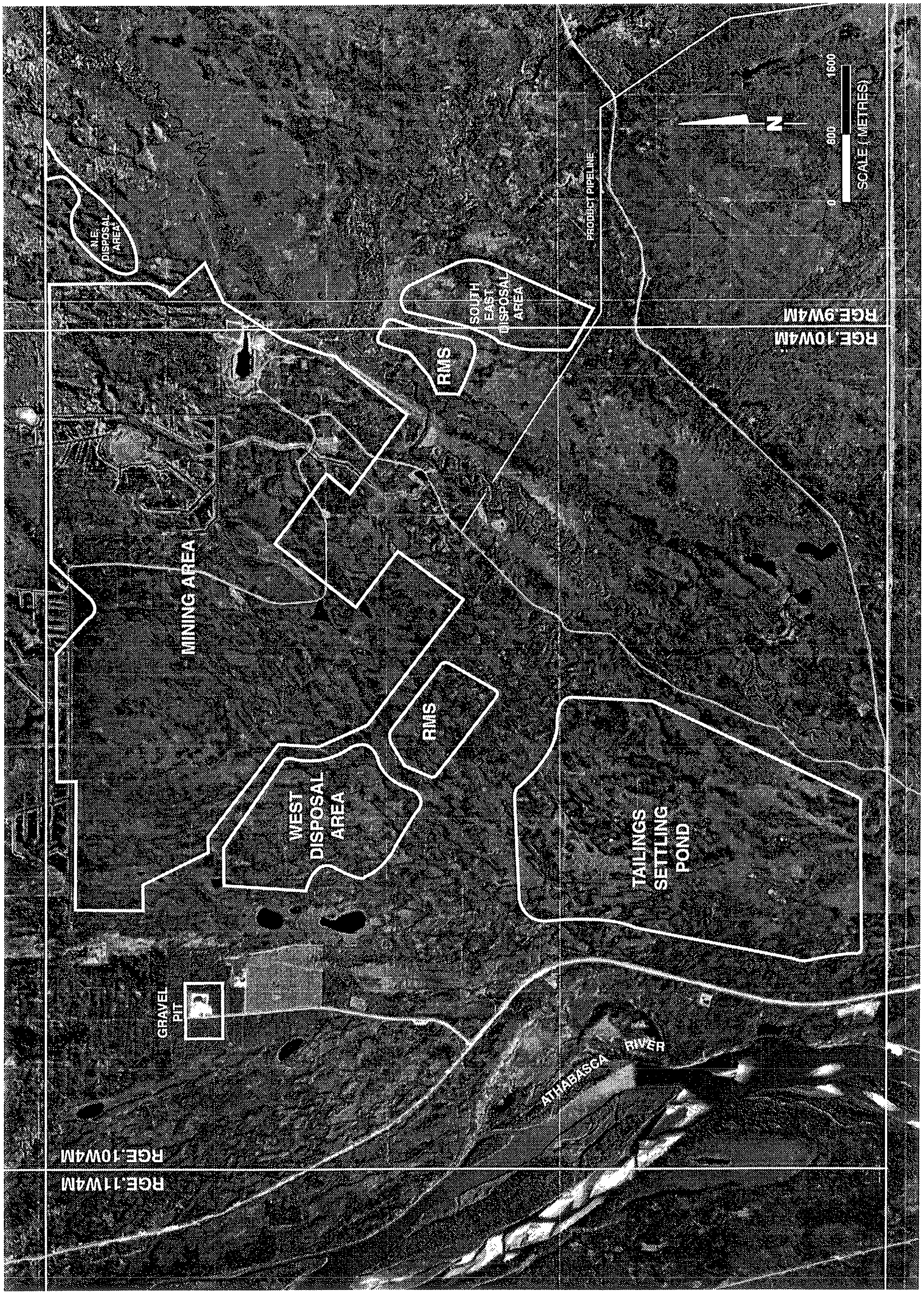
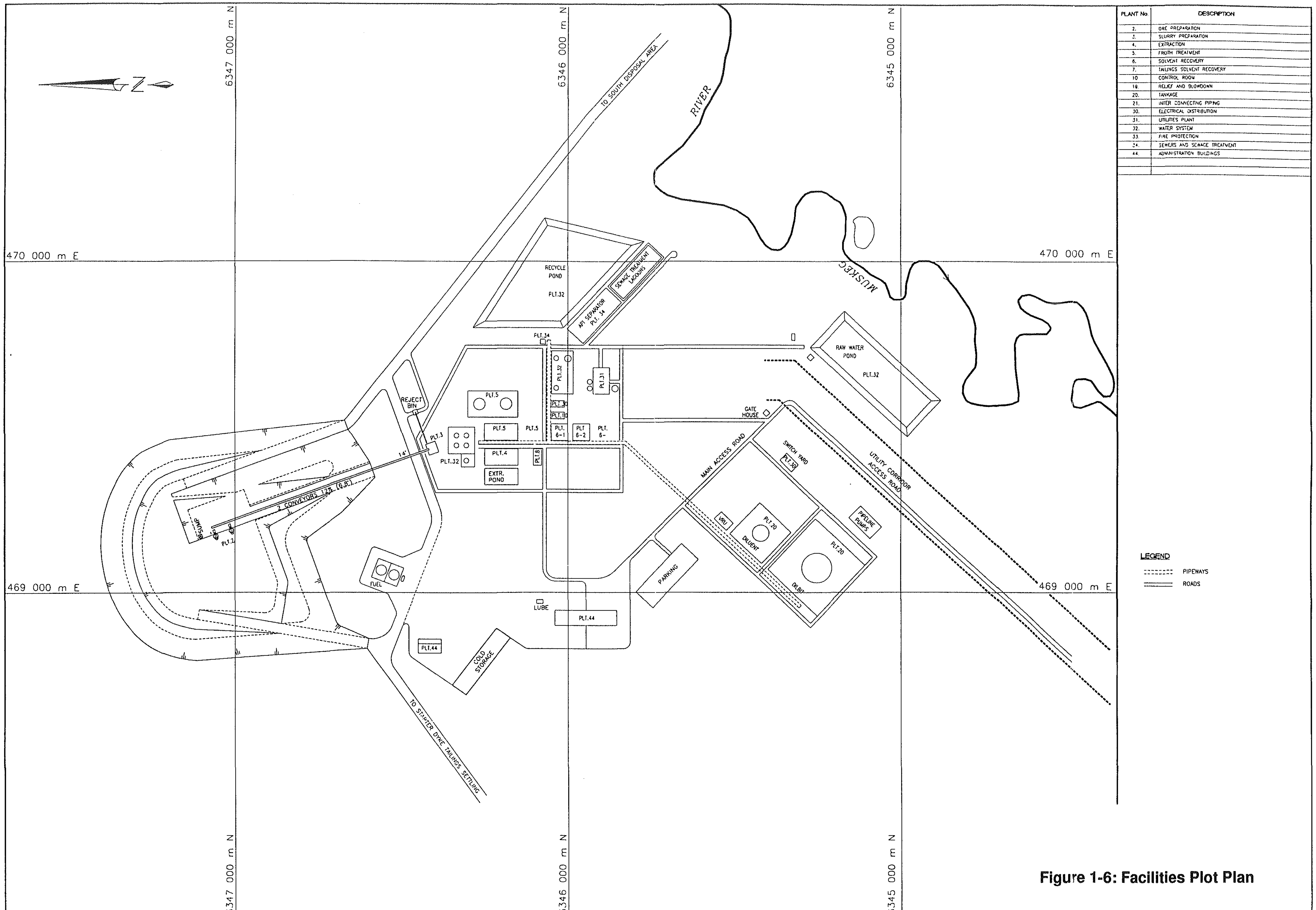


Figure 1-5: Aerial Photo of West Side of Lease 13



PLANT No.	DESCRIPTION
2.	ORE PREPARATION
3.	SLURRY PREPARATION
4.	EXTRACTION
5.	FROTH TREATMENT
6.	SOLVENT RECOVERY
7.	TAILINGS SOLVENT RECOVERY
10	CONTROL ROOM
19.	RELIEF AND BLOWDOWN
20.	TANKAGE
21.	INTER CONNECTING PIPING
30.	ELECTRICAL DISTRIBUTION
31.	UTILITIES PLANT
32.	WATER SYSTEM
33.	FIRE PROTECTION
34.	SEWERS AND SEWAGE TREATMENT
44.	ADMINISTRATION BUILDINGS

Figure 1-6: Facilities Plot Plan

SCOPE

This subject:

- outlines the principles that will be used to manage the biophysical and socio-economic aspects of the Muskeg River Mine
- identifies the key environmental issues
- summarizes the projected impact of the project, based on the current level of planning and preliminary engineering design

PRINCIPLES

The Muskeg River Mine will be developed based on the shared environmental management principles of Shell and BHP. These principles include:

- complying with all applicable laws, regulations and standards
- applying self-imposed standards and guidelines
- communicating with all stakeholders, including government and communities
- implementing an environmental management system to identify, control and monitor environmental risks arising from its operations
- setting targets for measuring, appraising, reporting and improving performance
- conducting ongoing research to improve environmental performance
- integrating environmental protection with traditional business decision-making

KNOWLEDGE AND EXPERIENCE BASE

Effective environmental planning, design and protection requires:

KNOWLEDGE AND EXPERIENCE BASE (cont'd)

- a comprehensive understanding of baseline environmental conditions from both a historical and current perspective
- a good understanding of relevant operating experience from Suncor and Syncrude, the two major oil sands operators in the region

The Muskeg River Mine Project is being developed in an area, and with similar technology, for which a great deal of background scientific and impact assessment knowledge is available. Since commercial development of the oil sands began in 1967 with the start-up of the Great Canadian Oil Sands (now Suncor) plant, numerous scientific and environmental impact assessment studies have been conducted in the surface mineable oil sands area. These include work by the following organizations:

- Alberta Environmental Protection and predecessor departments
- Alberta Oil Sands Technology and Research Authority
- Alberta Oil Sands Environmental Research Program
- Alberta Energy and predecessor departments
- Environment Canada
- Northern River Basins Study
- Suncor
- Syncrude
- OSLO Project
- Shell's Alsands Project

As well, Suncor and Syncrude have acquired extensive operating experience and shown continuous improvement, particularly in the areas of:

- reclamation
- air emissions
- water management

The Regional Municipality of Wood Buffalo and the City of Fort McMurray have developed into a thriving city of over 38,000 people. The municipal administration and other private agencies have extensive experience in planning and managing periods of rapid growth and the attendant social and economic challenges. The Muskeg River Mine Project is being developed against this background of knowledge and experience.

Shell is currently a member of several industry environmental planning groups in the region, such as the Oil Sands Infrastructure Committee, the Mayor's Housing Task Force, Regional Air Quality Coordinating Committee (RAQCC) and the Oil Sands Industry Cumulative Effects Assessment (CEA) working group, whose mandates are to ensure regional coordination and cooperation on environmental management issues.

KEY ISSUES

Key Environmental Issues

The key environmental issues arising from the development of the Muskeg River Mine are similar to those currently being managed by the existing operators and communities. In the past two years, two environmental impact assessments (EIAs) have been conducted in the area. One of these EIAs was conducted for Syncrude's Aurora Project, immediately adjacent to the north and southeast of Lease 13. The other was conducted for Suncor's Steepbank Mine, about 20 km due south of Lease 13.

The key environmental issues identified through consultation with stakeholders and regulators are the:

- impacts on local and regional air quality
- protection of the health of local and regional residents and Muskeg River Mine Project employees
- impacts on water quality
- health of the aquatic ecosystem in the Athabasca and Muskeg rivers
- impacts of surface disturbance on the terrestrial ecosystem, especially within the Muskeg and Athabasca river valleys
- effects on traditional land use and historical resources
- cumulative effects on wildlife populations and aquatic resources

Key Socio-Economic Issues

The key socio-economic issues identified through consultation with stakeholders in the Wood Buffalo region are:

- business and employment for local residents
- training and employment opportunities for aboriginal communities
- cumulative impacts on infrastructure and community services in the Regional Municipality of Wood Buffalo

IMPACT ASSESSMENT

In May 1997, Shell filed with the Director, Environmental Assessment Division, AEP, the Proposed Terms of Reference for the Lease 13 EIA. On November 7, 1997, the Director issued the Final Terms of Reference. These terms incorporate

IMPACT ASSESSMENT (cont'd)

the requirements of provincial and federal agencies and public comments. Based on these terms, Shell conducted a focused impact assessment, which includes a cumulative effects assessment. The results of the assessment are summarized in:

- Section 10 - Environmental Management
- Section 11 - Socio-Economic Development

The predicted impacts for the Muskeg River Mine Project are acceptable. The project will have no significant long-term impact on the environment, provided that the recommended mitigation measures are undertaken.

REGIONAL COOPERATION APPROACH

PRINCIPLES

Industry Approach

Shell is committed to working with regulatory agencies and regional stakeholders to facilitate responsible development, focused on ensuring resource conservation and promoting environmental protection. A key element will be broad consultation and consideration of other regional development plans.

The oil sands industry shares a common view of the logic and value of exploring opportunities for regional cooperation. Through the consultation process related to Syncrude's Aurora application, Syncrude, Mobil and Shell, as adjacent lease holders, defined several principles related to their support of the orderly, efficient and economic development of Alberta's oil sands resources (see Figure 1-7). This provides a broad framework to promote opportunities for cooperation between the respective organizations.

Within certain practical limits, such as the physical location and timing of development, Shell believes that several opportunities exist for regional cooperation. When common investment schedules and geographic proximity allow, cooperative development can:

- enhance economic return
- achieve resource conservation
- help mitigate adverse environmental, social and cultural impacts

Potential Areas for Cooperation

Considering the current status of proposed developments by the various companies, this translates into two likely hubs for cooperative activity:

- the Muskeg River West Area in 2001 and 2002 for the:
    - Syncrude Aurora North Mine
    - Muskeg River Mine
- Kearl Lake Area from 2003 onward for the:
    - Mobil Oil Canada Kearl Lake Mine
    - Syncrude Aurora South Mine
    - Shell Lease 13 future eastern expansions

Oil Sands Development - Principles of Cooperation

Syncrude Canada Ltd., Shell Canada Limited and Mobil Oil Canada support the orderly, efficient and economical development of oil sands resources in Alberta. This is best accomplished by the joint efforts of oil sands developers exploring opportunities for cooperation which will enhance the economic return and mitigate any potentially adverse environmental, socio-economic and cultural impacts. Each of the companies agrees to work constructively to explore opportunities for cooperation where developments are proximate in both physical location and timeline or other areas where the companies see mutual benefit from joint initiatives.

Subject to appropriate commercial arrangements, potential opportunity areas have been identified as:

- *coordination of environmental assessment, monitoring and planning:*
- *promotion of oil sands research and technology development including common funding and management of fundamental investigations and commercialization of promising technology:*
- *dissemination of oil sands technology and expertise through commercial arrangements and personnel exchanges;*
- *sharing of utilities and infrastructure to minimize duplication and to provide reliable low cost service;*
- *coordination of project management and execution planning to reduce adverse social and economic impacts and to enhance regional economic benefits;*
- *sharing of mine plans and joint mine planning where mining and/or reclamation should be harmonized to ensure efficient resource recovery and reclamation; and*
- *consultation and cooperation with each other and other members of industry in communicating with members of the public concerning oil sands development in this region*

Figure 1-7: Principles of Cooperation

ADVANTAGES OF INDUSTRY COOPERATION

The cooperation of nearby operators or developers is desirable from the standpoint of exploring opportunities to enhance economic return and to mitigate any potentially adverse impacts. However, where common lease boundaries exist, such cooperation is essential for coordinating mine development to:

- ensure that optimal resource recovery occurs
- provide the basis for effective reclamation planning

ADVANTAGES OF INDUSTRY COOPERATION (cont'd)

The history of the existing Syncrude and Suncor operations demonstrates the need for, and the practical application of, the cooperation of neighbours. Shell, BHP and all other operators share the EUB's interest in:

- minimizing resource sterilization
- optimizing environmental management
- optimizing the efficient development of the resource

Although this is of public interest, efficient and cost-effective development is also fundamental to, and directly aligned with, investor return. Shell, BHP and other oil sands developers are motivated to reduce any negative impacts because this will, in turn, limit liability and maximize investor return. Oil sands developers and regulators share a strong common interest for efficient and effective development of the oil sands.

Because of the near-term development schedules for Syncrude's Aurora North and Shell and BHP's Muskeg River Mine Projects, a priority focus for cooperative discussions has been placed on developments west of the Muskeg River. Shell and BHP staff have been working, and will continue to work, with Syncrude on:

- the location of roads and utility corridors
- geological and mine reviews and alignment
- lease boundary harmonization
- environmental information sharing and collaboration on studies
- project management and execution awareness and opportunity investigation
- infrastructure sharing

COOPERATION AGREEMENT

Shell and Syncrude have concluded, within the existing regulatory framework, a formal cooperation agreement that will promote the orderly and efficient development of Syncrude's Aurora North and Shell's Muskeg River Mine Project.

Specific aspects of Shell and Syncrude's cooperative efforts are discussed throughout this application, particularly in Section 4, Mining.

INDUSTRY COOPERATION OPPORTUNITIES

The shared motivation toward cooperation by industry operators in the region is being translated into a number of specific actions and initiatives. These initiatives include a focus in areas such as:

- environmental management

INDUSTRY COOPERATION OPPORTUNITIES (cont'd)

- socio-economic development
- technology development
- mine planning coordination
- infrastructure and service sharing
- project management and execution

ENVIRONMENTAL MANAGEMENT

Industry, government and other key stakeholders have established a number of collaborative environmental programs. With the Muskeg River Mine Project, Shell is starting to integrate into this existing framework. The project has provided an opportunity for Shell to benefit from the environmental program experience of the two existing operators. Shell also believes that Shell and BHP staff will be able to make a valued contribution in the future, based on their diverse backgrounds and their world-wide exposure and experience.

To date, Muskeg River Mine Project staff have become involved with the:

- Regional Air Quality Coordinating Committee (RAQCC)
- Regional Aquatic Monitoring Program (RAMP)
- Canadian Oil Sands Network For Research and Development (CONRAD)
- Regional End Land Use Committee

RAQCC Participation

The RAQCC manages the Southern Wood Buffalo Zone airshed of the Clean Air Strategic Alliance (CASA). RAQCC is responsible for monitoring air quality and has also developed an integrated environmental monitoring program for the effects associated with air contaminants. Until the Muskeg River Mine Project is operating, Shell has been invited to join as an observer.

RAMP Participation

The RAMP program was initiated in 1997. Shell is involved in this program with Syncrude and Suncor, in consultation with other interested parties. The focus is on completing thorough routine aquatic monitoring in the oil sands development region.

CONRAD Participation

Shell is involved in a number of CONRAD technical planning groups. The environmental group has focused on collaborative work on tailings management and related environmental research. The CONRAD Environmental Technical Planning Group also sponsors the CONRAD Environmental Technical Advisory Group (CETAG), which includes various other groups involved in

CONRAD Participation (cont'd)

environmental research relevant to oil sands, such as government agencies and universities.

Regional End Land Use Committee

Shell is a member of the Regional End Land Use Committee, which operates at a conceptual and policy level. The committee's focus includes sponsoring working groups to address specific technical issues.

Environmental Cumulative Effects

To ensure a long-term coordinated approach to assessing environmental cumulative effects, an industry group was established to work with regulators and other stakeholders in defining an acceptable framework and methodology. This included defining development activity scenarios and an agreed-on scientific basis for cumulative effects assessment. The results have been incorporated into the Muskeg River Mine Project EIA, as part of the regional planning considerations.

SOCIO-ECONOMIC DEVELOPMENT

In response to the heightened interest in oil-sands-related development and the number and variety of proposed projects, the Wood Buffalo Standing Committee on Oil Sands Development encouraged industry and municipality members to join together. A Regional Infrastructure Working Group was created to work with other agencies to understand the various project scenarios and potential socio-economic impacts. An Urban Population Impact Database Model was created to serve the needs of multiple users in detailing regional development activities and the potential impacts for planning infrastructure and services.

The group is also interested in strategies for resolving issues identified by the planning agencies. To support this, a Facilitation Committee was established in October 1997, consisting of senior executives of the four large mining projects, an in situ oil sands project representative, the Wood Buffalo Mayor, chairman of the Standing Committee on Oil Sands Development and regional MLAs. A coordinator has been hired by industry to work on defined issues and needs.

TECHNOLOGY DEVELOPMENT

As a member of CONRAD for many years, Shell is involved in a number of CONRAD's technical planning groups, such as the groups studying:

- in situ recovery
- environmental impacts
- surface mining

TECHNOLOGY DEVELOPMENT (cont'd)

- extraction
- upgrading

Shell is also a member of the Network Coordinating Council, a high-level planning committee. Shell believes that it can be a valued contributor to the advancement of oil-sands-related technology.

Since 1996, Shell has had a collaborative arrangement with Suncor for developing oil sands conditioning technology. Shell also has technology access agreements with Syncrude.

MINE PLANNING COORDINATION

A key feature of any oil sands development is a mine plan that is based on a balanced consideration of resource recovery, environmental protection, economics and extraction process efficiency. Shell plans to take a proactive role in these matters and to take all prudent actions within the constraints of economics and the legitimate rights and interests other operators might have. Shell and Syncrude, as adjacent lease holders with concurrent developments, are committed to working together and with the regulatory agencies to develop sensible, effective, integrated mine plans. The mine plans will be integrated to recover economic lease boundary reserves and to have complementary closure plans and landscapes. The key motivation for these early and ongoing discussions is to ensure that no plans preclude or marginalize future resource recovery potential.

Specifically, Shell and Syncrude have already begun to jointly review mine plans and map out strategies for lease boundary management.

INFRASTRUCTURE AND SERVICES

During development of the Aurora project, Syncrude and Shell agreed on road and utility infrastructure corridors that would meet the needs of both developments, while also ensuring that ore is not sterilized or environmental protection compromised. Syncrude described this cooperation in the additional information submissions for its Aurora Mine application. Other opportunities for cooperation on infrastructure and services continue to be explored. These will become clearer as the definition and execution plans for the Muskeg River Mine Project proceed. For example, it will make sense to coordinate emergency response activities (see Emergency Response in Section 15.3). This will be better defined once the needs are identified and the supporting staff for this function are in place for the Muskeg River Mine Project.

PROJECT MANAGEMENT AND EXECUTION

Shell and Syncrude have been exploring opportunities to maximize success and minimize any negative adverse effects from concurrent project developments. A number of opportunities have been identified and will be better defined and explored as the execution strategy for the Muskeg River Mine Project is developed in 1998, in parallel with the front-end engineering and design work. Shell is committed to taking a similar approach with other area developers in the oil sands and other industries.

OTHER MINERAL RIGHTS HOLDERS

Birch Mountain Resources Ltd. holds the industrial mineral rights in the lands that overlap and underlie Shell's oil sands lease rights. Shell, BHP and Birch Mountain staff have met to explore opportunities for cooperation, such as sharing geological and geophysical information relating to the respective crown lease holdings and coordinating field data programs. Shell and BHP will continue to promote ongoing communication and cooperation with Birch Mountain.

REGULATORY APPROVALS

REQUIRED APPROVALS

Shell requires a number of approvals at the municipal, provincial and federal levels in order to proceed with the Muskeg River Mine Project. The required approvals vary in scope from approval of the Lease 13 development plan to approvals for radio communication licences (see Table 1-1). Most of the required approvals are new. Others are amendments or renewals of existing approvals.

Table 1-1: Required Regulatory Approvals

Approval	Legislation	Date Required	Agency
Oil Sands Approval	Oil Sands Conservation Act	December 1998	EUB
Water Pipeline Approval	Pipeline Act	June 1999	EUB
10 Year Approval	Alberta Environmental Protection and Enhancement Act	December 1998	AEP
Permit to Divert and Use Water	Water Resources Act	December 1998	AEP
River Crossing	Water Resources Act	December 1998	AEP
Surface Rights	Public Lands Act	December 1998	AEP
Historical Resources Clearance	Historical Resources Act	December 1998	Alberta Community Development
Radio Communications Licences	Radio Communication Act	January 2000	Industry Canada
River Crossing	Navigable Waters Act	December 1998	Coast Guard
Development Permit	Bylaw 84/2	December 1998	R.M. Wood Buffalo
OH&S New Plant	Occupational Health and Safety Act	December 1998	Alberta Labour
Industrial System Exemption	Electrical Utilities Act	December 1998	Alberta Energy

CURRENT APPROVALS

Shell currently holds several surface rights approvals on Lease 13 (see Table 1-2).

Table 1-2: Crown Disposition within Lease 13

Crown No.	Facility
MSL 11674	Test pit, temporary camp and temporary pilot
LOC 5733	Airstrip and beacon site
LOC 5732	Main access road and observation well
LOC 5772	Road to lagoon area
LOC 5728	Observation wells and access roads
LOC 5795	Lease traverse road and old airstrips
LOC 5727	Eastern pump site and access road
LOC 5729	Camp connection road
LOC 6245	Test drainage ditch
MSL 820597	Main access road
MLP 890084	Camp and associated facilities
MLL 900007	Old campsite
MLP 810038	Storage area
LOC 971997	Drainage system and access road
	Consultative notation covering Lease 13

APPROVALS PENDING

An application for an experimental pilot facility on Lease 13 was filed with the EUB and AEP in November 1997. Approvals are expected to be received by the end of 1997.

SCOPE OF CURRENT APPLICATION

The application for approval of the Muskeg River Mine Project includes the requirements of the EUB and AEP. These requirements have been integrated to reduce the amount of duplication, particularly in the area of project descriptions, and to make the review of the documents by regulators and others as efficient as possible.

The application is presented in five volumes:

- Volume 1: Project Description, which contains:
  - the technical and other information required for both the EUB application under the Oil Sands Conservation Act and the AEP application under EPEA
  - a summary of the EIA

SCOPE OF CURRENT APPLICATION (cont'd)

- the information required for the AEP 10-year approval and the water resources permit

- Volume 2: Environmental Impact Assessment — Biophysical and Historical Resources Baseline Conditions
- Volume 3: Environmental Impact Assessment — Biophysical and Historical Resources, Part 1: Impact Assessment and Part 2: Supplements
- Volume 4: Environmental Impact Assessment — Biophysical and Historical Resources Cumulative Effects Assessment
- Volume 5: Environmental Impact Assessment — Socio-Economic Impact Assessment

Volumes 1, 2, 3 and 5 are being issued in December 1997. Volume 4, the Biophysical and Historical Resources Cumulative Effects Assessment, will be issued in early 1998.

A guide to the contents of Volume 1: Project Description is included in the Preface to Volume 1. A guide to the requirements of the Terms of Reference is included in EIA Volume 2.

RELATED REGULATORY PROCESSES

In early 1998, Shell plans to file applications with the EUB and AEP for the development of an upgrader adjacent to the existing Scotford refinery near Fort Saskatchewan, northeast of Edmonton. In mid-1998, an application for a pipeline from Fort McMurray to Edmonton will be filed with the EUB and AEP. The objective is to obtain regulatory approval for all facilities by the end of 1998.

COMPLIANCE WITH GOVERNMENT POLICIES AND PLANS

The Muskeg River Mine Project supports the Alberta Government's policy to encourage development of the oil sands resources of northeastern Alberta in a sustainable and environmentally sensitive manner.

A long-standing goal of the Alberta Government is to increase the opportunity for upgrading bitumen resources in the province. In support of that goal, most of the production from the Muskeg River Mine will be pipelined to the Scotford area for upgrading, and used as a refinery feedstock for the production of petroleum products for sale in Canada.

Shell will select contractors and suppliers on the basis of quality, reliability, cost and schedule.

COMPLIANCE WITH GOVERNMENT POLICIES AND PLANS (cont'd)

The Muskeg River Mine conforms with the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan objectives and guidelines that identify oil sands development as a permitted use in the Mildred-Kearl Lakes Resource Management Area.

The Muskeg River Mine conforms to Land Use Order MO6555-93 for the Regional Municipality of Wood Buffalo, which allows oil sands development as a discretionary use in the rural district in which Lease 13 is located.

REGULATORY CONTACTS

All communication on these regulatory applications should be directed to:

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LEASE PHYSIOGRAPHY

Lease 13, immediately east of the Athabasca River valley, is situated within the Clearwater Lowland physiographic division of the Saskatchewan Plain. Most of the lease comprises gently undulating terrain between 330 m above sea level (masl) in the southeast, and 284 masl in the west, at the crest of the Athabasca River escarpment. The eastern valley wall of the Athabasca River slopes abruptly 50 m down to river elevation (232 masl).

The Muskeg River flows diagonally across the lease in a southwesterly direction with a gradient of about 10 m over a 14 km reach (see Figure 2-1). Jackpine Creek (historically known as Hartley Creek) is the largest of four tributaries that enter the Muskeg River almost at right angles from the southeast. Northwest of the Muskeg River, the lease is poorly drained, with muskeg development, but there are no significant bodies of water within the lease boundaries.

McMURRAY FORMATION

The Cretaceous McMurray Formation, which contains all the reserves in the Athabasca surface mineable area, overlies a regional unconformity developed on Devonian carbonates. The uncemented sand, silt and clay of the McMurray were deposited between 110 and 90 million years ago in a dynamic coastal system that underwent marine transgression from north to south.

Middle Devonian strata underlying the McMurray oil sands are subdivided (in descending order) into the:

1. Beaverhill Lake Group, including the Waterways, Slave Point and Fort Vermilion formations (see Figure 2-2).
2. Elk Point Group, which includes the Watt Mountain, Muskeg (Prairie Evaporite), Keg River (Methy), Contact Rapids, and Lower Devonian La Loche formations.

Regionally, the Prairie Evaporite has a wedge-shaped cross-section tapering to the northeast. This profile developed as groundwater dissolved salt during the 170 million year hiatus between the Devonian and Cretaceous, along a front advancing from the northeast. The salt dissolution front is currently interpreted as lying below the Athabasca River, the salt having been removed from beneath Lease 13.

McMURRAY FORMATION (cont'd)

Evidence provided by the Syncrude Aurora North Mine, based on studies of post-Cretaceous deformation and downwarping of McMurray beds, suggests that in places significant salt removal occurred after Cretaceous sediments were deposited. There is no comparable evidence for similar collapse within Lease 13. Given the current position of the salt solution edge, and the local trends of the McMurray isopach, none would be expected.

Post-McMurray formations occurring in the Athabasca area include the Cretaceous Clearwater and Grand Rapids formations and Quaternary deposits of the Pleistocene and Holocene. The Clearwater and Grand Rapids formations are flat-lying marine sediments consisting of shale and sandstone.

Quaternary deposits consist primarily of glaciofluvial sheet sands with minor gravel in lenses or shallow channels. In places, the fluvial materials are underlain by thin lacustrine deposits. Glacial till deposits also occur locally. In low-lying areas, Holocene organic muskeg can be several metres thick.

Granular Deposits

Within Lease 13, Disposition Reserve 900051, known as the Susan Lake pit, is operated as a public gravel pit. Although there are no current public licences to remove gravel, a weigh house is provided, and gravel is used, as required, for road maintenance.

All gravel for mine development will be drawn from the developed Susan Lake deposit, which consists of six significant granular ridges on:

- Township 97, Ranges 10 and 11
- Township 96, Ranges 9, 10 and 11
- Township 95, Range 10 (the west half of Lease 13)

Disposition Reserve 900051 is situated on the southern portion of Deposit A, Ridge A. Deposit A, Ridges B and C also lie along the northern perimeter of Lease 13. In total, the Susan Lake deposit includes 61.6 million m^3 of coarse aggregate and 168 million m^3 of fine aggregate.

The Alberta Government is currently receiving tenders in preparation for awarding a contract to manage all aspects of gravel pit operation. Shell will arrange with the successful contractor to supply all the granular requirements for mine development and operation.

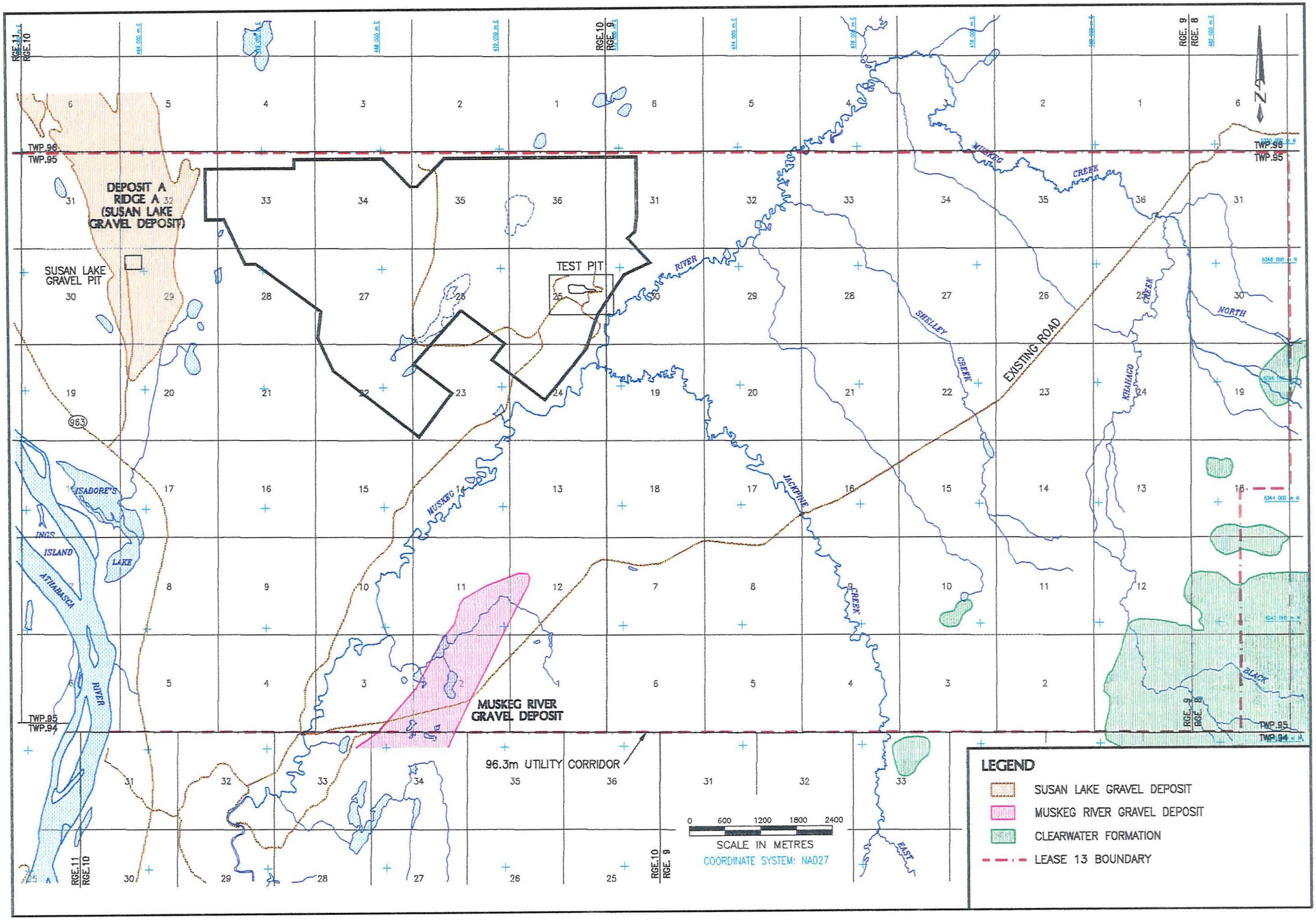


Figure 2-1: Lease 13 Physical Features

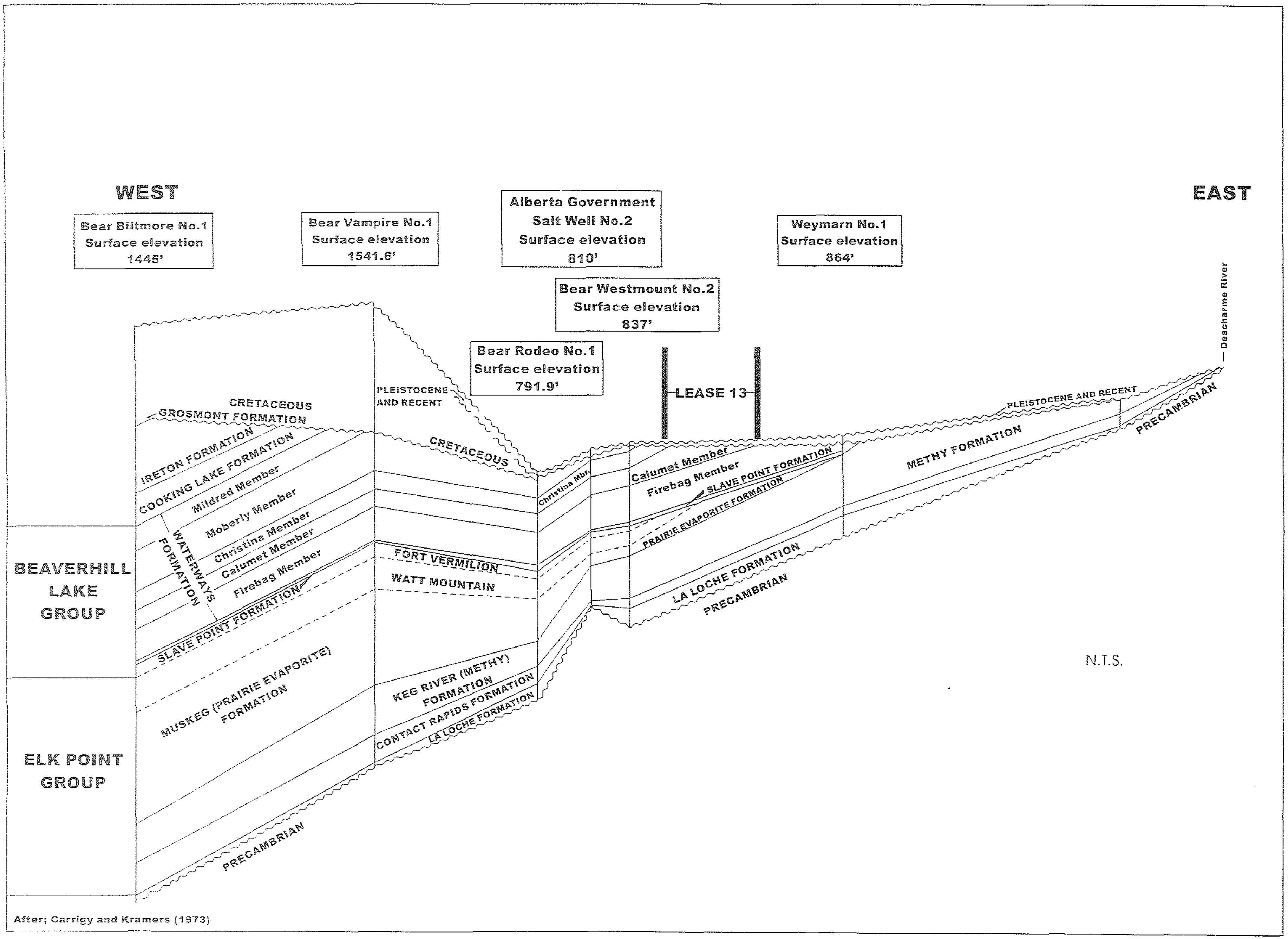


Figure 2-2: Geological Cross-Section (Precambrian to Recent)

McMURRAY DEPOSITION

The particular depositional model suggested for the McMurray Formation at Lease 13 reflects a sedimentation style characteristic of an open estuarine environment, with well-sorted sands that are porous and have high bitumen saturation. The lateral and vertical continuities of the rich sands are determined by the size of the estuary, as increased widths allow for thicker sands resulting from an amalgamation of stacked sequences. The deposition of fine grained (muddy) lateral accretion beds that could inhibit permeability is minimal. In the area of Lease 13, regional and localized lows in the Devonian caused exceptional thickening of the McMurray Formation and its sand units.

BEDROCK

As the regional Cretaceous-Devonian contact is unconformable, the age of the Devonian member underlying the McMurray Formation varies. The specific Devonian stratum beneath Lease 13 is the Calumet Member of the Waterways Formation, which is recognized as a nodular or reefal limestone with some calcareous shale and fossil content (crinoids and brachiopods). The elevation of the Devonian ranges from 140 to 250 m. Beneath the Muskeg River mine area, the Devonian surface has limited relief and maintains an elevation between 215 m and 225 m (see Figure 2-3). The surface rises to form a broad dome at over 250 m elevation just east of where the Muskeg River crosses the south lease boundary. The most pronounced feature on the lease is a north-to-south-trending valley up to 4 km wide, which transects the portion of the lease lying east of the Muskeg River. Elevations here dip as low as 140 m before rising again to between 210 and 220 m along the eastern boundary of the lease.

OVERBURDEN

The investigation of overburden materials on Lease 13 has had a long history. Between 1974 and 1997 over 1,600 boreholes, auger holes, test pits, core holes and muskeg probes were initiated in more than 20 different programs to evaluate overburden materials (see Figure 2-4). Using this data, maps of muskeg thickness and glacial deposits, and piezometric measurements of surficial waters were prepared.

Except for three specific areas, Quaternary deposits have an average thickness of 5 m or less over the entire lease. The Susan Lake and Muskeg River granular deposits are two of those areas, with Pleistocene sands and gravels that are over

OVERBURDEN (cont'd)

10 m thick in the Susan Lake ridge, and over 15 m thick in the valley of the Muskeg River deposit. In addition, a regional buried Pleistocene channel crosses the southeastern area of the lease (see Figure 2-5). The channel varies from 1 to 3 km in width and ranges in depth to more than 50 m from the surface.

Most Pleistocene sediment is water-lain. Glacial till is rare west of the Muskeg River. Holocene muskeg thickness averages less than 2 m, but can thicken locally to over 5 m (see Figure 2-6). In many areas there is no muskeg, and over other portions of the lease, including parts of the proposed mine area, muskeg directly overlies the McMurray Formation with no intervening glacial deposits.

Cretaceous Clearwater Formation sediments are limited, and restricted to the extreme southeastern corner of Lease 13. Small outliers of Clearwater sediments have been identified in a few areas west of the formation's edge. These are believed to be erosional remnants, or isolated ice-thrusted blocks that are out of stratigraphic position.

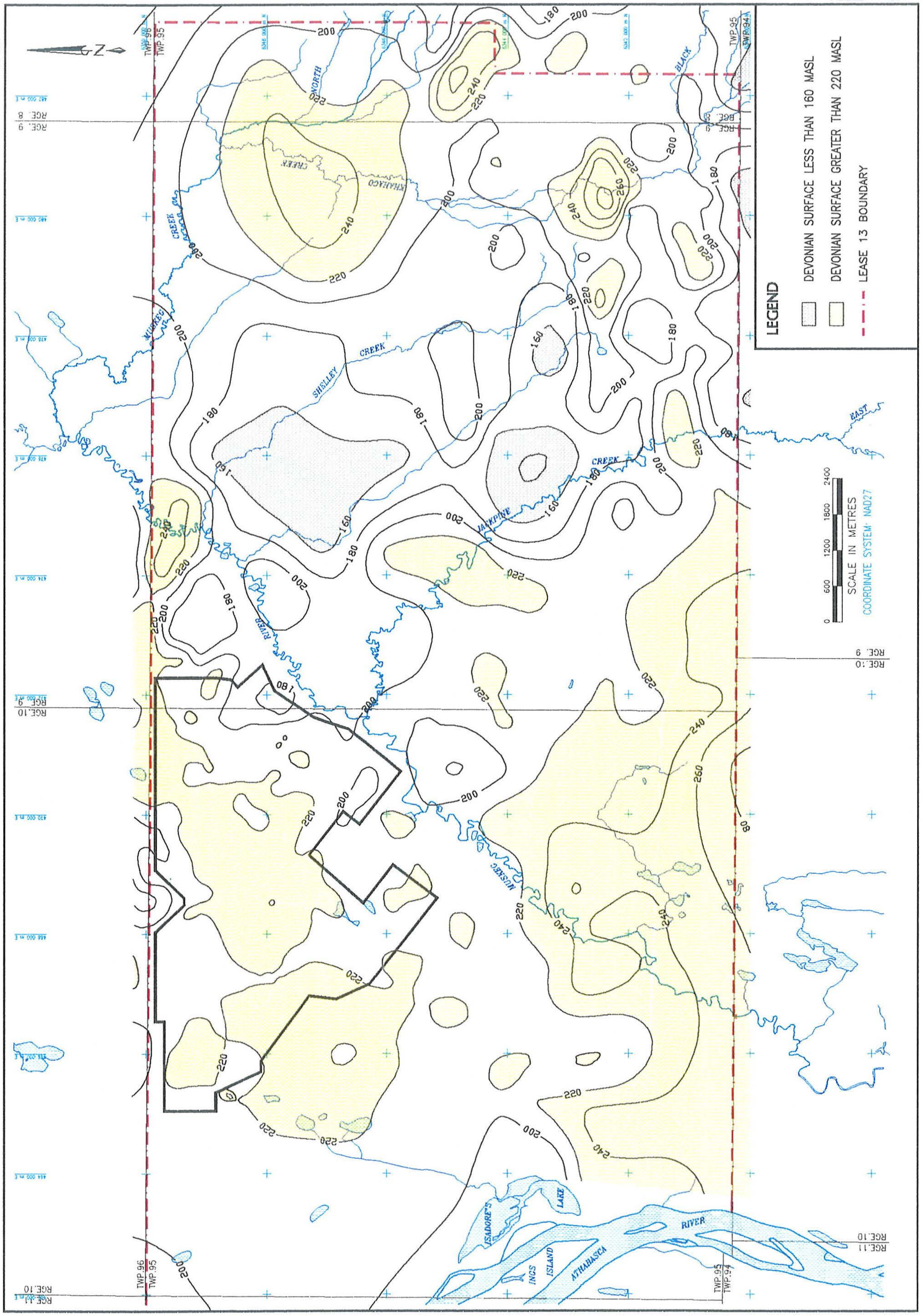


Figure 2-3: Devonian Surface Beneath Lease 13

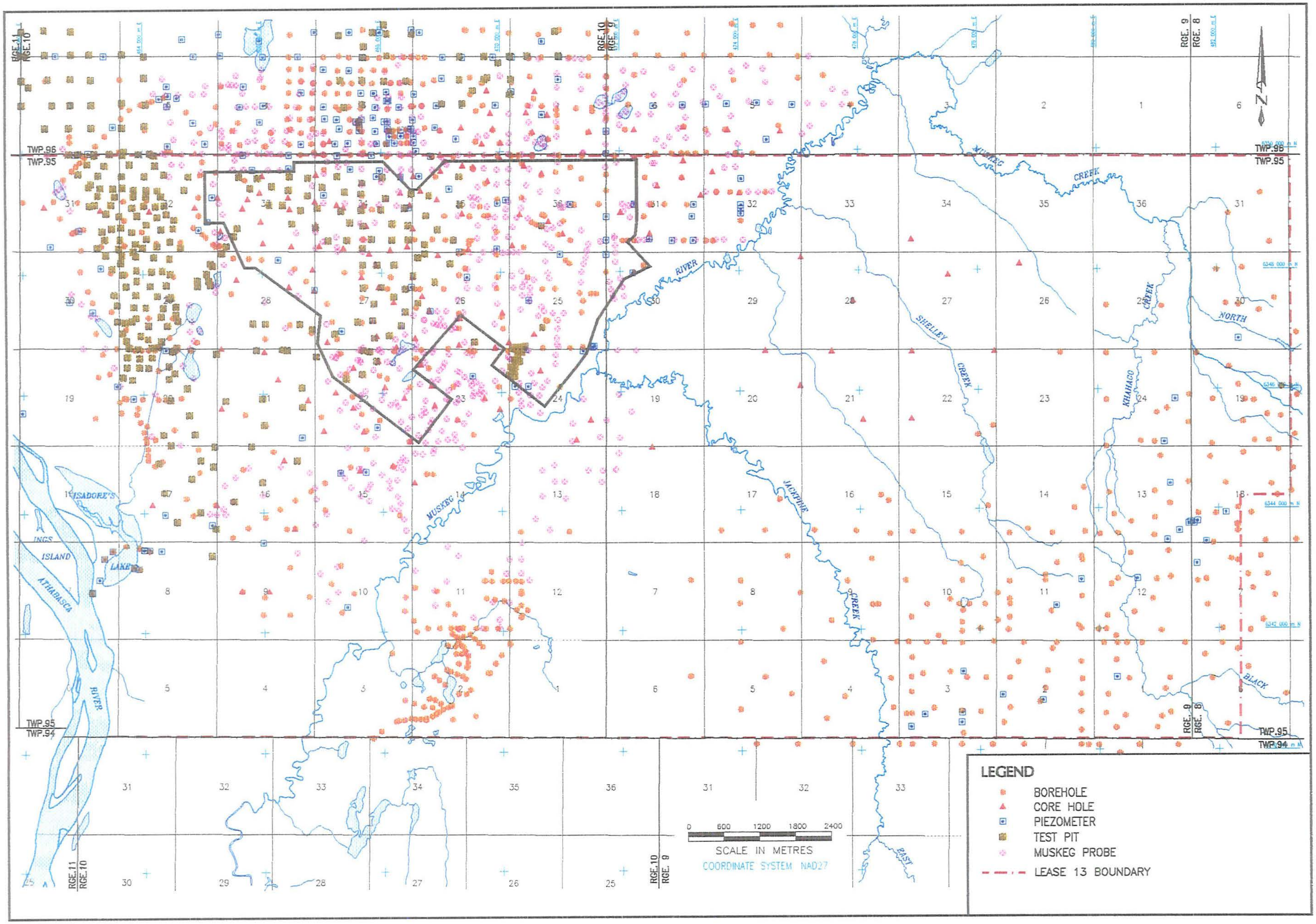


Figure 2-4: Overburden Survey Data Locations

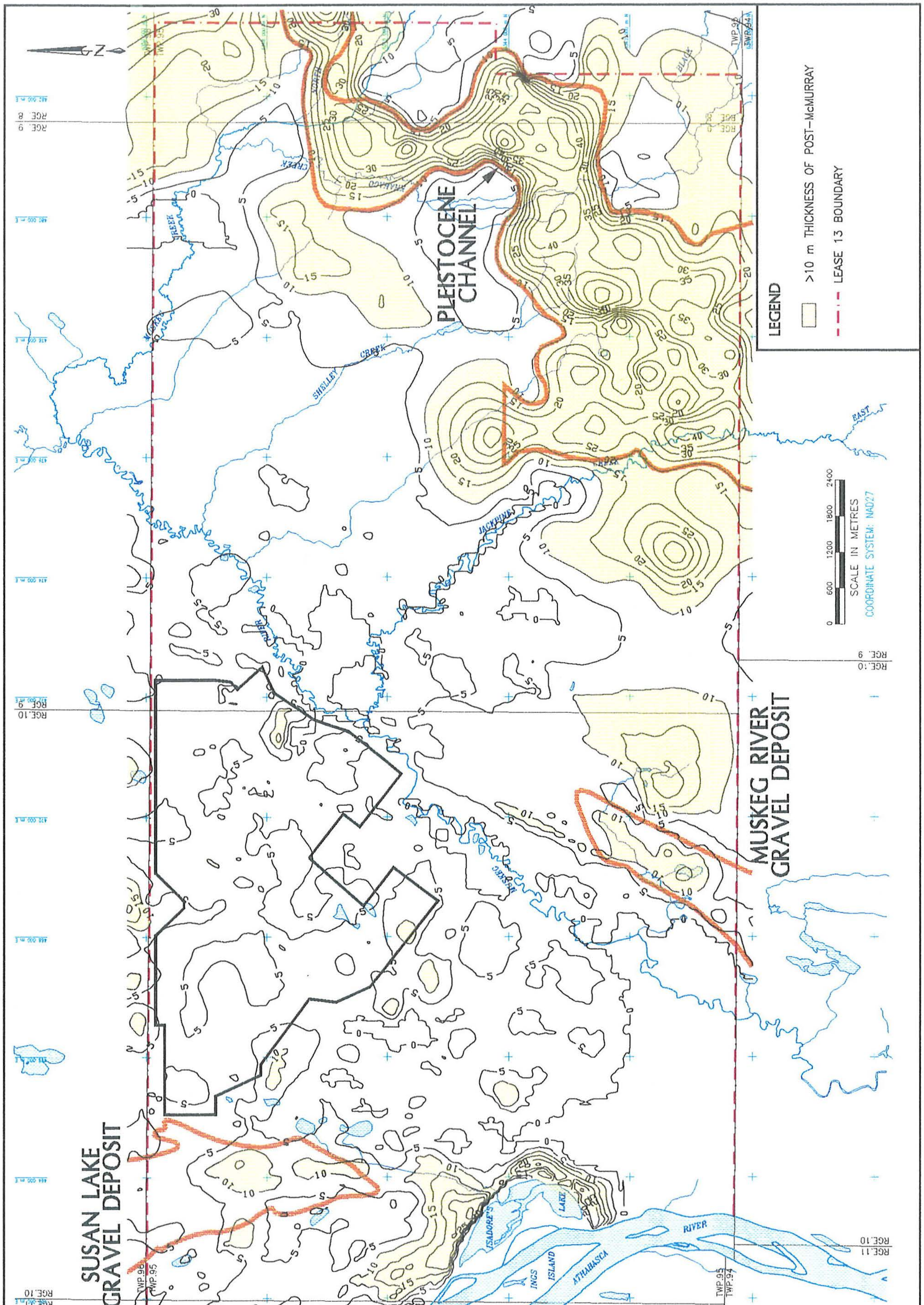


Figure 2-5: Isopach of Post-McMurray Deposits on Lease 13

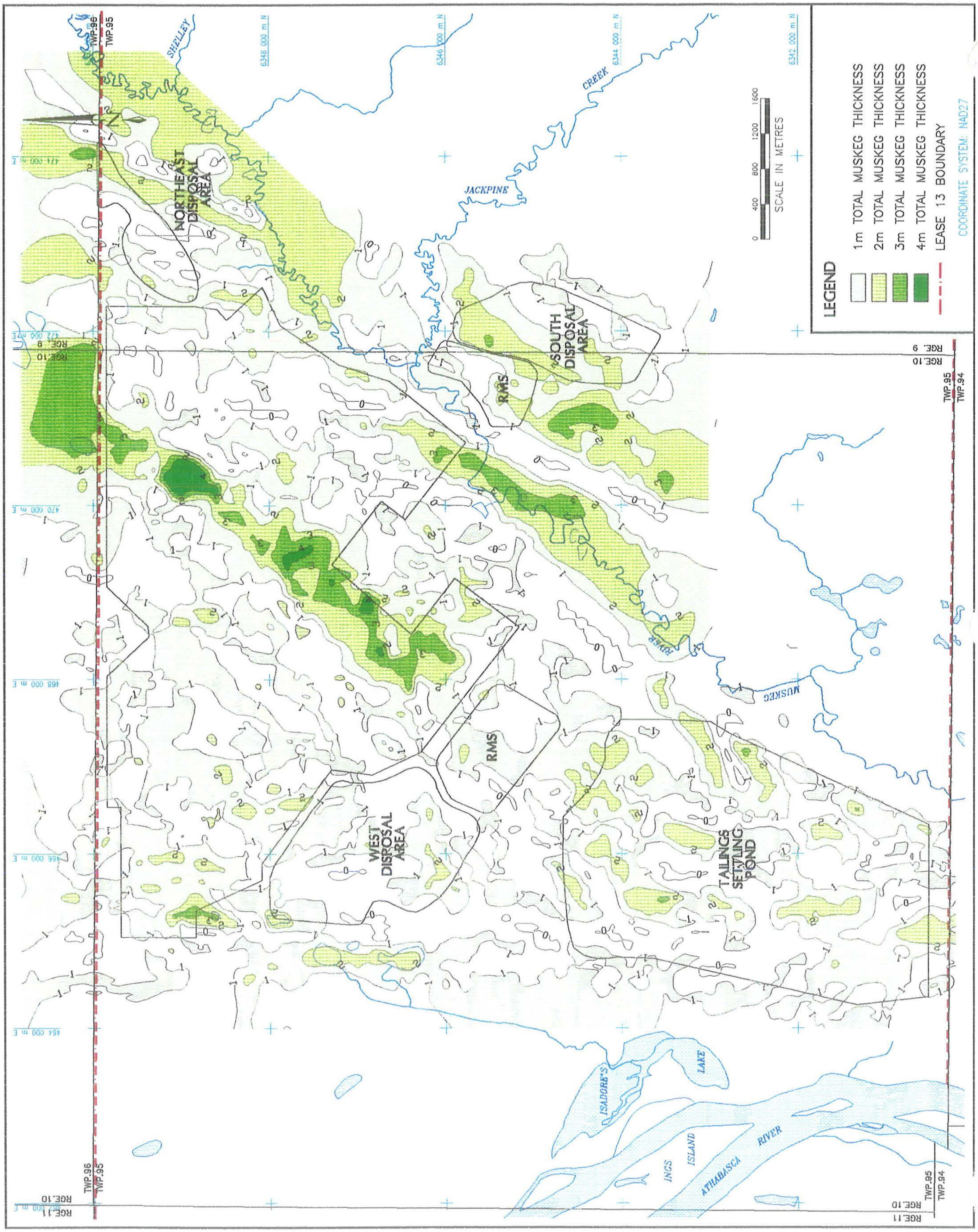


Figure 2-6: Muskeg Isopach with Pit, Tailings Settling Pond and Disposal Locations

DATA BASE

Drilling has always been the principal tool for resource delineation on Lease 13, although shallow seismic surveys have been conducted. The seismic data collected by Syncrude in 1995 and 1996 has been reviewed, but it is situated well away from the mine area.

DRILLING DENSITY

The quality and usefulness of individual well data are determined by the type and vintage of the well.

Exploration drilling on Lease 13 for resource evaluation occurred during six different periods (see Figure 3-1). However, the drilling density of test wells is not uniform over the entire lease. Figure 3-2 illustrates the distribution of wells resulting from different developments.

To date, the average drilling density is one well per 25 ha or about 10.2 wells per section. A density in the Muskeg River mine area of one well per 9 ha or about 29 wells per section has been established. East of the Muskeg River there is one well per 43 ha (six wells per section).

DATA QUALITY MONITORING

Data quality depends on the:

- drilling being competently completed
- samples being accurately collected and analyzed
- results being properly transcribed
- well locations being precisely surveyed
- successful repeated archiving and retrieval of data accumulated over 50 years

All wells used for modelling have been adjusted to a common survey system. Currently, because the bulk of exploration data is derived from the Alsands archives, the standard is NAD27. All current data points are back-converted from NAD83. As a survey control check, the Alsands coordinates were checked against modern coordinates. The Alsands and Shell coordinates were within 5 m to 15 m of each other in over 95% of occurrences. There are about 25 exceptions. For these, all available data was consulted, and air photos reviewed,

DATA QUALITY MONITORING (cont'd)

to determine the most reliably documented location. Only four wells were moved from Alsands coordinates, and in each case it was because archival maps showed well locations or access trails at the Shell location, but not at the supposed Alsands location.

A similar evaluation process was applied to establish an appropriate level of confidence for the data derived from wells of different exploration periods. Throughout the modelling process, only the best documented and most regionally consistent information was extracted from each well. Certain redundant clusters of wells from the injection tests of the 1960s were excluded from the database, but in sparsely represented areas, all available data was reviewed. Older limited data will be updated as new drilling results become available.

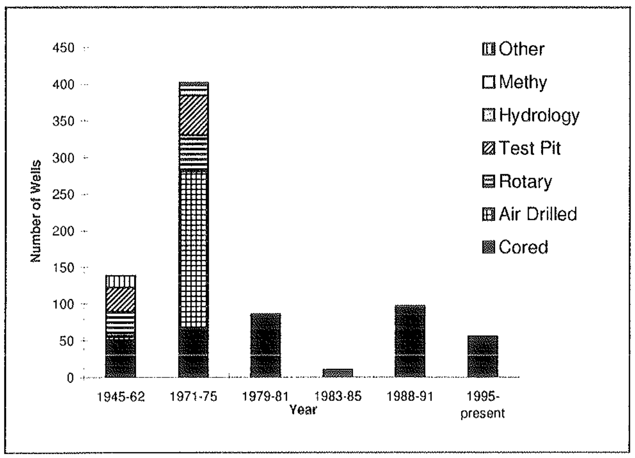


Figure 3-1: Chronology of Exploration Drilling on Lease 13

STRATIGRAPHIC CODING

Geological information was translated from the isolated data points represented by the wells to the three-dimensional volumes of a computer model, using numerical codes for facies and for zones.

Facies Codes

The importance of facies recognition is universally recognized in the oil sands industry as a key element for assessing resource potential. Facies are defined as distinct sedimentary units differentiated using, for example:

- grain size
- sorting
- rounding
- sedimentary structures
- degree of biological disturbance
- fossil content

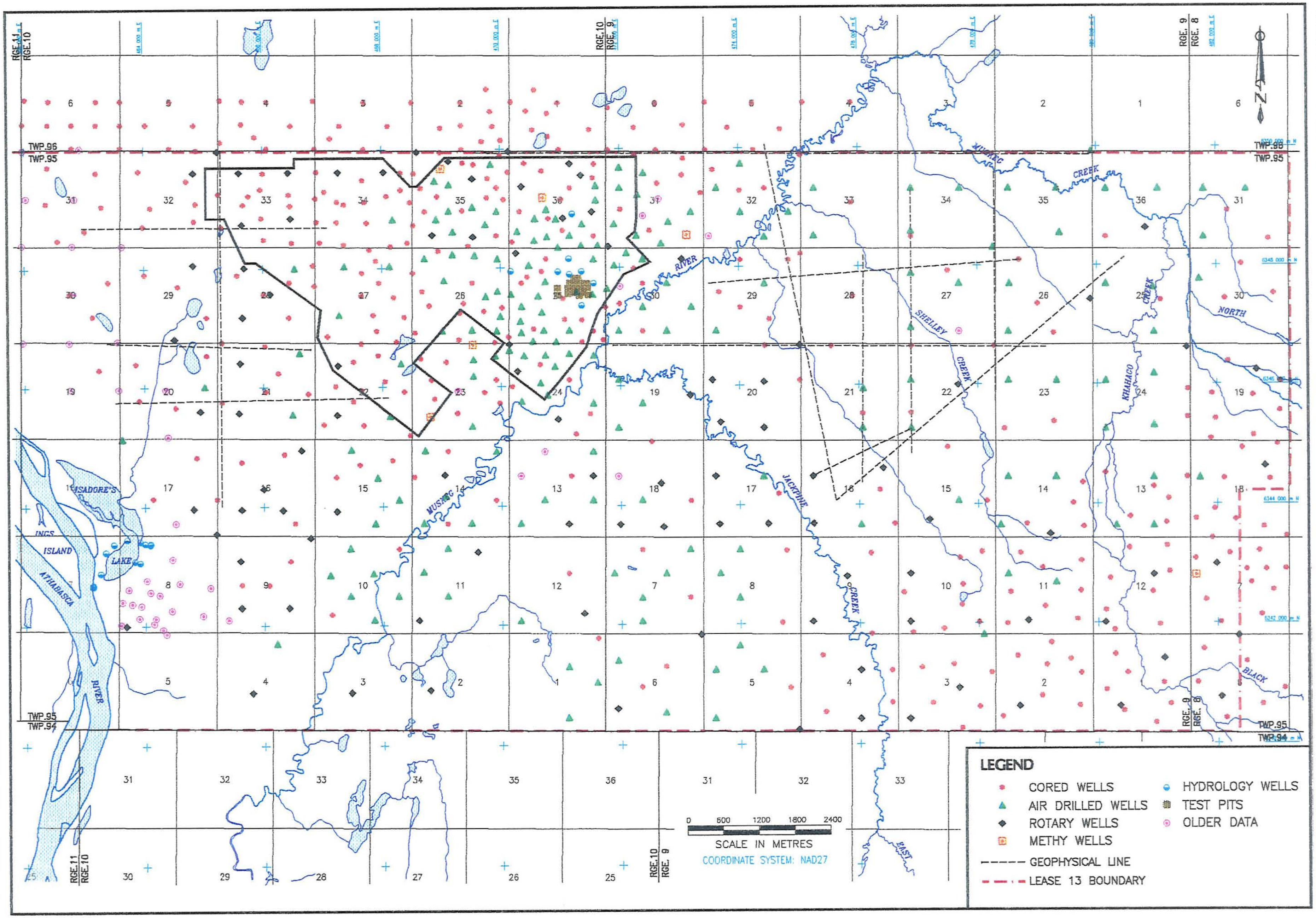


Figure 3-2: Oil Sands Exploration Drilling Density on Lease 13

Facies Codes (cont'd)

For Lease 13, the facies codes developed during the evolution of the Alsands project supply satisfactory and appropriate definition without excessive detail, and have been adopted for continued use.

Within the Muskeg River mine area, facies coding was available from the Alsands database. Elsewhere, facies codes (see Table 3-1) were developed for every well intersection possible, using:

- drillers' records
- geologists' well summary sheets
- complete lithological descriptions
- analytical reports
- core photos
- wireline logs (chiefly gamma, resistivity and density, but also neutron, sonic, SP and specialty 'tar sand assay')

Zones

For modelling purposes, the greater sedimentary sequence was divided into zones. These were designated using a combination of geological and resource-based elements under a consistent set of guidelines, to delineate the presence of ore with lateral continuity across the entire lease. Zones may be defined differently at each well location, depending on the specific local relationship between the facies sequence and bitumen saturation. They are intended to be interpolated between control points where their upper and lower boundaries have been identified using the most appropriate local parameters. Zones are not stratigraphic divisions in a strict geological sense, but are used for modelling purposes only.

Zone codes are shown in Figure 3-3. The defined ore zones are:

- Zone 2, which consists predominantly of Tidal Channel Sand
- Zone 4, which is almost exclusively Fluvial Channel Sand

The other zones are:

- Zone O, segregating all Clearwater and post-Cretaceous facies above the McMurray Formation

- Zone 1, the transitional zone above the Tidal Channel Sands, comprising a sequence of Muddy and Sandy Tidal Flats, mixed Flat and Channel sediments, Marine Shoreface material and, rarely, Offshore Muds

- Zone 3, centre reject (largely composed of Tidal Lagoonal Mud, but with a range of other facies)

- Zone 5, Fluvial Channel Sand that is water saturated (generally situated below the oil and water contact)

- Zone 6, including all Devonian strata (the Paleosol and limestone)

Table 3-1: Facies and Zone Codes for Lease 13

Zone	Facies Code		Facies	Description
	32		OVB	Overburden (undifferentiated)
	31		KM	Cretaceous McMurray (undifferentiated)
0	30	HOLOCENE	Ho	Holocene Organics
0	29		Hf	Holocene Fluvial
0	28		Hl	Holocene Lacustrine
0	27		He	Holocene Aeolian
0	26		Hc	Holocene Colluvium
0	25	PLEISTOCENE	Pfs	Pleistocene Fluvial Sand
0	24		Pfg	Pleistocene Fluvial Gravel
0	23		Pos	Pleistocene Outwash Sand
0	22		Pog	Pleistocene Outwash Gravel
0	21		Pl	Pleistocene Lacustrine
0	20		Pg	Pleistocene Till
0	19	CRETACEOUS	KCS	Clearwater Shale
0	18		KCW	Clearwater Wabiskaw
1	17		OSM	Offshore Mud
1	16		B	Beach
1	15		SF	Shoreface
1	14		TFS	Tidal Flat Sandy
1	13		TFM	Tidal Flat Muddy
1	12		TCTF	Tidal Channel\Tidal Flat
2	11		TC	Tidal Channel Sand
2	10		TCFC	Tidal Channel\Fluvial Channel Sand
2	9		TCB	Tidal Channel Breccia
3	8		TCM	Tidal Channel Mud
3	7		TLM	Tidal Lagoonal Mud
3	6		CS	Coal Swamp
3	5		FCPB	Fluvial Channel Point Bar
4/5	4		FC	Fluvial Channel Sand
4/5	3		FPOB	Floodplain\Overbank
6	2	DEV.	PSOL	Paleosol
6	1		LST	Limestone

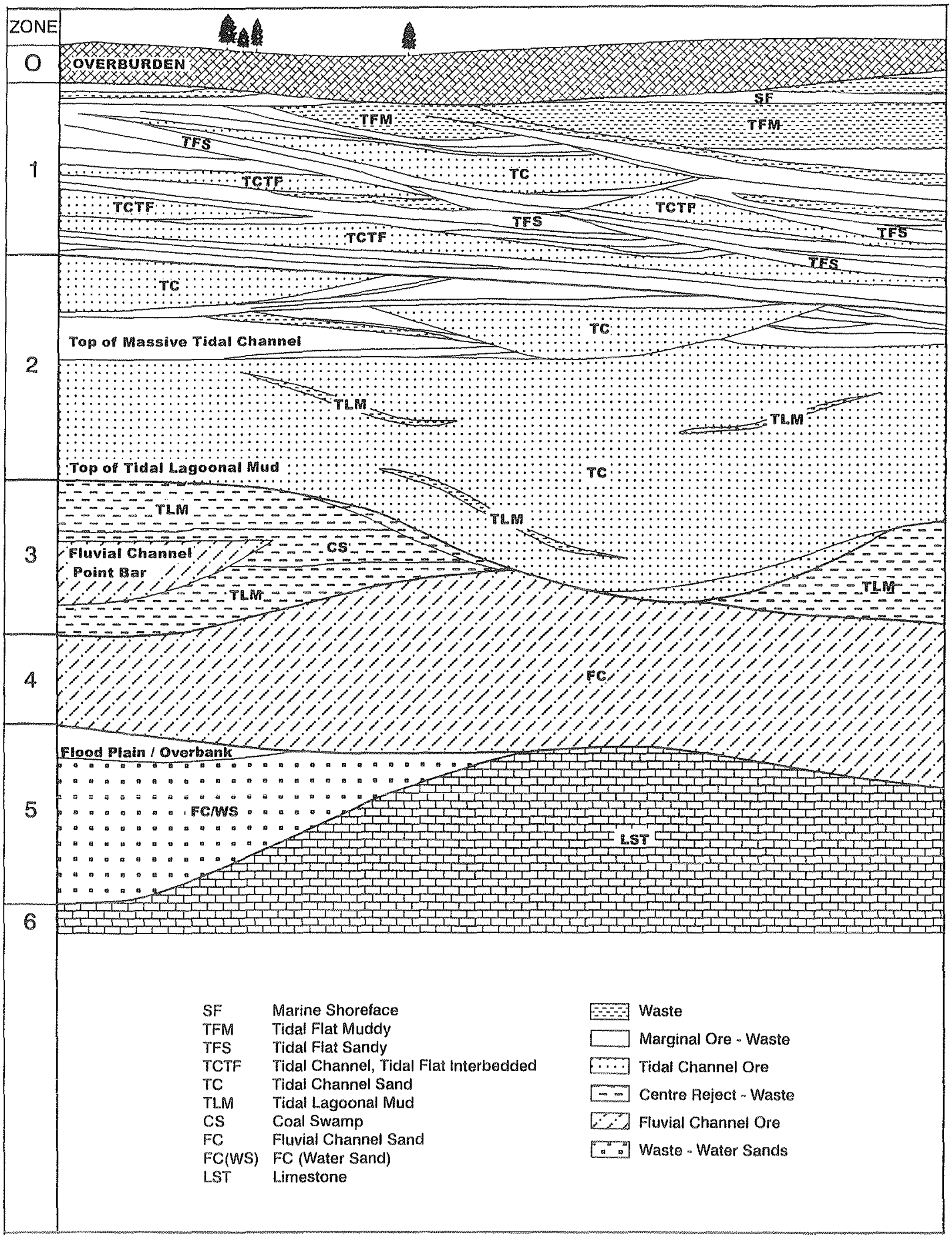


Figure 3-3: Sedimentary Zones and Zone Codes for Lease 13

Fines Data

One of the assumptions behind the facies-based geological modelling of Lease 13 is that there is a relationship between facies and the content of fine material with grain size less than 44 μm. This assumption has been tested by collecting

Fines Data (cont'd)

grain-size analyses on facies-based samples since 1981 (see Table 3-2). Currently, fines values are not carried in the model as a separate quantitative item. For the purposes of ore characterization, fines content is predicted by applying an average fines value for each facies contributing to an ore type, weighted by the volume content of each facies. The fines model will be continuously refined as new data is collected. Shell's 1997 field program supplied extensive particle-size analyses for an additional series of facies-based samples. Further grain-size analyses are planned for the 1998 field program.

Table 3-2: Average Fines Content by Facies

Facies	Abbreviation	Average Measured Fines (%) (<44 μm)	Average Measured Bitumen (%)	Average Cumulative Thickness (m)
Marine Shoreface	SF	22.1	6.0	15.3
Tidal Flat (sandy)	TFS	18.7	5.1	11.4
Tidal Flat (muddy)	TFM	24.5	4.2	11.3
Tidal Channel/Tidal Flat	TCTF	14.3	8.4	14.3
Tidal Channel	TC	7.7	11.8	15.6
Tidal Lagoonal Mud	TLM	32.0	2.6	6.3
Fluvial Channel (Oil Sand)	FC(OS)	6.9	11.7	15.3
Fluvial Channel (Water Sand)	FC(WS)	10.4	4.3	7.0
Tidal Channel Breccia	TCB	12.6	7.8	7.0
Fluvial Channel Point Bar	FCPB	13.4	5.7	3.6
Flood Plain/Overbank	FPOB	19.4	4.3	4.9

DATA FORMATTING

The essence of the computer-modelling process was the establishment of facies, zones and grade data using a consistent interpretation for every well. Every available file for wells lacking stratigraphic data (facies and zones) was examined. Every file for wells that already had Alsands facies and zones was re-examined.

A computer model operates most effectively when the input data includes continuous records of bitumen grade assays down each well. For Lease 13, an innovative approach has been adopted to compensate for the absence or loss of core. The Alsands Project made use of a large number of wells drilled over a long time span using evolving drilling technology. For intervals not represented by core, considerable effort was spent in developing and refining an algorithm that would calculate values for bitumen grade from the digitized gamma, resistivity and density traces of downhole petrophysical logs.

DATA FORMATTING (cont'd)

The 200 cored Alsands wells were used to calibrate the results for the remaining 430 wells. In this way, a much larger collection of reliable data has been accumulated than would be available from cored wells alone. All of the 160 wells drilled since 1982 have been cored, with recoveries better than 85% to 90%. The grade values for these were determined by Dean & Stark analyses, with any minor gaps filled by visual estimation based on gamma and resistivity logs.

Calculations and estimates of bitumen grade have been verified using several methods. A comparative study of measured against calculated bitumen values for several hundred analytical samples in 64 ore zones was conducted using 1981 Alsands core data. For this sample set, the calculation algorithm produced an average bitumen value 0.09% higher than that observed for the Dean & Stark results. This is well within the margin of error of 0.5% bitumen typical for the analyses.

A standard part of the geological description process is the tabulation of geologists' estimated ore grade for new core, and then subsequent comparison with the Dean & Stark results. Routine estimates of bitumen grade for missing intervals can therefore be performed with confidence.

Regional resource volumes are also calculated within a confidence limit. Ore grade is extrapolated no further than 600 m beyond the last available data point around the lease boundary.

GEOLOGICAL MODELLING

Model Structure

Landmark's *Stratamodel* is a widely used three-dimensional reservoir analysis program applied by Shell's Subsurface Group to model heavy oil and in situ oil sands. This proven technology was used to model the Lease 13 bitumen resource.

A *Stratamodel* project is built by first establishing a structural framework that defines the relationships between the zones. Each zone is represented by a top surface gridded at 100 m x 100 m from the original well intersections. The grid spacing defines the lateral dimensions of the model cells. The cell thickness, controlled by the distance between zone tops, varies from one zone to another. The zone surface grids do not cross, and are continuous over the entire lease. They are used in the model to control the interpolation of bitumen grade and facies codes between the well locations.

The model refers again to the original data files to interpolate grade and facies data into the cells that have been created. The interpolation algorithm used for the model is an enhancement of a classical inverse distance-squared formula, using a search radius that ranged from 500 m to 700 m, 900 m, 1,200 m and 1,500 m, depending on the distribution density of available data.

Model Philosophy

The detailed geological evaluation of each well contributing to the database supports a strong geological approach throughout the modelling process. Because the zone tops are identified using geological markers within the wells, and are interpolated into continuous geologically controlled horizons within the model, the interpolation of resource data, such as bitumen grade and facies, within the layers of the model, creates cells that are geological entities. Facies can logically be projected laterally within a facies-defined zone. Cells interpolated between drilled intersections defined as ore zones can logically be assumed to contain ore. Grade values can be projected confidently within geologically defined boundaries.

Model Building

The several phases of modelling include:

- creating values for model cells intersected by wells
- interpolating values into intervening cells not intersected by wells
- verifying that the algorithms used for interpolation are reasonable and realistic

Verifying Model Procedures

Checks of the modelling assumptions were made at each phase of the process.

As a basic confirmation, well assays were checked against nearby calculated cell values on model cross-sections.

The method used to interpolate data into model cells was subjected to substantial review, and a technique was developed to dynamically adapt the search radius of the extrapolation formula to suit the local data distribution density within the model.

The geometry of the model and the values associated with each cell were replicated in a modelling system developed by Norwest Mine Services. Resource volumes for selected subsections of the model were calculated and compared with *Stratamodel*. In each case, the values or volumes were comparable.

The well data set was loaded and modelled by BHP using the projection assumptions and algorithms used by the MINCOM system, a mine-modelling program developed by Mincom Pty. of Australia. In the Muskeg River Mine area, the total resource volume at a 7% grade cut-off was verified to within 0.5% of the value generated by *Stratamodel*.

Figure 3-4 illustrates the distribution of well-based data contributing to a typical cross-section through the proposed pit area. The cross-sections transect the block

Verifying Model Procedures (cont'd)

model at the same location and show the values for bitumen grade and for facies code.

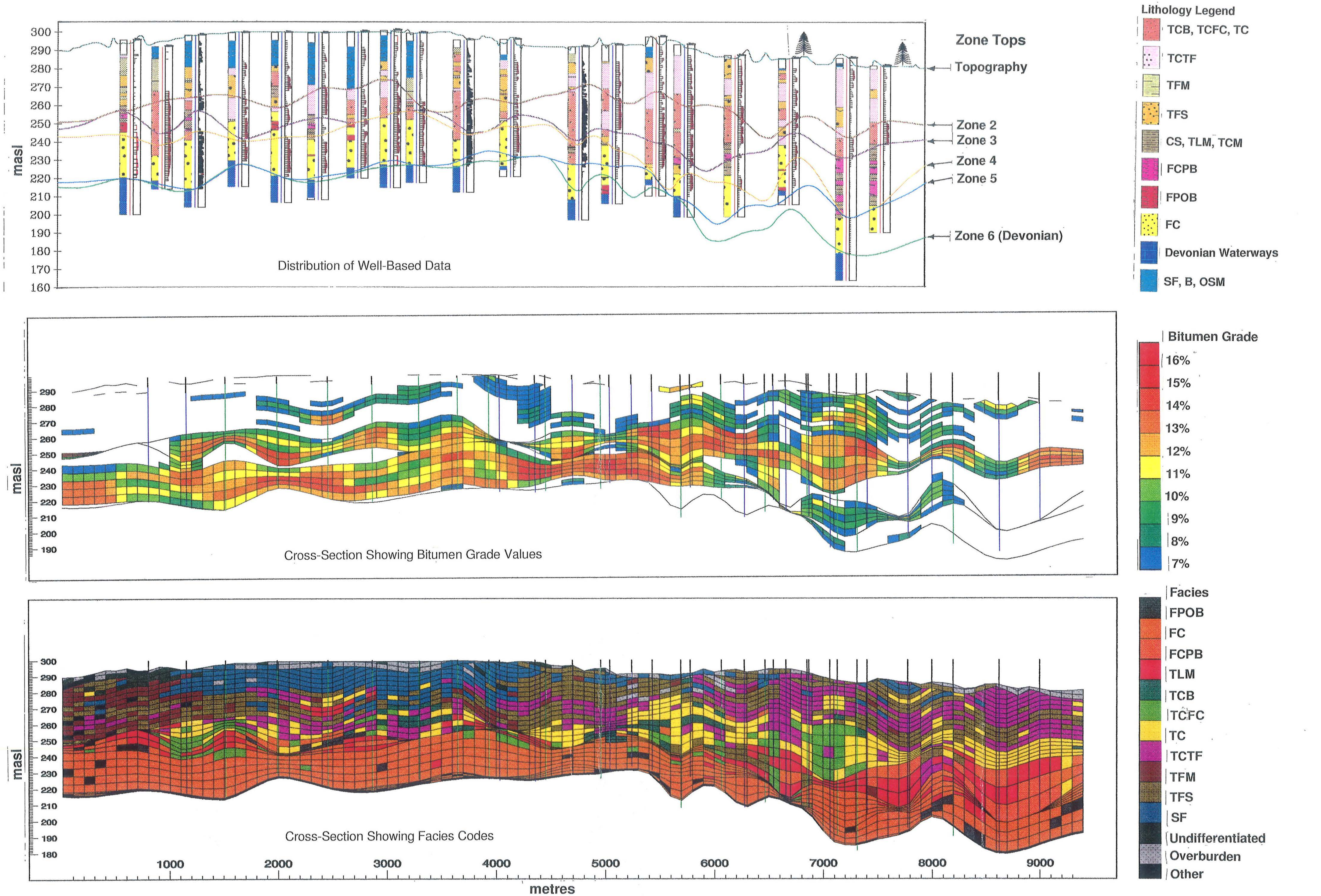


Figure 3-4: Well-Based Data, Bitumen Grades and Facies Codes

DETERMINING CUT-OFF GRADE

To determine the bitumen grade value to be used as a lower cut-off in the definition of ore for extraction plant feed, the balance between fines content and bitumen saturation for each facies was explored. To some extent, this balance is a natural relationship, which has been used in delineating ore zones. By intent, Zones 2 and 4 are designated as containing ore. They are selected in individual wells as continuous intervals of bitumen-rich sediment with a rapid fall off in grade observable above and below the zone interval. A bitumen content of 6% was used as an initial value to limit the ore zones.

Most of the economically mineable bitumen on the lease is contained within Zones 2 and 4. In Zones O, 3 and 5, there are isolated pockets of ore, which will be mined as extraction plant feed ore wherever appropriate. Zone 1 includes a variety of facies with a range of bitumen and fines content. The selection of cut-off grade has an impact on the volumes of oil sands classified as ore mostly in this zone. Regardless of cut-off grade, the ore from Zone 1 will require scheduling and blending to control the flow of fines-bearing material.

GRADE DISTRIBUTION CURVE

In contrast with a traditional statistical treatment of individual analytical data points, the grade distribution profile for Lease 13 is calculated by extracting from the computer model the actual tonnage of oil sands expected to occur at bitumen contents incremented by 0.5%. The tonnage calculation, built upon the modelling of uninterrupted bitumen sequences down each well, realistically depicts the expected in situ grade distribution. Figure 3-5 shows the tonnage of oil sands, as distributed by bitumen grade for the Muskeg River mine area, and also provides a zone-by-zone breakdown. Most of the lower grade oil sands are derived from Zone 1.

CUT-OFF SELECTION

The selection of cut-off grade influences all mine planning and resource estimates. The optimum cut-off grade was determined by using the block model for a volumetric analysis of the facies composition and bitumen grade for the ore of each zone.

The following considerations were included in the analysis:

CUT-OFF SELECTION (cont'd)

- resource conservation
- average plant feed grade and extraction recovery
- grade and facies distribution
- fines and grade attributed to each facies
- incremental economics of bitumen produced from low-grade ore

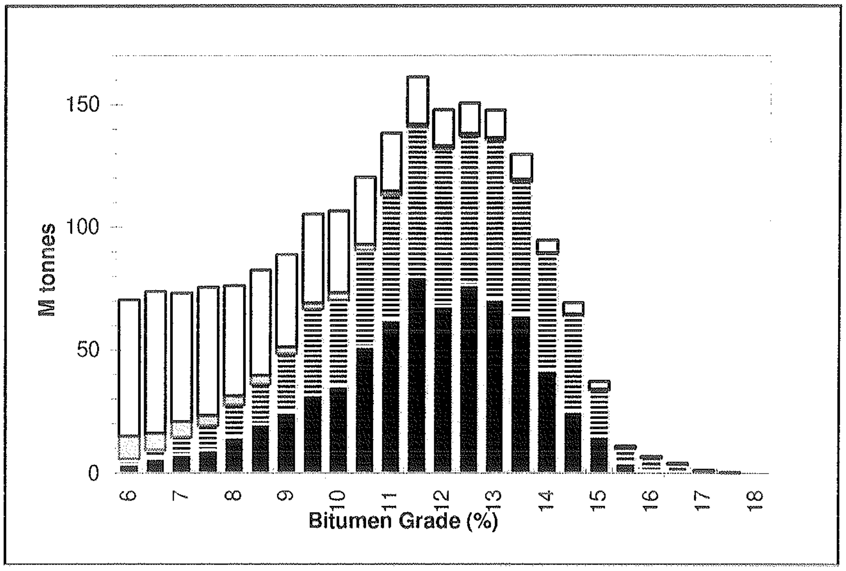


Figure 3-5: Lease 13 Mine Area Grade Distribution

An overall cut-off grade of 7% bitumen, by weight, was selected. However, since the opening cut of the mine draws a large volume of ore from the higher fines facies of Zone 1, a temporary increase in the ore cut-off grade will be necessary to ensure that the extraction and tailings circuits perform adequately during start-up.

The grade distribution curve (see Figure 3-6) illustrates the type of low-grade material derived from Zones 1 and 3. Typically, this low-grade ore will:

- range from 15% to 35% fines
- have below average recovery
- suppress recovery of premium facies ore (TC and FC)
- reduce overall extraction performance
- generate increased froth solids
- increase the volume of mature fine tailings

About 90% of the high fines facies, which contribute to 6% and 7% of the ore, comes from Zones 1 and 3.

CUT-OFF SELECTION (cont'd)

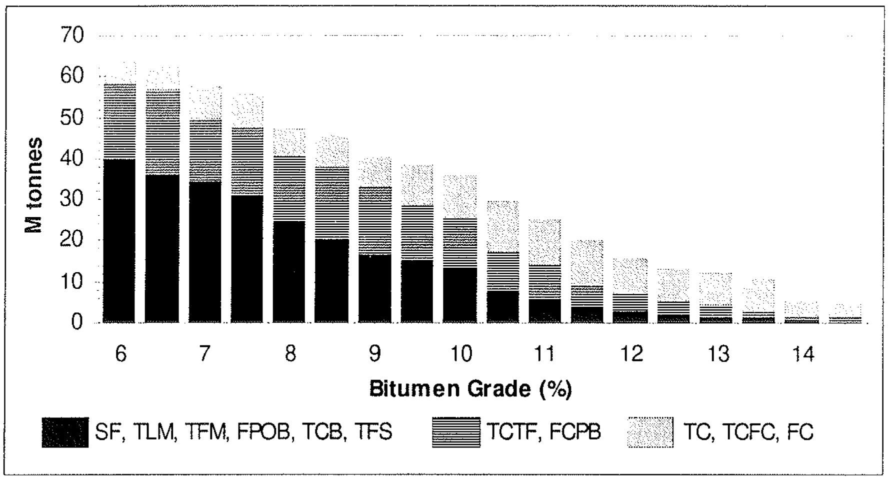


Figure 3-6: Bitumen Grade of Ore from Zones 1 and 3

The possibility of reducing cut-off grade from 7% to 6% was assessed, with the result that an additional 125 million tonnes of ore at an average grade of 6.5% bitumen could be delivered to the extraction plant, at an average rate of 6 million tonnes per year. Because of the poor extraction recovery of this low grade, high fines ore, the additional bitumen produced is estimated at 0.225 million m^3 (1.4 Mbbl).

The estimated impact on extraction plant costs would be:

- increased plant capital expenditures of $30 - $40 million
- increased plant operating expenditures of $10 - $15 million per year

The accumulation of these two impacts contribute to a total bitumen cost of between $75 and $90/m^3 ($12 - $14/bbl), which is above the break-even cost for the project. Therefore, a cut-off grade of 6% is rejected, in favour of an overall cut-off grade of 7%.

OREBODY OPTIMIZATION

The resource values in Table 3-3 were calculated using a 7% grade cut-off and a limit of 600 m extrapolation beyond the last data point at the lease perimeter. No other economic restriction is applied. All ore in the modelled area calculated to have a bitumen grade of 7% or above is included.

Over the lease area, the average waste to ore ratio is 0.69 bcm/t and the average ratio of total volume of material to the volume of bitumen in place (TV/BIP) is 10.65. The average ratio of total volume of material to the volume of net recoverable bitumen (TV/NRB) is 11.57.

Table 3-3: Total Resource for Lease 13 (7% Cut-Off)

	Ore		Bitumen		Waste
	Volume (Mm^3)	Grade (%)	(Mm^3)	(Mbbl)	Volume (Mm^3)
Zone O	101.3	9.7	20.3	127.7	1,476.5
Zone 1	1,211.1	10.2	254.2	1,598.8	3,700.1
Zone 2	2,941.4	11.6	704.9	4,433.4	339.4
Zone 3	167.6	10.2	35.1	221.0	2,692.9
Zone 4	1,477.8	11.1	338.1	2,126.5	302.5
Total	5,899.2	11.1	1,352.6	8,507.4	8,511.4

As the resource area is refined and data density increases, the segregation of ore into Zones 2 and 4 becomes more apparent. The definition of the Muskeg River mine site has identified an ore body with several favourable components. Over 70% of the mineable ore lies within Zones 2 and 4 at an average grade of just under 12% bitumen by weight (see Table 3-4). Waste volumes in these two zones are low, suggesting that the ore can be efficiently mined. Very little ore volume is found in Zones O and 3. A higher percentage of ore falls within Zone 1 in the pit, compared with the lease as a whole, because the exceptionally sandy quality of the upper facies (and associated low fines content) in this location has generated an excellent reservoir. The presence of this Zone 1 ore is a key consideration in the location of the pit.

In addition to a 7% cut-off, the pit limits are established using various economic criteria (see Final Economic Pit Limits in Section 4.2).

Table 3-4: Resource within Muskeg River Pit (7% Cut-Off)

	Ore		Bitumen		Waste
	Volume (Mm^3)	Grade (%)	(Mm^3)	(Mbbl)	Volume (Mm^3)
Zone O	6.5	10.6	1.4	9.0	71.6
Zone 1	201.3	9.7	40.1	252.4	334.0
Zone 2	316.3	12.0	78.0	490.8	8.4
Zone 3	16.3	10.5	3.5	22.1	115.5
Zone 4	336.5	11.8	82.2	517.1	13.2
Total	876.9	11.4	205.2	1,291.4	542.7

There are 200 million m^3 (1.25 billion bbl) of bitumen in the mineable ore of Zones 1, 2 and 4. The overall waste to ore ratio in the pit is 0.30 bcm/t, with an average TV/BIP ratio of 6.91 and an average TV/NRB of 7.46.

Apart from the resource within the proposed pit, the quantity of resource remaining under lease areas designated for disposal areas and the tailings settling pond has also been calculated. As shown in Table 3-5, the resource present under these areas is of low grade and at a high TV/BIP ratio. Continued exploration over the 1998 field program will further refine the shape, position and quantities of bitumen contained under these infrastructure areas.

Table 3-5: Remaining Resource under Disposal and Settling Pond Areas

	Ore		Bitumen		Average TV/BIP
	Volume (Mm^3)	Grade (%)	(Mm^3)	(Mbbl)	
Disposal Areas	134	10.5	30	187	13.2
Settling Pond	188	10.5	41	258	12.8

EXPANSION OPPORTUNITIES

Beyond the Muskeg River mine pit area, Lease 13 contains several additional ore bodies that have the potential for further resource delineation and eventual development. Figure 3-7 illustrates the distribution of economic ore with all areas of TV/BIP less than 12 shaded. Additional exploration will be required to confirm the quality and volume of the indicated ore.

The indicated resource areas (Areas 1, 2, 3 and 4) are roughly defined using a 7% minimum grade and the 12:1 TV/BIP maximum cut-off. The resource contained within each of these areas is shown in Table 3-6. These areas, taken together with the Muskeg River mine, comprise 354 million m^3 (2.2 billion bbl) of bitumen west of the Muskeg River, and 465 million m^3 (2.9 billion bbl) of bitumen east of the Muskeg River, for a total of 820 million m^3 (5.2 billion bbl) of bitumen lease wide. This amount, defined at a 7% minimum cut-off grade and a maximum TV/BIP of 12, is the potentially mineable resource, compared with the total lease-wide resource of 1,350 million m^3 (8.5 billion bbl).

Table 3-6: Resource Contained within Areas 1, 2, 3 and 4

	Ore		Bitumen		Average TV/BIP
	Volume (Mm^3)	Grade (%)	(Mm^3)	(Mbbl)	
Area 1	327	11.9	81	506	7.8
Area 2	297	11.3	69	433	9.2
Area 3	512	11.3	119	748	7.0
Area 4	1,429	11.7	346	2,177	7.8

Figure 3-8 shows the distribution of economic ore in a TV/NRB approach. A recovery curve relating to bitumen grade reduces the apparent available in situ bitumen in areas of reduced average grade. For a discussion of the recovery curve, see Bitumen Recovery and Quality in Section 5.3.

Figure 3-9 is a traditional waste to ore map, for which ore is defined as bitumen at a grade greater than 7% by weight.

Figure 3-10 is a total ore isopach map showing the thickness of all ore with a greater than 7% bitumen content over the lease area, within Zones 1, 2, 3 and 4.

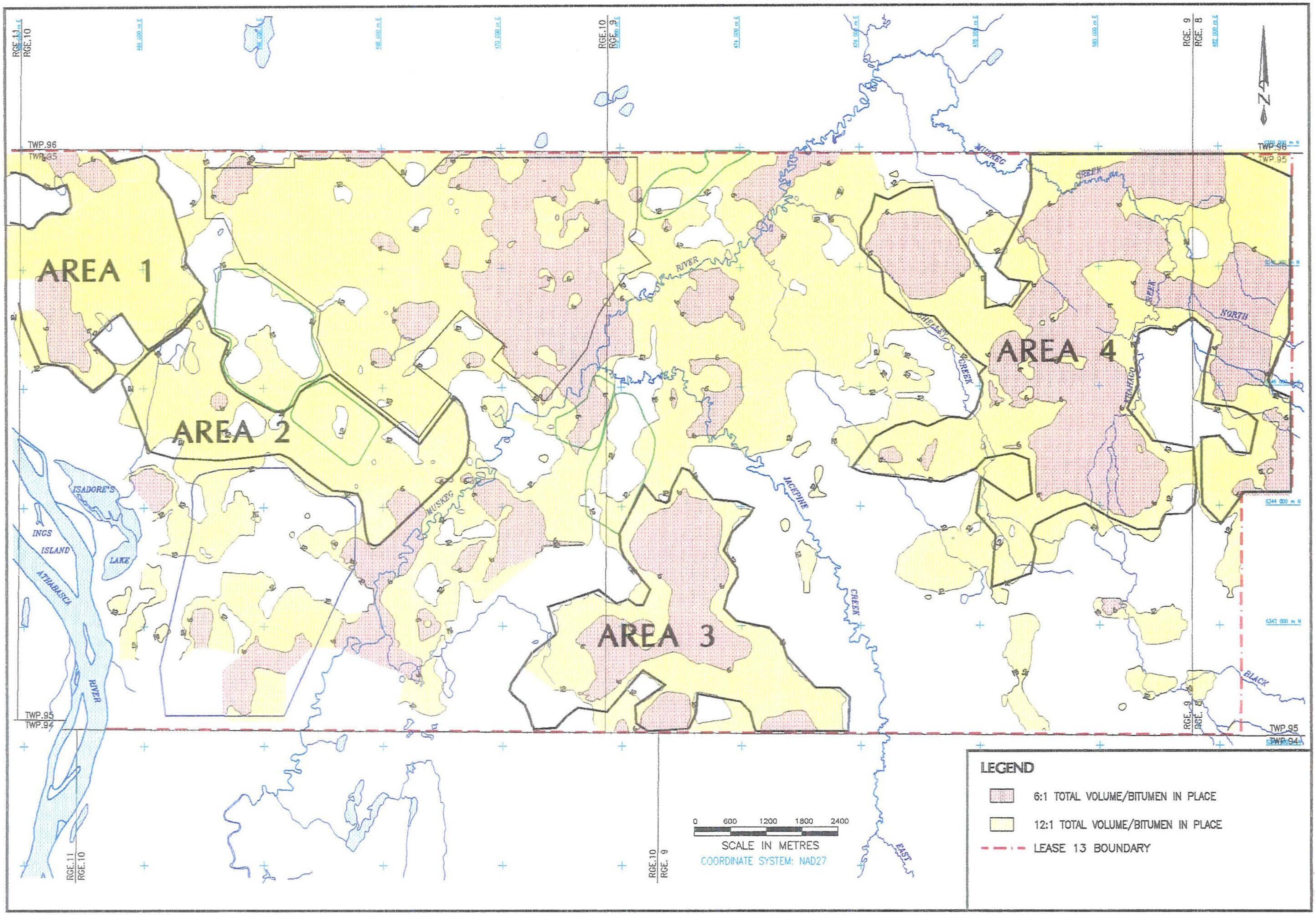


Figure 3-7: TV/BIP Showing Areas of Potential Future Expansion

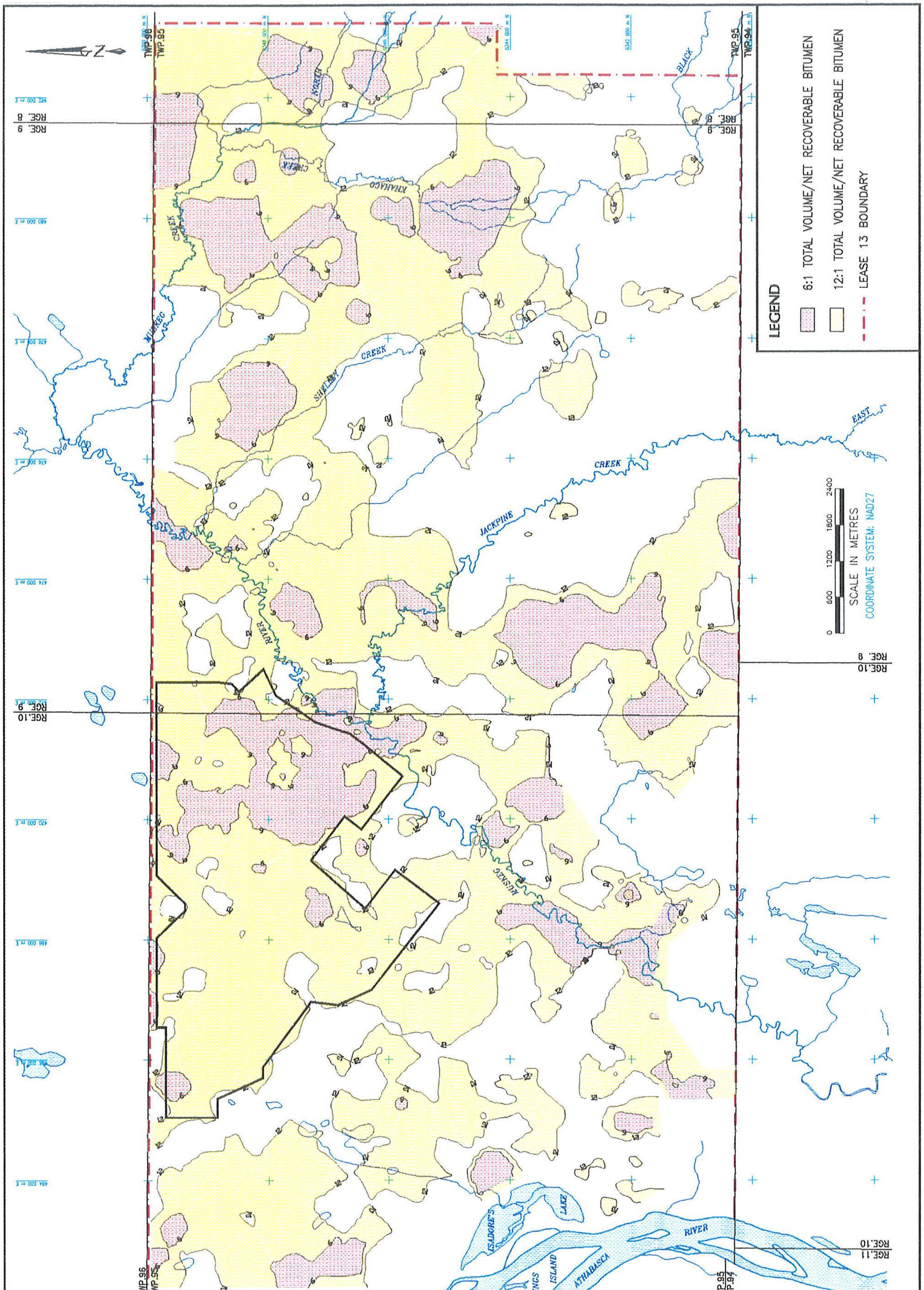


Figure 3-8: Total Volume to Net Recoverable Bitumen (TV/NRB)

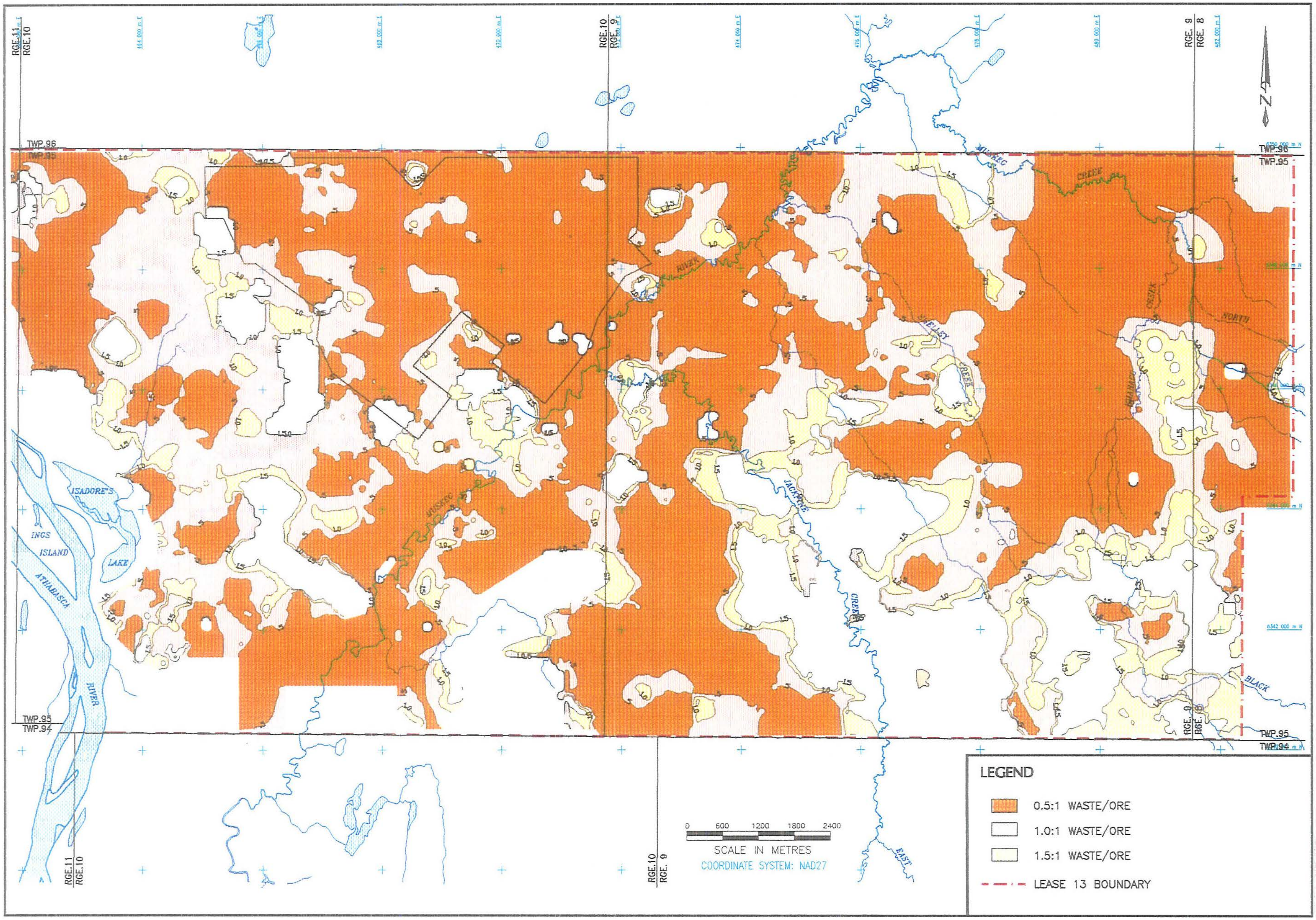


Figure 3-9: Waste to Ore (7% Cut-Off)

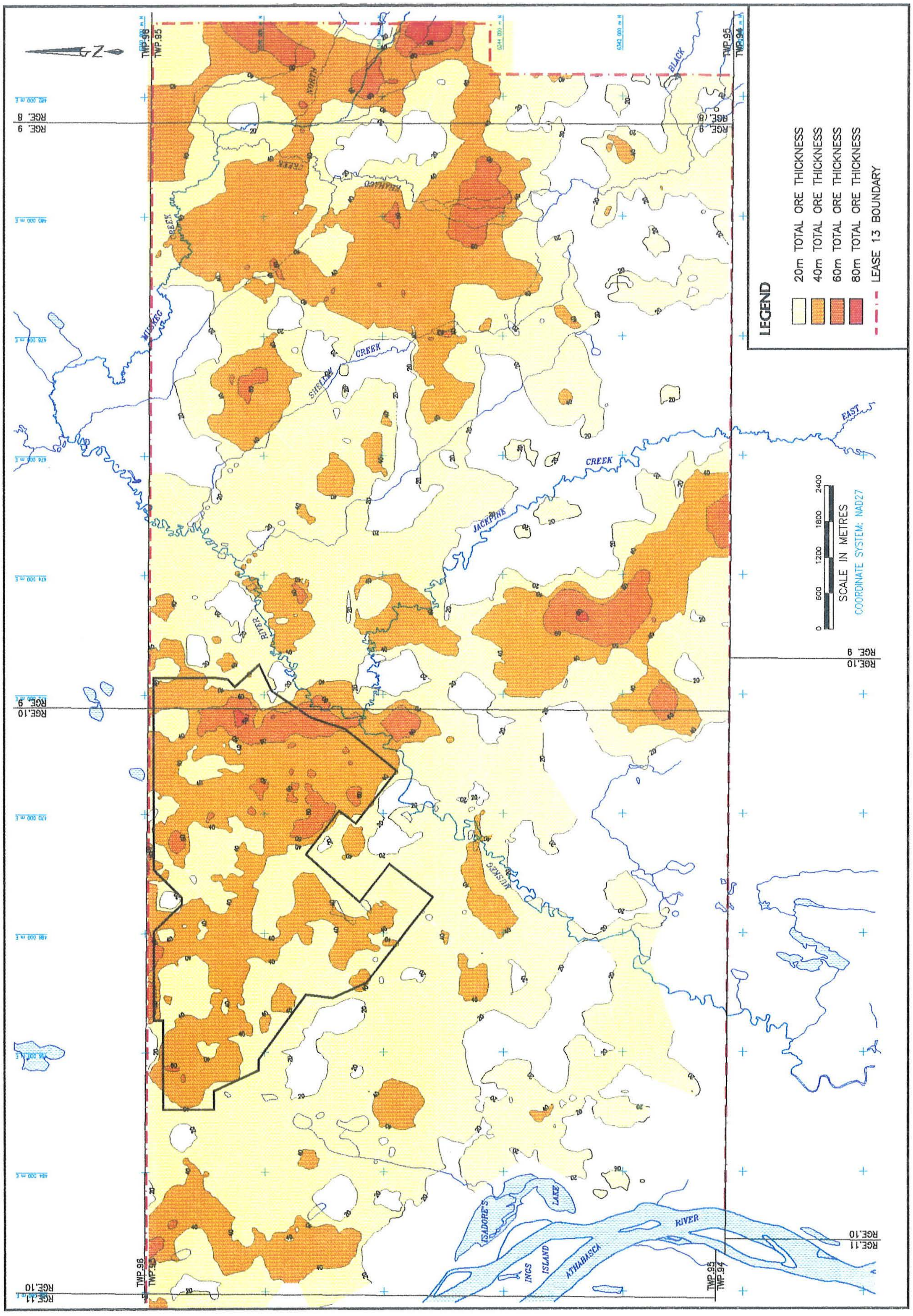


Figure 3-10: Total Ore Thickness (7% Cut-Off)

MINING METHOD SELECTION

Over the past several years, oil sands mining methods have undergone major changes. Previously, bucketwheels, or a combination of draglines and bucketwheels, were considered the most economical method of mining oil sands. Suncor and Syncrude have reviewed their mining systems and have converted to truck-and-shovel mining, using large trucks and shovels as a more efficient mining method.

The early scoping study for Shell's Muskeg River Mine Project included a review of the current and past practices at the two operating oil sands projects, and the proposed Steepbank (Suncor) and Aurora (Syncrude) projects. The new operations being developed at both Aurora and Steepbank will be based entirely on truck-and-shovel mining.

Truck-and-shovel mining offers significant advantages over dragline and bucketwheel operations, including:

- providing higher productivity
- offering better equipment availability
- providing operational flexibility, such as:
  - enabling interchange between ore and overburden removal
  - being responsive to complex geological conditions
  - providing the ability to blend ore for constant feed grade
- reducing risk, as it is known technology
- providing consistent and reliable ore feed to extraction plant
- minimizing oil sands losses through selective mining opportunities
- enabling mining, extraction and tailings operations to be better coordinated and integrated with progressive reclamation

Because of the success of these truck-and-shovel operations under similar conditions expected at Lease 13, together with the worldwide experience of Shell and BHP, this method has been selected for the Muskeg River Mine operation.

MINING OPERATION

The Lease 13 topography is relatively flat, with surface elevations across the mining area varying by only 10 m to 15 m. The Muskeg River flows from the northeast, past the eastern edge of the mining operation and the proposed tailings settling pond location.

No significant topographical features impact on the mine plan (see Figure 4-1).

The mine plan for Lease 13 assumes that conventional wet tailings from the extraction plant will be transported by pipeline initially to a tailings settling pond, then as consolidated tailings to dyked-off areas in the mining pit. The key features of the mine plan are:

- orderly resource development
- minimal truck haulage
- early in-pit disposal of tailings
- logical development of tailing containment cells within the mined-out area
- allowance for long-term stable reclamation

The mine plan also provides a consistent ore grade to the extraction plant, particularly in the early years, to stabilize the operation and to provide a foundation for process optimization.

MINING RESERVES

The resource on the west side of Lease 13 has the potential to support a mining life of between 30 and 40 years. The Muskeg River Mine has been designed to use the well-defined orebody with the highest geological confidence. The layout provides the opportunity for expanding the mine as further geological data is collected.

The selected mining area is divided into mining blocks. Within each mining area, quantities of the following are calculated for each mining bench:

- oil sands
- overburden
- centre rejects

The grade of oil sands is also calculated. For the parameters used to estimate oil sands reserves, see Section 4.3.

Mineable reserves were calculated bench by bench in mining cuts that reflect the proposed truck-and-shovel operating method. Each mining bench is about 1,000 m long, and 115 m deep (direction of advance) and 15 m high.

MINING RESERVES (cont'd)

The mineable oil sands reserves, overburden and centre reject quantities are shown in the mine production schedule in Table 4-1. Quantities are further divided into smaller cuts and ore zones for mine scheduling.

The mining areas contain a total of 1.8 billion tonnes of recoverable oil sands at an average grade of 11.4% with a final mining stripping ratio of 0.31 bcm per tonne. The selected mining area will support an extraction plant producing 8.7 million m^3 (54.75 million bbl) of bitumen per calendar year for over 20 years.

Table 4-1: Mining Reserves and Production Schedule

	Bitumen Production					
Year	Mbcm	(Mbbl)	Oil sands Production (Mt)	Overburden (Mbcm)	Centre Rejects (Mbcm)	Average Ore Grade (%)
1999-2002*	4.35	27.38	44.56	4.30	7.49	11.3%
2003-2005	26.10	164.25	263.71	6.44	37.04	11.5%
2006-2010	43.50	273.75	447.46	10.70	84.79	11.3%
2011-2020	87.10	547.50	887.33	37.10	325.39	11.4%
2021-2022	17.01	107.04	165.28	5.72	48.52	11.9%
Total	178.10	1,119.92	1,808.34	64.25	503.23	11.4%
*Note: Volumes in 1999 to 2002 exclude the crusher excavation volumes.						

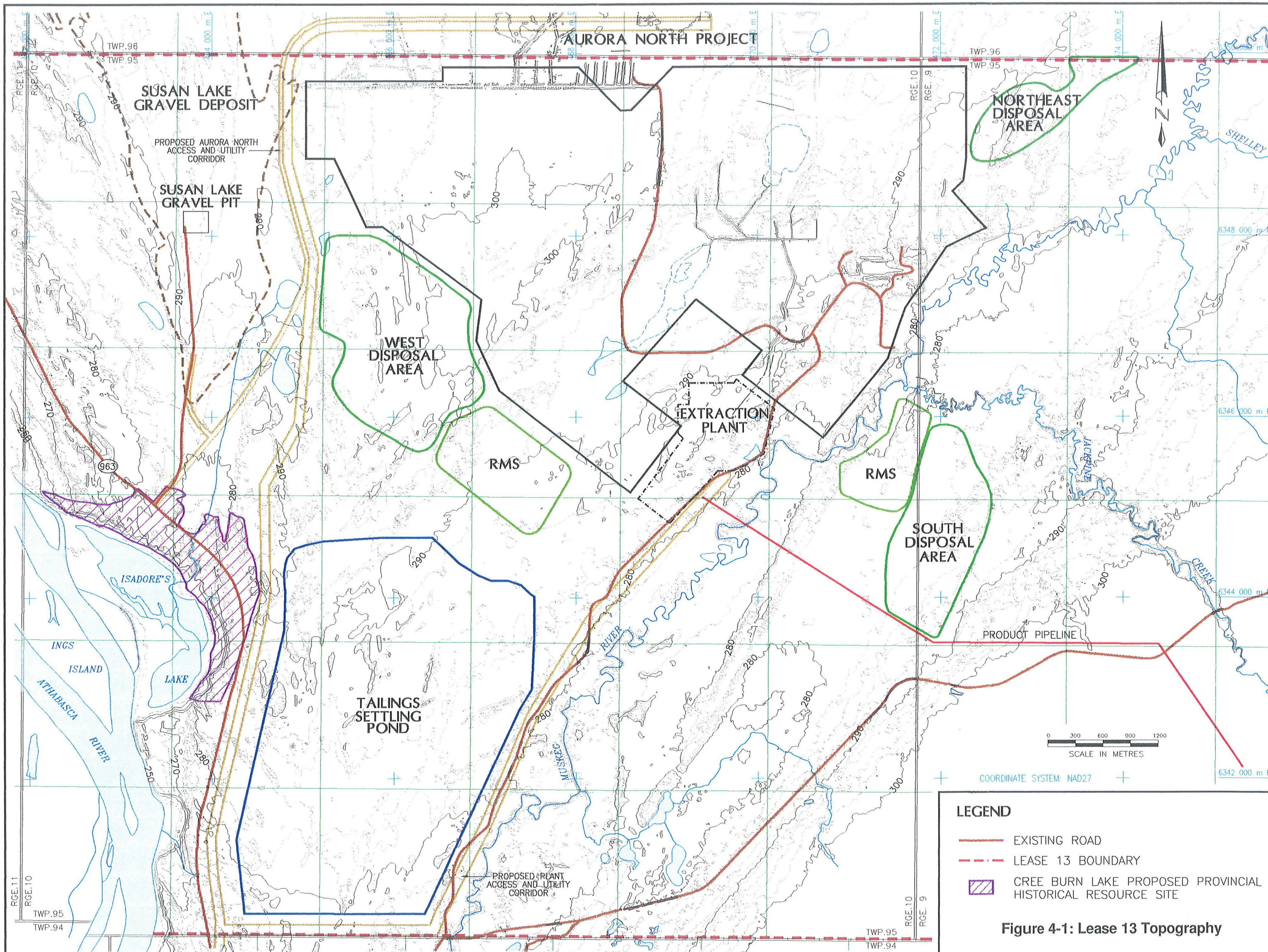


Figure 4-1: Lease 13 Topography

MINE PLAN LAYOUT

OBJECTIVES

The overall mining objective is to provide the lowest cost mine plan that meets the needs of mining, bitumen extraction and tailings management and allows logical progression into areas showing potential for economic reserves. These areas, which remain unaffected by the proposed mine plan, will be further defined with future exploration.

The extraction plant will operate efficiently if the throughput and feed grade is consistent. Therefore, a primary objective is to minimize grade variation. Mining operations will be carried out to facilitate blending high-and-low-grade ores.

The principal objectives of the mine plan are to:

- minimize ore sterilization
- provide reliable oil sands feed at consistent grade
- minimize the tailings settling pond area
- focus on in-pit tailings management
- delay high stripping ratio areas to support initial commercial viability
- provide an acceptable mine closure plan

In order to achieve these objectives at the lowest cost, a key mining strategy is to minimize haul distances. By developing the mine radially from the crusher pocket, oil sands haul distances will be kept as short as possible. The overburden and centre reject disposal areas will be strategically located in barren zones to the south, northeast and west of the main pit area.

MINING SEQUENCE

A screening analysis of three conceptual mining sequences was performed to optimize the balance of overburden stripping, oil sands mining, feed grade and tailings disposal to assist with the selection process for the key infrastructure options. Sequence 1 provides the best economic scenario, regardless of plant site location or tailings area. This is mainly because of the high grade, low stripping ratio and the short haul distances to the crusher.

The final detailed sequence was optimized from many iterations of mining, extraction and tailings disposal analyses before the final mining sequence was chosen.

INFRASTRUCTURE LOCATIONS

The options for siting key infrastructure were primarily determined from the analysis of economic pit limits. The analysis provided the preliminary alternatives for locating the plant site, the opening cut and crusher, tailings settling pond, access and utilities corridor and disposal areas. The primary objective was to locate facilities on resource areas of low economic potential, to minimize the potential for resource sterilization.

The plant site and tailings settling pond locations were evaluated using typical cost estimates based on differences, to determine the best economic option. The final selection is a balanced view of:

- cost
- resource conservation
- environmental impacts
- future development potential
- geotechnical considerations

An overview of the production sequences, plant site options and tailings location options are shown in Figure 4-2.

The access and utilities corridor selection process is described in Offsites (see Section 7.5).

Plant Site Location

Two potential plant sites were evaluated:

- Plant Site 1 on the south central side of the pit
- Plant Site 2 on the west side of the pit near the west storage disposal area

These sites are located on areas of low economic potential, and are reasonably close to the main orebody.

An economic analysis, including the net present cost of hauling ore, tailings pipelines, and developing the access corridor, established the economic benefits of each option. The key factors considered in the assessment included:

- incremental net present cost
- environmental impact
- geology and potential geotechnical impact
- access
- future developments

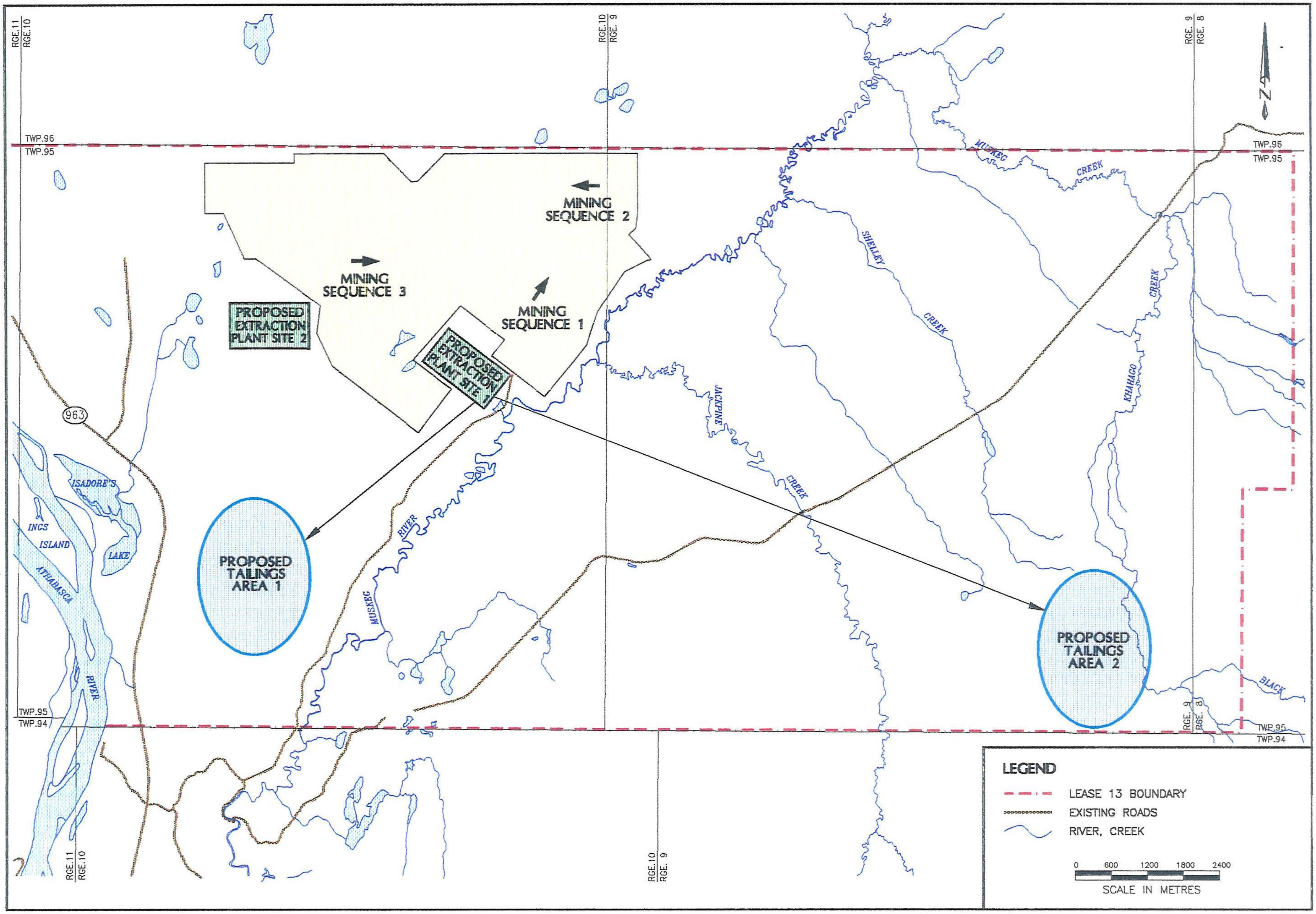


Figure 4-2: Infrastructure Options

Plant Site Location (cont'd)

Plant Site 1 was selected primarily because it:

- offered significant savings on ore transportation costs
- is located adjacent to low ratio oil sands reserves
- enables the crusher to be located within 5 km of most of the oil sands ore
- has no significant environmental implications
- has more potential for better geotechnically competent subsurface geology
- is closer to most of the Lease 13 reserves, which is better for potential expansion to the east

Both sites are environmentally acceptable, but Site 2 is marginally preferable from an environmental perspective, based solely on its distance from the Muskeg River Valley.

Table 4-2 summarizes the key plant site impacts.

Table 4-2: Plant Site Impacts

	Plant Site 1 South Central	Plant Site 2 West Side
Ore Sterilization	Low	Low
Cost:		
• Site preparation	Low	Low
• Tailings pumping	Low	Low
• General mining	Low	High
• Access corridor	Medium	Low
Geotechnical:		
• Surficial geology	Low	Medium
• Topography	Low	Low
Expansion potential to the east	High	Low

Tailings Location

Two potential locations for external tailings storage were evaluated:

- Tailings 1 on the southwest portion of Lease 13
- Tailings 2 on the southeast portion of Lease 13

A tailings storage location on the western side of Lease 30 was rejected because of the impact of ore sterilization and the distance from the plant site.

The analysis of the alternative tailings pond locations included:

Tailings Location (cont'd)

- incremental tailings pumping and pipelining capital and operating costs
- road construction and site preparation costs
- incremental haulage costs for starter dyke construction
- ore sterilization
- environmental implications

The results showed positive economic benefits for establishing the tailings pond as close to the plant site as possible. Tailings Area 1 has an economic advantage over $800 million (on a net present value basis) over Tailings Area 2. Without Tailings Area 1 as the proposed location, the economics of the Muskeg River Mine would be significantly eroded, to the extent that the project could not proceed if tailings had to be pumped to any of the more distant locations.

Minor quantities of potentially economic ore will be covered by the tailings settling pond. The ore is mainly shallow, low grade tidal channel ore. Significant fluvial channel ore is absent in this area because of:

- increasing basal aquifer thickness under the tailings settling pond
- thinning of the fluvial channel sands under the Muskeg River as a result of a Devonian high

Additional drilling has been planned for the 1998 winter program to provide further geological definition of the area.

Shell will continue to improve its geological understanding of the area, and update resource estimates as the project develops. As detailed planning of mining and tailings handling continues, a high priority will be given to minimizing:

- the tailings settling pond area
- the amount of ore sterilized through further optimization and detailing of mine plans and tailings management

Table 4-3 summarizes the key tailings settling pond impacts.

Opening Cut and Crusher Location

The crusher site was selected because of its close proximity to the extraction plant site, and because it does not sterilize any significant amount of economic ore. The lack of economic ore mainly results from the thick centre reject material and the absence of any significant fluvial channel sands.

The crusher site is also located relatively close to the main orebody, and central to most of the Lease 13 West ore, providing short hauls for trucks.

Opening Cut and Crusher Location (cont'd)

Other factors considered in selecting the opening cut were:

- low fines ore during the early years
- consistent feed grade to the extraction plant
- reduced tailings settling pond and water requirements
- reduced external storage of overburden and centre reject material
- ability to begin early reclamation

Overburden and Muskeg Storage Areas

Mine planning indicates that out-of-pit disposal of about 137 million m^3 of overburden and centre reject material will be required. Three potential areas have been identified to minimize the:

- haulage distance
- amount of ore sterilized

The three areas that meet this criteria are:

- west disposal area
- northeast disposal area
- south disposal area

The final slopes of the disposal areas will include microtopographic features consistent with requirements of the final reclamation strategies. Whenever possible, areas of natural vegetation will be left undisturbed between areas of development.

Table 4-3: Tailings Settling Pond Impacts

	Tailings Area 1 SW-L13	Tailings Area 2 SE-L13
Ore Sterilization	Medium/Low	Low
Cost:		
• Site preparation	Low	High
• Tailings pumping	Low	High
• General operation	Low	High
• Reclamation and closure	Low	High
Geotechnical:		
• Surficial geology	Low	Medium
• Topography	Low	Low
Environmental:		
• Level of clearing required for access roads	Low	High
• Elimination of minor creeks and streams	Low	High
• Degree of visual impact from Highway 963	High	Low

Overburden and Muskeg Storage Areas (cont'd)

Two major reclamation material storage areas will be established to temporarily store material for future reclamation. Muskeg will be stored in the two storage areas, providing a ready supply of material for progressive reclamation. To ensure the geotechnical stability of the muskeg storage areas, they will be developed within structural shells, constructed of suitable overburden material.

Muskeg River Crossing

The south disposal area is required for about 53 million m^3 of overburden and centre reject material. A river crossing is proposed to enable overburden, centre reject material and muskeg to be hauled across the Muskeg River to the south disposal area.

The siting of the crossing was based on surveyed cross-sections and incorporated the following criteria:

- river bank profile
- mine haul road layout
- main site access

Preliminary investigations indicate that a multi-plate, large diameter, culvert type of structure is preferable. Installing the crossing will involve temporarily disturbing the river. This will be done in winter, to minimize the disturbance to the river during construction.

Detailed engineering, environmental assessment and mitigation planning will be completed in late 1999 before installation early in 2000.

ECONOMIC PIT LIMITS

Reserve Evaluation

Reserve blocks from the geological model were evaluated using typical mining and extraction costs, to provide a general plan of potential economic ore. The full cost of bitumen production from each block was determined laterally and vertically, to allow pit limits to be selected and to identify an economic pit floor. In most cases, the pit floor coincided with the bottom of the lowest major oil sands horizon.

The reserves building process also includes checks for data integrity and for developing an optimized pit floor. Floor optimization ensures that no uneconomic ore (below an economic horizon) is included in the reserves.

Mining criteria were applied to establish a minimum mining block 3 m thick with an average minimum bitumen grade of 7%.

Factors Affecting Economic Pit Limits

Determining economic ore reserves within the oil sands industry is a continually evolving process. A grassroots operation like the Muskeg River Mine has to support the full cost of development, including the base facilities and associated infrastructure. The commercial risk profile is higher for a grassroots development than it is for an expansion of an existing operation.

The industry and government agencies have used some empirical relationships for high-level determination of economic reserves. The two most commonly used are:

- a cut-off waste-to-ore strip ratio of about 1:1 (bcm:bcm)
- a TV:BIP ratio of 12:1 (bcm:m^3) where:
  - TV = total volume of ore and waste mined (bcm)
  - BIP = bitumen in place (m^3)

The TV/BIP ratio is more useful than the stripping ratio, as it allows for grade variation and all volumes of material that need to be mined to obtain bitumen.

A further refinement is TV/NRB (total volume to net recovered bitumen). This introduces the recovery performance of the extraction plant into the estimation of bitumen production potential.

Determining an economic pit limit depends on production costs and the value of the commodity produced. The economic cut-off is the point at which the total costs exceed the value of the product. Full costs for producing bitumen were used to establish an economic limit to help establish the final pit outline. This limit represents the minimum value required for a cubic metre of bitumen, to support the mining and extraction costs. The costs for waste mining, ore mining, extraction, overheads and reclamation were determined from the combined experience of Shell's mining team for this type of project.

The cost estimates were established from the economic analysis through the mine planning process. The comparative commodity price balanced against these costs is Shell's proprietary market forecast price.

Final Economic Pit Limits

The final economic pit limit was determined from evaluations, using the following criteria:

- cut-off stripping ratio of 1:1 (bcm:bcm)
- TV/BIP of 12 (bcm:bcm)
- economic criteria and average mining costs
- other factors, such as:
  - geologic confidence
  - average ore grade

Final Economic Pit Limits (cont'd)

- infrastructure locations
- environmental impacts

The final pit limit is shown in Figure 4-3.

The planned pit limit is also constrained by offsets to the lease boundary to the north and the Muskeg River to the east. The Muskeg River Mine has been designed to release ore independent of the Syncrude Aurora operation to the north. Cooperation with Syncrude has been initiated to ensure that all economic ore at the boundary is extracted. Both Shell and Syncrude are committed to effective joint planning at the lease boundary to capture resources. This is formalized through a joint cooperation agreement.

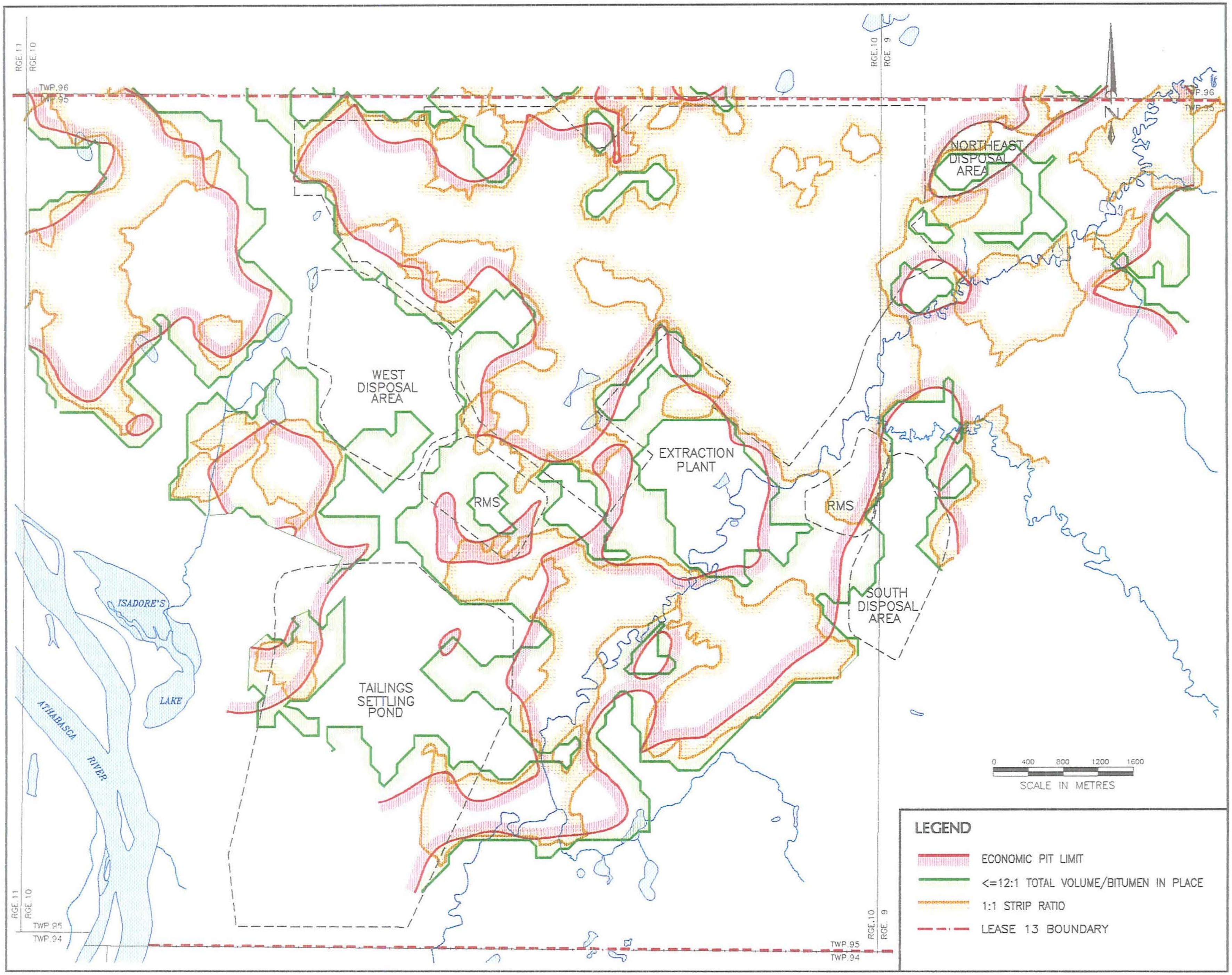


Figure 4-3: Factors Affecting Economic Limits

MUSKEG RIVER OFFSET

The factors affecting economic limits show potential for mineable ore beneath the Muskeg River. Shell recognizes the environmental impact of mining disturbance through the Muskeg River area, and the mine plan for this application excludes this ore from the mining reserves. For environmental reasons, and to recognize guidelines in the *Fort McMurray - Athabasca Oil Sands Subregional Integrated Resource Plan,* 100 m of undisturbed ground offset from the river is proposed (see Section 4-3).

The integrity and overall economics of the ore under the river are not compromised by the proposed Muskeg River Mine, so the ore associated with this area can remain as a potential viable resource for the future.

Options Evaluated for Developing Ore Beneath Muskeg River

To ensure that the viability of the ore beneath the Muskeg River is not affected by Shell's decision to avoid this area, the potential for development was reviewed. Factors considered included:

- economics
- ore sterilization
- environmental disturbance
- impact on external tailings

The options investigated included:

- relocating the river before mining
- relocating the river through mined-out pits on the east or west of the current position
- relocating the river through mine closure systems

These investigations show that there is no significant economic reason for Shell to include these reserves in the proposed mine plan. The main reasons for this include:

- near term environmental disturbance
- significant project schedule and commercial risks because of delayed environmental assessment for the initial Muskeg River Mine development proposal
- additional pre-project capital for river relocation
- increased area for the tailings settling pond if provision is made for re-locating the river through the Muskeg River Mine on engineered fill

Flood Limit Offsets

The flood limits of the Muskeg River and Jackpine Creek have been assessed for 10-year and 100-year maximum flow conditions. The offset of the pit and storage areas is sufficient to prevent any significant inflow or erosion. Between 1 and 2 m of levee structure will be constructed as a safety berm and perimeter road.

MINE PLANNING CRITERIA

SCOPE

The project and mining criteria in Table 4-4 were used to develop the mining plan. The criteria are based on the current operating conditions at the existing oil sands mines, and are consistent with recent proposed oil sands projects. As the project develops, further detailed mine planning and engineering might result in minor changes to these criteria.

Pit electrical distribution is by overhead lines to mobile substations and by trailing cables.

The final profile of the disposal areas will consider geotechnical and environmental requirements. A typical disposal cross-section is shown in Figure 4-4.

Figure 4-5 shows a mining cross-section. Figure 4-6 shows highwall design detail.

GEOTECHNICAL ANALYSIS

Objective

A review of the geotechnical conditions that affect the disposal areas and pit walls of the proposed Muskeg River Mine was undertaken, to identify key geotechnical issues that would be addressed during mine plan development.

No new data was obtained from the field or laboratory for this analysis. Previous geotechnical work on Lease 13 was carried out by Shell as part of the Alsands project in the late 1970s and early 1980s. This established overall guidelines for designing pit walls and overburden disposal areas for dragline and bucketwheel operations. Much of this data and analysis is applicable to truck-and-shovel mining. In addition, Syncrude and Suncor's operating mines have provided useful operating information that has been used to supplement the geotechnical assessment of Lease 13.

Geotechnical Conditions

The geotechnical stability of the pit walls and disposal areas relies on the understanding of the key subsurface geologic features. Table 4-5 shows the generalized stratigraphy of Lease 13. The Clearwater Formation (which requires specific attention, because of its weak geotechnical strength) has been largely eroded, and occurrences are limited to isolated erosional outliers.

Table 4-4: Mine Planning Criteria

Parameters	Criteria
Project:	
General Operation:	
• Commissioning	January - June 2002
• Full production	July 1, 2002
• Mine life	Over 20 years
• Mine operation	365 days per year, 24 hours per day
Extraction Plant Operation:	
• Bitumen production	23,850 m^3/d (150,000 bbl/d) or 8.70 Mm^3/a (54.75 Mbbl/yr)
• Coarse rejects	2% (by weight)
• Average feed grade	11.4%
• Average mine production	12,100 t/h (stream day basis)
Mining:	
Material In Situ Density:	
• Muskeg	1.00 t/bcm
• Overburden	2.11 t/bcm
• Oil sands	2.08 t/bcm
Material Swell:	
• Muskeg (placed)	30%
• Overburden	20%
• Oil sands	20%
Material Final Slopes:	
• Muskeg storage areas	3:1 (18°)
• Waste storage areas	3:1 (18°)
• Oil sands storage area	1.9:1 (28°)
Open Pit Wall Design Parameters:	
• Maximum bench height	15 m
• Safety Berm:	
• at oil sands and overburden interface	10 m
• at every bench in oil sands	10 m
Electrical Distribution:	
• Primary voltage to mine site	144 kV
• Pit distribution voltage	25 kV
• Shovel voltage	6.9 kV
• Small loads	480 V
• Mine drainage	25 kV/6.9 kV/480 V

Geotechnical Conditions (cont'd)

Slope geometry and stratigraphy at various locations around the pit and through the overburden and centre reject storage can be summarized as follows:

- the depth of Holocene and Pleistocene surficial material is rarely greater than 10 m
- the Clearwater Formation is generally absent. Only isolated occurrences are present within the mine development area.
- the centre reject zone consists predominantly of tidal lagoonal muds, although other material is present in minor layers
- the regional dip is generally less than 5°, although the dip of the strata within Lease 13 varies locally

Table 4-5: Geotechnical Conditions

Geologic Unit	Sedimentary Facies	Lithology	Typical Thickness (m)
Holocene	Muskeg	Organic soil	1 - 3
	Eolian, fluvial and lacustrine	Sands and gravels, silts and clays	1 - 3
Pleistocene	Fluvial	Sands and gravels	2 - 4
	Lacustrine	Clays and silty clays	1 - 3
	Fluvial	Glacial till	Variable up to 6
Clearwater Formation	Marine	Clay shale	Few occurrences up to 9
McMurray Formation	Marine	Sands and clays	Variable 5-7
	Estuarine	Sands, silts, muds, rich and lean oil sands	15-25
	Lagoon	Clay and silty clay	5-10
	Fluvial	Sands, silts, muds, rich and lean oil sands	15-25
Devonian	Paleosol	Residual soil, high clay content	Highly variable up to 1.5
	Bedrock	Carbonate rock	

Evaluation of Failure Mechanisms

The geotechnical analysis considered the potential failure mechanisms that might be present in an oil sands mining operation. These include:

- slumping of saturated glacial materials

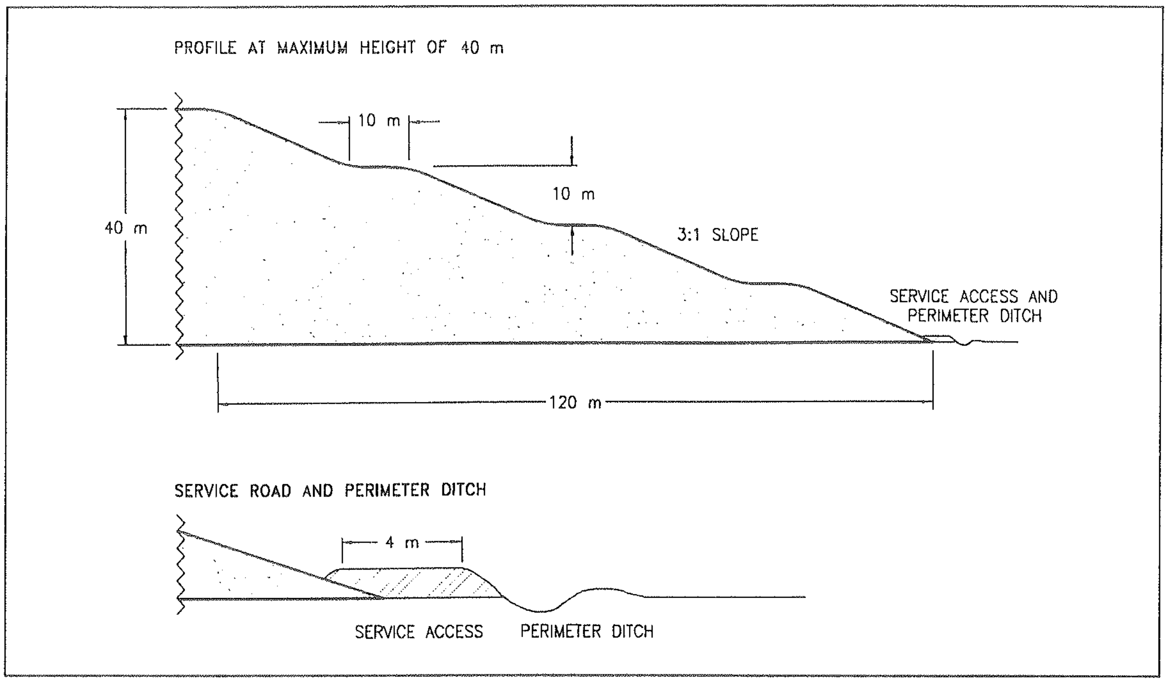


Figure 4-4: Typical Disposal Cross-Section

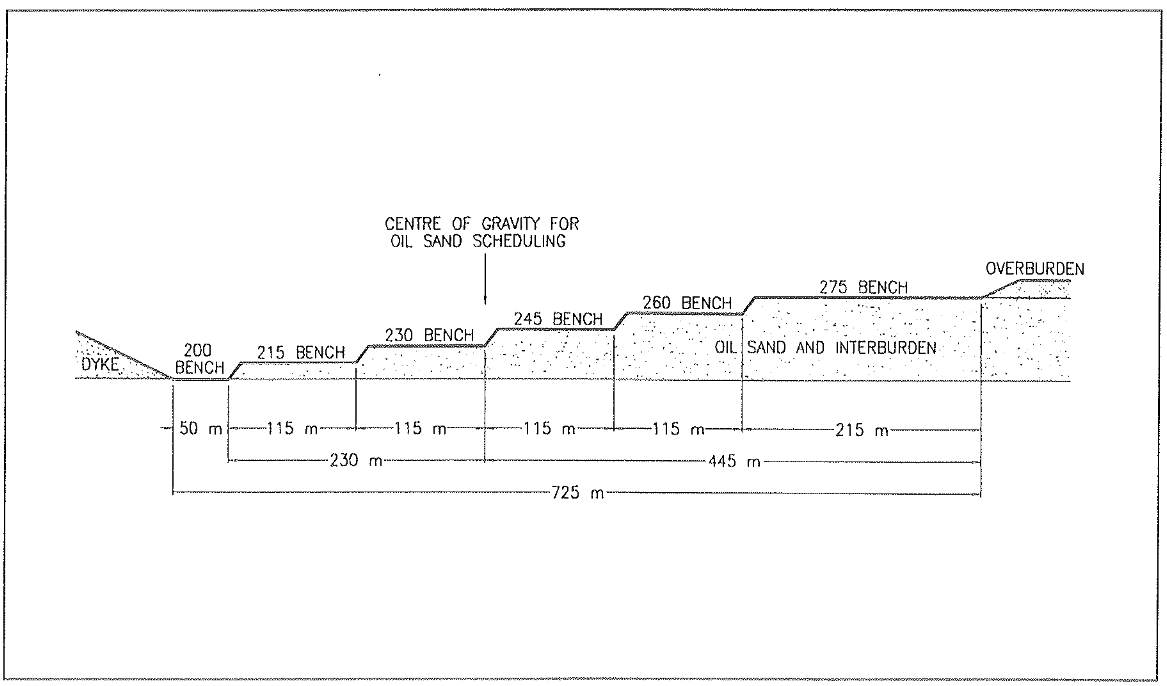


Figure 4-5: Typical Mining Cross-Section

Evaluation of Failure Mechanisms (cont'd)

- sliding on weak layers at residual strength, including:
  - sliding on marine clay layers
  - sliding on clay layers within the oil sands
  - sliding on Paleosol clays
- flows in rich oil sands ore
- rapid loading of weak surficial materials
  - rapid loading of lacustrine clays and silts
  - overburden and centre reject storage over muskeg
- slope instability of the external storage areas

The failure modes and control strategies are shown in Table 4-6. The experience of existing oil sands operators was used in identifying the control strategies for these types of failures.

A general summary of the major dip orientations is shown in Figure 4-7. Future exploration programs will provide additional data on the dip of key structures to assist with ongoing detailed geotechnical analysis.

Geotechnical Conclusions

The review shows no major instabilities that could threaten the overall integrity of the current mine plans for highwall, overburden and centre reject storage layouts. A review of failure mechanisms shows that the most important stability issue is the delineation and evaluation of weak layers in the mining sequence.

As detailed mine planning proceeds, further important stability issues will be addressed with detailed geotechnical assessment of the:

- highwall slopes in the plant site area — to establish appropriate setbacks for plant site structures and ore storage area
- external storage areas —to focus on distribution and geotechnical properties of marine clay layers
- final highwalls — to determine where dyke abutments are to be located
- mine opening — to focus on highwall blockslides and monitoring

Table 4-6: Failure Modes and Control Methods

Failure Mode	Higher Risk Areas	Effects	Control Strategy
Highwalls:			
Sliding on marine clays	Areas beneath some storage areas	Large slides	Establish setbacks Re-slope upper highwalls in high-risk areas
Blockslides in low plastic clays	Areas containing clay layers dipping out of the highwall at greater than 10°	Large slides	Develop monitoring and remedial action plan Establish setback in high-risk areas
Blockslides in high plastic clays (salt marsh clays)	Plant site area	Large slides up to 100 m wide	Develop monitoring and remedial action Establish setbacks and remedial action plan in high-risk areas Investigate and design required for plant site area
Rich ore flows	Areas containing bitumen content over 13%	Activation of blockslides. Bench scale slumping to 2:1	Control excavation rate in high-risk areas
Surficial slumping	Poorly drained areas	Slumping highwall crest areas to 4:1	Clean, as required Maintain setbacks of major roads and other long-term infrastructure at 40 m from slope toe
Storage areas:			
Dumping over muskeg	Local areas beneath some storage areas	Difficult to establish stable dumping platforms	Drainage before storage area construction Pre-consolidation of thick muskeg areas
Slumping of overburden storage area slopes	Areas containing large quantities of snow	Difficult to establish stable storage stockpiling platforms	Clean snow in critical areas Trim, as required, for reclamation
Slumping of muskeg storage area slopes	Saturated muskeg and other surficial materials	Containment within the pond area might be difficult to achieve	Construct structural shells
Failure of reclamation capping material	Poorly drained storage area slopes	Vegetation difficult to establish	Ensure adequate drainage on storage area surfaces Ensure adequate compaction of capping material

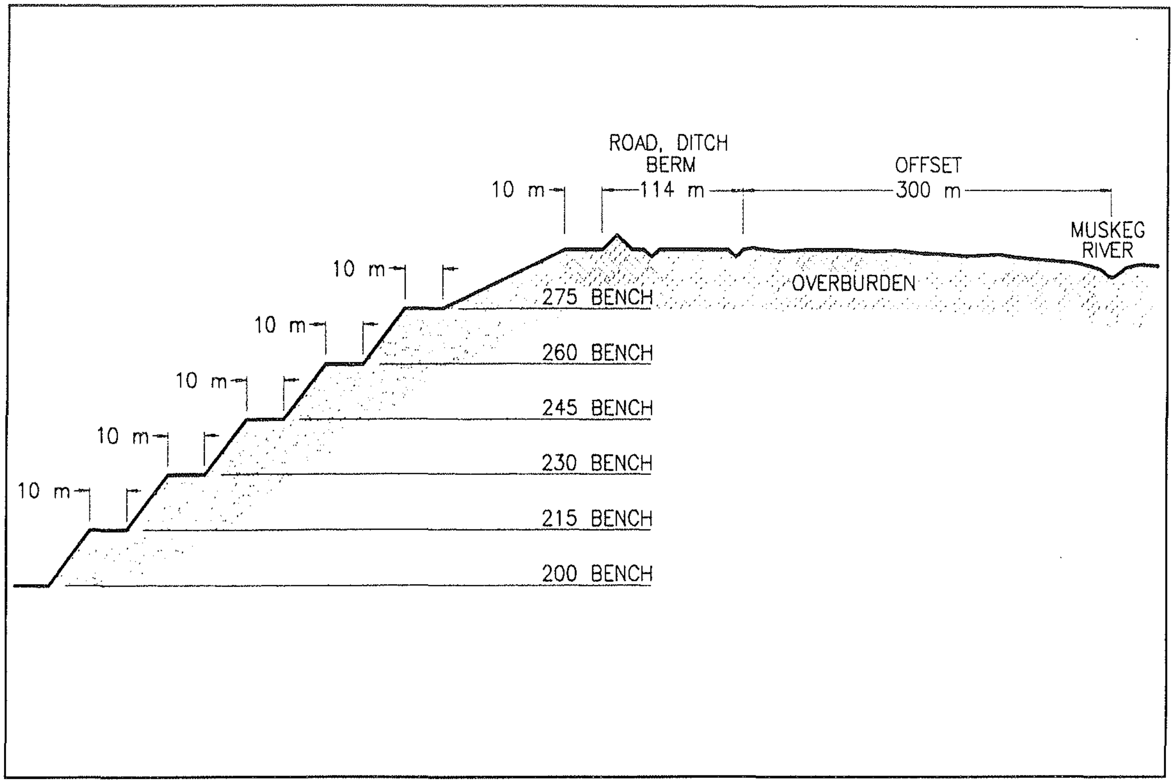


Figure 4-6: Highwall Design Detail

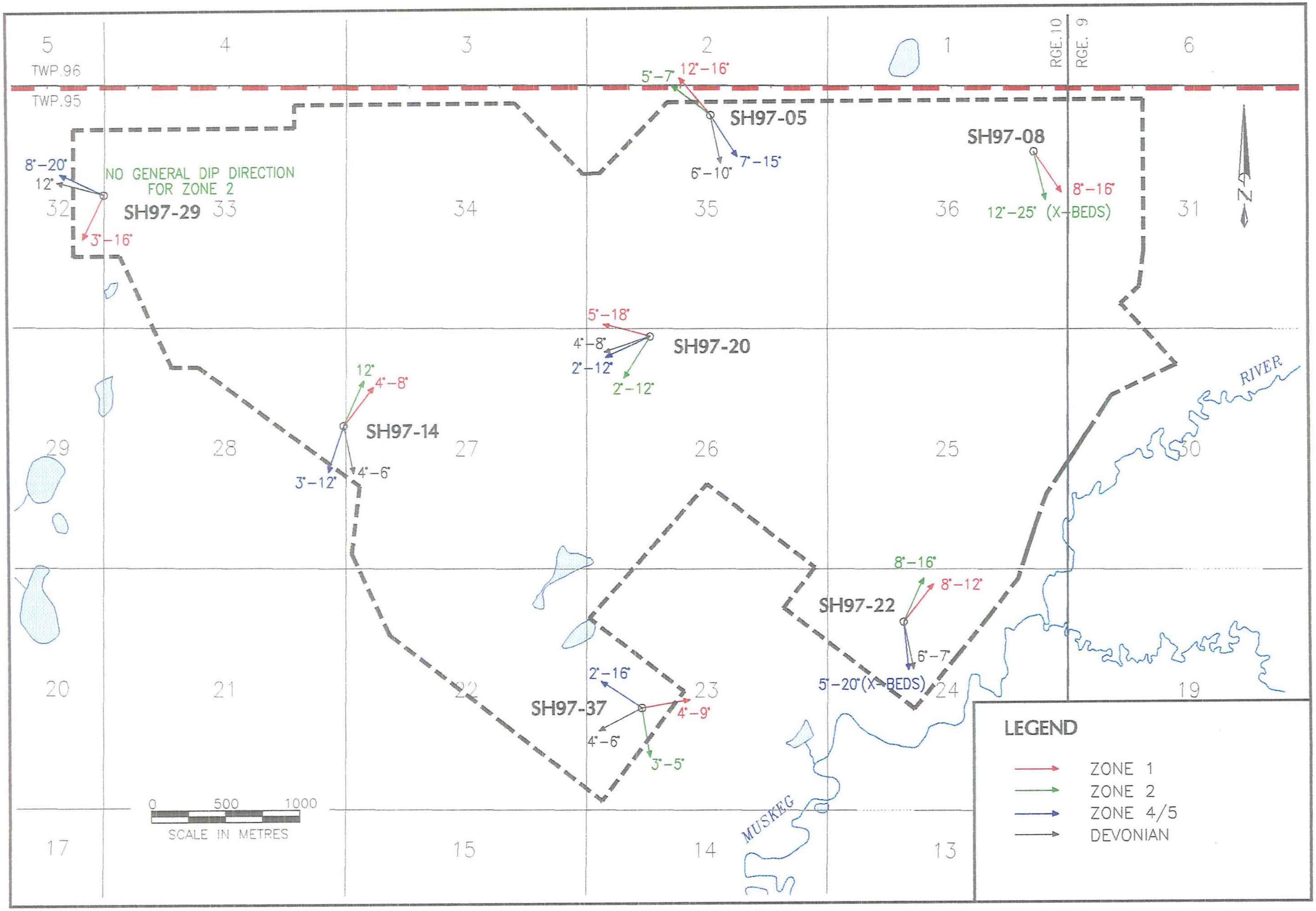


Figure 4-7: Summary of Major Dip Orientations

MINING METHOD

Preparation

Preparation of the site will begin in early 1999 to provide sufficient time for clearing and drainage. Before mining begins, the land surface will be cleared and grubbed, two to five years ahead of the mining faces. This preparation will enable drainage ditches to be constructed before mining activity. Perimeter wells will be installed to depressurize the basal aquifer.

After an area has been cleared and drained, the muskeg will be removed. Sufficient muskeg will be stored for future reclamation. If an area is ready to be reclaimed, the muskeg will be hauled directly to the site to avoid stockpiling.

The overburden, centre rejects and oil sands will be loaded using large cable shovels and hydraulic shovels where selectivity is required. The loaded oil sands will be hauled by large rear dump trucks to the crushers, where the lump size will be reduced to less than 400 mm. The oil sands will then be transported on conveyor belts out of the pit to the extraction plant. The overburden and centre reject material will be hauled to either the disposal areas or back into the pit.

Disposal Areas

Overburden and centre reject disposal areas will be constructed in lifts to achieve 3:1 final slopes. Lift thickness, typically 10 m, will depend on the strength of the material being placed as well as the efficient control of surface drainage. To ensure stability, they will be closely monitored during construction and redesigned, if necessary.

In accordance with mine planning objectives, including minimizing ore sterilization, the use of the northeast disposal area will be delayed until 2007. This will allow sufficient time to complete geological and economic assessment of the ore in the area.

Dyke Construction

The construction of tailings dykes with overburden and centre reject material will require on-site engineering and supervision control. Dyke construction will include truck haulage, placing fill material by bulldozers and graders, and compaction.

Blasting During Winter Conditions

During the winter, oil sands will freeze, causing reduced productivity and increased wear on shovels and crushers. Frozen oil sands will be drilled and blasted during the winter to improve the efficiency of mine operations. Drilling and blasting will be performed by qualified contractors. Exposives will be transported, stored, used and disposed of, in accordance with appropriate provincial and federal regulations.

INITIAL OPENING

The initial opening is adjacent to and northwest of the extraction plant. The truck dumping elevation will be 260 m, and the base of the crusher site 245 m (about 45 m below the surface). The conveyors will be 625 m long and set on a 12% ramp, which will be excavated as part of the prestripping operations for the initial opening.

PRESTRIPPING

Prestripping activities will begin as soon as the initial mine area has been cleared, drained and muskeg has been removed. This early start results from the need to provide material for constructing the tailings settling pond starter dyke to be used in preloading muskeg materials. The material for this will come from the crusher excavation and from overburden obtained from the first mining block.

About 12.3 million m^3 of material will be required to construct the starter dyke. This will use all the crusher excavation material and much of the prestrip material required to develop working faces in the first mining block. Any surplus material will be sent to the south disposal area.

Excavation of the crusher station will release 1.712 million tonnes of oil sands that will be placed on a temporary storage area and used for extraction plant commissioning. The plant is scheduled to begin commissioning in January 2002 and begin full production operations by July 1, 2002. During the rest of the year, a further 44.6 million tonnes of oil sands will be mined.

Sufficient muskeg will be removed and stored for reclamation. Wherever possible, muskeg removal will be planned so that it can be placed directly onto areas for reclamation, to minimize stockpiling.

CONTINUING OPERATIONS

Annual Production Volume

The mine will produce sufficient ore to yield 8.70 million m^3 (54.75 million bbl) of bitumen product for over 20 years (see Table 4-7).

Table 4-7: Mine Production Schedule

Year	Waste		Oil Sands	Recoverable Bitumen		Bitumen Grade
	Overburden (Mbcm)	Interburden and Centre Reject Mbcm	(Mt)	Mm^3	(Mbbl)	%
2002	4.30	7.49	44.56	4.35	27.38	11.3
2003	3.33	13.71	89.13	8.70	54.75	11.0
2004	1.30	11.67	87.07	8.70	54.75	11.6
2005	1.80	11.67	87.50	8.70	54.75	11.6
2006	1.82	7.97	90.30	8.70	54.75	11.2
2007	2.60	12.21	89.97	8.70	54.75	11.2
2008	0.50	21.58	90.76	8.70	54.75	11.1
2009	2.30	29.10	90.35	8.70	54.75	11.2
2010	3.48	13.92	86.09	8.70	54.75	11.7
2011	2.19	24.21	87.14	8.70	54.75	11.6
2012	2.14	31.18	90.34	8.70	54.75	11.2
2013	2.84	36.42	88.29	8.70	54.75	11.4
2014	3.36	19.76	90.97	8.70	54.75	11.1
2015	5.32	36.39	94.03	8.70	54.75	10.8
2016	3.94	43.76	88.23	8.70	54.75	11.5
2017-2021	21.64	167.06	435.42	37.80	237.75	11.6
2022	1.39	15.11	78.19	8.31	52.30	12.3
Total	64.25	503.23	1,808.34	178.04	1,119.92	11.4
Note: Excludes the crusher excavation volumes for 1999-2001.						

The life of mine composite plan (see Figure 4-8) shows the overall mining sequence.

Status from 2000 to End of 2022

Status at End of 2005

The status of the mine from 2000 to the end of 2005 is shown in:

- Figure 4-9 for 2000
- Figure 4-10 for 2002
- Figure 4-11 for 2005

Two adjacent mining areas will be developed to the east of the crusher and will progress northeast, parallel to the Muskeg River.

The early development will be in some of the highest grade, lowest fines and lowest strip ratio oil sands available on Lease 13. Overburden and centre reject material will be taken to the south disposal area and, before the end of 2005, some in-pit dykes will be constructed.

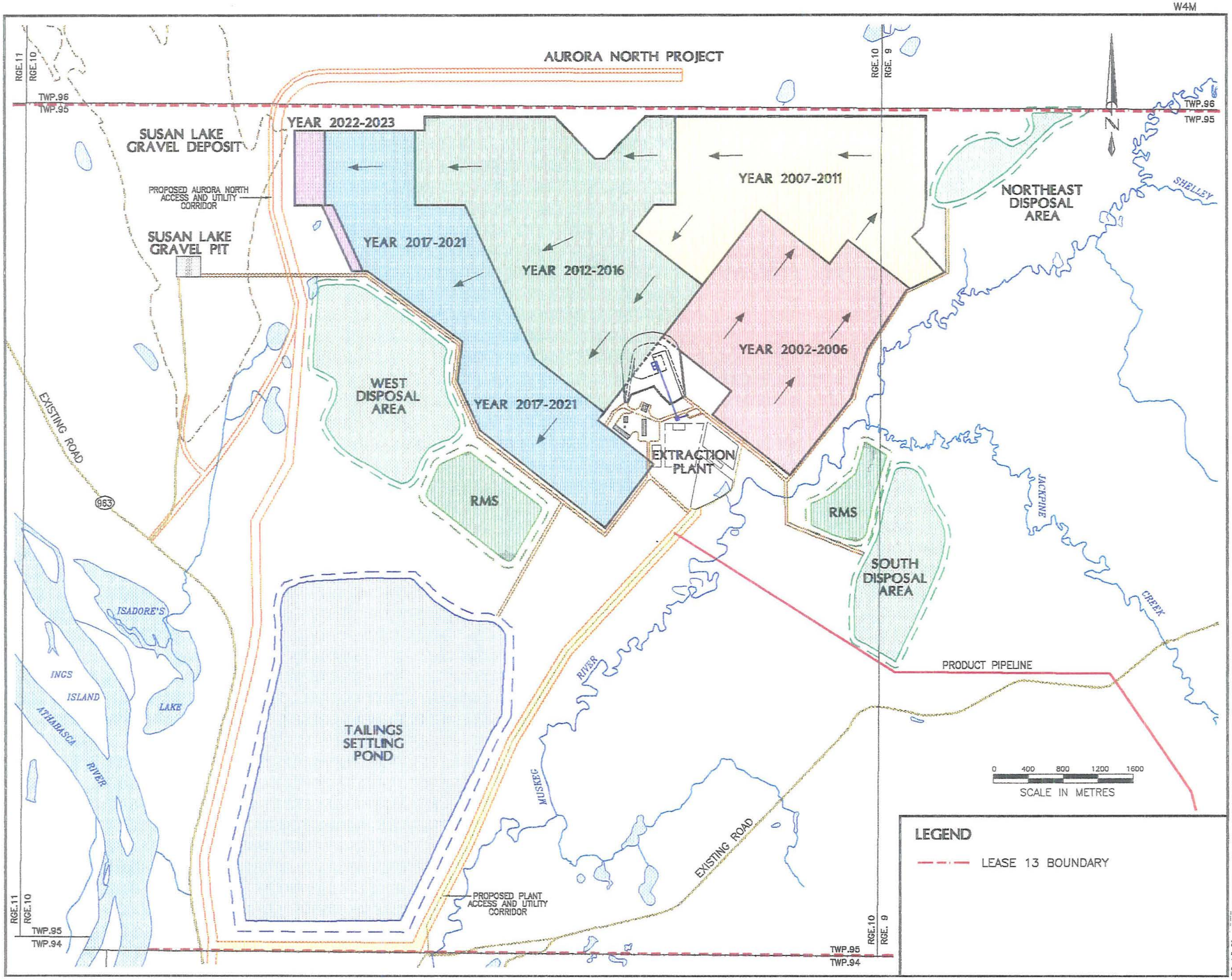


Figure 4-8: Life of Mine Composite Plan

Status at End of 2010

From 2006 to 2010 (see Figure 4-12) the mining faces will have reached the north and east final pit limits, and the mine will advance westward along the north lease boundary. Some high-grade ore immediately to the west of the main dyke will be required to maintain blending options for achieving consistent feed grade to the extraction plant.

The dykes constructed for in-pit tailings Cells 1a, 1b and 2 will be completed.

Most of the high-grade, low-strip-ratio ore will be exhausted, resulting in higher sustained oil sands production volumes with overburden and centre reject volumes increasing to over 20 million bcm per year. The northeast disposal area will be completed as the mining faces progress westward.

Status at End of 2020

From 2010 to 2020 the mine will continue advancing west and southwest. A new truck haul route will be established between the dykes to haul oil sands from the west areas to the crushers. By the end of 2020, Dykes 4, 5 and 6 will have been completed.

Beginning in 2012, some of the in-pit centre reject will be deposited on Cell 1, which by then will be a mature, consolidated tailings deposit. There will be sufficient room in the pit to allow overburden and centre reject material to be hauled and deposited in mined-out areas. This will minimize the longer hauls to the west disposal area.

Status at End of 2022

Figure 4-13 shows the final year (2022) mine configuration as it approaches completion. The final dykes will be constructed and a void will be left at the western limit of the pit, which will form an end-pit lake as part of the final mine closure plan. Once Dyke 7 has been completed, overburden and centre reject can be hauled to mined-out Cell 6 to minimize the longer hauls to the west disposal area.

Mining and Reclamation Status

For the status of the mine at the end of every year from 1999 to 2022, see the Conservation and Reclamation Plan in Section 16.4.

TAILINGS PLAN

The development of the volumetric schedules for the tailings plan (dykes, cells and in-pit disposal areas) will be conducted in association with the mining plan.

Tailings deposition using conventional methods will begin in 2002 in the tailings settling pond southwest of the extraction plant. This pond will be used until

TAILINGS PLAN (cont'd)

2022, although from 2006 onward the rate of deposition will be reduced as in-pit deposition is initiated.

For further discussion of the tailings plan, see Section 6.

MAJOR EQUIPMENT

Current mine planning is based on a large-scale truck-and-shovel operation, using existing and proven technology (218-tonne trucks and existing shovel sizes). The performance of larger equipment, such as 300-tonne trucks and large hydraulic excavators, being tested throughout the mining industry will be carefully reviewed. Proven successes will be a catalyst for introduction into the Muskeg River Mine.

A list of the major mining equipment is provided in Table 4-8.

Table 4-8: Major Mine Equipment

Equipment	2002-2005	2006-2010	2011-2015	2016-2020
Cable shovels	2	3	4	4
Hydraulic shovels	4	4	4	5
Trucks (218-tonne)	27	34	41	42
Trucks (85-tonne)	7	7	6	6
Bulldozers (large track-type)	5	8	10	12
Bulldozers (rubber-tired)	3	4	4	4
Graders	5	5	5	6
Water trucks	3	3	3	3
Compactors	2	2	2	2

MASS BALANCE

A full mining mass balance is shown in Table 4-9.

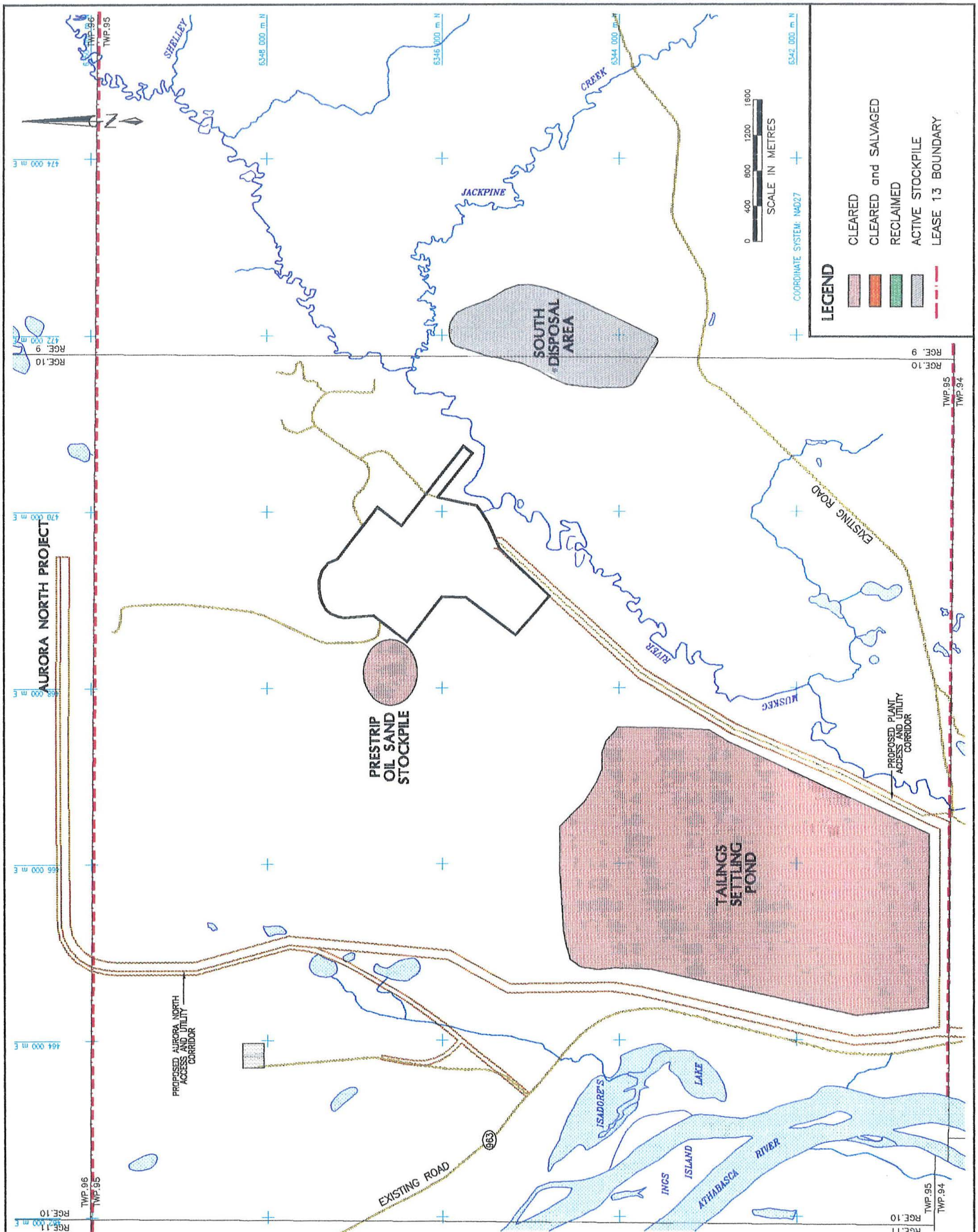


Figure 4-9: Status of Mine at 2000

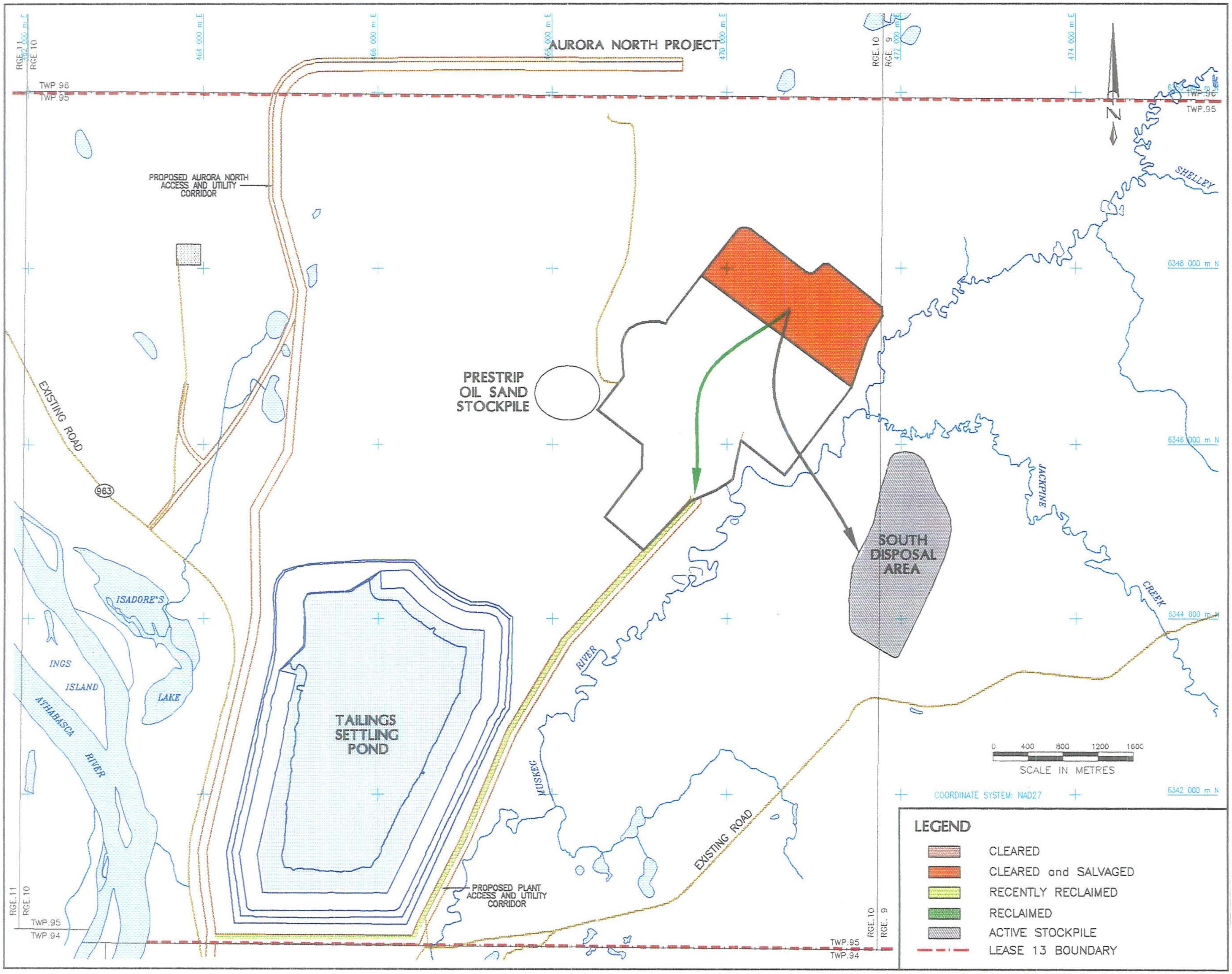


Figure 4-10: Status of Mine at 2002

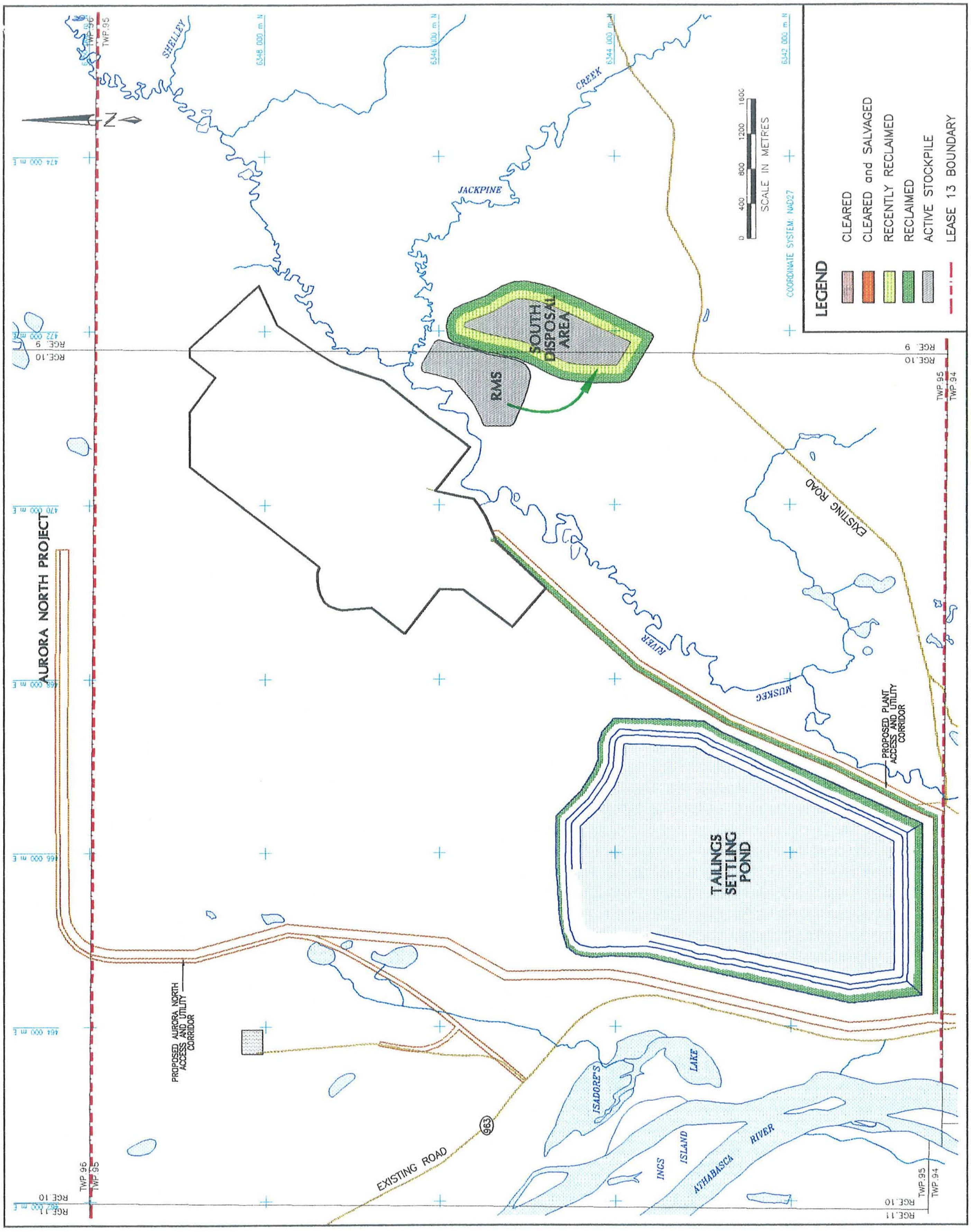


Figure 4-11: Status of Mine at 2005

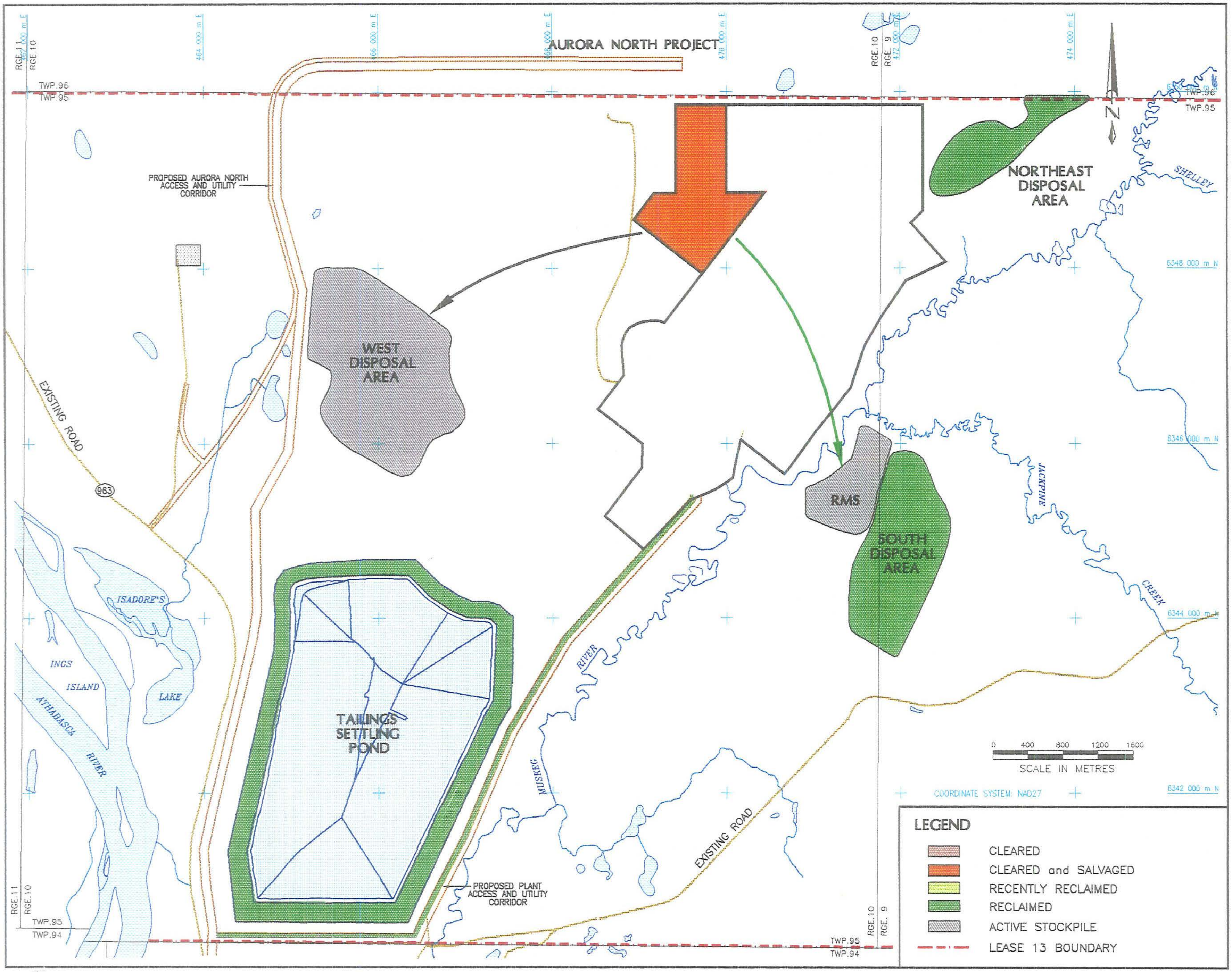


Figure 4-12: Status of Mine at 2010

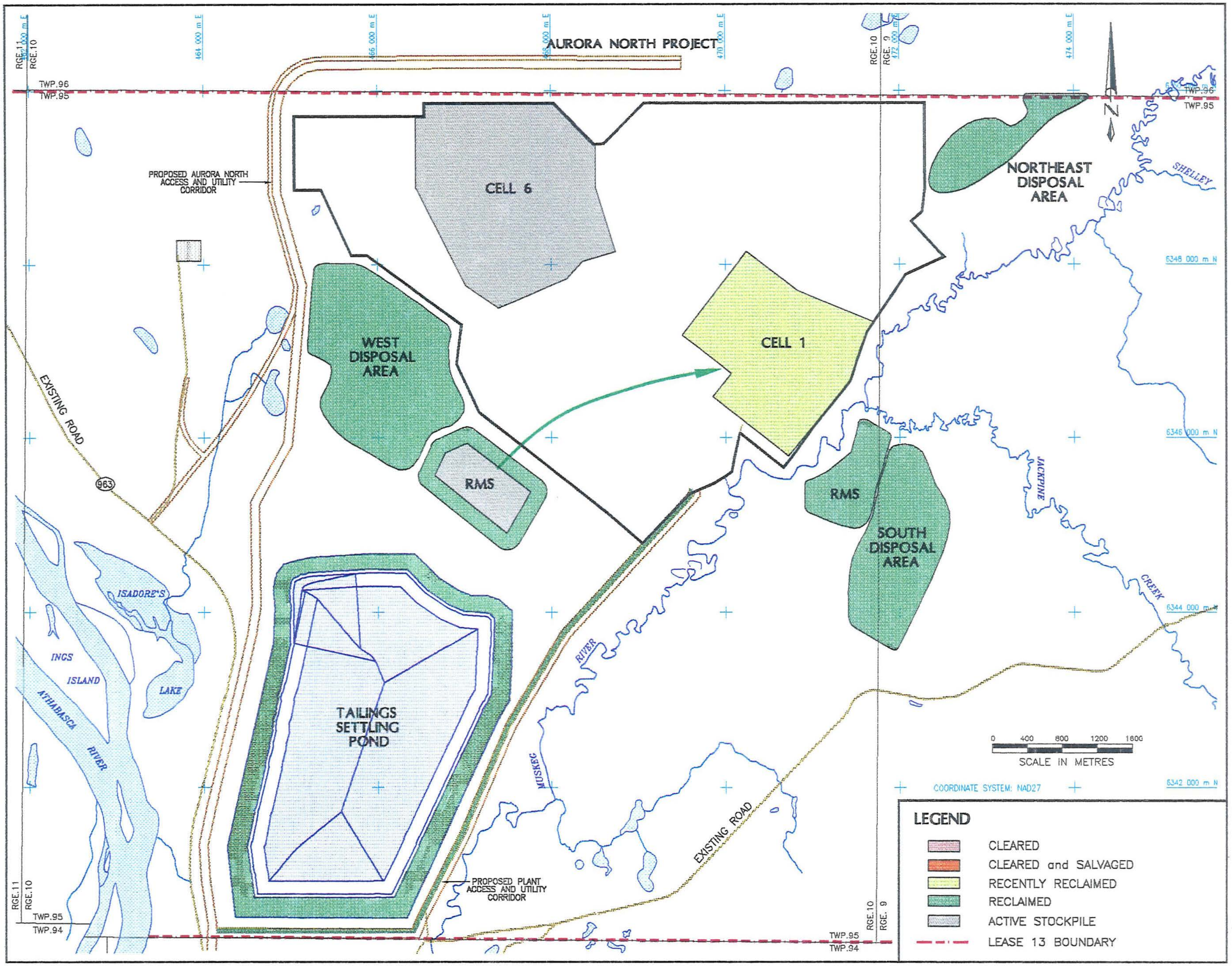


Figure 4-13: Status of Mine at 2022

Table 4-9: Mining Mass Balance

			DYKE CONSTRUCTION									DISPOSAL AREAS								
	Waste (OB+IB) BCM	Waste (OB+IB) km3	Tailings Settling Pond km3	Dyke 1 km3	Dyke 2 km3	Dyke 3 km3	Dyke 4 km3	Dyke 5 km3	Dyke 6 km3	**SUB TOTAL DYKES** km3	% of total to Dyke	SE Storage km3	NE Storage km3	West Storage km3	Cell 1 Storage km3	Inpit Cell 4 km3	Inpit Cell 5 km3	Inpit Cell 6 km3	Ovb. to muskeg storage shells km3	**SUB TOTAL** km3
2001	2,083	2,500	2,500							2,500	**100%**								638	638
2002	11,792	14,150	9,800							9,800	**69%**	2,689							1,662	4,350
2003	17,036	20,443										18,782							1,662	20,443
2004	12,971	15,565		600						600	**4%**	14,757							208	14,965
2005	13,473	16,168		1,800	700					2,500	**15%**	12,641							1,026	13,668
2006	9,790	11,748		2,000	5,000					7,000	**60%**	3,722							1,026	4,748
2007	14,815	17,778		6,000	5,500					11,500	**65%**		4,412						1,866	6,278
2008	22,082	26,498		5,000	6,800	4,300				16,100	**61%**		8,533						1,866	10,398
2009	31,395	37,674		3,000						3,000	**8%**			32,808					1,866	34,674
2010	17,400	20,880		3,000						3,000	**14%**			16,014					1,866	17,880
2011	26,403	31,684		8,000						8,000	**25%**			21,818					1,866	23,684
2012	33,323	39,988		6,000						6,000	**15%**				33,637				350	33,988
2013	39,262	47,114		5,400			2,000			7,400	**16%**				39,364				350	39,714
2014	23,115	27,738					14,000	2,000		16,000	**58%**					11,388			350	11,738
2015	41,713	50,056					8,000	5,000	2,000	15,000	**30%**						34,705		350	35,056
2016	47,705	57,246					6,500	6,000	4,000	16,500	**29%**							40,396	350	40,746
2017	37,741	45,290						6,000	6,000	12,000	**26%**							32,939	350	33,290
2018	37,741	45,290						8,000	10,000	18,000	**40%**							26,939	350	27,290
2019	37,741	45,290						9,000	15,000	24,000	**53%**							20,939	350	21,290
2020	37,741	45,290						3,800	12,000	15,800	**35%**							29,139	350	29,490
2021	37,741	45,290							7,000	7,000	**15%**							37,939	350	38,290
2022	16,498	19,798																19,798		19,798

MINE DEVELOPMENT SCHEDULE

The mine development schedule is based on being able to produce bitumen at the annualized full production rate on July 1, 2002. This will be the earliest date for bringing the mine into full production. About three and a half years are required for feasibility studies, mine permitting and site development.

The first stage of clearing, drainage and grading work for the plant site and haul roads will be completed by the end of September 1999, allowing construction of the office, workshop complex and extraction facilities to proceed soon after.

Prestripping will start in November 1999, to accommodate the required dyke construction schedule. Suitable material from this excavation will be used to build the starter dyke of the tailings pond. Prestripping will also expose oil sands, which will be stored for use during extraction plant commissioning. The crusher site will take just over one year to excavate. The oil sands will be stored north of the extraction plant. The excavation volume will be about 8.1 million bcm of waste and 1.7 million tonnes of oil sands.

This results in the crusher site being ready for construction in early 2001. The schedule leaves over twelve months for installing and commissioning the crusher and conveyors before full mine production on July 1, 2002.

SITE PREPARATION

Clearing

Salvageable timber will be recovered by logging contractors and the balance piled and burned. Clearing will be completed at least three years before mining operations begin, to provide sufficient time to complete the muskeg removal, ditching and drainage.

For further information on clearing, see Conservation and Reclamation in Section 16.4.

Muskeg Removal

Muskeg will be removed during the winter, and hauled to the muskeg storage areas. As the mine progresses, and when practical, muskeg will be hauled directly to areas undergoing reclamation.

Surface Drainage and Depressurization

The drainage plan for the mine site will include surface drainage and basal aquifer depressurization. Basal aquifer depressurization is required ahead of mining to ensure stability of the mine openings.

The mining area is relatively flat, ranging in elevation from about 285 m to 300 m. The area is characterized by gentle slopes, wet muskeg, shallow ponds and a poorly defined drainage system. The eastern mining areas slope toward the Muskeg River, which in turn flows into the Athabasca River. The western mining areas generally slope southwest toward the Athabasca River. Underlying the oil sands deposit are basal aquifers ranging in thickness from 0 m to 50 m. The aquifers will require depressurizing before mining activity begins.

Surface water will be handled by diversion ditches and mine water ditches. Before mining begins, diversion ditches will be constructed to divert clean surface water around the mining area and into the existing Muskeg or Athabasca River drainage systems. Suitable monitoring and, if necessary, treatment facilities will be installed before discharge. The diversion ditches will be designed to take advantage of ditches built for the Alsands Project. Finger ditches will be constructed annually to divert surface water from wet areas into the main diversion ditches. Water from the active mining areas will be diverted into sumps by in-pit surface water ditches. It will then be transported via pipelines to the plant settling ponds.

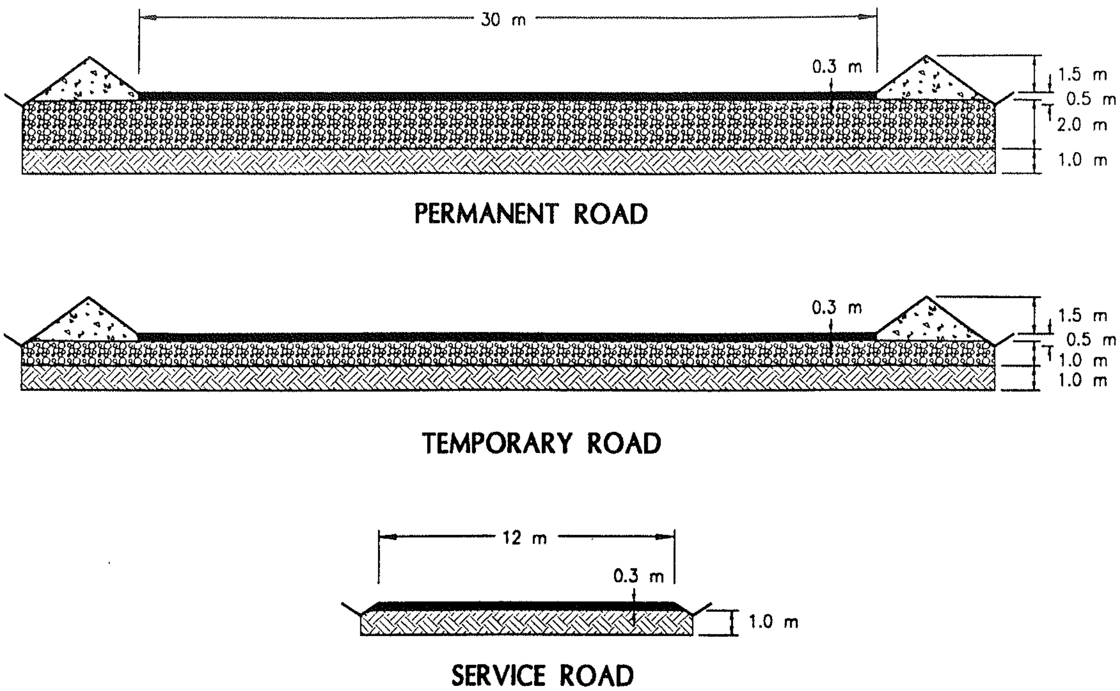
Depressurizing of the basal aquifers will begin when sufficient starter dyke is constructed to contain the water. This will require about 38 wells (15 horsepower each) spaced at 450 m intervals around the perimeter of the mine. Each well will pump about 500 m^3/d, providing additional water for the extraction process. To support the dewatering system, a perimeter road will be required for servicing the wells. In addition, each well will be serviced by a 25 kV power line and a transformer. The basal aquifer depressurizing system will remain in operation for the full life of the mine.

Grading

Rough grading will be required at the plant office and maintenance building site as part of the site-clearing program. A gravelled construction laydown area will be built for the preassembly and assembly of the crusher-conveyor system and the major mining equipment.

Haul Roads

Permanent and temporary haul roads will be built for truck haulage (see Figure 4-14). The permanent roads will be used for longer than one year and will provide long-term access to the crusher and the external storage areas. Temporary roads will typically be used for less than one year. These roads will be located within the active mining area and will be relocated periodically as mining progresses.



LEGEND

- SURFACE (CRUSHED GRAVEL, LEAN OIL SAND MIXTURE)
- BASE (PIT–RUN GRAVEL)
- SUBBASE (COMPACTED TILL OR LEAN OIL SAND)
- SAFETY BERM (UNDIFFERENTIATED WASTE)

NOTE: ALL ROADS TO BE CONSTRUCTED WITH A 1% CROWN

CALCULATED VOLUMES

MATERIAL	PERMANENT ROAD bcm^3/km	TEMPORARY ROAD bcm^3/km	SERVICE ROAD bcm^3/km
SURFACE (CRUSHED GRAVEL, LEAN OIL SAND MIXTURE)	9000	9000	3600
BASE (PIT–RUN GRAVEL)	78,900	39,400	N/A
SUBBASE (COMPACTED TILL OR LEAN OIL SAND)	39,500	39,500	13,500

Figure 4-14: Road Construction Scheme

Haul Roads (cont'd)

Service roads will be built to provide light vehicle access during construction and maintenance of drainage ditches and the mine electrical distribution system.

A permanent road will be built to the tailings settling pond, the south storage area and muskeg storage areas during the preproduction period. During the construction period, the following roads will be constructed:

- 16.5 km of permanent roads
- 8.1 km of temporary roads
- 18 km of service roads

A temporary road will also be built from the pit to the Susan Lake granular resource deposit. The gravel will be screened and crushed, then hauled and placed with mine equipment. Wherever practicable, gravel will be reclaimed from temporary mine and service roads as mining progresses.

Shell and BHP will work cooperatively with the managers of the gravel deposit to ensure its orderly development and operation.

During the life of the mine, the plan will require construction of a total of:

- 31 km of permanent roads
- 412 km of temporary roads
- 94 km of service roads

Office and Shop Complex

The Muskeg River Mine has been planned on the basis of being completely owned and operated by Shell and BHP, with minimal use of contractors. All management, maintenance and operations are planned to be conducted from the site.

Preliminary plans for the 10,400 m^2 office and shop complex are designed to provide:

- offices for all the site staff, including extraction and utilities
- facilities for maintaining all mine, extraction and utilities equipment

The repair bays will be capable of handling 320-tonne trucks in the future. A mechanical availability factor of 85% was used to estimate the number of repair bays for major equipment. The office will be located above the dry washrooms and will cover an area of 1,840 m^2. The extraction maintenance area will be 1,840 m^2.

Mine Electrical Power Distribution

A substation, built at the entrance to the site facilities, will transform the 144 kV Alberta grid supply to 25 kV for power supply to the mining operation.

Overhead 25 kV power lines will supply the mining area. During the preproduction period, a 25 kV power line will be built to provide power to the operation and to supply power to the basal aquifer depressurization wells. A second line will be built around the first mining area and extended to cover the north end of the mine.

Before 2010, a third major extension will be built for the dewatering wells around the western pit limit. In subsequent years, mine distribution lines will be built along the western limit of the pit.

At appropriate locations, 25 kV breakers and 25 kV to 6.9 kV portable transformers will be used to supply power to the electric shovels.

For more details on electrical power, see Section 7.2.

AURORA NORTH MINE

Syncrude's application for the Aurora North and Aurora South mines was approved in EUB Decision Report 97-13. Lease 13 shares common boundaries with both of these mining projects.

The Muskeg River Mine and the Aurora North Mine have about 10 km of adjoining lease boundary. About 3.5 km of this has coincident mining excavations. Some of the aspects that either have, or will continue to be, discussed between Shell and Syncrude are:

- orderly and efficient resource use
- access
- infrastructure
- boundary ore
- tailings
- environmental management

Common Mine Development

Shell and Syncrude assessed the potential benefits of developing the Muskeg River Mine and the Aurora North Mine from a common opening at the boundary. The key features of the investigation included considering a common:

- opening at the boundary
- plant site location at the Aurora North site
- external tailings pond at the Aurora North site
- lease boundary dyke

The assessment revealed that there were no economic benefits for pursuing a more detailed analysis of a common mine opening. The additional costs of this option, particularly with low-grade, high-stripping ratio, longer ore haulage and the longer tailings pumping distance, significantly outweighed the benefits of a common opening and tailings settling pond area. A common Shell and Syncrude tailings pond would require a large surface area and there is no area where such a facility would not cover economic ore reserves.

The results showed that Shell and Syncrude have more economic incentives to remain with their original, independent proposals, resulting in more efficient use of the oil sands resource.

Reserves at the Lease Boundary

A primary concern with independent oil sands mining projects operating with a common boundary, is to ensure that no potentially economic ore is sterilized. To address this concern, Shell and Syncrude have begun discussing mine planning initiatives and have developed a boundary agreement to facilitate the orderly and effective mining of the oil sands from their respective leases. Specific areas covered by the agreement include:

- coordination of mine plans
- recognition of the timing of mining activity
- optimized construction of storage facilities
- reclamation strategies
- ownership and disposition of reserves and stripping material
- calculation of compensation basis

Recent discussions have led to an agreement between Shell and Syncrude for the location of Syncrude's tailings corridor on Lease 13. The timing of the respective mine plans shows that the tailings corridor can be successfully relocated through the mined-out pit (Syncrude East Pit) before the Muskeg River Mine progresses through the area.

This will result in all of the ore at this boundary location being available for the respective companies to mine.

Aurora North Mine Access

The Aurora North extraction facility will eventually be surrounded by mining activity from the Muskeg River Mine and the Aurora North Mine. Access to the Aurora North operation will be hindered by the progress of mining by both operators.

Recent reviews of mine plans have resulted in several opportunities being explored to ensure that sufficient flexibility is available when mining near the Aurora North access corridor. Minor alterations to the Syncrude production sequence in the centre pit provide the opportunity for the successful relocation of the Aurora North access corridor through the mined-out centre pit. This will enable all of the ore at the boundary to be mined, as well as minimizing costs on relocating access later in the mining operation.

Ongoing reviews of the Shell and Syncrude mine plans will be held to ensure that the resources and operations at the lease boundary are managed effectively. Where appropriate, work groups will be established involving EUB staff to ensure that all concerns are incorporated into the planning process.

Common End-Pit Lake

The opportunity for a common end-pit lake was also reviewed with Syncrude. This was found to be infeasible because the Aurora North mine will be completed further west and over 10 years later than the Muskeg River Mine.

OTHER LEASE INTERESTS

Mobil

The Muskeg River Mine does not have a mine boundary with any other organization, except Syncrude. However, future developments might result in shared mine boundaries with other area lease holders, such as Mobil at Lease 36. Shell is committed to work with such organizations to define effective boundary management plans, in the same way as it has worked with Syncrude on the Aurora North development.

Northlands

Northlands Forest Products conducts timber harvesting operations in the Lease 13 area. Shell will establish a formal communication process to ensure that cooperative planning and development occurs.

Alberta-Pacific

Alberta-Pacific holds the Forest Management Agreement for the Lease 13 area. Shell will establish a formal communication process to ensure that cooperative planning and development occurs.

INTRODUCTION

PROCESS SELECTION CRITERIA

The challenge of building a robust grassroots oil sands extraction facility for the Muskeg River Mine has provided Shell with an opportunity to learn from the successful operation of the existing oil sands plants, as well as make substantial levels of financial investment in new technology development. This investment has allowed new ideas to be considered, which could lead to lower cost, simplified, safe operations with enhanced reliability and reduced environmental impact. Investment in the advancement of technology within the oil sands industry has been consistently supported and encouraged by the Government of Alberta, EUB and other stakeholders.

The need to meet market product quality requirements and to ensure that the level of risk associated with starting up this new operation is managed to an acceptable level has been paramount in selecting the appropriate technology for further development.

In addition, technology development has to take place within the schedule constraints of the total project, which is based upon a start-up of operations before 2003. Starting operations before 2003 will also enable Shell to meet the Lease 13 tenure requirements of producing bitumen by August 9, 2003.

The extraction process selected for the Muskeg River Mine Project takes advantage of a number of recent advancements in the recovery of bitumen from oil sands and builds on the existing application and modification of the proven Clark hot water extraction process. The focus in selecting the proposed process was to produce a bitumen product that meets pipeline specification and downstream marketing and processing requirements. At the same time, the process selection criteria place a priority on those processes that:

- reduce the energy intensity, compared to existing operations, through lower process temperatures
- reduce the reliance on process additives, such as caustic, that impair the settling of solids in the tailings settling pond
- provide reliability and high throughput
- attain levels of overall hydrocarbon recovery efficiency that are comparable to, or higher than, those achieved in existing operations

PROCESS SELECTION CRITERIA (cont'd)

- offer an acceptable technical risk in starting-up the facilities and the opportunity to reach design capacity within the first year of operation

- provide the opportunity to improve environmental performance

- produce a bitumen product of a quality that would enable efficient upgrading processes to be applied that achieve high overall hydrocarbon recovery, with reduced levels of low value byproducts, such as fuel gas and coke

SELECTED EXTRACTION PROCESS

Major Features

The Muskeg River Mine extraction process involves two identical production trains which incorporate a:

- high-capacity oil sands feed system
- novel oil sands slurry preparation and ore conditioning system
- warm water primary extraction process
- paraffinic solvent froth treatment process

High-Capacity Oil Sands Feed System

A high-capacity oil sands feed system that matches a large-scale truck-and-shovel mining operation will be provided. The feed system will use primary feeder crushers currently in oil sands service to reduce the size of the mined oil sand for transportation by conveyor to the slurry preparation facilities.

Oil Sands Slurry Preparation and Ore Conditioning System

The oil sand slurry preparation and ore conditioning system will use rotary breakers to further reduce the size of the mined oil sands and slurry it before it is conditioned and stored in agitation tanks.

Warm Water Primary Extraction Process

The warm water primary extraction process will operate at between 45°C and 50°C without using process additives. The process temperature is lower than existing operations and will result in lower net energy requirements. Commercially demonstrated process steps will be used to provide recoveries comparable with current commercial operations. During 1997, the performance of the process was demonstrated in a 6 t/h pilot operated by the Canadian Centre for Mineral and Energy Technology (CANMET) on behalf of Shell and Suncor. The pilot was specifically designed to evaluate bitumen recovery from various grades of oil sands feed with tank-conditioned oil sands.

Paraffinic Solvent Froth Treatment Process

Two-stage centrifugation, using a paraffinic solvent, will be used to remove most of the water and solids from the bitumen froth. After centrifugation, the bitumen will be further treated in a product clean-up phase with additional solvent in a series of separating vessels, to allow the remaining water and solids to be removed.

This process builds on current commercial operating practice using dilute bitumen centrifugation, as well as on the technology development efforts using paraffinic solvent by Shell and others since 1995 as part of a CONRAD research program. The process will produce a bitumen product containing significantly lower levels of solid contaminant than that obtained by using existing commercial techniques.

SELECTION BASIS

The extraction and froth treatment process was selected following a review of many options for separating bitumen from oil sands, which have been put forward over the past 30 years of commercial oil sands development. The selection process is described in Section 5.4.

The selected process comprises a combination of process steps that are either commercially proven for oil sands application, commercially used in other mineral processing applications, or have been shown to be viable through research and piloting.

SLURRY PREPARATION AND ORE CONDITIONING

Rotary Breaker Slurry Feed Preparation

Run-of-mine oil sands will be passed through a coarse sizing and feed system (see Figure 5-1) consisting of two truck dump hoppers, each with its own crusher capable of handling up to 12,000 t/h of mined oil sands and sizing the oil sands lumps to less than 400 mm. Each crusher will be capable of providing total plant feed. Pan feeders will transfer the sized oil sands onto either of two 625-m long, 2100-mm wide, angled plant feed conveyors. The conveyors will elevate and transfer the oil sands to the slurry preparation system.

The oil sands will be fed into one of two rotary breakers. Each rotary breaker, commonly used in the coal mining industry, will comprise a rotating perforated drum in which mined material is broken down by tumbling action until it reaches a size that enables it to pass through the holes in the drum. Hard, non friable material, typically waste rock, will pass through to the far end of the drum and be rejected.

Water, at 80°C, will be added to the rotary breaker to wash the sized oil sands through the holes in the drum and to produce a slurry feed with a maximum lump size of 50 mm and a temperature of 50°C. Most of the oil sands will already be small enough to pass immediately through. Lumps of oil sands larger than 50 mm, particularly frozen lumps, will be broken down by tumbling action as they travel along the length of the drum, and will eventually pass through the holes. Waste rock too large to pass through will be rejected at the far end of the drum and will later be returned to either waste stockpiles or the mine by trucks.

Rotary Breaker Slurry Feed Preparation (cont'd)

In 1996, a successful field trial of a rotary breaker was carried out by Shell and Suncor at Suncor's Tar Island mining operation. This trial demonstrated the operability and performance of the breaker under harsh winter conditions. The trial also demonstrated that the equipment can handle high levels of throughput while also achieving low levels of oversize oil sands reject. Suncor will be installing four rotary breakers in its Steepbank Mine development.

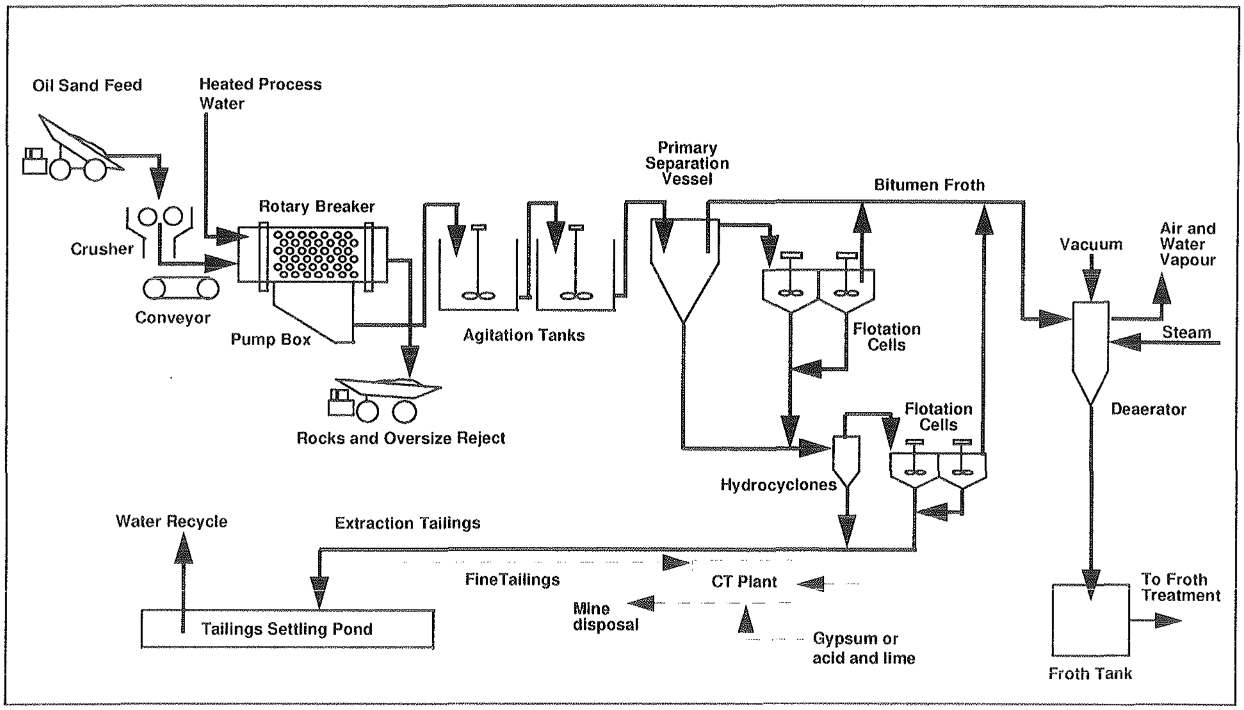


Figure 5-1: Extraction Process Schematic

Agitation Tank Oil Sands Conditioning

Oil sands slurry will be pumped from the rotary breakers, at a density of between 1.5 t/m^3 and 1.6 t/m^3, to the first of several agitation tanks. As the tanks will be linked in series, the oil sands slurry will move from one tank to the next. The agitation tanks will:

- condition the oil sands by providing sufficient retention time to allow heated water and mechanical agitation to further reduce the size of oil sands lumps, particularly those frozen during winter operation. The conditioning will release natural surfactants in the oil sands and initiate the separation of the bitumen from the sand grains.
- provide surge capacity between the mine and the extraction process

Work carried out by the Saskatchewan Research Council in 1996 and follow-up piloting in 1997 by CANMET, both under the direction of Shell and Suncor,

Agitation Tank Oil Sands Conditioning (cont'd)

successfully demonstrated the viability of using agitation tanks for conditioning the oil sands. This work, together with parametric modelling of oil sands lump digestion rates, showed that similar conditioning mechanisms take place to those experienced in the commercially demonstrated high-density hydrotransport of oil sands.

PRIMARY EXTRACTION

The primary extraction process will use similar equipment and processes to those currently used in existing commercial operations. However, unlike current operations:

- sodium hydroxide (caustic) will not be added as a bitumen separation aid in the Muskeg River Mine extraction process
- the process temperature of 45°C to 50°C will be substantially lower than the 70°C and 75°C required in the conventional Clark hot water process

Three stages of separation are involved:

- primary separation
- middlings recovery
- tailings oil recovery

Conditioned oil sand from the slurry tanks will be fed into one of the two primary separation vessels. In this vessel, bitumen will be separated from the sand by gravity and will float to the surface as a froth. This froth will contain bitumen, water and fine sand and clay particles. The composition of the froth will vary and is expected to range between 55 wt% and 65 wt% bitumen. A projected average froth quality of 63% bitumen, 28% water and 9% mineral solids has been used for material balance purposes. Sand not reporting in the froth will settle to the bottom of the vessel where it will be removed for further bitumen recovery. A froth underwash will be introduced near the top of the vessel to enhance separation. The process temperature at this stage will be between 45°C and 50°C.

A middlings stream will be taken from the primary separator and further processed in a number of flotation cells. Mechanical agitation and air addition in these cells will help to recover the bitumen, by gravity separation, from the finer sand and clay particles. The floated bitumen froth will be combined with that from the primary separation vessel. The underflow from the flotation vessels, together with the underflow from the primary separation vessel, will pass on to the final stage of bitumen recovery.

The combined underflow from the first two separation stages will be pumped through a number of hydrocyclones where gravitational forces will be increased

PRIMARY EXTRACTION (cont'd)

by centrifugal action. The overflow from the hydrocyclones will be processed in a number of flotation vessels, similar to those used to process the primary separation vessel middlings stream. Froth from these flotation vessels will be combined with that from the first two stages and deaerated before it is stored in a storage tank awaiting froth treatment. The underflow from the flotation vessels will be combined with the hydrocyclone underflow and pumped as primary tailings to the tailings settling pond.

The froth must be deaerated to release entrapped, non-condensable air before it is pumped to a storage tank and before solvent is added in the froth treatment process. The froth will be deaerated by increasing its temperature to 65°C and by introducing low-pressure saturated steam and applying a partial vacuum. Using a partial vacuum allows the deaerator to be operated at a lower temperature than existing operations, which operate at 80°C to 85°C. At the proposed process conditions, no hydrocarbon vapours are expected to be drawn off with the air and water vapour. The water vapour will be condensed and recycled for use in the process.

CONSOLIDATED TAILINGS PLANT

A plant for manufacturing consolidated tailings (CT) will be installed four years after the start-up of bitumen production. This plant will receive mature fine tailings from the tailings settling pond. Tailings from the extraction plant will pass through two stages of hydrocyclones. The underflow from the hydrocyclones will be added to the mature fine tailings and gypsum or acid and lime in a mixing tank. The resulting mixture will be pumped to mined-out areas for final storage and reclamation.

Fine material from the overflow of the second-stage hydrocyclone will be sent to the external tailings settling pond. For a further description of CT manufacturing, see Consolidated Tailings Operation in Section 6.3.

FROTH TREATMENT

Treatment Stages

Solids and water will be removed from the primary extraction froth in two stages:

- a solids removal stage
- a final product clean-up stage

Solids Removal Stage

The solids removal stage will involve two-stage dilute bitumen centrifugation, similar to that used in existing commercial operations in which both decanter

Solids Removal Stage (cont'd)

type and disc-stack type centrifuges are used. Existing operations use naphtha as a diluent to reduce viscosity and aid the centrifugation process, but Shell proposes to use a paraffinic solvent made up of a mixture of pentane and hexane. Process temperatures during centrifugation will be about 40°C to ensure that vapour pressures are low enough for vapour containment. The ratio of solvent to bitumen in the froth feed at this stage will be about 0.7:1.

The product from the solids removal stage will contain water and fine solids, typically at concentrations of 3% water and more than 0.5% solids, which do not meet the BS&W specification for commercial pipeline operation. In addition, the remaining fines, typically less than 1 µm, will impair certain downstream upgrading and refinery operations. Their removal is beneficial to the use of hydrogen-addition bitumen upgrading processes, such as those proposed by Shell at its Scotford upgrader, and to enable Shell to take advantage of bitumen marketing opportunities. See Section 13.1 for a discussion on the upgrading process.

The underflow from the solids removal phase will pass through a tailings solvent recovery unit before being sent as secondary tailings to the tailings settling pond. Recovered solvent will be recycled for use in the process.

Product Clean-Up Stage

A product clean-up phase, based on the addition of further quantities of the paraffinic solvent, will be used to remove the remainder of the water and solids.

Since 1995, the use of paraffinic solvents to remove water and solids from bitumen froth has been piloted by Shell and others as a CONRAD research effort at the CANMET froth treatment pilot facilities at the Western Research Centre in Devon, Alberta. This work has involved evaluating various types of solvent, as well as the use of froth produced from bitumen extraction processes with and without the addition of caustic.

The results of this work indicate that, by mixing sufficient quantities of paraffinic solvent, typically in the ratio of 2:1 solvent to bitumen in the froth, and allowing the resultant mixture to settle, a diluted bitumen product can be obtained that contains extremely low levels of contained solids and water. Over 85% bitumen can be recovered in a single-stage settling arrangement.

The removal of the fine solids and water from the bitumen is related to the solubility of the bitumen in the paraffinic solvent, combined with the incipient precipitation of a small quantity of heavy hydrocarbon solids, known as asphaltenes. Asphaltenes are a component of the naturally occurring bitumen and are normally rejected as coke from fluid and delayed coking upgraders. Removing some asphaltenes during the product clean-up phase is necessary, as it is directly associated with the removal of the fine solid particles from the bitumen. The use of paraffinic solvents to precipitate asphaltenes is well understood and has been documented in technical literature.

Product Clean-Up Stage (cont'd)

The proposed configuration for the product clean-up phase is a two-stage mixer separator arrangement with the product from the second stage being recycled to the first stage.

About 85% of the bitumen is expected to be recovered in the first-stage separator, as that percentage was achieved in pilot tests. This level of recovery can be increased by increasing the temperature. However, using elevated temperatures with paraffinic solvents requires the use of pressurized vessels to maintain the resultant vapour pressure. To maintain process conditions below the boiling point of the solvent, process temperatures in the product clean-up phase will be about 30°C. Separator vessels and mixers will be blanketed with nitrogen at sufficient pressure, around 5 kPa, to suppress solvent vaporization.

To improve the recovery of bitumen at process temperatures below the boiling point of the solvent, the underflow from the first stage will be treated in a second-stage separator.

The underflow from the first-stage separator will be an emulsion of:

- diluted bitumen
- water
- mineral solids
- a small amount of precipitated organic solids asphaltenes (about 3% to 4%, by weight, of the bitumen in the froth treatment process feed)

Pilot work carried out by Shell has demonstrated that adding additional quantities of solvent to the first-stage separator underflow, and increasing the solvent to bitumen ratio to over 4:1, dissolves the remaining bitumen and enables the mineral and organic solids to settle by gravity in a second-stage separator. The dissolved bitumen product from the second-stage separator will be recycled to the first-stage separator and the overall recovery from the first stage will be increased to 96%.

Tailings Solvent Recovery

The underflow tailings from the product clean-up phase will be combined with that from the solids removal stage. Solvent remaining in this combined underflow secondary tailings stream will be removed in the tailings solvent recovery unit (TSRU) using nitrogen gas as a stripping agent. A partial vacuum will also be maintained in the vessel to aid solvent recovery. This process differs from existing operations which use steam as the stripping agent. Nitrogen, an inert gas, was selected to avoid the need to add high levels of heat that would otherwise be required to preheat the froth treatment tailings stream from 37°C to over 80°C to make steam stripping effective. Following its use in the TSRU, the nitrogen will be recovered and recycled

Tailings Solvent Recovery (cont'd)

Alternatively, natural gas can be used as a stripping agent instead of nitrogen in the TSRU. If natural gas is selected, it will be recovered and used as a fuel for process water heating. The final stripping method will be selected following piloting in 1998.

The recovered solvent will be cooled and the heat recovered with cold extraction process water. The solvent will be returned to tankage for continued use in the process. The use of a paraffinic solvent is expected to result in solvent losses to the tailings of about 0.3 wt% to 0.4 wt%, which are comparable to, or less than, those in conventional froth treatment processes using naphtha diluent. With these levels of recovery, emissions of volatile organic compounds (VOCs) from tailings areas are low.

The use of paraffinic solvent will further reduce the impact of VOCs. As paraffinic compounds are known to be less photochemically reactive than aromatic compounds, emissions of volatile organic compounds (VOCs) from the tailings settling pond will have less effect on ground-level ozone than an aromatic solvent. The effect of paraffinic components is estimated to be up to six times less than aromatic components, based on reactivity factors suggested in the *Canadian Council of the Ministers of the Environment (CCME)* NO_X*/VOC Management Plan.*

Solvent Recovery

The diluted bitumen product from the froth treatment phase will contain more solvent than the 30%, by volume, that is required for pipeline transportation. Excess solvent will be removed in a solvent recovery unit (see Figure 5-2).

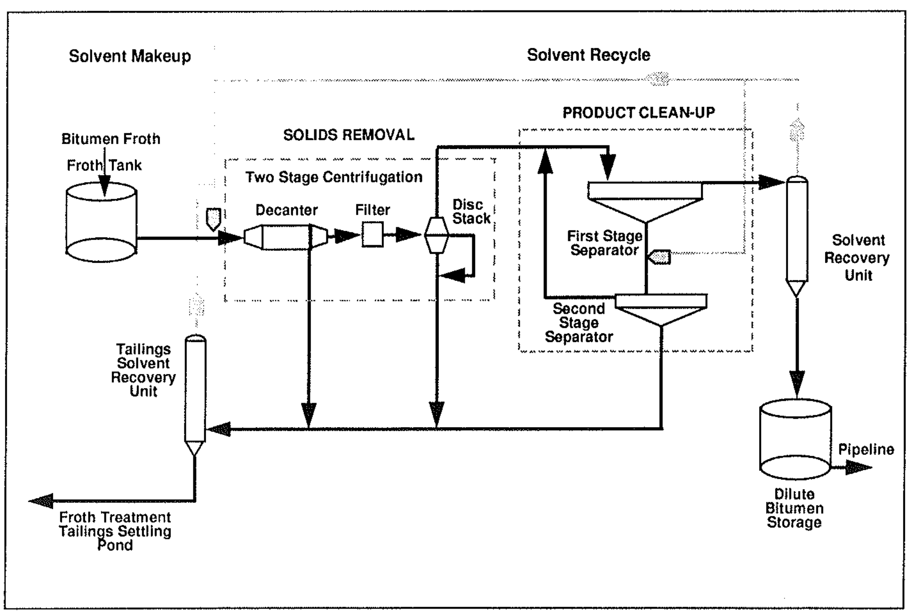


Figure 5-2: Froth Treatment Process

Solvent Recovery (cont'd)

This unit will flash and condense the solvent in two stages. Recovered solvent will be recycled for continued use in the froth treatment process. The diluted bitumen product will be stored in tanks, then transported by pipeline. The solvent recovery unit differs from the diluent recovery units in existing operations where operating temperatures are higher and all the naphtha diluent is stripped off.

Shell does not plan to capture and use any portion of the stripped solvent as a fuel. A small quantity of non-condensable gases is expected to accumulate in the solvent recovery vessels. These gases will be intermittently drawn off. Solvent fractions will be recycled. Gaseous components will be disposed of through combustion as a heat source.

Relief and Blowdown System

A relief and blowdown system will be installed to safely and effectively dispose of any solvent vapours which might accumulate as well as be generated during a large process upset or a shutdown of operations. The system will consist of a low-pressure flare and will accommodate loads from:

- froth treatment
- the solvent recovery unit
- the tailings solvent recovery unit

Odours are not expected to be a concern from the use of this process.

PRODUCT QUALITY

The bitumen product from the product clean-up phase is expected to contain less than 800 ppm of mineral solids and less than 0.2% water. In addition, the diluted bitumen product will contain 30%, by volume, paraffinic solvent for transportation.

OIL SANDS MATERIAL TRANSFER PLAN

Shell is requesting EUB approval to:

- receive third-party oil sands material at its site for processing
- produce and ship oil sands material from its site for processing at third-party facilities

For the purpose of this request, oil sands material is defined as mined ore or intermediate process streams, such as bitumen froth.

OIL SANDS MATERIAL TRANSFER PLAN (cont'd)

The proximity of other existing and proposed oil sands operations presents a unique opportunity for future flexibility and optimization. The ability to process third-party ore provides an opportunity to supplement production for brief periods of time, if there are any shortfalls in feedstock.

The converse is true for potential supply to other area processing facilities. With the emerging ability to transport intermediate process streams, such as bitumen froth, over longer distances, the potential exists for moving material between area operations.

Shell's first priority is to supply all process materials from its own operations. If this cannot be accomplished, it might be possible to use an external source of material, if available. Alternatively, Shell could take advantage of excess capability for producing intermediate streams to supply other area operators periodically.

Approving this type of flexibility in oil sands material production and supply would encourage alternative concepts to be evaluated both within Shell and by others and would benefit overall oil sands development.

PLANNED PILOT WORK

Shell and BHP are continuing to develop aspects of the paraffinic solvent froth treatment process in their research facilities, using bench-scale and small-scale pilot equipment. A 20 t/h pilot facility located on Lease 13 is planned for 1998. This pilot will be used to confirm commercial process conditions, bitumen and solvent recoveries as well as to provide information for front-end engineering and design.

BYPRODUCT MINERAL RECOVERY

Shell and BHP have reviewed the results of the Alberta Chamber of Resources *Oil Sands Coproducts Study, 1996.* This report identifies the opportunity to recover titanium and zircon from centrifuge plant tailings. Once commercial bitumen extraction operations are in place, tailings streams will be assessed for mineral concentration, and opportunities for byproduct mineral recovery will be evaluated.

EXTRACTION RECOVERY

The expected bitumen recovery is 91%. Table 5-1 summarizes the recovery at various stages of the extraction process, from slurry preparation through primary extraction and froth treatment, for a plant feed grade of 11.4 %. This recovery does not include any losses from the product clean-up stage and can be used to compare the extraction recovery obtained from existing operations. Primary extraction recovery is linked to the quality of feed from the mining operations. The expected annual average plant feed grades are shown in Mining Reserves in Section 4-1.

Table 5-1: Extraction Bitumen Recovery

Process Step	Recovery (%)
Slurry preparation	99.8
Primary extraction	93.0
Froth treatment	98.0
Recovery	91.0

PRODUCT CLEAN-UP RECOVERY

The expected recovery from the product clean-up phase is 96%. The rejected material consists of bitumen resins and asphaltenes. Ultrafine solids and water are also rejected. This has the benefit of providing a clean bitumen product suitable for upgrading using catalytic hydrogen conversion technology, such as that proposed for the Scotford upgrader. This technology allows for an additional overall 12% hydrocarbon recovery (see Upgrading Options in Section 13.1). Therefore, the overall hydrocarbon recovery is higher than that achieved by bitumen extraction processes feeding upgraders where coke is rejected.

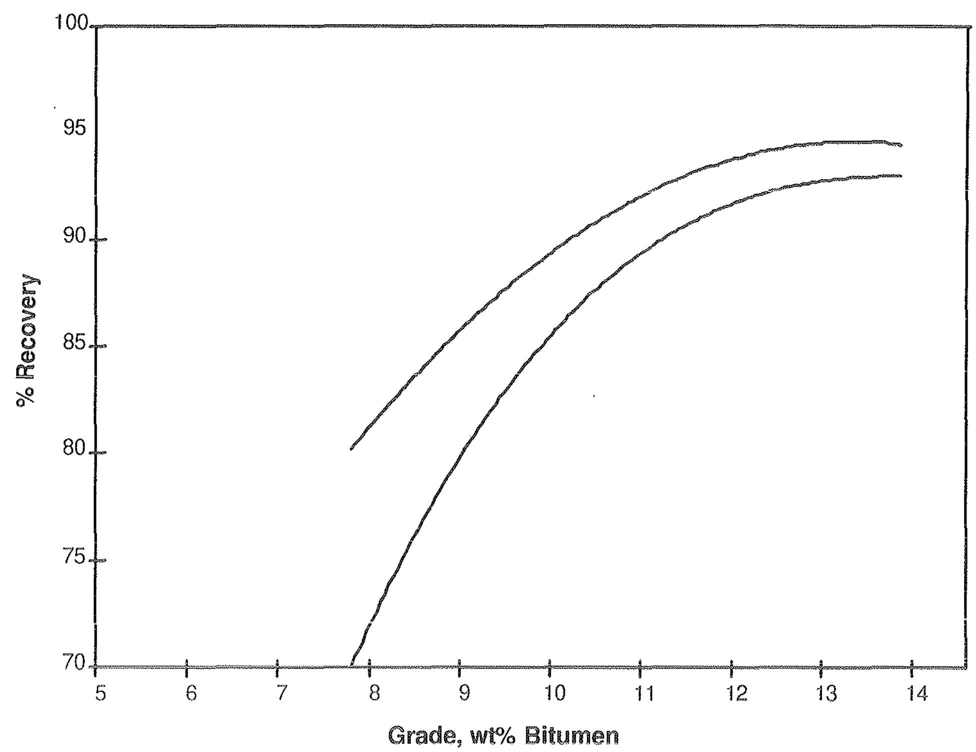
EXPECTED RECOVERY VERSUS PLANT FEED GRADE

Figure 5-3 shows the expected bitumen recovery versus plant feed grade. These recoveries have been demonstrated through the bench-scale testing and pilot work carried out in 1996 and 1997 and are consistent with performance in current commercial operations.

OTHER PROCESS OPTIONS

Shell is aware of the EUB's desire to increase the primary extraction recovery target in commercial operations to 94%. Shell is committed to achieving this target over time. Because the proposed extraction process will involve some novel configurations and will operate at lower process temperatures without process additives, a period of five years after initial start-up of the facilities will be required to ensure that the target can be met.

If Shell's commercial operations fall short of this target, the use of process additives and other process options will be evaluated. If process additives are considered necessary to increase bitumen recovery, their use will be evaluated against economic and environmental impacts. Most of these impacts are known, such as the impact of caustic on the behaviour of tailings settling and bioremediation of tailings water.



$y = -0.7271x^2 + 18.597x - 24.755$
$R^2 = 0.9658$

Figure 5-3: Bitumen Recovery versus Ore Grade

SELECTION STAGES

The method applied by Shell in selecting the proposed extraction process configuration is shown in Figure 5-4.

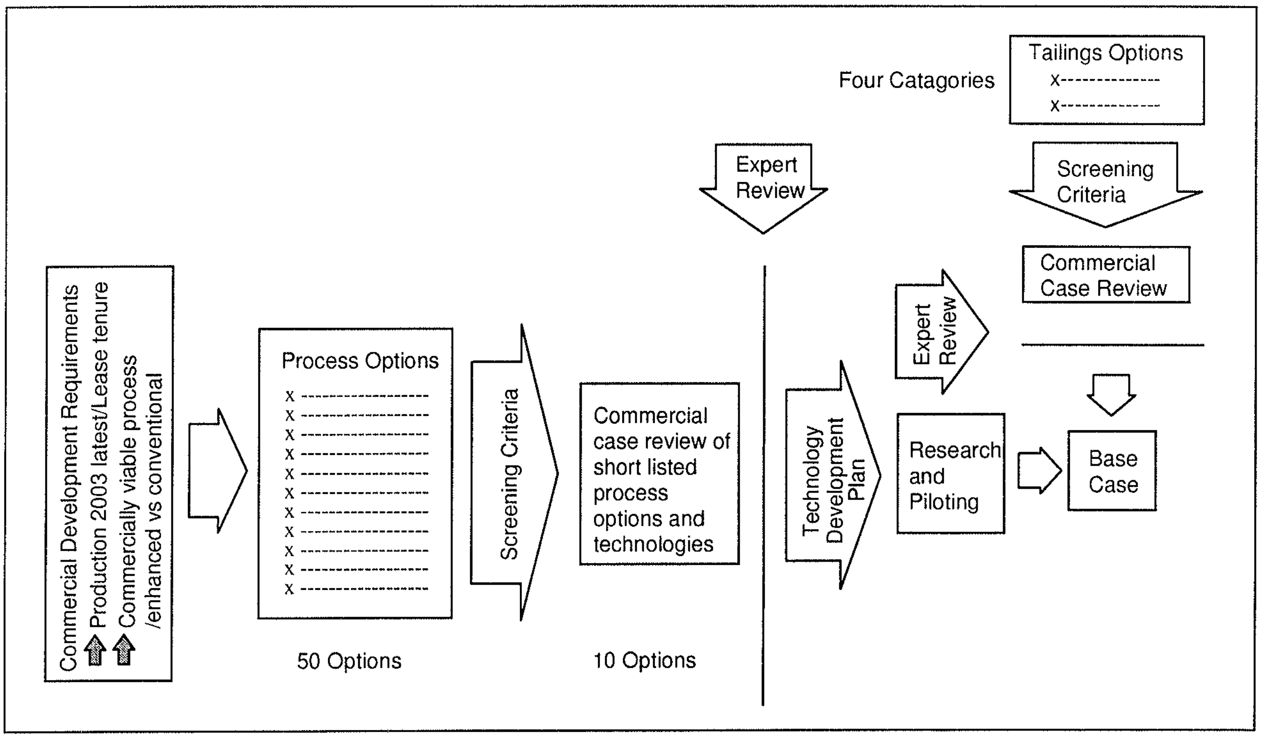


Figure 5-4: Process Selection Schematic

Defining a robust commercial case involved six key stages:

1. Screening a large number of known processes or process components against a set of screening criteria.

2. Selecting a few suitable processes or process components for further evaluation.

3. Reviewing the evaluation with corporate, industry, government and academic specialists with particular knowledge of the various aspects of bitumen extraction and the associated technology disciplines.

SELECTION STAGES (cont'd)

4. Selecting a conventional process base case from which optimization enhancements were pursued through a focused technology development program.
5. Conducting a detailed assessment of tailings management alternatives.
6. Defining a commercial case for advancement to front-end engineering and design, which incorporates the proven elements from the technology development to date.

PROCESSES SCREENED

In selecting the proposed bitumen extraction process, Shell carried out a screening level review of the known processes capable of extracting hydrocarbon product from bituminous sands. The catalogue of processes published in the *Oil Sands Bitumen Extraction Process Evaluation Report,* Dynawest Projects Ltd., 1984, undertaken on behalf of the ERCB, was amended and used. The list was amended by including processes that:

- have since been reported in the literature
- have been assessed in other regulatory submissions
- have been made known to Shell by the proponents of the technology and are considered potentially viable by Shell

The processes screened fall into three main categories:

- water-based processes
- solvent-based processes
- pyrolysis type processes

SCREENING CRITERIA

To aid the selection process, the following screening criteria were used:

- stage of technology development
- years to commercial application
- accessibility of the technology and freedom to act
- capital intensity
- environmental performance
- complexity and reliability
- technical risk
- prototype required

Stage of Technology Development

The stage of technology development considered the level to which the technology has been taken, such as:

- conceptualization
- bench-scale testing
- small-scale pilot
- large-scale pilot
- commercial-scale demonstration and operation

Years to Commercial Application

Consideration was given to the number of years it would take to bring the technology from its current stage of development to one in which engineering design for a commercial project can be undertaken. To meet Shell's requirements, the selected technology had to enable front-end engineering and design to take place in 1998 and detailed engineering to start in 1999.

Accessibility of the Technology and Freedom to Act

Consideration was given to whether technical information related to the technology was either public knowledge and completely accessible or whether it was proprietary, and covered by patents. Also considered was whether or not technical information on all or part of the technology could be used for engineering design and commercial use without technology licensing arrangements.

Cost

The capital cost of constructing a commercial plant using the technology was used as a major screening parameter. Consideration was also given to the level of unit operating cost inferred from such factors as complexity and reliability.

Environmental Performance

Environmental performance was measured by the impact of the process on the environment, especially through the need to manage waste streams from the process, and most particularly tailings.

Complexity and Reliability

Consideration was given to the number of process units required compared to commercial operations. Reliability is related to the mechanical complexity of individual units. High reliability was given to demonstrated commercial performance.

Technical Risk

Technical risk was assessed by relating the stage of technology development and understanding the fundamental chemical and physical principles involved.

Prototype Required

Consideration was given to whether a commercial prototype was required to demonstrate commercial performance and the viability of the process before the design of the commercial facilities.

Additional Considerations

Although not used as a specific criterion for screening, consideration was given to whether application of the technology could lead to future significant improvements in cost and environmental performance.

SCREENING PROCESS

About 50 technologies were considered. By applying the screening criteria, 10 complete extraction processes or components of extraction processes were selected for further consideration:

1. Oil sand slurry transport.
2. Tank agitation for conditioning and storage.
3. Warm water (between 45°C to 50°C) extraction with no caustic addition.
4. Cold water (between 25°C and 45°C) extraction with coal flotation chemicals.
5. Bitmin extraction process.
6. Froth treatment using paraffinic solvent with settlers or with centrifuges.
7. Hydrocyclones.
8. Consolidated and combined tailings.
9. Paste tailings.
10. UMATAC pyrolysis process.

The first nine technologies are water-based bitumen extraction processes. The remaining technology, the UMATAC pyrolysis process, has been developed over a number of years and has now reached a semi-commercial stage for soil remediation and is proposed for commercial demonstration in an oil shale application.

TECHNOLOGY DESCRIPTIONS

Oil Sands Slurry Transport (Hydrotransport)

Developed as a lower cost alternative to long distance conveyor transport and large rotating conditioning drums, oil sand slurry transport (hydrotransport) technology has been successfully demonstrated in commercial application for a number of years.

Hydrotransport consists of creating a high-density oil sands water slurry close to the mine face and delivering the ore to the separation circuits through a slurry pipeline. The ore is conditioned while being transported in the pipeline, replacing the conditioning drum, or tumblers, used in the original commercial applications of the Clark hot water process. Hydrotransport became feasible at process temperatures of 50°C or less, where direct steam injection is not required to heat the slurry. Sufficient pipeline distance is required to provide the time and energy for conditioning.

Hydrotransport has been retrofitted into existing operations to replace tumblers, reduce process temperature and avoid conveyor extensions where mining operations have progressed further from the extraction facilities. Applications planned for grassroots mines have positioned the extraction facilities near the tailings disposal site. This will apportion most of the total transport distance between the mine pit and the tailings disposal site, to facilitate ore conditioning in the pipeline.

Tank Agitation for Conditioning and Storage

Tank agitation for conditioning and storage has been successfully used in the mineral and coal industries for maintaining solids in suspension and in preparing slurries of uniform density ahead of slurry pipeline transportation. This technology can be applied to provide surge capacity ahead of the extraction process by storing oil sand in a slurry form rather than in a dry state. Variations in the feed rate of mined oil sands delivered to the extraction plant can thereby be accommodated.

In storing and maintaining oil sands in suspension in the tanks, mechanical shear forces are applied either through mechanical stirrer agitation or by circulating the slurry using large hydraulic pumps. The shear forces incurred with this agitation are similar to, but up to four times greater than, those in a slurry pipeline. This shear energy, combined with heat transfer from the heated water in the slurry, provides sufficient energy to break down frozen lumps of oil sands. The separation of the bitumen from the oil sands is also initiated, i.e., the oil sands are conditioned.

Agitation tanks offer an alternative or possible addition to hydrotransport where optimal ore transport distances in the mine plan would not provide sufficient conditioning. Retention time and mechanical energy can be controlled in the design, whereas pipeline conditioning is a function of required transport distance. They also provide the opportunity to vary process conditions, such as

Tank Agitation for Conditioning and Storage (cont'd)

retention time and mechanical energy input, whereas slurry pipelines are fixed as a function of pipeline length.

Warm Water Extraction

The warm water extraction process applies conventional extraction concepts proven in commercial operation, but at a process temperature of 50°C to 55°C, rather than the 70°C to 75°C required in the conventional Clark hot water process. If high slurry densities are maintained, lower process temperatures result in lower energy requirements.

Bench and pilot testing has shown that, with the increased retention time during conditioning, bitumen recovery comparable to that obtained by the Clark hot water process can be achieved at lower process temperatures. The addition of sodium hydroxide as an aid for separating bitumen from the sand and clay particles is not required. Because sodium hydroxide acts as a particle dispersant, excluding it from the process is expected to improve the water clarification settling characteristics of fine tailings particles in recycle water.

Cold Water Extraction Process

Bitumen extraction pilots using process temperatures of between 25°C and 45°C have been carried out by others. At these temperatures, the addition of air and coal flotation-chemicals, such as kerosene and methyl isobutyl carbinol (MIBC) is required. These chemicals aid the flotation of bitumen and enable acceptable levels of bitumen recovery to be achieved. Hot water is introduced in the primary separation vessel as a froth underwash to enhance separation and to further heat the bitumen froth and increase its mobility.

Bitmin Extraction Process

The Bitmin extraction process uses a novel counter-current rotating-drum separator to provide conditioning and frozen lump digestion of the oil sands feed. Oil sands are introduced by a feed conveyor to about the middle of the rotating-drum, where they are contacted by hot slurry. Slurry and sand fractions move counter-currently and discharge from opposite ends of the drum. The additional residence time provided by the counter-current drum enables conditioning and frozen lump digestion to take place without introducing steam, and at lower temperatures than are required in a Clark hot water conditioning drum.

The conditioned bitumen slurry from the separator is further processed by conventional flotation methods to remove additional sand and clay fractions. Tailings from flotation are thickened using flocculant addition in a thickener and clarifier. The thickened material is then added to rejected sand fractions from the counter-current separator, filtered through conventional belt filters, and disposed of as semi-dry tailings. Water reclaimed from the thickener is heated and recycled as process water.

Bitmin Extraction Process (cont'd)

The Bitmin extraction process produces a bitumen froth of similar quality to that produced by the Clark hot water process.

Semi-dry tailings require less tailings storage area.

Paraffinic Froth Treatment

The paraffinic froth treatment technology uses the demonstrated phenomenon that, when sufficient quantities of paraffinic solvents are added to bituminous froth emulsions, an inversion of the emulsion takes place with water and fine solids being released. Some heavy hydrocarbon components of the bitumen are also precipitated. The more aromatic naphtha diluent applied in conventional froth treatment does not produce this effect. Laboratory and pilot testing has shown that a range of paraffinic solvents can be used, such as:

- butane
- pentane
- hexane
- natural gas condensates

The ratio of solvent to froth required to achieve inversion depends on the molecular weight of the paraffin, i.e., a lower ratio of butane to bitumen is required than with natural gas condensate.

When paraffinic solvent is added to bitumen froth in the ratio of about 2:1 and the mixture is given enough time to settle, more than 85% of bitumen in the froth can be recovered in the product. Recovery has been shown to increase with temperature. Further processing is required to recover the remaining bitumen from the settled solids and water.

Centrifuges are used in many industries to separate solid-and-liquid, and liquid-and-liquid phases. Successful application depends on the specific gravity difference between the phases. Therefore, centrifuges can be used to either process the bitumen froth to reduce the initial solids loading (as in existing operations) or to process the remaining emulsion of solids, hydrocarbon, solvent and water after inversion occurs. The approach with the lowest technical risk is to use centrifuges in the more conventional mode to process bitumen froth, as commercially applied in existing oil sands operations. Removing water, water-soluble salts and mineral solids, as well as asphaltene rejection, produces a superior feedstock for catalytic hydrogen-addition upgrading processes.

Consolidated Tailings

Work carried out by Syncrude and Suncor has shown that adding lime, acid and lime, or gypsum to mature fine tailings formed in tailings ponds increases the settling rate of clay fines and the ability to capture these fines within the coarse tailings fraction. This increase is orders of magnitude greater than if the clay

Consolidated Tailings (cont'd)

fines were left untreated. If released water is allowed to drain, a competent dry soil layer can be achieved. Both companies have proposed using this method to:

- treat the mature fine tailings currently contained in their existing tailings ponds
- treat any ongoing production of fine tailings streams
- increase the proportion of mine pit area that is backfilled to achieve a dry reclaimable soil surface for site reclamation

Thickened Paste Tailings

Adding chemical flocculants to aqueous mixtures containing fine solids provides a means for agglomeration of the solids to take place with resulting increase in settling rate and final solids density. Flocculant is usually added in large diameter thickener or clarifier vessels designed to provide the necessary retention time for settling to occur. Water released during settling can be recycled as process water, thereby also recovering heat which otherwise would have been lost. The selection of flocculant appropriate to the solids to be agglomerated and the amount of addition required are the major factors determining whether a commercial application is feasible.

Research is being carried out by Syncrude and Suncor to select an appropriate flocculant for oil sands tailings streams to improve the settling rates of fine clays. As well, research on addition rates is ongoing. Depending on the amount of coarse sand particles contained with the clays in the tailings stream, the thickened tailings will contain between 30% and 55% water. The manner in which this thickened, but not completely dewatered, material can be managed and reclaimed has not yet been developed.

A relatively dry tailings can be achieved by adding the flocculated clay fines to coarse material, then mechanically dewatering the mixture through belt filtration. However, the capacity limitations of individual belt filtration machines and the cost of additional solids handling makes this alternative financially unattractive.

PROCESS COMPARISON

Figure 5-5 summarizes the shortlisted technologies and indicates how they were combined to develop process options for comparison. Screening level economics were developed for each of the option configurations and compared to a baseline process configuration using technologies representing a next generation version of existing extraction plant configurations.

Results of Screening Analysis

For the Muskeg River Mine, processes using rotary breakers and agitation tank conditioning have better economics than those using drum conditioners or hydrotransport. Hydrotransport could be used in conjunction with rotary breakers and agitation tanks if mining operations were extended beyond the limits shown in the mine plan. Because agitation tank conditioning has not yet been applied in commercial oil sands operations, it involves a higher technical risk than hydrotransport. To mitigate this risk, Suncor has agreed to share with Shell production performance data from its Steepbank Mine rotary breaker and surge tank installation. The Steepbank Mine has a planned start-up in 1998. In addition, Shell will further pilot agitation tank conditioning as part of its pilot work in 1998.

Cases	Conditioning			Froth		Tailings		
	Drum	Slurry Pipeline	Slurry Tank	Naphtha Centrifuge	Paraffinic	Conv.	CT	Dry
Baseline	✓			✓			✓	
Warm Water - Conventional Tailings	✓				✓	✓		
Slurry Transport - Warm Water		✓			✓	✓		
Slurry Transport - Cold Water		✓			✓	✓		
Agitation Tank - Warm Water			✓		✓	✓		
Bitmin	✓				✓			✓
Warm Water - Dry Tailings	✓				✓			✓

Figure 5-5: Extraction Process Options

Lower temperature processes require less energy input, but require process additives to achieve acceptable levels of bitumen recovery. Shell believes that the technical risk of reducing process temperatures below the range of 45°C to 50°C is higher. At low process temperatures (between 25°C and 35°C), the physical and chemical mechanisms involved in the separation and flotation of the bitumen are different from those developed in the Clark hot water and warm water processes. Shell will continue to consider lower process temperatures. However, the current state of development of low-temperature processes is not sufficiently complete to allow them to be considered as the preferred option. The process configuration selected by Shell will not prohibit the use of lower process temperatures once commercial operations are established.

Froth treatment processes using naphtha dilution centrifuging are the basis for the existing commercial operations. Naphtha is readily available for these operations from the on-site upgrading process. Therefore, the use of naphtha as a

Results of Screening Analysis (cont'd)

process diluent has less technical risk than using paraffinic solvents. However, naphtha dilution centrifuging does not obtain the required product specification for pipelining. It also does not provide the opportunity to selectively reject asphaltenes. Therefore, Shell has selected the use of paraffinic solvents as the commercial basis on which to progress with piloting and front-end engineering in 1998.

Tailings management options were evaluated further to incorporate current knowledge and data from existing operations. This evaluation was validated through a review by experts from industry, research and academia. Industry participants included representatives from the existing operations. For further details of the tailings process selection, see Evaluation of Tailings Management Methods in Section 6.2.

OVERVIEW OF TAILINGS OPERATIONS

TAILINGS SETTLING POND

The warm water extraction process plant will produce most of the tailings as a slurry product consisting predominantly of water, sand and fine tailings (silts and clays). A second, smaller amount of fine tailings will be produced from the froth treatment process plant. Any residual bitumen that is not recovered in these two processes will remain on the sand and fines. The froth treatment tailings stream will also contain rejected asphaltenes and minor amounts of residual solvent (see Selected Process Scheme in Section 5.2). During the first four years of operation, all of the tailings will be deposited in a tailings settling pond. Starting in the fifth year of operation, decreasing amounts of tailings will be deposited in the pond as a result of placing tailings in-pit.

The settling pond will be located in the southwest area of the lease. For the topography in the pond area, see Section 4.1.

The starter dyke for the pond will be constructed of mine overburden and will follow the outline shown in Figure 6-1. The balance of the pond structure will be constructed from tailings. Tailings will be discharged into settling cells on top of the dyke to raise elevations. They will also be beached on the interior of the dyke to produce a broad, stable structure.

When deposited on the beaches or into the cells, the tailings stream will undergo segregation settling. Coarse sand will quickly settle on the beaches or in the cells. A dilute silt and clay slurry of thin fine tailings (TFT) will flow into the main pond water. The fines will settle from the pond water, and the clarified water will be recycled to the extraction process. The fine solids will ultimately thicken and settle to about 30% solids over five years, or less, to a mature fine tailings (MFT) layer.

CONSOLIDATED TAILINGS IN-PIT

In the fifth year of operation, the first mine pit area will be available for in-pit tailings placement. To avoid a continual buildup of fine tailings, the fines must be incorporated into the coarse sand deposit. This will be done by using a consolidated tailings (CT) process, whereby settled fine tailings (MFT) from the tailings settling pond will be removed hydraulically and mixed with coarse dewatered sand produced in the extraction plant. The MFT will be chemically treated to allow the fines to agglomerate and, when combined with the sand, will

CONSOLIDATED TAILINGS IN-PIT (cont'd)

produce a non-segregating mix for deposition in the mine pit. Over several years, the CT deposits will consolidate further and increase in strength.

Under this plan, the tailings settling pond will remain in operation over the project's life to serve as a settling basin for the fine tailings, which are recovered for the CT mix. At the end of the project's life, the MFT will be at the minimum working inventory and the mine pit will contain all of the consolidated tailings. The mine pit area will be available for restoration as final CT consolidation progresses. The tailings settling pond area will be drained into an end-pit lake and reclaimed after the end of mining operations (see Reclamation Approach in Section 6.5).

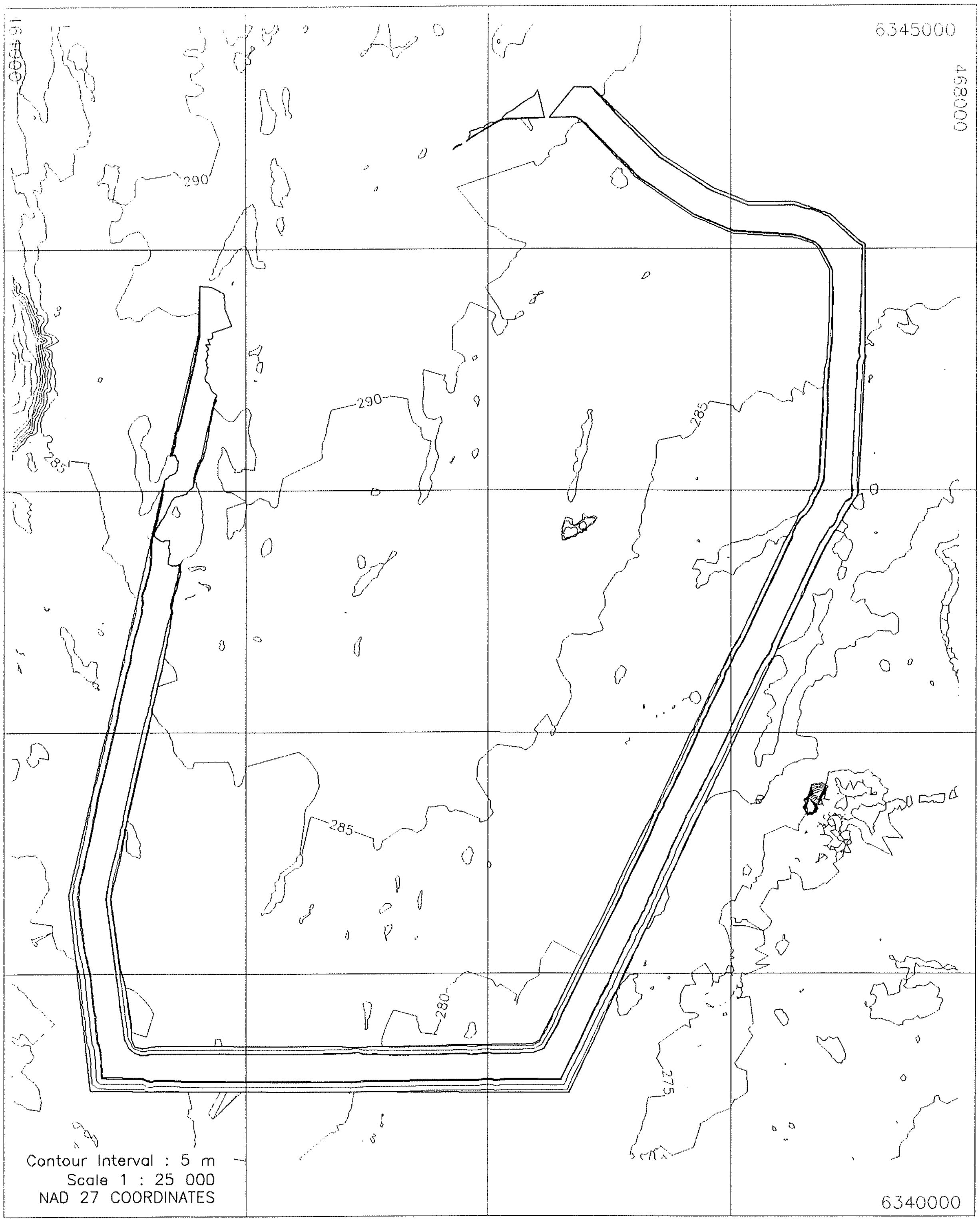


Figure 6-1: Outline of Tailings Settling Pond Overburden Starter Dyke

EVALUATION OF TAILINGS MANAGEMENT METHODS

OBJECTIVES OF TAILINGS MANAGEMENT PLAN

The objectives of the selected tailings management plan and tailings handling technology for the Muskeg River Mine Project were to:

- provide acceptable technical risk with technology phasing, if necessary
- effectively integrate tailings handling with all aspects of mining and extraction
- be environmentally acceptable during operations and after mine closure
- minimize the size of tailings storage areas external to the mine pit
- be cost effective over the tailings management life
- provide geotechnically stable storage structures and final landscapes
- enable the landscape to be returned to productive capability with biologically self-sustaining systems
- be simple to operate and minimize winter impacts

OPTIONS EVALUATED

Several tailings management methods were evaluated for the project (see Table 6-1), including:

- phased-in production of consolidated tailings
- the production of consolidated tailings from plant start-up
- paste stacking
- the production of solid tailings by filtration

Phased-in Production of Consolidated Tailings

The concept of a tailings settling pond with consolidated tailings in-pit involves placing all tailings from the extraction plant in the tailings settling pond for the first four production years. During the fifth year, the first mine pit would become available for tailings placement and production and in-pit storage of consolidated

Phased-in Production of Consolidated Tailings (cont'd)

tailings (CT) would begin. The consolidated tailings would be produced from MFT recovered from the tailings settling pond and sand from the cyclones in the extraction plant. The TFT from the cycloning would be sent to the tailings settling pond for settling into more MFT. The consolidated tailings production rate and, therefore, the depletion rate of the MFT inventory would be determined by the in-pit volume availability, but all MFT would be recovered from the pond by the end of the mine life. At that time, operations to move the residual TFT and recycle water to the end-pit lake would begin in order to allow pond restoration to start as early as possible.

Production of Consolidated Tailings from Plant Start-Up

Producing consolidated tailings from plant start-up could be attractive if this approach were able to reduce the volume of external storage, be relatively reliable to operate and be cost-effective. This concept uses a cycloning operation similar to the base scheme to produce a dewatered sand underflow and fines-rich overflow. The overflow stream would then be fed to a thickener vessel, where the fines settle to a thick paste. Consolidation would be enhanced by the use of chemical flocculants. The thickened paste slurry produced from the bottom of the thickener would then be combined with the sand from the cyclone underflow to produce the consolidated tailings, which would be pumped to the tailings settling pond (in the early years after start-up) or to in-pit storage (in later years).

The ability to produce consolidated tailings depends on the composition of the tailings mix, including:

- the sand to fines ratio
- the clay to water ratio
- fines dispersion

The variables must be controlled, because the variability of the natural ore grade, plus operating variations and upsets, will reduce capture efficiency from theoretical maximums. Therefore, production of consolidated tailings is not a 100% on-stream efficiency operation. A segregating tailings stream will be produced part of the time and storage volume must be available in the tailings settling pond or the in-pit area to accommodate this stream. Facilities to return the TFT, MFT and water produced in this storage will also be required.

Paste Stacking

Paste is made from fine tailings, which are densified to a high solids content by settling in a thickening vessel. Chemicals are usually required to make the fine particles flocculate, which aids the settling and densification process.

Paste stacking is based on separately handling the thickened fines (paste) and dewatered sand streams in an attempt to produce solid tailings without the need for filtration. The sand would be transported to the tailings settling pond area or in-pit to build sand cells. Infilling by the fines paste results in a solid structure, if

Paste Stacking (cont'd)

the paste stabilizes either by compression dewatering or, more likely, freeze and thaw action. Study of this concept revealed substantial technical and commercial issues, which ruled it out as an option for further consideration.

Moving the sand by truck requires a separate truck fleet for this purpose. If the sand were moved hydraulically instead, water would have to be added at the plant, followed by dewatering at the storage area. With respect to the fines (paste), a high solids concentration, up to 60%, must be produced to make a stable deposit after in-pit placement. This is not possible in conventional thickener operations. Further, it is not feasible to pump material at this solids concentration through long pipelines.

Production of Tailings by Filtration

To produce filtered tailings, thickened fines from a thickener vessel and dewatered sand from cyclone underflow are produced in the same way as for the consolidated tailings scheme. After the two streams have been combined, they are dewatered further on a belt-filter press to produce a solid cake. The cake is then transported by truck or conveyor belt to a pit area. This approach best meets the objective of reducing tailings settling pond storage and providing an early landscape in the mine pit for reclamation. However, filtering has a major drawback. It requires many large, enclosed mechanical filtration units, which results in an expensive facility. Large filtration units have not been commercially demonstrated in oil sands tailings operations. Further, a separate fleet of trucks or a conveyor system would be required for transporting the cake back to the mine pit for placement, which would increase fuel consumption and air emissions.

EVALUATION CRITERIA

The detailed review of the available techniques considered the following key criteria:

- Technical viability.
- Net present value capital and operating cost over the mine life.
- Fit the tailings settling pond to Lease 13 layout, with minimum area.
- Commercial readiness of the technology.
- Compatibility of the process with the extraction operations.
- Flexibility to exploit new technology.
- Simplicity of operations.
- Provide post-closure stability of landscape and structures.
- Provide earliest placement of tailings in-pit.
- Allow earliest site reclamation.
- Fit with mine plan.
- Minimize water quality impacts.
- Minimize impact of winter operations.

Table 6-1: Comparison of Tailings Management Alternatives

CASE	DESCRIPTION	ADVANTAGES	DISADVANTAGES	RISKS
1. Base Case	Tailings settling pond storage, CT production starts after four years	• Lowest risk operation. Time is available during early operation to develop and test the CT method. • Acceptable project economics. • Thickener system not required. All MFT is generated in the tailings settling pond. • All of the MFT is recovered from the tailings settling pond by end of mine life. • Potential faster settling behaviour from caustic-free extraction process will allow earlier water recycle and less river intake.	• Large pond for clarification and settling of TFT to MFT. • Tailings settling pond is operated for life of mine. • Sand structure remains at end of mine and requires reclamation for long-term landscaping and drainage.	• MFT may not be of sufficiently low water content when required for CT. • Settling behaviour of fines from caustic-free extraction needs to be verified. • Consolidated tailings (CT) parameters, i.e., segregation boundaries, water chemistry, geotechnical behaviour, need to be verified.
2. CT at Plant Startup	CT from initial operation with cyclone and thickener	• Production of paste in plant allows warm water recycle with energy savings.	• Tailings settling pond is operated for life of mine and is required for tailings storage during early operations, for handling non-CT events and for reclaim water recovery. Size same as base case. • Once deposited in tailings settling pond, CT cannot be moved. End-of-mine lake area in pit will be larger. • Precludes phasing in of CT operations. High risk for early operation because of unknown parameters and unproven equipment. • Poorer economics than base case.	• Operation of cylones, thickener and CT plant all required for initial operation. These operations are not proven. • Quality of thickener recycle water not known. May get ultrafines buildup which impairs extraction performance. • Key parameters for CT production, i.e., clay contents, sand/fines ratios, water chemistry and segregation boundary are not known with certainty.
3. Paste Stacking	Paste from initial operation to mine and stack in sand cells	• Paste operation allows warm water recycle in plant for energy efficiency. • Somewhat smaller tailings settling pond.	• Complex operation to produce desired paste solids content, i.e., double cyclones, deep bed thickener. • Expensive flocculants required to obtain target paste solids content. • Tailings settling pond still required for early operation, non-paste events and water recovery. • Separate operations for fines and sand is complex and expensive. Minimum fines captured naturally, since no combined tails beaching operations. • Paste must be deposited sub-aerially to prevent repulping. Decanting operation also required. Winter operation deemed infeasible. • Freeze and thaw likely required to provide stable fines deposit. • Poorer economics than base case.	• Ability to produce paste of required thickness unknown and needs R&D. • Quality of thickener recycle water is unknown. May get buildup of ultrafines which inhibit extraction performance. • Pumping limits for paste are unknown. • Paste consolidation and stability behaviour unknown.
4. Filtered Tailings	Filtration of sand and thickened fines in belt filter presses	• Tailings to in-pit earlier, therefore smaller tailings settling pond needed. • Preconsolidation in filtration system means minimum settling in-pit after placement - early reclamation possible. • Less complex overburden plan. • Energy savings due to warm water internal recycle in plant. • Earlier mine reclamation on stable deposit.	• Prefiltration conditioning requires cyclone and thickener operation and use of flocculants. • Filtration plant is large and costly, with multiple filtration units. • Filtration plant needs to be indoors for weather protection - unable to process froth treatment tailings (solvent risk). • Narrow operating range for reliable production of solid filter cake. Upset operations require routing to backup storage and recovery from same. • Require separate truck fleet to backhaul tailings. Freezing issues with handling damp tailings. • Capital costs high and overall economics unfavorable.	• Large scale filtration operations on oil sands tailings is not demonstrated. • Requirement for thickening and filtration chemical agents is not defined and could escalate operating costs significantly. • Quality of filtration recycle water is unknown. Buildup of ultrafines would inhibit extraction performance. • End dump filtered tailings are loose and may be subject to liquefaction. Detailed engineering studies and testing required.

SELECTED OPTION

Detailed technical evaluations were carried out with the assistance of representatives from existing industry operators, academia and experienced consultants. Based on the evaluations, it was concluded that the commercial case for the Muskeg River Mine tailings management should be based on phased-in production of consolidated tailings for in-pit placement. Table 6-2 summarizes the ranking of the tailings management options.

Table 6-2: Evaluation of Tailings Management Alternatives

Technology	Ranking
Phased-in CT after Year 4	1
CT at start-up	3
Paste stacking	Technically infeasible
Filtered tailings	2

The key factors influencing the decision were that:

- Using a tailings settling pond for combined tailings in early operation provides the simplest approach and the most flexibility to manage start-up and initial operations.
- The tailings settling pond, used initially for storing total tailings and settling TFT to MFT, can be used after CT production starts to serve as a thickener and as a storage area for non-CT streams.
- Consolidated tailings operations begin when in-pit storage volume becomes available in the fifth year of mine operations.
- The consolidated tailings production rate starts at 30% and builds up to a maximum to match available mine volumes and MFT availability. This allows CT operating experience and improved plant reliability to build up over several years.
- CT consolidation settling occurs at a rate that provides an acceptable schedule for reclamation operations.
- The consolidated tailings plant is the simplest configuration, requiring only cyclones and chemical addition facilities. This enhances overall operations reliability.
- Because consolidated tailings are not produced until the fifth year of operation, there is adequate time to finalize research and development work to identify the most reliable consolidated tailings production method.
- Any benefits in caustic-free tailings behaviour related to tailings handling can be studied before consolidated tailings methods are finalized.

SELECTED OPTION (cont'd)

- This option is the most economic and contributes to realizing acceptable economics to advance a commercial development on Lease 13.

TECHNOLOGY DEVELOPMENT

Shell recognizes that developing tailings handling methods that minimize land disturbance and the consequent impact on the environment and oil sands resource recovery is a high priority for the industry.

Based on the assessments and its reviews of industry progress on tailings handling methods, Shell has concluded that tailings handling methods based on a phased-in CT approach are the most advanced in terms of technical and commercial development. It is the only alternative method to current practice about which enough is known to enable it to be used in project design.

CT technology was developed as a result of more than five years of work by the Fine Tailings Fundamentals consortium, and is now being field demonstrated by both Syncrude and Suncor. Syncrude and Suncor have proposed to apply this method in current and future operations. CT deposits have the benefit that, as they progressively consolidate towards a geotechnically stable mine backfill, they allow for reclamation of the disposal sites as a solid landform. The reduced volume of total material that must be disposed of, both in-pit and out-of-pit, results in less total land disturbance and a reduced potential for loss of oil sands resources. Shell recognizes that ongoing research is required and is working through CONRAD to better define the:

- optimum CT composition
- consolidation behaviour
- release water properties
- reclamation techniques

All tailings technologies require an initial out-of-pit storage area until in-pit placement can begin, usually four to six years after project start-up. With the application of CT technology, Shell has tried to minimize this out-of-pit storage area. The minimum area is dictated by:

- sand volumes
- dyke geometry
- construction limits
- site-specific conditions

Using the tailings settling pond as a recycle water clarifier and fines thickener provides maximum operating flexibility and avoids the capital and operating costs associated with the alternative of performing this function with plant equipment. The CT method also allows low-cost slurry transportation techniques

TECHNOLOGY DEVELOPMENT (cont'd)

to be used. These transportation methods are well proven and used worldwide in the minerals industry for solids handling and transportation.

Shell will continue to actively explore improved tailings management methods. There are inherent economic and environmental incentives in reducing tailings settling pond storage and tailings processing costs for equipment and chemicals. However, currently, the use of hydraulic transport and the phase-in of CT production provide the only technically secure approach and the best economics.

FALLBACK PLAN

If a fallback approach is required, the more conventional method of depositing mature fine tailings into the mine pit, with closure by water capping, would be used. Meanwhile, other methods that take advantage of the expected behaviour of the caustic-free tailings will also be investigated through pilot tests and engineering studies. This will include work with a new integrated pilot plant to be operated in 1998 in support of front-end engineering and design.

TAILINGS MANAGEMENT PLAN

SCOPE

The tailings management plan addresses the objective of minimizing the size of the tailings settling pond. This is accomplished by arranging the mine plan to provide available in-pit CT storage area as soon as possible (in the fifth year of operation) and subsequently ramping up CT production as mine pit area is available. This subject describes the sequencing of tailings activities and provides the material balances for the tailings settling pond and in-pit tailings operations.

TAILINGS SETTLING POND

The tailings settling pond required for storing all tailings during early operations (see Figure 6-2) will be designed and sized to accommodate the tailings production before mine pit storage is available.

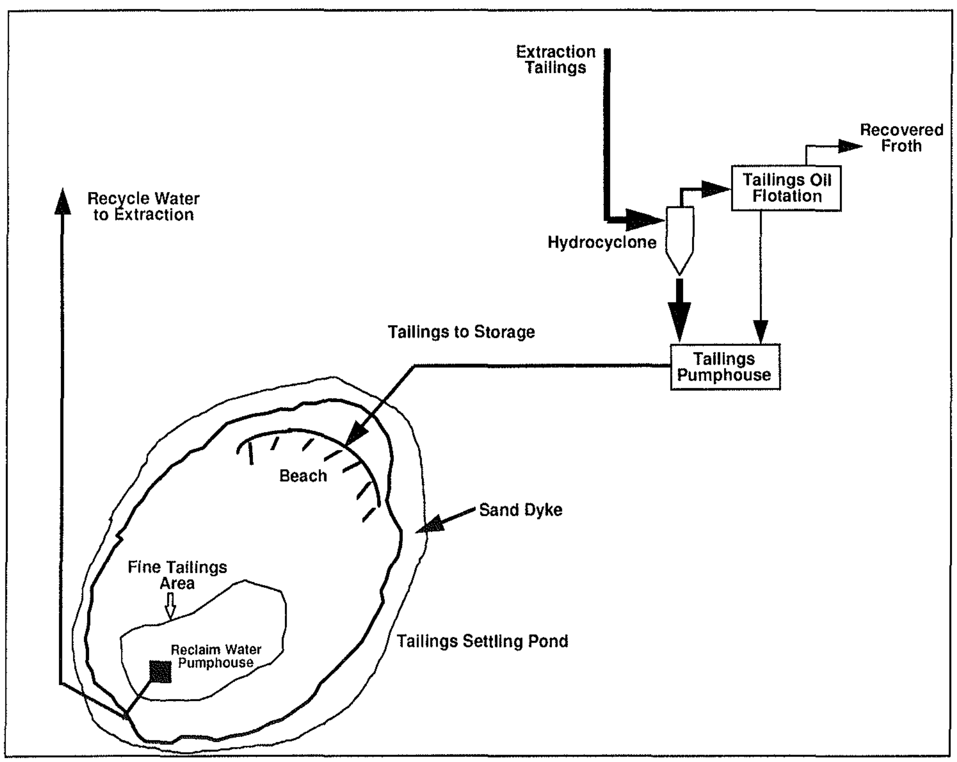


Figure 6-2: Initial Tailings Operations

TAILINGS SETTLING POND (cont'd)

Initial mine overburden will be used to construct the initial starter dyke. This will be followed by construction with sand tailings to build a pond retention structure of compacted sand and beach. This retention structure will be simultaneously infilled with TFT, which will settle and allow recycle water to be reclaimed. The TFT will settle or dewater to a higher solids concentration to produce an MFT layer. Meanwhile, the deposition of sand beaches will also trap and entrain a large percentage (up to 60%) of the fine tailings.

The pond will continue to provide storage for tailings sand, MFT and recycle water during the operational life of the mine, as required to support the CT operations. The pond layout is shown in:

- Figure 6-3 showing year end 2005
- Figure 6-4 showing year end 2022

Figure 6-5 shows the overall construction concept for the pond.

CONSOLIDATED TAILINGS OPERATIONS

Consolidated Tailings Plant

When in-pit space contained by overburden dykes and pit wall is available, consolidated tailings production will begin (see Figure 6-6). The consolidated tailings plant is scheduled to start operations in the fifth year after the initial mine start-up, and will operate for the project's life. Plot space for these facilities will be provided in the initial plant layout.

Chemical addition and mixing equipment will be added for the CT operations. The chemicals will be either gypsum or sulphuric acid and lime, depending on the water chemistry. The gypsum and lime will be commercial grade.

MFT recovery equipment and MFT return lines from the tailings settling pond will also be installed for startup of CT production.

CT Process Considerations

The consolidated tailings plant will operate jointly with the extraction plant where the cyclone separators produce two streams:

- a fines and water-rich overflow stream
- a sand-rich underflow stream

The cyclone overflow will be routed to the tailings settling pond to settle out fine tailings and to dewater them. The consolidated tailings will be made by:

1. Reclaiming settled fines (MFT) from the pond.
2. Combining the MFT with cyclone underflow in the plant.
3. Chemical treatment.

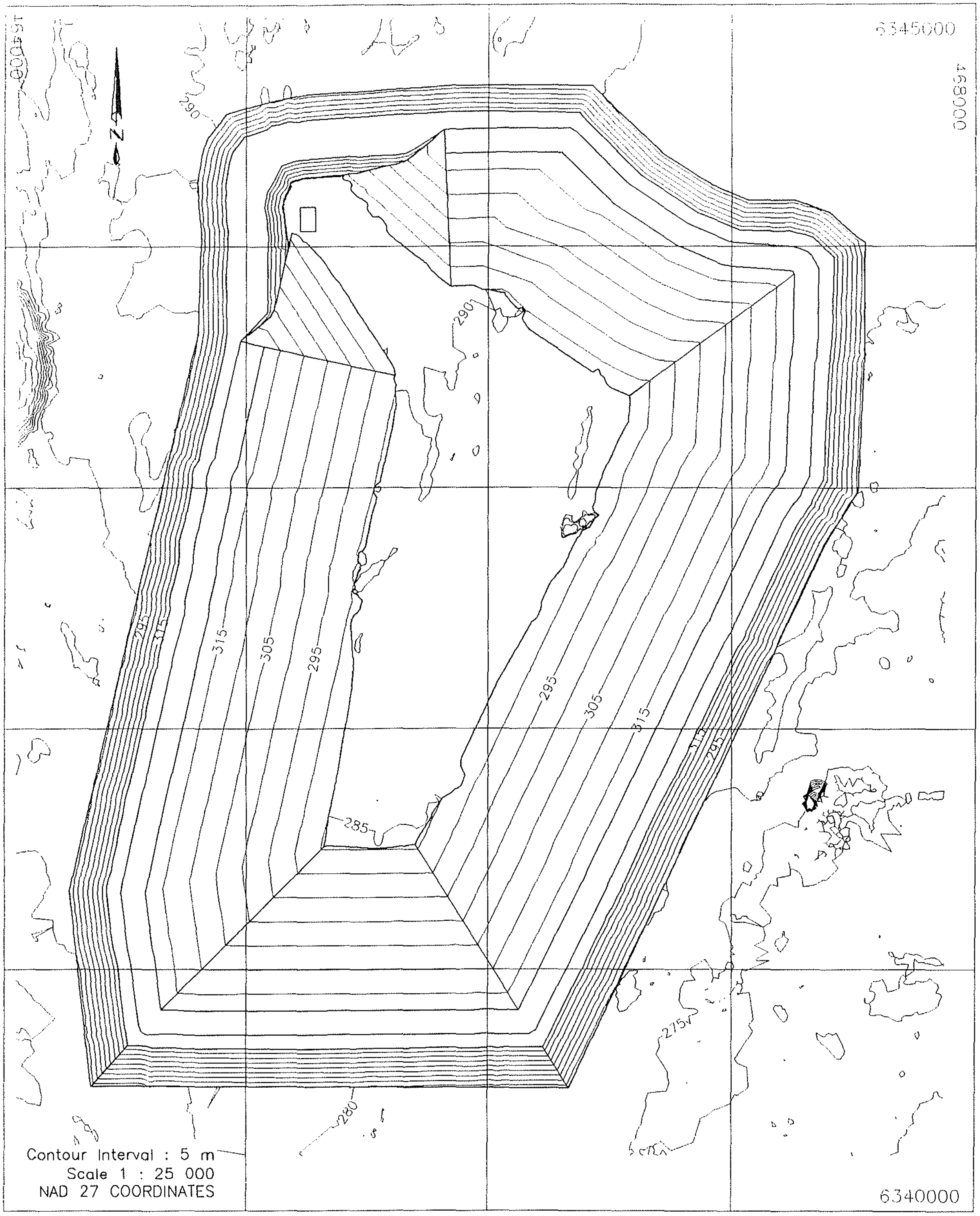


Figure 6-3: Tailings Settling Pond at December 31, 2005

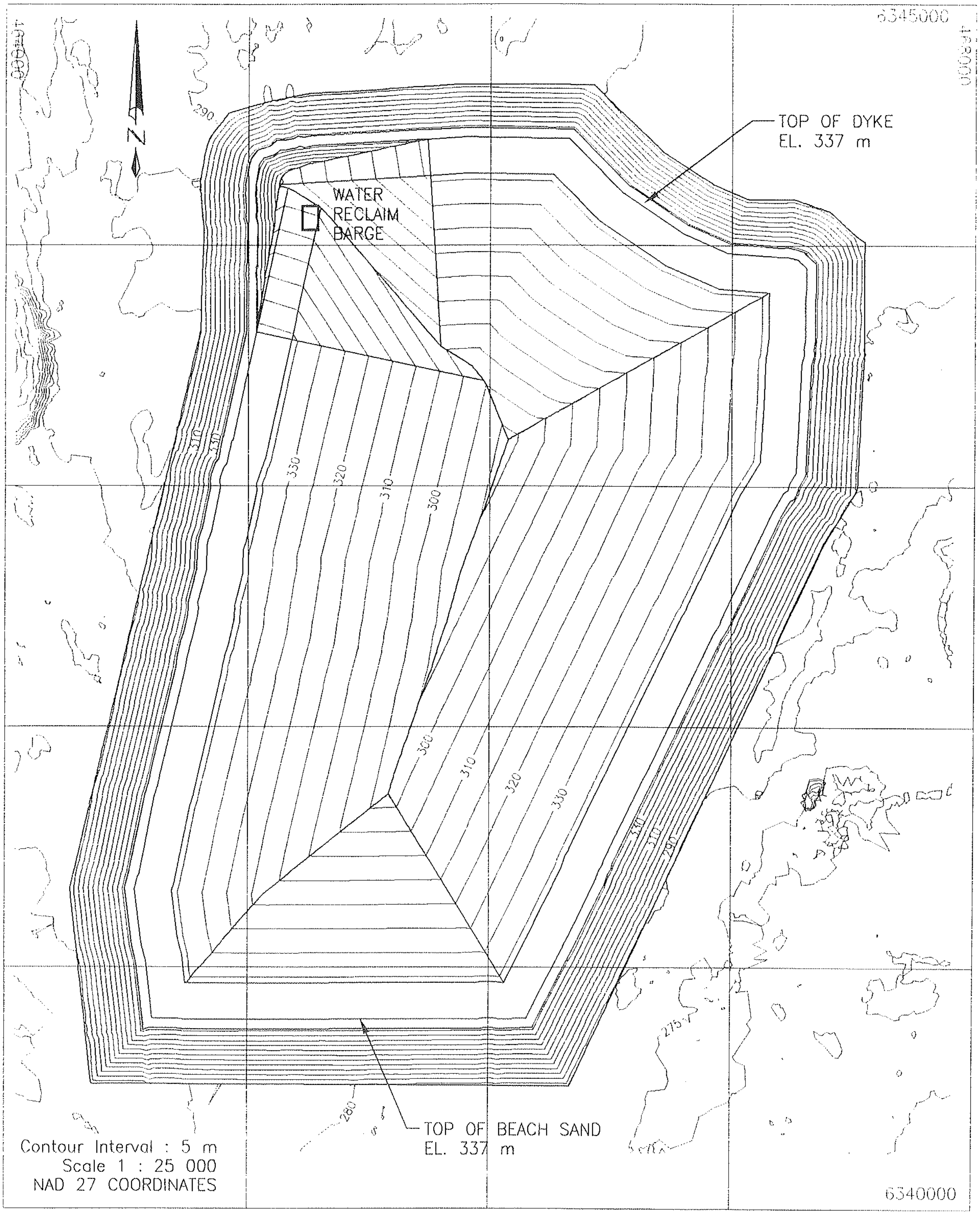


Figure 6-4: Tailings Settling Pond at December 31, 2022

CT Process Considerations (cont'd)

Depositing the cyclone overflow to the tailings settling pond will form a limited amount of beach and contribute a thin fine tailings stream, which will settle to MFT for subsequent use in consolidated tailings. Because most of the tailings will now be going directly into the pit as CT, the annual amount deposited in the tailings settling pond will be greatly reduced.

The consolidated tailings management plan recognizes that the production of consolidated tailings as a non-segregating product will not occur all of the time. First, the consolidated tailings plant is an operating facility with an assumed reliability factor of 95%. Second, when consolidated tailings are generated by mixing sand, MFT and chemicals, it is estimated that the process will produce a non-segregating mix 85% of the time. Therefore, the overall consolidated tailings stream factor is 81%.

The segregating stream that is formed during these non-CT operations must be handled within the overall operating scheme. It will continue to be routed to the in-pit cell or diverted to the tailings settling pond. In either case, the stream will segregate and deposit beach and runoff containing fine tailings. If in-pit, the beach will be deposited along with consolidated tailings. These beaches will fill the upstream crests of the in-pit dykes, assisting in overall dyke integrity. The fine tailings will then be returned to the tailings settling pond.

At the end of the mine's life and the end of plant and CT operations, the tailings settling pond will contain a residual volume of TFT that has not settled to MFT, with a clear water zone on top. To facilitate reclamation of the tailings settling pond area, this TFT and water will be transferred to the end-pit lake after it has been sufficiently aged to reduce toxicity.

SEQUENCE OF TAILINGS ACTIVITIES

The tailings management plan meets the primary objective of placing tailings into the mine pit as soon as possible, in order to minimize the size of the tailings settling pond. Before in-pit filling can begin, an economically sized area of pit floor contained by both in-pit dykes and elements of the perimeter pit wall must be available. The overall schedule that fits these requirements is given in Table 6-3.

TAILINGS MATERIAL BALANCE

The annual material balance over the life of tailings placement is given in Table 6-4, which shows the material balance flows each year to both the tailings settling pond and the pit. Figure 6-7 shows the overall accumulated amounts of the various tailings components over the project life.

IN-PIT TAILINGS PLACEMENT

The topographic site plan (see Figure 6-8) shows the proposed in-pit dykes. The in-pit volumes and elevations for in-pit tailings placement are shown in Table 6-5.

In-pit tailings placement begins with CT placement in Cell 1 in 2006.

As a result of mine pit volume restrictions, full CT production cannot be achieved initially and production will be ramped up from 30% to 85% of total tailings produced between 2006 and 2013. The in-pit volume can support full CT production after 2013. Planning for in-pit volumes and tailings and water handling requirements consider a CT plant reliability factor of 95% and an efficiency of the CT process of 85%, giving an overall CT production stream factor of 81%. Both segregated sand and MFT will be produced during the periods of non-CT operation.

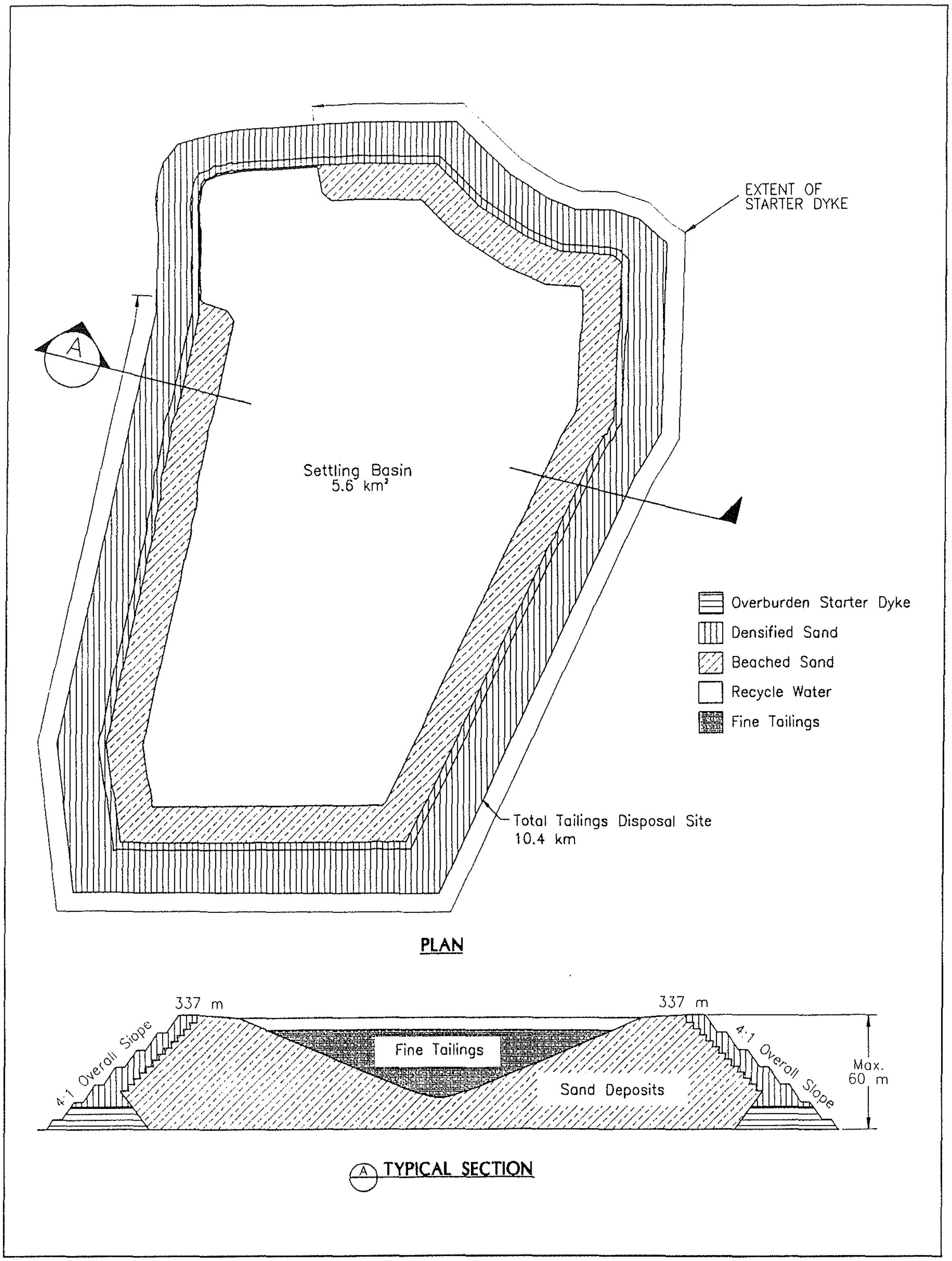


Figure 6-5: Tailings Settling Pond Construction Concept

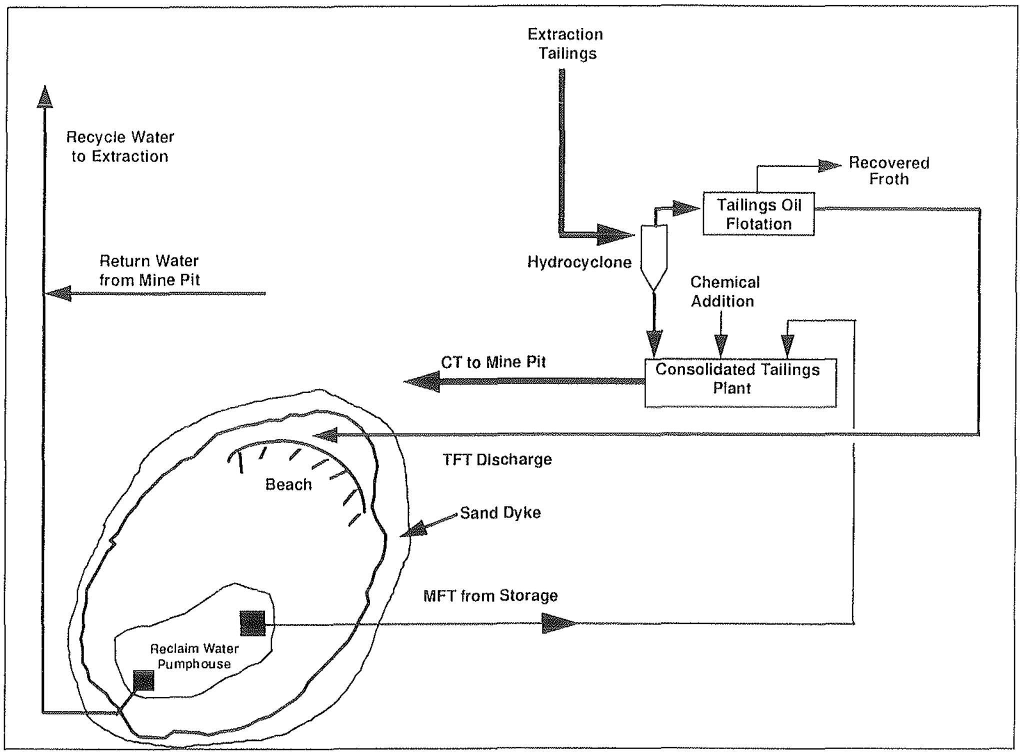


Figure 6-6: Production of Consolidated Tailings Using Stored MFT

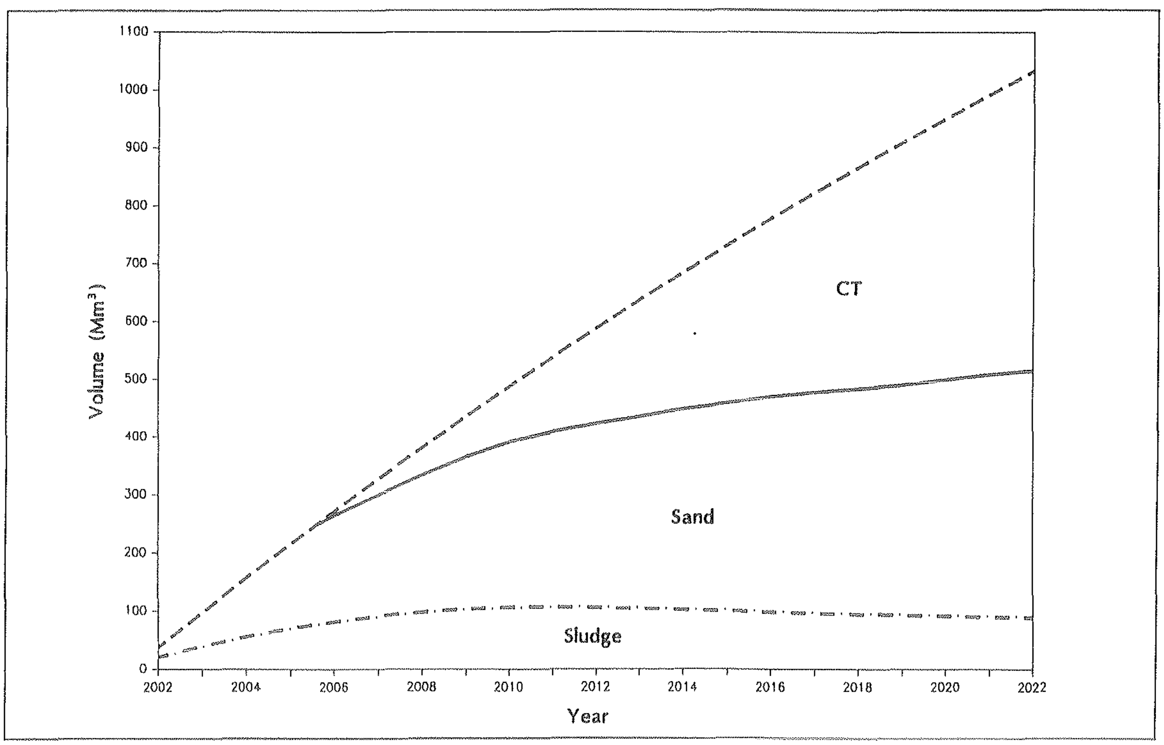


Figure 6-7: Muskeg River Mine Tailings Inventories

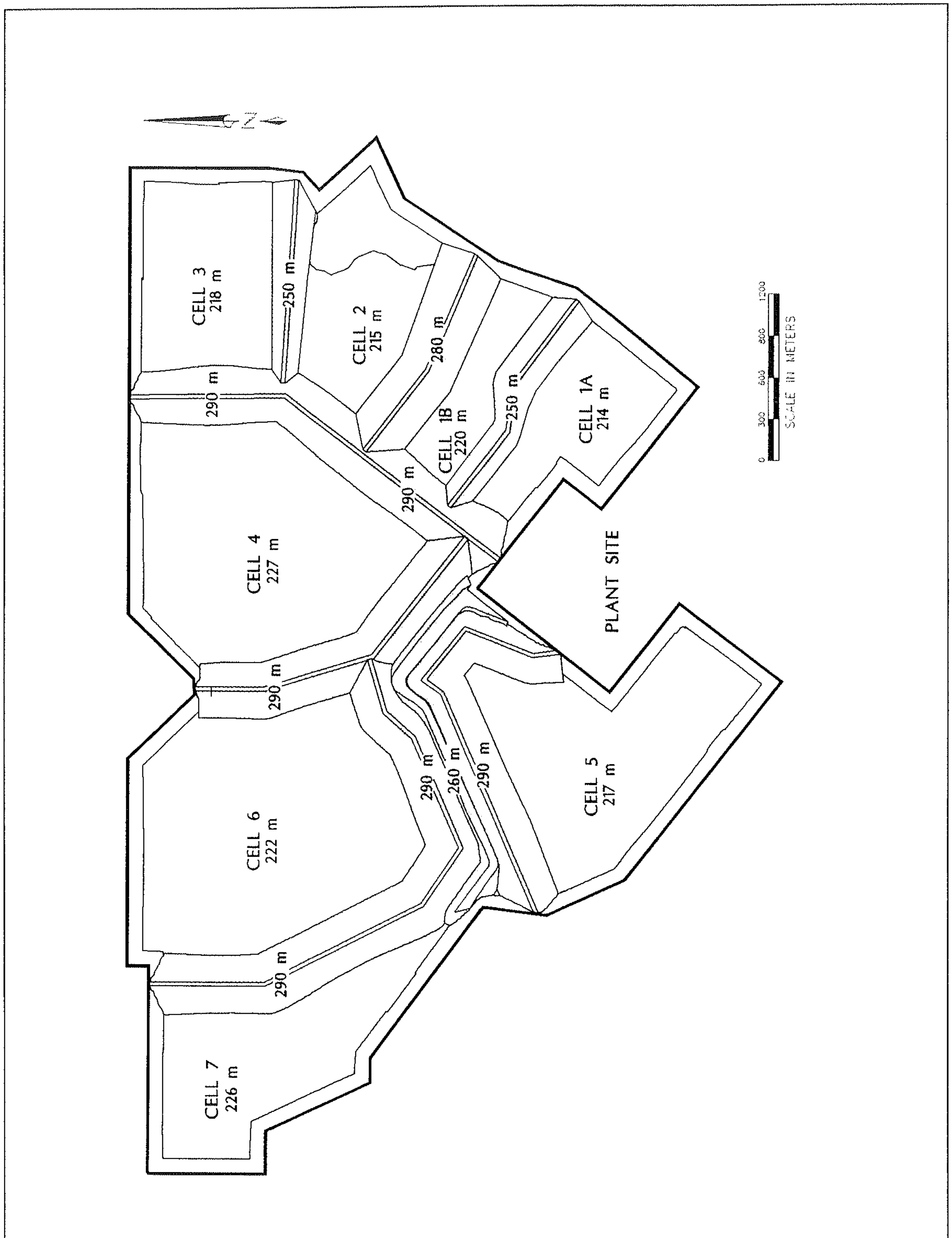


Figure 6-8: Site Plan Showing Proposed In-Pit Dykes

Table 6-3: Tailings Activity Sequence

Location	Timeline	Activity
Tailings settling pond	1999-2001	Construction on muskeg, sand drainage layers, upstream cut-offs as required and starter dyke construction.
	2002-2005	Conventional disposal (cell, beach, and fine tailings settling pond).
	2006-2013	Mature fine tailings transferred for CT operations at rate of 30% ramping up to 85%.
	Post 2022	Transfer remaining thin fine tailings to the end-pit lake. Daylight interior bowl of tailings settling pond with drainage outlet to north. Use spoil to make up in-pit pond grades, as appropriate. Three to four years is required to allow for drawdown effects on interior beaches. Transfer sand from tailings settling pond, as required, to make up grade for lease drainage plan and end-pit lake littoral zones
In Pit	2002-2006	Rejects placed in Cell 1. Overburden dyke construction to start Cell 1.
	2006 -2011	Continue overburden dyke construction. Place CT in Cell 1. Oversize rejects end-dumped in Cell 1 concurrent with CT.
	2011-2022	Continue reject placement in Cell 1 over CT.
	2012-2022	Infill remainder of cells. Transfer MFT from segregating CT operations to tailings settling pond. Reject placement on Cell 2 and 3 over CT. Use portion of non-CT production sand stream to infill over design CT elevation in Cells 1, 2 and 3. Infill Cell 6 with overburden. Transfer sand from tailings settling pond, as required to make up elevation deficiencies in final grade as a result of CT settlement and final drainage topography. Waste overburden and intraburden to Cells 1, 2 and 3 to make up elevation deficiencies in final grade as a result of CT settlement and final drainage topography.

Table 6-4: Material Balance for Tailings Settling Pond and CT Production

	Tailings Settling Pond									CT Production	
Year	O/B (Mm^3)	Dyke Cell Sand (Mm^3)	Beach Sand (Mm^3)	Cumulative Sand Stored (Mm^3)	Cumulative TFT and MFT (Mm^3)	MFT @ 30% Solids (Mm^3)	Cumulative Water (Mm^3)	Top of Dyke Elev. (m)	Sand for Post CT Overfilling (Mm^3)	% of Mine Feed to Cyclones	Annual CT to Mine Pit (Mm^3)
pre 2002	11.0										
2002		7.5	14.6	22.1	12.0	0	9.6	297	0	0	0
2003		15.0	29.2	66.3	32.4	0	32.3	306	0	0	0
2004		15.0	28.0	109.2	48.0	0	20.0	313	0	0	0
2005		15.0	28.2	152.4	61.9	0	20.0	320	0	0	0
2006		15.0	17.2	184.6	74.1	0.99	20.0	325	0	30	12.2
2007		15.0	8.7	208.3	84.3	5.19	20.0	328	0	50	19.9
2008		15.0	8.9	232.2	93.6	9.47	20.0	331	0	50	19.4
2009		7.0	17.1	256.3	98.7	14.00	20.0	333	0	50	18.6
2010		3.1	10.2	269.5	101.3	17.20	20.0	335	0	75	26.7
2011			9.6	279.1	102.5	20.19	20.0	336	0	85	30.7
2012			5.3	284.4	104.6	23.01	20.0	337	4.6	85	33.7
2013			4.1	288.5	105.7	22.45	20.0	337	1.5	95	36.0
2014			4.2	292.7	107.0	21.54	20.0	337	1.5	95	36.2
2015			4.3	297.1	104.4	16.24	20.0	337	1.6	95	37.0
2016			4.1	301.1	101.4	13.52	20.0	337	1.5	95	33.9
2017			4.0	305.2	98.6	11.29	20.0	337	1.5	95	37.2
2018			4.0	309.2	95.9	9.48	20.0	337	1.5	95	36.1
2019			4.0	313.2	93.3	8.24	20.0	337	1.5	95	35.0
2020			4.0	317.2	90.9	5.99	20.0	337	1.5	95	33.9
2021			4.0	321.2	88.4	3.54	20.0	337	1.5	95	37.1
2022			4.0	325.2	86.4	1.49	20.0	337	1.4	95	35.5

Table 6-5: In-Pit Cell Volumes Summary

	Cell 1						
	Total Volume 130 Mm³		O/B Volume 8.1 Mm³		CT Volume 121.9 Mm³		
	% Streams to Cell 1	Cumulative C/T (Mm³)	Cumulative Beach (Mm³)	Sub total Cell 1 Storage (Mm³)	Cumulative O/B and Reject Storage (Mm³)	Total Cell 1 Storage (Mm³)	CT Elevation (m)
2002					0		
2003					0		
2004					1.0		
2005					2.0		
2006	100	12.2	1.9	14.1	3.0	17.1	230
2007	100	32.0	5.0	37.1	4.1	41.1	245
2008	100	51.5	8.2	59.7	5.1	64.8	249
2009	100	70.1	11.3	81.4	6.1	87.5	259
2010	100	96.8	15.8	112.6	7.1	119.7	272
2011	31	104.5	17.4	121.9	8.1	130.0	275
2012					9.1		
2013					10.1		
2014					11.2		
2015					12.3		
2016					13.3		
2017					14.3		
2018					15.3		
2019					16.3		
2020					17.3		
2021					18.2		
2022					19.2		

	Cells 2 and 3						
	Total Volume 210 Mm³		O/B Volume 0 Mm³		CT Volume 210 Mm³		
	% Streams to Cell 2 and 3	Cumulative C/T (Mm³)	Cumulative Beach (Mm³)	Sub total Cell 2 and 3 Storage (Mm³)	Cumulative O/B and Reject Storage (Mm³)	Total Cell 2 and 3 Storage (Mm³)	CT Elevation (m)
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
2010							
2011	69	23.0	3.6	26.5	0	26.5	232
2012	100	56.7	8.9	65.6	0	65.6	245
2013	100	92.7	14.8	107.5	0	107.5	253
2014	100	128.9	20.9	149.8	0	149.8	264
2015	100	165.9	27.1	193.0	0	193.0	276
2016	49	180.1	29.9	210.0	0	210.0	283
2017							
2018							
2019							
2020							
2021							
2022							

Table 6-5: In-Pit Cell Volumes Summary (cont'd)

Cell 4
Total Volume 170 Mm^3 O/B Volume 11.7 Mm^3 CT Volume 158.3 Mm^3

	% Streams to Cell 4	Cumulative C/T (Mm^3)	Cumulative Beach (Mm^3)	Sub total Cell 4 Storage (Mm^3)	Cumulative O/B and Reject Storage (Mm^3)	Total Cell 4 Storage (Mm^3)	CT Elevation (m)
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
2010							
2011							
2012							
2013							
2014	0	0	0	0	11.7	11.7	
2015	0	0	0	0	11.7	11.7	
2016	51	19.70	2.99	22.7	11.7	34.4	244
2017	100	56.94	8.74	65.7	11.7	77.4	259
2018	100	93.04	14.48	107.5	11.7	119.3	271
2019	100	128.04	20.23	148.3	11.7	160.0	283
2020	32	136.20	22.07	158.3	11.7	170.0	285
2021							
2022							

Cell 5
Total Volume 148.8 Mm^3 O/B Volume 35.1 Mm^3 CT Volume 113.7 Mm^3

	% Streams to Cell 5	Cumulative C/T (Mm^3)	Cumulative Beach (Mm^3)	Sub total Cell 5 Storage (Mm^3)	Cumulative O/B and Reject Storage (Mm^3)	Total Cell 5 Storage (Mm^3)	CT Elevation (m)
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
2010							
2011							
2012							
2013							
2014							
2015					35.1	35.1	
2016					35.1	35.1	
2017					35.1	35.1	
2018					35.1	35.1	
2019					35.1	35.1	
2020	68	25.76	3.91	29.7	35.1	64.8	251
2021	100	62.82	9.66	72.5	35.1	107.6	270
2022	100	98.34	15.35	113.7	35.1	148.8	283

Table 6-5: In-Pit Cell Volumes Summary (cont'd)

	Cell 6 Total Volume 210.2 Mm^3 O/B Volume 210.2 Mm^3 CT Volume 0 Mm^3						
	% Streams to Cell 6	Cumulative C/T (Mm^3)	Cumulative Beach (Mm^3)	Sub total Cell 6 Storage (Mm^3)	Cumulative O/B and Reject Storage (Mm^3)	Total Cell 6 Storage (Mm^3)	CT Elevation (m)
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
2010							
2011							
2012							
2013							
2014							
2015							
2016					40.7	40.7	
2017					74.0	74.0	
2018					101.3	101.3	
2019					122.6	122.6	
2020					152.1	152.1	
2021					190.4	190.4	
2022					210.2	210.2	

	Cell 7 Total Volume Available 118.7 Mm^3 O/B Volume 0 Mm^3 CT Volume 0 Mm^3						
	% Streams to Cell 7	Cumulative C/T (Mm^3)	Cumulative Beach (Mm^3)	Sub total Cell 7 Storage (Mm^3)	Cumulative O/B and Reject Storage (Mm^3)	Total Cell 7 Storage (Mm^3)	CT Elevation (m)
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
2010							
2011							
2012							
2013							
2014							
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022	Fines and water transferred to end-pit lake from tailings settling pond after 2022 is 106.4 Mm^3.						

SCOPE

Facilities for handling the tailings sand, fines and water, and to produce and place CT, represent a major portion of the Muskeg River Mine site facilities. This subject describes the:

- design and construction of the tailings settling pond and in-pit holding dykes
- design of the tailings handling equipment

TAILINGS SETTLING POND DESIGN CRITERIA

The layout of the tailings settling pond is governed by production volumes and geotechnical criteria. The annual volumes of sand and fine tailings that require storage were calculated by the tailings materials balance (see Tailings Management Plan in Section 6.3). The major design criteria for the tailings settling pond retention structure, settlement area and seepage collection are summarized in Table 6-6.

FOUNDATION DESIGN GEOTECHNICAL CONSIDERATIONS

The evaluation of the tailings foundation design for the Muskeg River Mine included an evaluation of known site conditions from Alsands work and geological interpretations.

During the Alsands development, the foundation conditions were investigated by a combination of drilling and geophysical methods. Further exploration will be undertaken in the 1998 winter field program.

The foundations are underlain by a combination of:

- muskeg
- holocene clay
- clay and clay till
- sands and gravel
- ice-rafted Clearwater Formation
- McMurray Formation, including clays

Table 6-6: Tailings Settling Pond Retention Structure Design Criteria

Component	Design Considerations	Off-Setting Factors
Retention Structure:		
Offsets	East 200 m from Highway 63 and 800 m from the Athabasca River. North and east 100 m from the Shell plant access road and 200 m from the Muskeg River.	Additional 100 m from Highway 63 provides environmental buffer zone.
Overall geometry	Downstream slope at 4:1. Crest width 40 m. Maximum dyke height 60 m.	Intermediate berms required for monitoring access. No Clearwater or McMurray marine clays are likely present (see Regional Geology in Section 2.1).
Construction method	Modified upstream method with step out over beach sands.	Design based on compacted dilatant zone having minimum extent to support weak BBW sands.
Overburden starter dyke	Overburden required to a width 2/3 of dyke height. Muskeg consolidation requires pre-construction of initial sand lift and overburden starter dyke beginning in winter 1999-2000.	Overburden not required in higher elevation sections to north.
Compacted cell	Conventional cell construction and compaction. Fines content (less than 44 μm) of cell sand assumed to be 4%.	
Settlement Pond:		
Pond size	Dictated by sand storage volume.	Preferred below water deposition to enhance fines capture in beaches.
Beach	Beaches based on a 5% overall slope. Beaches based on having 9.3% fines (less than 44 μm).	Slope of BBW steeper than BAW, average assumed for design.
Water inventory	No reclaim water for about two years until 3 m deep clear water zone is formed.	May require one year or less with caustic-free tailings.
Fine tailings consolidation	Pond design assumes five years settling time to 30% solids content.	Might get more favourable response of quicker settlement and higher solids content with caustic-free tailings.
Seepage Collection:		
Interior drainage	Seepage from construction water and infiltration collected internally by collector pipes and filter cloth drains. Seepage in range of 0.5 m^3/d/m run.	All process water returned to pond.
Toe ditch	Collects seepage water from drain outtakes and surface runoff.	Water collects in sumps and is pumped back to pond. Ditches and sumps sized for low temperature water and winter freezing.
Toe road	Located beyond toe ditch.	

Muskeg

Muskeg of from 1 to 3 m thick is found throughout the area. This requires that pre-construction be started no later than January 2000 to ensure that the muskeg compaction schedule can be met.

Holocene Clays

Highly plastic and calcareous clays can be expected under the muskeg.

Clays and Clay Till

Generally, the clays are medium to highly plastic lacustrine clays underlain by till.

Sands and Gravels

Sands are commonly found under the muskeg and holocene clay complexes. Dune sands are present locally with no surface cover. Meltwater channels can be expected.

A broad outwash ridge of sandy gravel (Susan Lake deposit) exists to the north. The tailings settling pond is located south of this granular resource.

Ice Rafted Clearwater Formation

Weak Clearwater Formation shales that are apparently ice-rafted remnants are present locally.

McMurray Formation Clays

The Alsands study identified the presence of weak clays within the upper McMurray Formation. Geological evaluation has shown that these deposits are not extensive enough to cause concern about the overall stability. This allows slopes of 4:1 to be used for dyke construction.

CONSTRUCTION METHOD

Offsets

The outside toe of the tailings settling pond storage dyke will be offset:

- 100 m from the east access road and 200 m from the Muskeg River
- 200 m from Highway 63 on the west side and 800 m from the Athabasca River

Starter Dyke and Perimeter Facilities

Before the extraction plant starts up, a starter dyke will be constructed with overburden from the pre-stripped mine area and crusher excavation. This starter dyke will form the outline of the tailings settling pond and will be constructed to an elevation of 291 masl. This elevation was determined by sizing the tailings settling pond for sand, TFT and water storage to the spring of 2003, then subtracting the volume of dyke sand available in the summer of 2002 from the total volume of the perimeter dyke. A 10.9 km dyke will be required with a top width of 125 to 160 m with an outside side slope of 4:1 and an inside slope of 3:1. Stage loading construction methods will be used. Stage loading involves the incremental placement of fill and provides time for water to drain from the muskeg. After drainage, the muskeg will consolidate, forming a competent foundation.

A drainage ditch will be excavated next to the outside toe of the total dyke circumference. A road will be located next to the ditch, and along the full length of the dyke.

Tailings Sand Dyke Construction

Construction of the sand dykes on top of the starter dyke will start in 2002, immediately after plant start-up. Figure 6-9 shows a typical cross-section of the dyke.

The design and construction methods proposed for the sand dykes are similar to those used by Suncor and Syncrude in their current tailings settling pond operations. The sand dykes will be constructed with side slopes ranging from 3:1 to 4:1 depending upon the final evaluation of the existing subsoil conditions at the site.

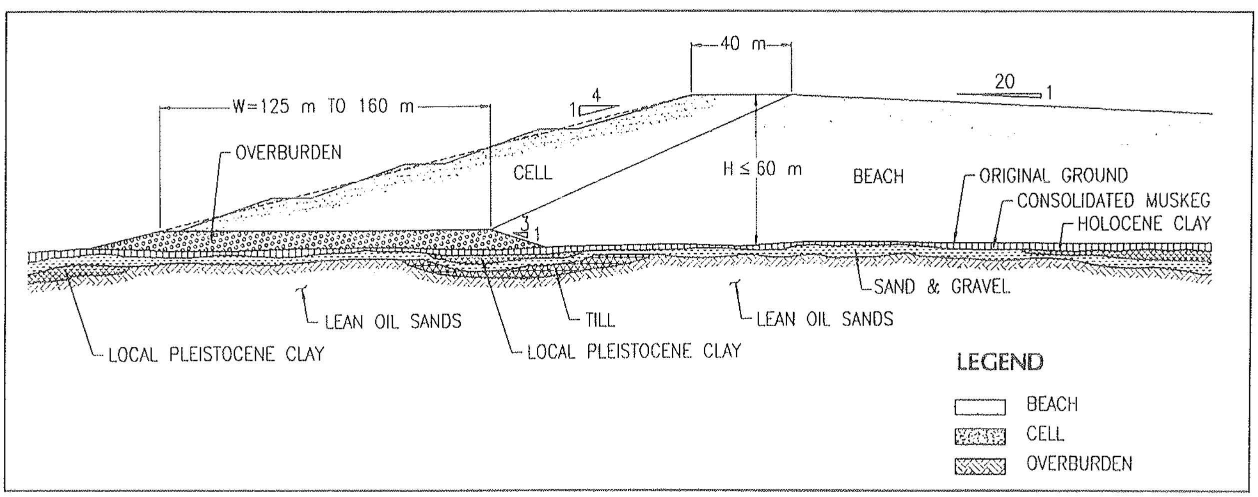


Figure 6-9: Typical Tailings Settling Pond Dyke Cross-Section

Tailings Sand Dyke Construction (cont'd)

The dyke section will be designed as a hydraulic fill structure. To provide a stable section under all expected conditions, the structural portion of the dyke will be compacted to a minimum 70% relative density. To control the phreatic surface and prevent seepage water from exiting on the downstream slope, seepage control will be provided by internal drains.

The dykes will be constructed by an upstream method, as the starter dyke will form the downstream toe of the final dyke section. The sand in the dykes will be placed by the hydraulic cell method, which involves placing tailings by hydraulic sluicing into cellular units that are usually parallel to the longitudinal axis of the dyke. These cells will be between 30 m and 90 m wide and 300 to 600 m long and will be sloped away from the tailings discharge area. Initially, the cells will be bounded by shallow sand dykes between 1.5 m and 2 m high, pushed up by bulldozers. The tailings stream will be discharged into these cells. The coarse sand will settle out by gravity and the fines fraction in suspension will flow out through an overflow weir into the pond.

Dyke-building experience indicates that the specified minimum densities of over 70% can be achieved by wide-track bulldozers operating in the cells during hydraulic sluicing.

Cell construction cannot be sustained when visibility is poor. Therefore, in winter, the tailings will be discharged directly into the pond upstream of the compacted dyke section. A beach of uncompacted sand will be formed, which will abut the compacted dyke section and extend into the pond on relatively flat slopes of 1:20. The beach runoff water containing fines will flow to the low side or end of the tailings disposal area being developed at any particular time.

Seepage Control and Perimeter Facilities

Seepage will occur from the sand tailings dykes. The sources of this seepage are:

- water from the clear water zone near the pond surface
- fine tailings consolidation water
- water from the hydraulic placement of sand tailings

This seepage will be collected by filter drains constructed at the downstream slope, then conveyed to the ditch excavated parallel to the downstream toe of the dam. From the ditch, the water will be pumped back into the pond. The filter drains are required to contain the phreatic surface within the sand embankment, thereby meeting the stability requirements.

The shallow perimeter ditch that collects water from the filter drains will also intercept seepage flows in the foundation soils. This ditch will have much of its base excavated into the subsurface lean oil sand deposit beneath the pond, thereby intercepting flows along the interface between the surficial soils and

Seepage Control and Perimeter Facilities (cont'd)

impermeable lean oil sand layer. The water level in the ditch will be maintained by pumping the inflow back into the pond.

The drainage ditches will be designed to intercept the maximum seepage from the tailings dykes. If necessary, these ditches will be deepened to the extent practical.

A system of monitoring wells will be installed to determine the seepage water quality and the hydraulic gradient toward the receiving waterbody.

FACTORS AFFECTING POND SIZE

Clarification Area

The pond clarification area is large enough to obtain sufficient solids settling to clarify the extraction recycle water.

Clear Water Zone

The clear water zone (CWZ) must be at least 3 m deep to:

- ensure that wave action and current effects do not roil up settled sediments at the mudline
- enable the reclaim barge to operate properly, thereby minimizing the re-suspension of settled solids

TFT/MFT Transition

The transition from TFT to MFT occurs about 12 m below the bottom of the CWZ.

Beach Angles

An important criterion is the angle used for upstream beach slopes formed by the segregating sand. For planning purposes, an overall slope angle is assumed that combines beach above water (BAW) and beach below water (BBW) slopes. Generally, BBW beaches are steeper than BAW beaches and vary from 3% to 5% and can be as flat as 0.5%. Beach slope angles of 5% were used for this design.

Water Reclamation

Water reclamation is an essential component of a tailings operation that uses hydraulic transport. However, to avoid affecting the extraction process, water cannot be recycled to the extraction plant until it is adequately solids free. Water from the tailings settling pond will not be recycled until after the first two full

Water Reclamation (cont'd)

production years to ensure that the water is of the required quality. If faster settling behaviour of the TFT is realized, this recycle will be started sooner.

TAILINGS HANDLING FACILITIES

Tailings Pumping and Pipelines

Tailings will be pumped by conventional centrifugal pumps located at the extraction plant. The distance and elevation changes will require booster pumps, depending on the final layouts and overall system hydraulics. The current design layouts are based on a pipeline solids content of 56.6 wt% for raw tailings at a peak rate of 11,950 m^3/h.

CT pipeline operations will allow for a solids content of up to 64.5 % solids. Allowable line solids content for pumping, together with the required solids and fines contents for CT production, govern the operation of the CT facility.

MFT and Water Return Systems

The mature fine tailings collecting in the tailings settling pond at 30 wt% solids will be collected and transferred to the CT plant. Fine tailings produced in-pit by inefficient CT operations might also be collected from in-pit cells, depending on settling and consolidation performance of the fines. If recovered, these fines will be sent either to CT production or to the tailings settling pond for eventual final use in CT production.

If the MFT produced by the extraction process achieves a higher solids content than 30 wt%, different pumping systems or dilution might be required for economic transport, depending on rheology.

Reclaim barges and pipelines will be used to return water from the tailings settling pond and the in-pit cells. The barge for the tailings settling pond will be moored at the north end. Access will be maintained in a dyke segment with centreline dyke construction. For MFT return, the reclaim barge will require considerable mobility and floating return lines.

Both MFT and water reclaim barges will be required for the in-pit systems. CT discharge will take place from the in-pit dyke crests toward the mine pit walls, with the reclaim systems located along pit wall segments. For this reason, some form of road access down the pit walls will be required.

IN-PIT DISPOSAL DESIGN

Design Criteria

The major design criteria for the in-pit dykes, CT settlement, and reclamation for the in-pit disposal operations are summarized in Table 6-7. Figure 6-10 shows a typical cross-section of an in-pit dyke with CT fill.

In-Pit Dykes

The proposed layout of the in-pit dyke system, the CT volumes and placement schedule are described in Section 6.3. The pit will be divided into seven separate cells. Cells 1, 2, 3, 4 and 5 will be filled with CT, overburden, and reject material. Cell 6 will be filled with overburden and centre reject capped with tailings sand dredged from the tailings settling pond. Cell 7 will be left as it is until the end of mining, when excess fine tailings and water cap from the tailings settling pond will be pumped into it at a rate that will ensure adequate time for natural toxicity reduction before discharge from the lake.

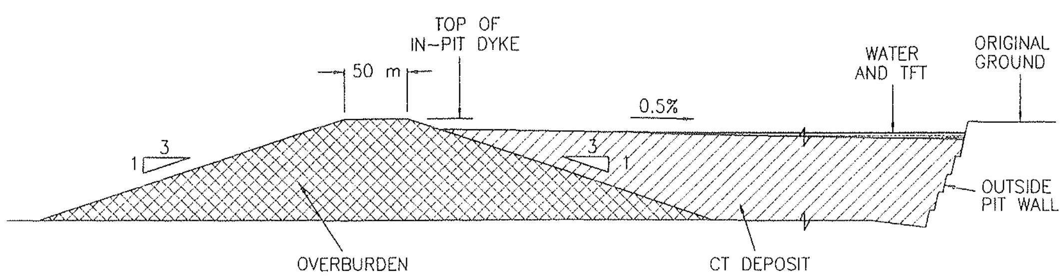


Figure 6-10: Typical In-Pit Dyke with CT Fill

The desire to limit the size of the tailings settling pond led to a partitioning of Cell 1, Cell 2 and Cell 3 with a series of in-pit dykes, to allow early CT disposal while active mining is continuing. Ultimately, the cross dyke in Cell 1 and the dyke between Cells 2 and 3 will be submerged by the CT deposit.

All in-pit dykes will be constructed of interburden and overburden. Sand will not be used. Construction of in-pit dykes will begin in 2005. The current tailings plan calls for CT disposal to start in-pit in 2006. By the end of 2009, the in-pit dykes for Cell 1 will be constructed to full height. By the end of 2012, the in-pit dykes for Cells 2 and 3 will be constructed to full height.

Table 6-7: In-Pit Disposal Design Criteria

Component	Design Considerations	Off-Setting Factors
In-pit Dykes:		
Geometry	In-pit dyke slopes 3:1 using good quality fill.	Geological interpretations indicate that pit floor conditions are favourable with no Continental Pond Mud facies.
Construction Method - unzoned fill	No water ponded against dykes required to support unzoned fill dam. Preferential placement of more pervious material in downstream section.	CT disposal plan must accommodate some subaerial beaches between CT pond and dyke, otherwise dykes must be designed as water retention structures, requiring zoned fills and filters. Final design might evolve to steeper upstream slope partially supported by CT and flatter downstream slope to accommodate overburden types.
CT Settlement:		
Infilling consolidation	Design predictions based on sand to fines ratio (SFR) of 5 to 6 and predicted CT geotechnical parameters.	Key variable is clay content of MFT used for CT, based on current orebody data.
Post infilling settlement	Estimated at 3 m in 20 years for SFR of 5 to 6.	Faster settlement possible with caustic-free tailings.
Reclamation:		
Post CT deposition infilling	Mine plan requires additional material placed over CT to accommodate settlement and overall drainage requirements.	Sources are rejects (Cell 1, 2 and 3), overburden, and sand from external facility. Tailings sand is not available for CT deposit infilling.
Infilling stability	Surface layer that is trafficable in winter over frost crust and with immediate stable capping, i.e., no inversion of capping.	Might need drainage ditches down to CT to allow lateral drainage of CT consolidation water.
Fines consolidation in end-pit lake	Thin fine tails will consolidate to at least 30% solids content over several years.	Caustic-free tailings might consolidate faster and to higher solids content.

CT Placement

For current planning purposes, the CT discharge into each pit is assumed to take place from the in-pit dyke crests toward the mine pit walls at the far end of each pit, so that each dyke will be buttressed by a CT beach. The fluid cell level at the far end of each of the deposits will be kept low by a water reclaim and decant operation.

Final infilling requirements and schedule for the respective pits is determined by the:

- overall mine plan
- dyke layouts
- mass balance
- CT behaviour

CT Placement (cont'd)

These factors are highly interactive. Therefore, the CT infilling plan must address the following considerations:

- the CT surface post-infilling settlement rate depends on the rate of infilling and the sand to fines ratio
- the in-pit topographical surface required for long-term drainage is at a higher elevation than the infilling levels reached by CT deposition, even assuming that there is no CT settlement
- progressive reclamation of in-pit segments will be undertaken during the operational mine life
- the time required to complete the reclamation plan must be minimized
- as a result of overall watershed requirements, the area and volume of the end-pit lake after mine closure is restricted

The geotechnical implications of these factors are that:

- additional fill must be placed over CT surfaces to account for both settlement and elevation differences between mine plan constraints and drainage topographical requirements. This fill must be placed while the CT is still not fully consolidated. This will be done either hydraulically or with mobile equipment, depending on the fill source.
- additional fill requirements must be met from several sources, which are, in order of desirability:
  - oversize rejects produced from ore
  - tailings sands produced when the CT plant is not operational
  - overburden hauled from working mine faces
  - tailings sand rehandled from the tailings settling pond, which can only be accessed after mining is complete

Placement of additional fill over the CT is governed by the foundation support offered by CT and the requirements to provide the release of consolidation water. As fill will have to be placed before all settlement is realized, fill will have to be placed higher than the final grade requirements and allowed to settle. Provisions for releasing pore water might slow down the rate at which settlement actually occurs, as there will be some restriction to drainage. This means that some adjustments to overall drainage systems must be expected during the pre-closure monitoring phase.

CT Placement (cont'd)

The drainage requirements for CT after overfill placement will be met with a combination of selective trench drainage placement and localized ditches. When actual CT properties are more definitively known, drainage spacing requirements will be finalized. Infilled CT thicknesses are from 55 to 70 m. A drainage spacing of 400 m would allow a spacing to depth ratio of about 6:1 to 8:1, which is considered reasonable.

End-Pit Lake

The mine and tailings plan results in a void at the end of the mine that will become an end-pit lake.

The 86.4 million m^3 of fine tailings and 20 million m^3 of water cap remaining at the end of the tailings settling pond's life will be transferred to the lake. This operation will take several years to accomplish as dewatering will be restricted by:

- rapid drawdown considerations of the tailings settling pond's interior beach slopes
- the rate that will enable natural biological decay of any residual toxicity associated with the water

This phase of the project will be coordinated with sand removal from the tailings settling pond required for infilling over the in-pit CT storage areas.

The fine tailings will settle to a volume of about 45 million m^3 within a few years after transfer is complete and will slowly consolidate thereafter.

The lake will form part of the Muskeg River watershed area.

TAILINGS SETTLING POND

Dyke Reclamation

Reclamation of the tailings settling pond's outside dyke slope will begin as early as 2004 and will incrementally follow the dyke cell construction until one year after dyke construction is completed in 2012.

Reclamation After Mine Closure

In order to handle the fine tailings and water left in inventory in the tailings settling pond in 2022, this material will be transferred to the end-pit lake and stored under a water cap. Transferring fluid to the end-pit lake will result in a bowl-shaped depression within the dyke structure with a storage capacity of about 118 million m^3. Several options were developed to deal with the closure and reclamation of the pond structure. These options include:

- excavating a channel to drain the tailings settling pond to the end-pit lake
- moving tailings sand into the bowl-shaped depression
- constructing a bouldery ground plug to the north of the barge section. Excavating a drainage channel through this overburden would enable water from the tailings settling pond to be released. The bouldery overburden spillway would erode more slowly than would the dyke's sand.
- constructing a bouldery ground plug into the barge section. This would require 1.5 million m^3 of overburden and would increase capital costs.
- placing additional beach sand into the bowl-shaped depression. This would require that an in-pit storage cell be used to thicken TFT before the mine closed.
- infilling the bowl-shaped depression with CT and moving sand beaching and TFT and MFT operations to an in-pit cell
- moving some or all of the tailings sand to in-pit cells

Reclamation after Mine Closure (cont'd)

The reclamation plan selected will involve:

- dredging some of the tailings sand from the tailings settling pond for placement in-pit. This will result in the dyke height being lowered from 60 m to about 33 m.
- excavating a drainage channel through the perimeter dyke at the north end of the facility

The drainage channel will drain water collected in the tailings settling pond to the in-pit lake. The volume of the excavation required for the drainage channel is 0.15 million m^3. Figure 6-11 shows the tailings settling pond after 126 million m^3 of sand has been relocated in-pit and the drainage channel has been excavated. The resulting top of dyke elevation is 310 m.

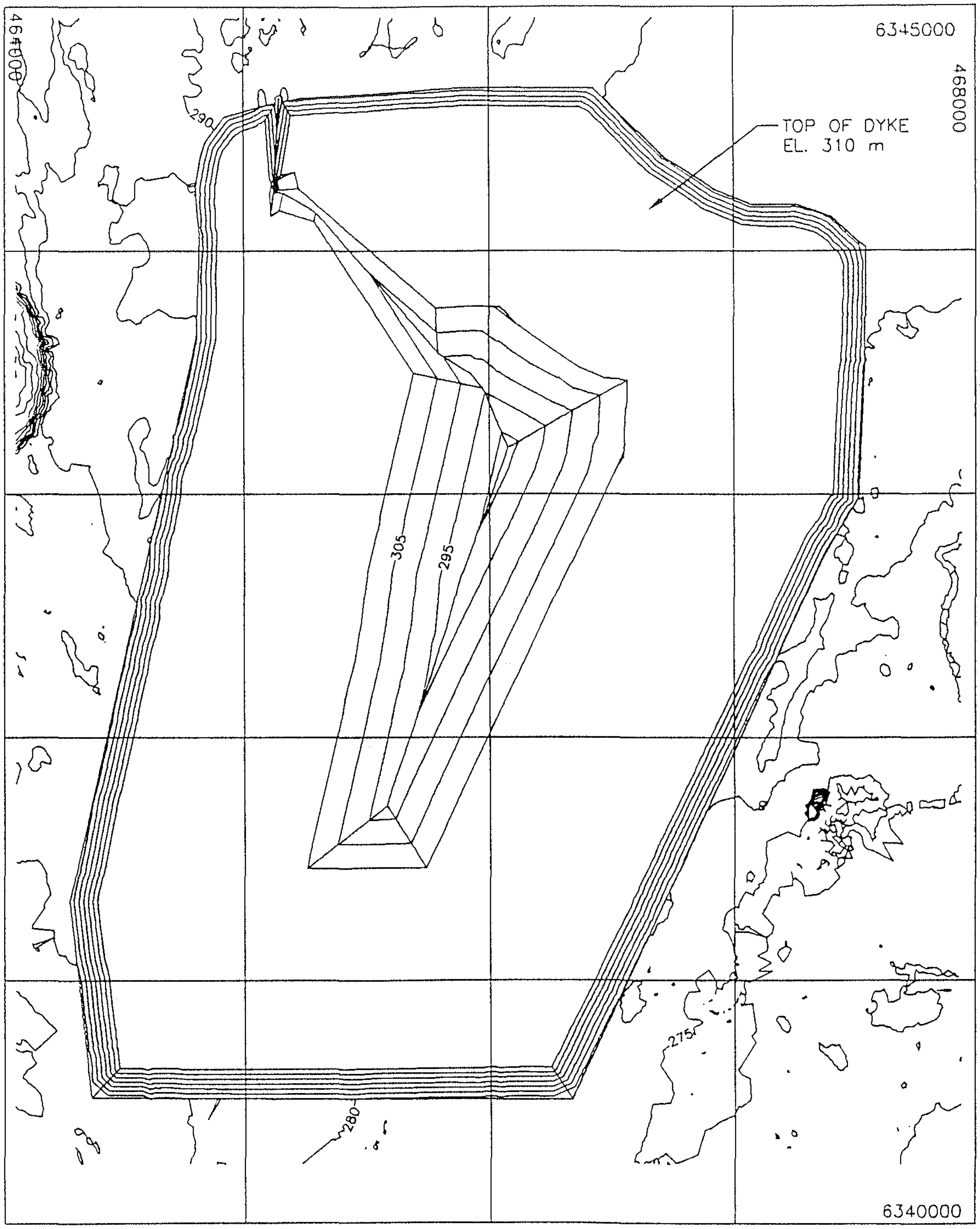


Figure 6-11: Tailings Settling Pond at December 31, 2030

EXTRACTION PROCESS

The settling behaviour of the fine tailings produced by caustic-free conditioning is expected to be superior to the behaviour of fines from the caustic process. This conclusion is based on evidence from testing in the CANMET pilot facility.

Faster settling of fines and clays provides several potential benefits. First, the clear water zone in the tailings settling pond becomes solids free faster, allowing water to be recycled to the extraction process earlier. This has the potential to reduce the amount of fresh water drawn from the Athabasca River. Project operations will be managed to take any advantage of this effect. Also, the faster consolidation of TFT to MFT in the pond ensures that MFT will be available for earliest production of CT. In addition, the pond area required for settling would be smaller. However, the pond area for the Muskeg River Mine Project is governed by the volume of sand storage. Therefore, no reduction in footprint can be realized for faster fines settling.

FINE TAILINGS HANDLING

Fine tailings behaviour greatly influences the tailings handling scheme and the ability to provide a site closure plan consisting of a restored, self-sustaining landscape in the original mine area. Production of mixed tailings, consisting of the fines and coarse sand, as a non-segregating, geotechnically stable deposit is one means of meeting this objective and is the reason for adopting the consolidated tailings technology. This method is superior to other approaches (see Evaluation of Tailings Management Methods in Section 6-2).

Shell is aware that other tailings management methods have been proposed in the industry and intends to study these alternatives by collaborative research through CONRAD. Shell will also verify and optimize the CT process through:

- ongoing pilot tests and bench programs
- other tests, as required, after project start-up

Shell will also monitor Suncor and Syncrude's success in implementing CT commercially.

The integrated pilot plant planned for 1998 will also allow tailings streams to be tested to verify the basic behaviour of fine tailings, including:

FINE TAILINGS HANDLING (cont'd)

- settling rates
- consolidation with time
- geotechnical characteristics
- effects of water chemistry with a non-caustic extraction process

CONSOLIDATED TAILINGS TECHNOLOGY

For the Muskeg River Mine design, the consolidation response of CT deposits has been predicted using mathematical modelling based on geotechnical finite strain calculations. Such calculations use predicted sand and fines ratios and geotechnical characteristics of the coarse sand and fine tailings. These predictions have provided the volumetric parameters for in-pit placement and consequent end-pit lake volume. Bench testing of tailings produced from caustic-free pilot tests in 1998 will confirm these parameters, so that the volume and stability predictions can be checked. The beneficial consolidation effects of caustic-free tailings are expected to produce a stable landscape amenable to mobile equipment traffic. This will facilitate reclamation.

INTRODUCTION

SCOPE

This section outlines the current design basis, the existing regional infrastructure, the demand profiles, onsite power generation options and regional integration options for the major utilities and offsites required for the Muskeg River Mine Project.

Utilities

The major utilities for the project are:

- electrical power
- natural gas

The demand profile, and supply and distribution options for auxiliary utilities, including diesel fuel, nitrogen, plant air and steam, are also discussed.

Offsites

The offsites required for the project include:

- a utility corridor
- an access road
- a natural gas pipeline
- solid waste disposal
- hazardous waste storage
- storage tanks
- fire suppression
- underground piping
- chemical storage
- communication equipment
- standby generators, if required

The offsites associated with water are discussed in Section 8.3, Water Supply.

CURRENT DESIGN BASIS

The electrical power and heat configuration for the Muskeg River Mine Project represents a basic approach to heat and electrical supply.

CURRENT DESIGN BASIS (cont'd)

Natural gas heaters supply heat to a heat medium system and electrical power requirements are satisfied by grid electrical power (see Figure 7-1). A basic approach to energy supply has been taken at this stage of the project as process and design needs must be finalized before utilities can be optimized, particularly where third-party supply alternatives need to be considered.

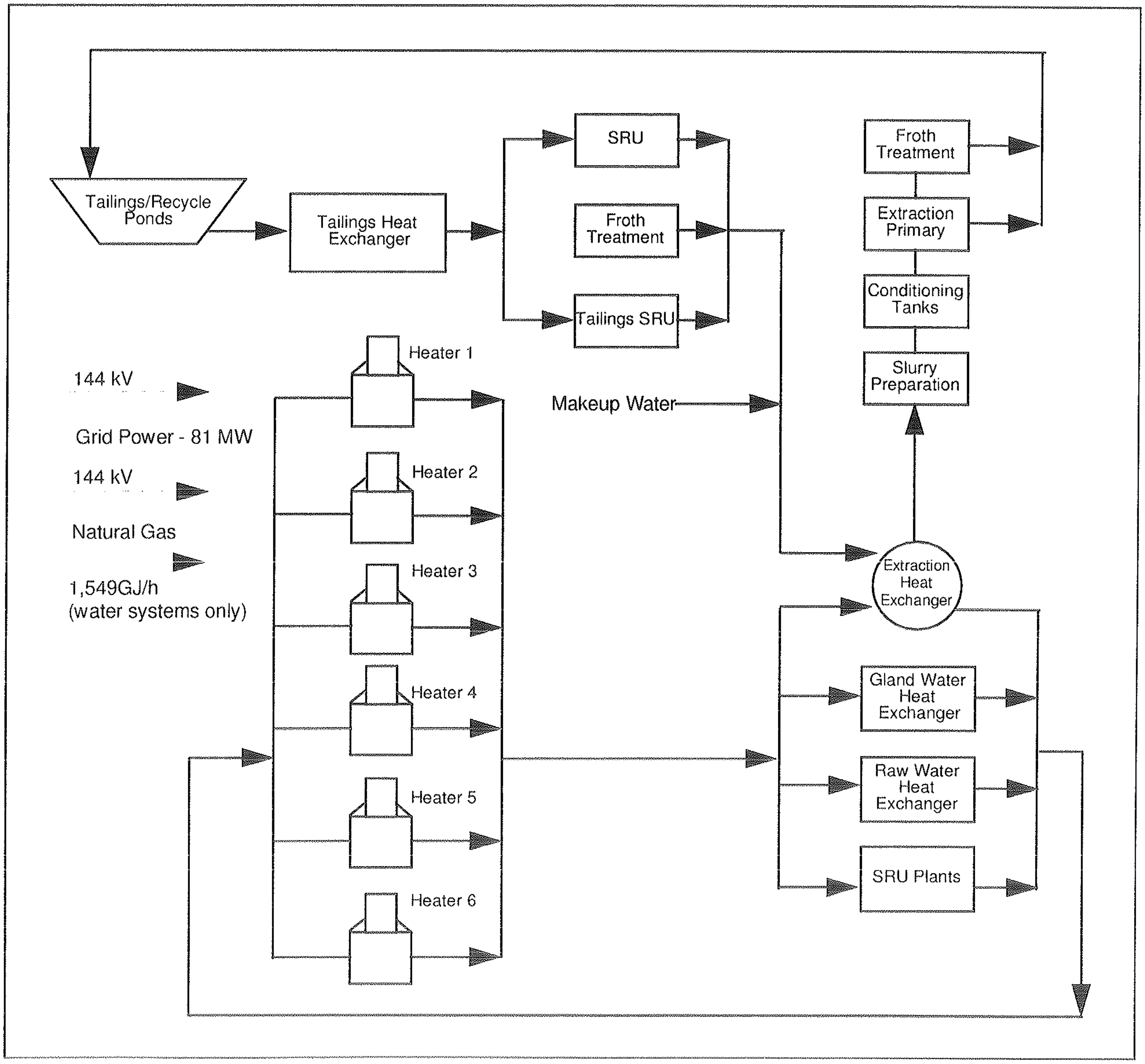


Figure 7-1: Electrical Power and Heat Configuration

Energy management is a key parameter for project success, from the standpoint of both its economic and its environmental impacts. Extensive work will be carried out to ensure that the heat and electrical utilities for the Muskeg River Mine provide the best solution, taking into consideration:

CURRENT DESIGN BASIS (cont'd)

- air emissions, including those associated with offsite power generation
- capital cost
- operating cost
- net present value over project life
- operating reliability
- operating flexibility

Several studies of electric power and process heat generation are currently under way, including:

- the on-site cogeneration of electrical power and heat
- cooperation with other projects in the region coming online in the same time frame (see Electrical Power in Section 7.2)

By evaluating these options, every attempt is being made to ensure that the utilities and offsites provided for the project are economic, environmentally responsible and efficient.

EXISTING REGIONAL INFRASTRUCTURE

Electrical Power

Electrical power in the Lease 13 area is currently supplied by an Alberta Power Limited (APL) substation at Ruth Lake (see Figure 7-2). This substation is supplied by two 240 kV lines.

The Ruth Lake substation supplies power to users in the surrounding area through:

- two 144 kV power lines into the city of Fort McMurray
- two 72 kV power lines to Syncrude, Mildred Lake
- two 72 kV power lines to the Suncor Tar Island facility
- one 25 kV line to the underground test facility west of Ruth Lake
- one 25 kV power line to Fort McKay and oil sands leases east of Fort McKay

Natural Gas

Natural gas is currently supplied to the Fort McMurray area by two pipeline systems connected to the NOVA Gas Transmission Ltd. (NGTL) system, a:

- 4.5 million Sm^3/d capacity Simmons pipeline system
- 2.3 million Sm^3/d capacity Albersun pipeline system

Natural Gas (cont'd)

The total capacity of these systems is currently committed to supplying existing commercial, residential and industrial facilities in the region.

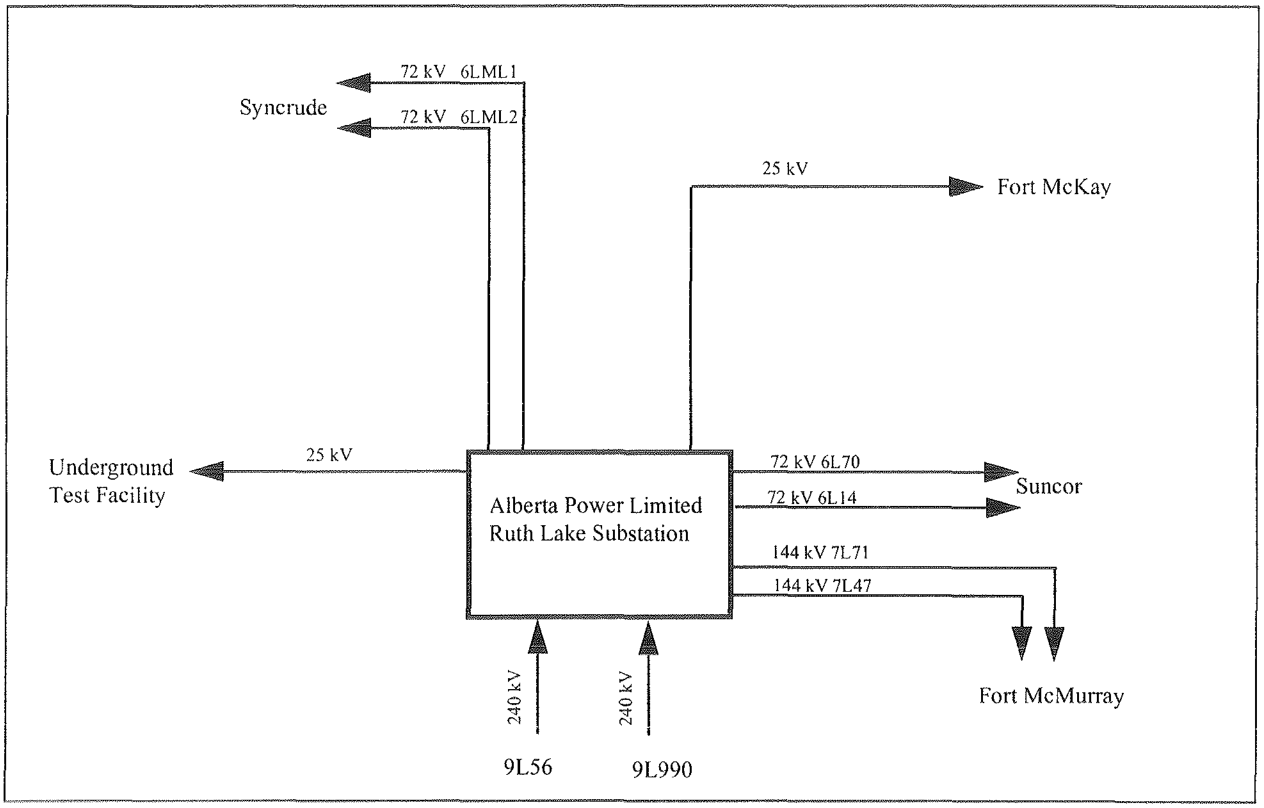


Figure 7-2: Existing Electrical Power Supply System

ELECTRICAL POWER

DEMAND PROFILE

The electrical demand profile for the Muskeg River Mine Project (see Table 7-1) does not change appreciably from winter to summer, except for interconnecting piping, lighting and heat tracing, which ranges from 200 kW to 800 kW.

During front-end engineering and detailed design phases, electrical and heat requirements will be studied in detail with a focus on their reduction.

Table 7-1: Lease 13 Electrical Load Summary

Plant Name	Connected (kW)	Annual Avg. (kW)
Mine	8,000	6,700
Ore preparation	13,000	6,700
Slurry preparation	10,700	6,900
Extraction	20,200	12,600
Froth treatment	6,100	4,300
Diluent recovery	6,700	3,000
Tailings diluent recovery	1,700	1,300
Tailings disposal	21,000	12,300
Control room	500	400
Relief and blowdown	112	88
Tankage	2,500	1,500
Interconnecting piping, lighting and heat tracing	1,000	550
Utilities	3,000	2,000
Water systems	24,600	18,200
Fire protection	242	38
Waste treatment	126	105
Buildings	1,000	800
Pipeline station	5,000	3,800
Total (MW)	125	81

SUPPLY FROM ALBERTA POWER

The 81 MW required by the Muskeg River Mine Project will be provided by two 144 kV power lines from APL's Ruth Lake substation or Beaver Lake substation. Two power lines will be required to provide a reliable power supply.

Within the lease boundary, these power lines will be located within the designated utility corridor (see Section 7.5). Off lease, the following line routing options are being considered:

- from APL's Ruth Lake substation, through Syncrude's Mildred Lake Mine on the east berm
- from APL's Ruth Lake substation around the western limit of Syncrude's Mildred Lake Mine
- from APL's Beaver Lake substation around the western limit of Syncrude's Mildred Lake Mine

All three routes cross the Athabasca River at Peter Lougheed Bridge and follow the existing area utility corridor along the east side of the river to the Lease 13 utility corridor.

These options are subject to the final configuration of power line infrastructure in the area. Currently, other projects in the area are building lines. Future options will consider how these new lines might be incorporated into an efficient and environmentally responsible regional solution.

In selecting the final route, the criteria will be to:

- minimize route length to lower capital costs, line losses and surface disturbance
- minimize additional surface impact by using areas previously disturbed
- determine if the route is available, particularly with respect to the east berm option
- avoid active areas in the mine plan
- avoid historical resource sites or any other area of special cultural or environmental interest

APL has provided Shell with preliminary costs, system performance data and right-of-way requirements for transmission planning alternatives from both the Ruth Lake substation and Beaver Lake substation. APL indicated that, if a 200 MW cogeneration unit in the Cold Lake area, and some other self-generation in east Edmonton were to be developed, system re-enforcement to the Edmonton utility corridor would not likely be required.

SUPPLY FROM ALBERTA POWER (cont'd)

APL will seek approval for the power lines when a final configuration and routing plan has been selected.

POWER DISTRIBUTION

Power from the two 144 kV power lines from the APL Ruth Lake substation will pass through transformation and be converted to 25 kV for power distribution throughout the project. If necessary, higher voltage transmission will be considered as the project distribution voltage.

ON-SITE POWER GENERATION OPTIONS

On-site power generation is not currently part of the project design basis. However, on-site power generation with cogeneration of process heat is being investigated. A configuration of cogeneration units using natural-gas-turbine-driven electrical power generators, with waste heat recovery from the units being used to heat the heating medium, might be effective in providing:

- improved energy efficiency (through lower overall CO_2 emissions)
- improved economics for utility supply

Potential configurations using one (electrically balanced) or two (heat balanced) 80 MW nominal cogeneration units are currently being investigated. These units might not only reduce the power requirements from APL, but might also result in excess electrical power being sold to the Power Pool of Alberta.

Preliminary investigations suggest that the overall CO_2 emissions associated with the project are decreased when cogeneration is incorporated, because of the:

- use of waste heat
- elimination of line losses

However, further investigation of incremental economics and potential commercial arrangements is required before any form of cogeneration is pursued.

If cogeneration is adopted, approval would be sought under Part 2, Section 9, of the *Hydro and Electric Energy Act* to construct and operate the gas turbine-powered generators and their associated generator substation.

INDUSTRIAL SYSTEM DESIGNATION

Shell will also be asking the EUB to designate the electrical generation, transmission and distribution facilities that form part of the Muskeg River Mine

INDUSTRIAL SYSTEM DESIGNATION (cont'd)

as an industrial system, under Section 3(1)g of the *Hydro and Electrical Energy Act*. This application will be filed when the transmission line design and generation options have been decided.

REGIONAL INTEGRATION OPTIONS

An evaluation is currently under way with Syncrude to determine if there are sufficient benefits to justify integrating heat and power generation for the Aurora North and the Muskeg River mines, given their close proximity and similar schedules. A number of options are being considered with various configurations of power line interconnections and gas-turbine cogenerator sets.

As with on-site power generation options, increased energy efficiency, environmental responsibility and improved economics will be sought in any integration configuration proposed.

DEMAND PROFILE

The natural gas demand for the project is outlined in Table 7-2. On-site infrastructure and the incoming natural gas pipeline will be designed for 2,500 GJ/h.

During front-end engineering and detailed design phases, natural gas requirements will be studied in more detail to optimize energy efficiency.

The demand profile will also be influenced by the outcome of on-site power generation studies.

Table 7-2: Lease 13 Natural Gas Demand

Plant Name	Winter (GJ/h)	Summer (GJ/h)	Annual Average (GJ/h)
Relief and blowdown	2	2	2
Utilities	186	131	162
Water systems	1,700	1,337	1,550
Buildings	195	0	114
Total	2,083	1,470	1,828

SUPPLY OPTIONS

A number of pipeline options to supply natural gas from the NGTL distribution network are currently being considered, including a potential regional development option with area natural gas users. Details of the specific pipeline option to be used will follow in a separate application by the pipeline proponent.

Letdown and Distribution

Natural gas from the supply pipeline will reach Lease 13 at about 2,000 kPa. This pressure will be reduced at the plant to a pressure suitable for distribution within the lease.

SCOPE

Auxiliary utilities include:

- diesel fuel
- nitrogen
- plant air
- steam

DIESEL

Demand Profile

Diesel fuel will be required for use in mine equipment, ore trucks and light-duty vehicles. The average annual diesel consumption is about 65 million litres over the mine life. Consumption will peak in 2020 at about 80 million L. Recognizing the impact of using this volume of diesel, Shell intends to embark on future collaboration with equipment suppliers to investigate emissions reduction. Shell expects to make a significant contribution in this area, given its knowledge and depth of experience in vehicle fuels and combustion technology.

Supply Options

Several diesel supply sources are being considered, including refineries in the Edmonton area and other oil sands producers in the Fort McMurray region. The diesel will be delivered to the site in tanker trucks. Four to five tanker trucks per day will be required.

Depending on the diesel source secured, an option is to transport diesel via pipeline, either in a dedicated system with other users or in batch mode on other systems. If this option proves commercially and economically feasible, it will be investigated further.

Distribution

Diesel delivered to the site will be stored in above ground tanks at several locations near the mine site. Tanks will be located within impermeable berm systems to contain the diesel if there are any leaks. About 1.3 million litres, equivalent to a seven-day supply, will be stored in the tanks for distribution.

NITROGEN

Demand Profile

Nitrogen is required for:

- inert gas blanketing of tanks and equipment in the extraction and froth treatment plant
- solvent stripping in the tailings solvent recovery unit (TSRU)

Supply Options

Nitrogen will be supplied by a conventional air separation unit at the Muskeg River Mine plant site.

Distribution

Nitrogen will be distributed from the nitrogen generation unit to on-site users, by a low-pressure piping network.

PLANT AIR

Demand Profile

Instrument and utility air requirements (see Table 7-3) do not change appreciably from winter to summer.

Supply Options

Instrument and utility air will be supplied on site and separately by conventional industrial air plants.

Distribution

Instrument and utility air will be distributed by separate low-pressure piping networks.

STEAM

About 100,000 kg/h of 1000 kPa(g) steam is required for:

- froth deaeration
- solvent recovery
- heat tracing
- utility steam

STEAM (cont'd)

This demand will be supplied by two conventional natural-gas-fired utility boilers. These boilers will require about 163 GJ/h of natural gas on an annual average basis.

For a description of the boiler feed water treatment facilities, see Boiler Feed Water Treatment in Section 8.3.

Table 7-3: Lease 13 Instrument and Utility Air Summary

	Instrument Air	**Utility Air**
Plant Description	**Continuous Sm^3/min**	**Maximum Sm^3/min**
Ore preparation	0.7	4.2
Slurry preparation	0.7	2.8
Extraction	17.0	28.3
Froth treatment	2.8	18.4
Diluent recovery	5.7	11.3
Tailings diluent recovery	1.4	2.1
Tailings disposal	1.4	2.1
Relief and blowdown	0.8	0.8
Tankage	0.6	1.4
Utilities	1.0	25.5
Water systems	1.4	1.4
Fire protection	0.4	0
Waste treatment	0.8	0.8
Buildings	3.4	14.7
Total	38.1	113.8

OFFSITES

SCOPE

The offsites required for the project include:

- a utility corridor
- an access road
- a natural gas pipeline
- solid waste disposal
- hazardous waste storage
- storage tanks
- fire suppression
- underground piping
- chemical storage
- communication equipment
- standby generators

The offsites associated with water are discussed in Section 8.3, Water Supply.

UTILITY CORRIDOR

A utility corridor to the Muskeg River Mine and extraction facility has been designated (see Mine Development in Section 4.5). The routing of this corridor follows the access road on the north side of the Muskeg River. No stream or pipeline crossings are associated with this corridor. This corridor will contain:

- the two new 144 kV power lines from APL's Ruth Lake or Beaver Lake substation

- the natural gas pipeline

- the intake water pipeline from the Athabasca River

- communication connections

Approval for the construction of any lines or pipelines within this corridor will be the subject of future applications, either by Shell or third-party utility providers.

UTILITY CORRIDOR (cont'd)

In selecting the route for the utility corridor, the following items were considered:

- the route should be within Lease 13 as far as possible to minimize impact on neighbouring activities
- the length of the route should be minimized to lower capital costs, mine life energy usage and travel time
- the right-of-way must be wide enough to accommodate:
    - power lines
    - a natural gas pipeline
    - a water intake pipeline
    - communication connections
- the routing should:
    - minimize the impact on resource recovery
    - not pass through active areas in the mine plan
    - be sufficiently distant from waterways to avoid environmental impact
    - minimize the impact on historical resources and other areas of environmental significance
- preference should be given to following the existing rights-of-way to avoid further environmental disturbance

Two potential utility corridor routes were considered. One followed the existing area's utility corridor north on the west side of the proposed tailings pond, turning east toward the extraction plant after reaching the north side of the proposed tailings settling pond. The other followed the lease boundary east along the south side of the proposed tailings settling pond, then followed the existing access road north to the extraction plant.

Table 7-4 compares these routes against the route selection criteria.

The route south of the proposed tailings settling pond was chosen because it:

- was shorter
- had less impact on resource recovery
- avoided the proposed historical resource site
- made greater use of existing rights-of-way

ACCESS ROAD

Access to the Lease 13 site will be via Highway 963. A 2.25 km tie-in road will be built from the highway to the existing access road, along the road allowance at the southern lease boundary. The current access road will be upgraded to a two-lane gravel surfaced road located in the utility corridor. Dust mitigation measures, including watering, will be adopted.

For information on secondary roads and haul roads, see Section 4.5.

Shell holds the existing access road under crown disposition License of Occupation 5732, which is administered by AEP. Shell plans to use this road for access to the mine and extraction plant. Following project approval, the disposition would be amended to one that will allow for access to these facilities to be restricted at the lease boundary.

Table 7-4: Comparison of Utility Corridor Routes

	North of Tailings Settling Pond	South of Tailings Settling Pond
Within Lease 13	yes	yes
Route length	13 km	11 km
Sufficient width	yes	yes
Impact on resource recovery	high	low
Avoids active mining areas	yes	yes
Sufficient distance from waterways	yes	yes
Avoids areas of special interest	near eastern edge of proposed historical resource site	yes
Uses existing rights-of-way	45% of distance	82% of distance

NATURAL GAS PIPELINE

The new natural gas pipeline will be connected to the NGTL system. As several options and sources of supply are currently being investigated, the routing of this pipeline beyond the utility corridor cannot yet be determined.

SOLID WASTE DISPOSAL

A Class II industrial landfill will be located at the Lease 13 site in the southeast corner of the west disposal storage area. This location was chosen to avoid ore sterilization and to provide easy road access from the extraction facilities. Of the three disposal storage areas (west, northeast and south), the west disposal storage area was chosen, given its proximity to the extraction plant and existing berm road and to avoid increasing traffic across the Muskeg River. The details of this landfill will be provided in a future submission, according to EPEA waste

SOLID WASTE DISPOSAL (cont'd)

control regulations. The landfill will be designed and operated according to AEP's *Guidelines for Industrial Landfills.*

The landfill will be about 100 m x 100 m and be isolated from the rest of the west disposal storage area by a berm. The walls and the floor of the landfill will be lined with a synthetic liner. A surface run on and runoff control system will be provided. A groundwater monitoring system, consisting of observation wells hydraulically up gradient and down gradient, will be installed.

Liquid hazardous waste or hazardous waste containing free liquids will not be accepted at the landfill. These wastes will be isolated in the hazardous waste storage area.

Solid waste to the landfill will be minimized by:

- salvaging scrap metal
- recycling paper
- recycling lead acid batteries
- leasing tires or participating in vendor return programs

HAZARDOUS WASTE STORAGE

A hazardous waste storage area will be developed to provide interim storage for wastes that are unsuitable for the Class II landfill. This area will be operated according to the standards set out in the EPEA Waste Control Regulation and will be fully secured to control access.

A waste management specialist will:

- control the area
- conduct waste inventories and yard inspections regularly

To ensure that containers are sound and properly labelled, all wastes will be inspected before being accepted into the area. A waste manifest will be required and logged for every container that enters the area. Necessary equipment and materials to respond to spills within the area will be on hand.

The storage area will be fully lined with an impermeable, heavy-duty, industrial-grade synthetic liner. Runoff from the area will be contained and collected. It will be analyzed regularly to verify that all storage containers are intact. If the runoff is of an acceptable quality, it will be transferred to the recycle pond.

Wastes leaving this area will be taken to either:

- a regulated and recognized hazardous waste disposal facility, such as the Alberta Special Waste Treatment Centre in Swan Hills

HAZARDOUS WASTE STORAGE (cont'd)

- a recognized recycler of items, such as oil filters and lead acid batteries
- the on-site landfill, if analytical testing verifies the acceptability of disposing of the material there

STORAGE TANKS AND DYKE

Storage tanks will be designed to meet the requirements of EUB Guide 55, *Storage Requirements for the Upstream Petroleum Industry.*

Outdoor storage tanks for dilute bitumen product, diluent, and diesel fuel will be surrounded by a perimeter dyke. Consistent with industry practice, the dyke will be capable of handling the volume of the largest tank in the dyke or one half the total volume of all tanks within the dyke. Vacuum trucks will be used to collect any spills for recycle or disposal, as appropriate. Drain connections to the dyked area will normally be closed and used only to drain the dyked area of surface water.

FIRE SUPPRESSION

The facilities include a fixed fire water system, capable of supplying 910 m^3/h of water. The fire water will be taken from the raw water pond.

Fire water will be distributed in a standard ring header circuit. The system will be capable of supplying all fixed facilities, including tanks containing dilute bitumen product, diluent or diesel fuel. Non-process buildings will be equipped with a sprinkler system, except in the computing centres, where an inert fire extinguishing agent will be used.

UNDERGROUND PIPING

Underground piping will be provided for the following systems:

- fire water distribution
- domestic sewer
- surface runoff

For further information on the sewer treatment system, see Waste Water Treatment in Section 8.3.

The surface runoff collection system is designed to collect surface water runoff and direct it to the recycle pond for reuse. Contributors to this system include:

- runoff from:
    - storm sewers

UNDERGROUND PIPING (cont'd)

- vehicle washing
- fire water

- waste water from facilities other than extraction and froth treatment

CHEMICAL STORAGE

Table 7-5 lists the chemicals used in significant volume in the proposed facilities.

Sodium hypochlorite and chlorination equipment will be installed in a room physically isolated from other equipment. This room will be equipped with separate ventilation and local warning alarms connected to the control room.

All liquid chemicals will be stored in indoor tanks. The tank capacity will be determined by the usage rate and truck delivery volumes. Concrete perimeter dykes will be provided for all tanks to control leaks or spills. Vacuum trucks will collect any spilled chemicals for disposal or recycle, as appropriate.

Table 7-5: Annual Chemical Usage

Chemical	Amount (per year)	Application
Sodium hypochlorite	2,200 L	Water disinfectant and biocide
Lime	7,300 kg	Water softening and clarifying
Alum	370 kg	Water clarifying
Sulphuric acid	3,700 kg	Water antiscalant and resin regeneration
Caustic soda	185 kg	Resin regeneration

COMMUNICATION EQUIPMENT

A two-way radio system will be established for mine and extraction plant operations. Radio transmission facilities will be incorporated into building structures. A standalone radio tower will not be required. A separate application for a frequency designation will be submitted to Industry Canada.

Telephone communication lines will be run below ground, inside the utility corridor.

STANDBY GENERATORS

Emergency diesel electrical generators will be installed at the extraction plant to provide sufficient power to maintain emergency lighting, emergency heating and reduced process circulation during a total electrical power failure. These

STANDBY GENERATORS (cont'd)

generators are expected to be used infrequently. The power rating for the generators has not yet been determined.

OFFSITES FOR WATER SYSTEMS

For information on offsites associated with water, including water intake, potable water and boiler feed water, see Water Supply in Section 8.3.

TOPOGRAPHY AND DRAINAGE SYSTEMS

The main drainage system in the area is the Muskeg River and its tributaries (see Figure 8-1). The terrain is generally flat, except for Muskeg Mountain southeast of the lease. Surface elevations range between 325 masl and 240 masl in lowland areas and up to 610 masl on Muskeg Mountain. Ground slopes of less than 0.5% are typical of the poorly drained lowland areas. Slopes of 1% to 3% are encountered on the edge of Muskeg Mountain at elevations greater than 350 masl.

Precipitation in the area is moderate, with an annual mean value of 426 mm, 80% of which falls as rain and the remainder as snow. Potential evaporation is estimated at 588 mm. Precipitation is greater in summer than in winter, with mean monthly values up to 80 mm in July and 16 mm in February. There is usually snow on the ground between October and April.

The mean monthly temperature varies between -19.8°C in January and 16.6°C in July. Temperature extremes between -50.6°C and 37°C have been recorded. On average, the temperature stays below freezing for 121 days each year.

The dominant surface material in the lowlands is muskeg, which is highly absorbent and poorly drained. It has a high water table near the surface immediately following snow melt. Muskeg thickness ranges from 0.5 to 3.5 m and, in some places, overlies the surficial aquifer.

HYDROGEOLOGY

The regional hydrogeology of the oil sands area of northeastern Alberta was investigated by the Alberta Research Council (ARC) in the mid to late 1970s. During the investigation, ARC installed 75 observation wells at 15 locations. Also, during this period, Shell drilled additional wells in the Muskeg River Mine Project area.

The results of these investigations, in conjunction with additional site-specific hydrogeologic data developed during the Alsands and Muskeg River Mine projects, were used to develop the groundwater management plan. Details on site hydrogeology are provided in EIA Volume 2, Section D3.

REGIONAL AQUIFERS

A typical northeast-southwest geological cross-section of the project area is shown in Figure 8-2.

The important aquifers in the project area, in ascending order, are:

1. the Methy aquifer
2. the basal aquifer
3. surficial aquifers
4. the Pleistocene channel

Methy Aquifer

The Methy aquifer is represented by interbedded dolomite and anhydrite located about 190 m below ground surface. Its hydraulic properties are highly variable, with conductivities ranging from about 7×10^{-8} cm/s to 3×10^{-7} cm/s.

The dominant hydrochemical types of Methy groundwater are C1-Na and C1-SO_4-Na-Mg. The water is saline with total dissolved solids ranging from 9,824 mg/L to 78,666 mg/L. Chloride concentration varies widely, ranging from 6,000 mg/L to 43,000 mg/L, and sodium from 6,000 mg/L to 27,300 mg/L.

Basal Aquifer

The basal aquifer consists of unconsolidated fine-to coarse-grained sand (0 to 50 m thick) deposited on the Devonian bedrock. Hydraulic conductivities vary from 3×10^{-2} cm/s to 2×10^{-3} cm/s. Piezometric surface elevations in the western area of the lease vary from 289.9 to 230.9 masl (4.5 to 61.5 m below the ground surface). The pH of the basal aquifer groundwater varies from 7.4 to 8.5. Total dissolved solids range from about 1,430 mg/L to 7,407 mg/L. The dominant hydrochemical types are C1-HCO_3-Na and HCO_3-C1-Na. Chloride concentration varies within a wide range from 81 mg/L to 2,793 mg/L and sodium from 243 mg/L to 1,477 mg/L.

The potentiometric surface and groundwater flow gradient is from northeast to southwest of the project area. This implies that the basal aquifer is continuous across the lease boundary.

Surficial Aquifers

Surficial aquifers are represented by relatively thin (less than 20 m) fluvioglacial sands and gravels, Pleistocene sandy till, and locally fine-grained sands of Cretaceous age. These aquifers are usually unconfined. Depth to groundwater varies from 0 to 7 m below the surface. A limited ditching program on the Alsands project site on Lease 13 in 1980 to remove muskeg lowered the groundwater from a depth of 1 m to 3 m. This indicates that a properly designed finger ditch scheme should adequately drain the muskeg and facilitate its removal.

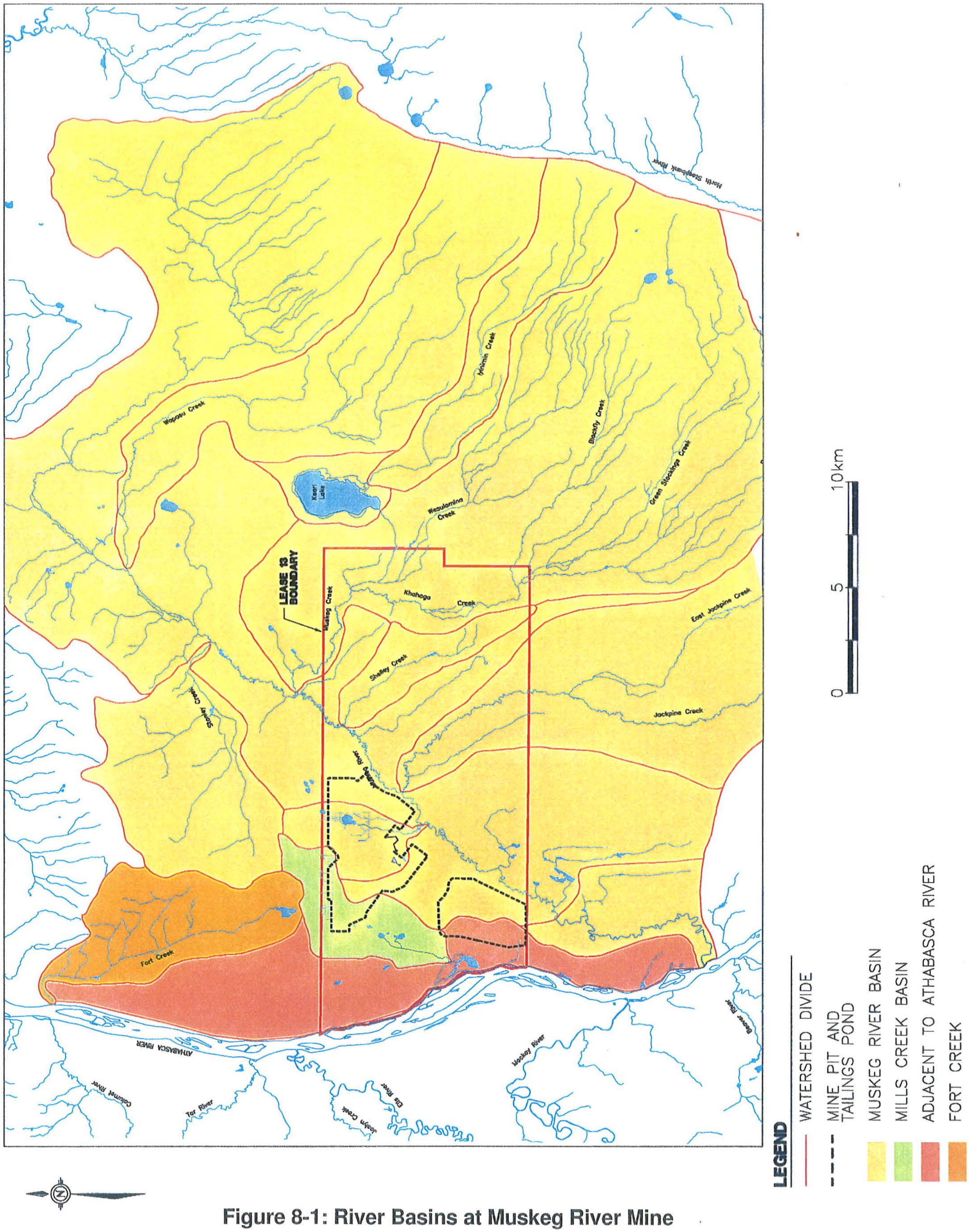


Figure 8-1: River Basins at Muskeg River Mine

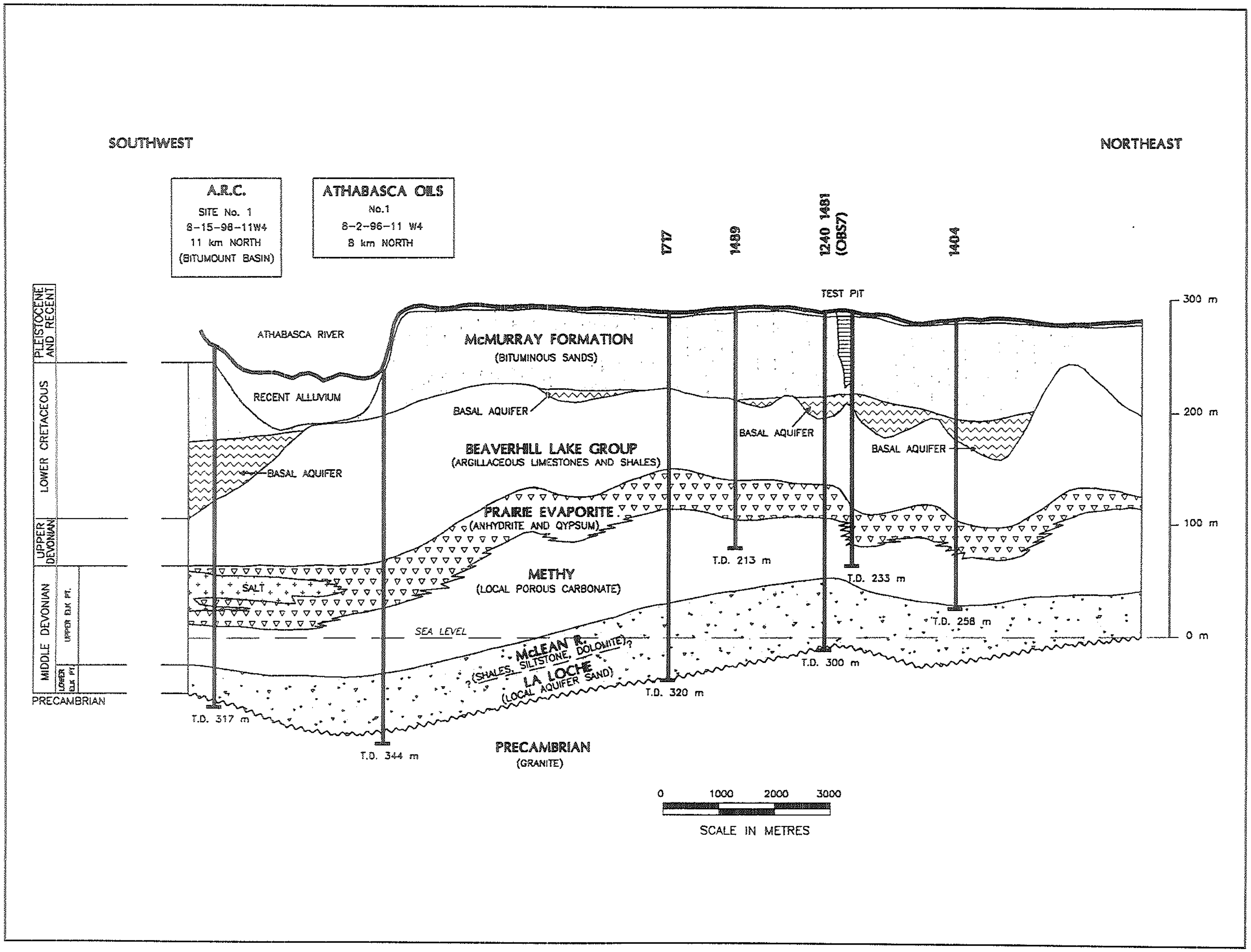


Figure 8-2: Geological Cross-Section of the Project Area

Pleistocene Channel

The Pleistocene buried channel on the southeast-corner of the Lease 13 west area is a partially confined aquifer with moderate conductive zones confined to sand-and-gravel-filled channels. The aquifer is typically 20 m thick on Lease 13 and thins southward. The static water level in the main channel is about 4 m below ground surface. Flow has been observed from the Pleistocene channel upward to the surficial aquifer, but not in the reverse direction. The water quality is generally good. Mining is not likely to disturb this aquifer.

AQUIFER INTERCONNECTIVITY

There is a fundamental difference in water chemistry between the Methy aquifer and the basal aquifer, demonstrating the absence of aquifer interconnectivity. Sodium and chloride concentrations in the Methy are 10 to 100 times higher than in the basal. The Methy waters are also characterized by sulphate ions, compared with the predominantly bicarbonate chemistry in the basal.

The pressure regimes of the Methy and basal aquifers are also distinct. In the northeast part of the lease, the piezometric surface in the basal aquifer is higher than that of the Methy by 10 m. This is reversed in the southwest area of the lease where Methy pressures exceed those of the basal by more than 25 m. This situation could not exist if there was any significant water exchange between the aquifers.

DEWATERING

In 1974, a test pit was excavated on Lease 13 for mining and geotechnical evaluations. The pit also provided a practical test of the potential for successfully controlling water inflow to mine developments. The test pit penetrated the McMurray Formation to a total depth of 70 m. The surficial water was drained by ditching. The basal aquifer had a hydrostatic head of 5 m below surface. Pumping at a peak rate of 45 L/s began 12 months before excavation, with the following results:

- the hydrostatic head of the basal water sand was held below the pit floor for five months
- 30 m of drawdown was measured 1,220 m north of the test pit
- drawdown of at least 25 m was observed over an area of 100 ha

The widespread impact of pumping indicates that, although the basal aquifer is not continuous, its three-dimensional permeability allows it to respond hydraulically as a single aquifer over large areas.

Although deep drilling has shown that the Methy aquifer has a hydrostatic head about 25 m below surface, no identifiable saline Devonian waters were detected by the extensive monitoring operations conducted during the test pit excavation.

DEWATERING (cont'd)

Continuous observation of the Methy aquifer piezometers revealed that there was no response to the basal aquifer pumping.

WATER CONSERVATION

PRINCIPLES

The water conservation plan for the project is based on:

- minimizing the withdrawal of water from the Athabasca River. This goal will be achieved by putting the surface and groundwater to beneficial use by capturing and recycling the water that :
    - comes in contact with the developed area
    - is produced in the mining operation
- releasing the on-site water from the undeveloped area to the nearby streams, to minimize the impact to the natural hydrologic system
- minimizing the water accumulation at the plant site by maximizing the water use efficiency. This goal will be achieved by recycling and reusing water to the maximum extent possible
- minimizing the losses to evaporation and seepage. This goal will be achieved by:
    - constructing perimeter trenches around surface waterbodies to collect the seepage for reuse
    - eliminating or minimizing the area of water storage ponds to the extent feasible
- optimizing the water system, both for quantity and quality, to create a practical reclamation plan at closure
- maintaining normal flows in the Muskeg River

SCHEDULE

Table 8-1 lists the field activities that affect water management from the start of the project to closure.

During operations, a water management model will be used to optimize the water system for quantity and quality for each activity. The water management model

SCHEDULE (cont'd)

will also be used as a predictive tool to take appropriate action to meet the water management goals.

Table 8-1: Schedule of Muskeg River Mine Water Management Activities

Date	Activity
January to April 1999	Start constructing roads, diversion and ditches for muskeg drainage and overburden dewatering at the plant site with an area of 3.1 km^2.
May to October 1999	Start muskeg drainage and overburden dewatering involving a total drainage area of 3.1 km^2.
November 1999 to April 2000	Start plant site stripping and site preparation.
May 2000	Start plant construction. Start perimeter dyke construction at tailings settling pond (clearing and grubbing). Start muskeg drainage and overburden dewatering for one-fifth of the initial five years (mine area of 0.89 km^2).
November 2000	Start excavation for crusher.
May 2001	Start diverting surface runoff from mine crusher area to tailings settling pond. Start muskeg drainage and overburden dewatering for a new 0.89 km^2 mine expansion area.
November 2001	Start mine stripping.
May 2002	Start muskeg drainage and overburden dewatering of a new 0.89 km^2 mine expansion area. Start pumping water from the Athabasca River to fill clear water and recycle pond reservoirs (combined capacity of 0.5 million m^3).
July 2002	Start plant operation. Start overburden removal for mine. Start basal aquifer dewatering.
2004	Start water recycle operation.
2006	Start CT production at 30% capacity.
2007	Start CT production at 50% capacity.
2010	Start CT production at 75% capacity.
2011	Start CT production at 85% capacity.
2013	Start CT production at 95% capacity.
2021	Complete muskeg drainage and overburden dewatering.
2022	Stop mining.
2023	Start to pump MFT porewater from the tailings settling pond and CT porewater from the mine pit into the end-pit lake.
2027	Start to pump consolidated MFT from the tailings settling pond into the bottom of the end-pit lake.
2031	Complete reclamation drainage facilities. Start performance monitoring.
2051	Stop closure and performance monitoring.

WATER USE EFFICIENCY

The tailings settling pond design criteria require that tailings water not be recycled for the first two years. During that time, the withdrawal of river water will be at a maximum, and water use efficiency, measured as a percentage of recycled water to the total water requirement, will be at a minimum. Later, during operations, the water use efficiency will be consistently higher and is expected to reach a maximum of 90% (see Figure 8-3).

All surface and groundwater that comes in contact with the developed area will be collected and used in the process.

A minimum surface area for detention and storage ponds will be engineered, to meet the process water requirements. The objectives are to minimize losses to evaporation and deep seepage.

Treated sewage water will be reused in the process to increase the water use efficiency.

WATER INVENTORY

Minimizing the free water inventory in surface ponds at the project site is an important goal of the water management system. This goal will be achieved by maximizing the water use efficiency.

Figure 8-4 shows the water inventory at the end of the project life. Free water in the ponds is calculated to be about 9% of the total inventory, about equal to one day's process water requirement (see Water Balance in Section 8.4).

The mine closure plan and related water management considerations are discussed in EIA Volume 3, Section E16.

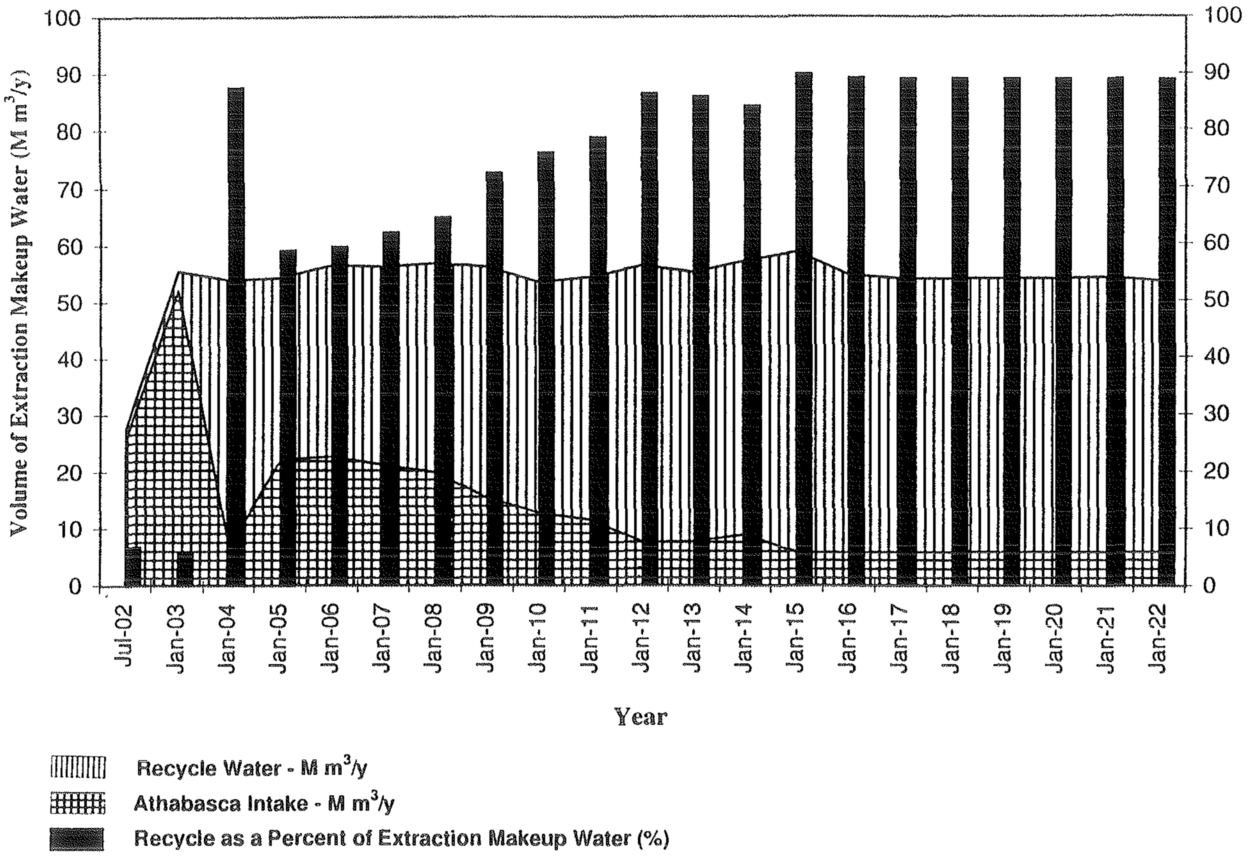


Figure 8-3: Volume of Extraction Makeup Water

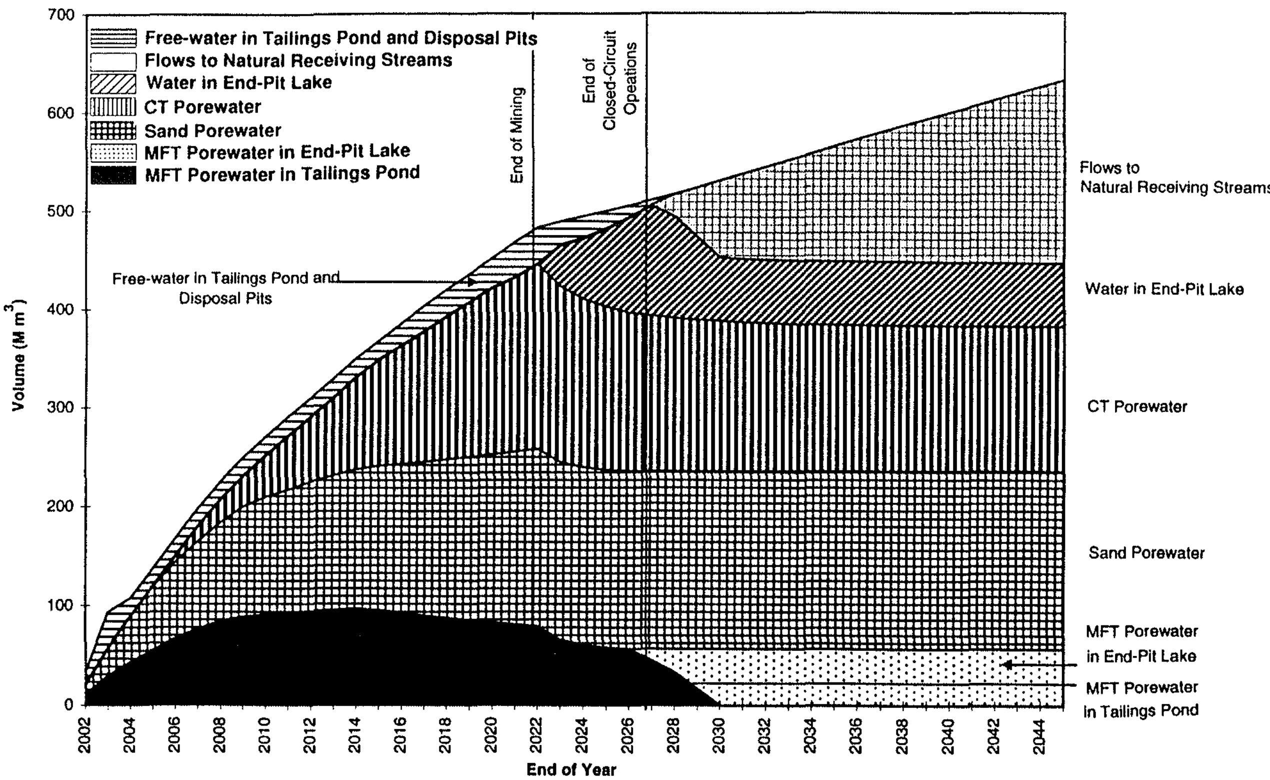


Figure 8-4: Water Inventory at End of Project

WATER SOURCES

Process water will originate from the following sources:

- the Athabasca River
- the basal and surface aquifers
- runoff
- connate water (water entrapped in the oil sands)

Surplus tailings water from the current operations was investigated as a possible alternative to pumping water from the Athabasca River. The evaluation revealed that this option was infeasible. The tailings water from the caustic processes of the current operations was determined to be detrimental to the non-caustic process of the Muskeg River Mine Project.

WATER REQUIREMENTS

The Muskeg River Mine Project is designed to produce 23,850 m^3 (150,000 bbl) of bitumen per calendar day. The plant design requires 8,560 m^3/h of water to process the required amount of oil sands.

Approval is required to withdraw water from the Athabasca River at the design rate of 80 million m^3/a. This amount of withdrawal will not be exceeded under any circumstances.

To withdraw 80 million m^3/a of water from the Athabasca River, the installed pumping capacity, including the standby capacity at the river intake system, has been designed at 12,000 m^3/h.

Considering the plant downtime for maintenance and repair, and deducting other available sources of water, the average maximum withdrawal rate from the Athabasca River is calculated at 6,284 m^3/h or 1.75 m^3/s.

WATER WITHDRAWAL

The Athabasca River is a major water source for processing the oil sands. It is a perennial river whose flow is greater than 90 m^3/s, 99% of the time. Figure 8-5 shows the flow duration curve developed from the available flow records.

WATER WITHDRAWAL (cont'd)

Figure 8-6 shows a histogram of yearly water withdrawal rates for:

- an average year (a year in which the total precipitation is normal)
- a wet year (a year in which the total precipitation is above the normal amount and statistically likely to occur once in 10 years)
- a dry year (a year in which the total precipitation is below the normal amount and statistically likely to occur once in 10 years)

The water withdrawal rate is at a maximum for the first two years of operation when recycling of tailings water is not possible. In the third year of operation, recycling of tailings settling pond water becomes feasible. During that year, the water withdrawal rate drops to about 17% of the maximum withdrawal rate. During the fourth year of operation, the accumulated water in the tailings settling pond is depleted to the desired level and the withdrawal rate increases to about 50% of the maximum amount for about 10 years. Thereafter, the withdrawal rate is about 10% of the maximum until the end of the operation.

ATHABASCA RIVER INTAKE

Intake Design

Four different types of intake design (see Figure 8-7) were considered for the intake structure:

- buried perforated pipes in the river bed conveying water to an intake well and pump house built on the river bank
- a concrete intake in the middle of the river with openings on both sides and a pipe conveying the water to an intake well and pump house on the river bank, a structure similar to the one currently used for the City of Fort McMurray water system
- a rock filter, built flush with the river bank to exclude the river debris entering the intake pond, and a pump house built on the river bank
- water wells, capable of induced filtration, on the permeable river bank

The buried pipe option was not selected because it is prone to clogging and frequent maintenance. The mid-river concrete intake type was not a desirable option because it will be an obstruction to river navigation. The remaining two types, rock filter intake and induced wells on the river bank, are technically acceptable for consideration.

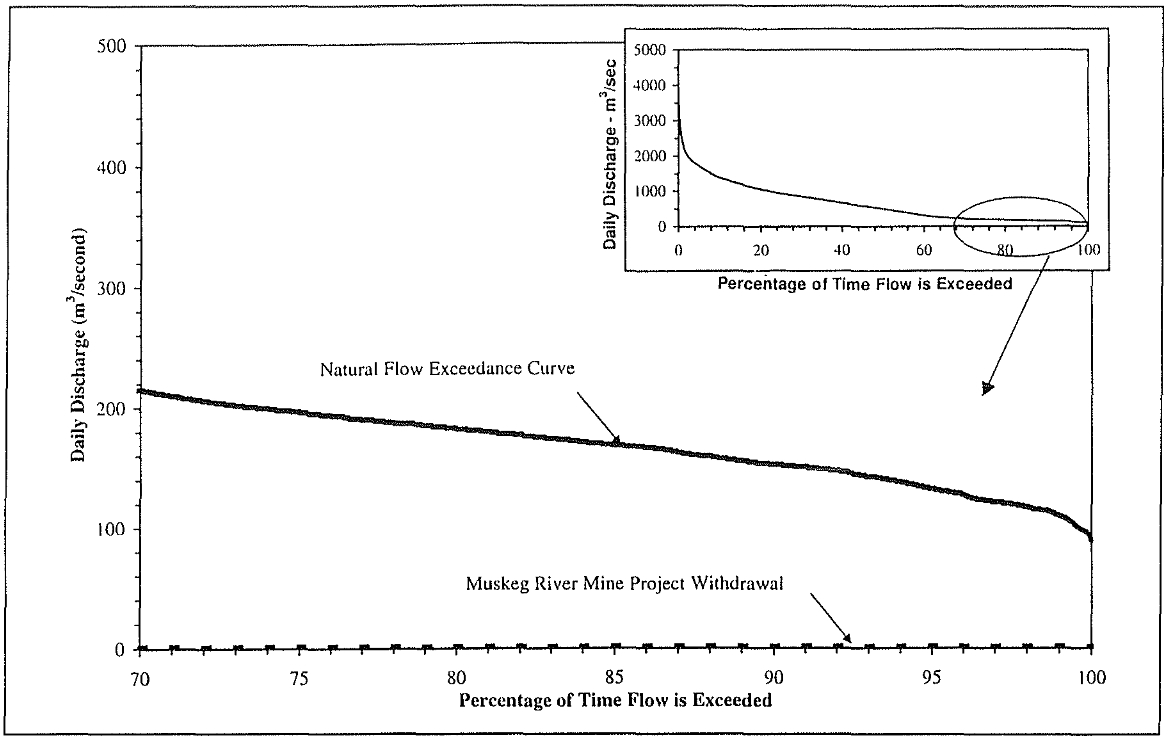


Figure 8-5: Athabasca River Flow Duration Curve

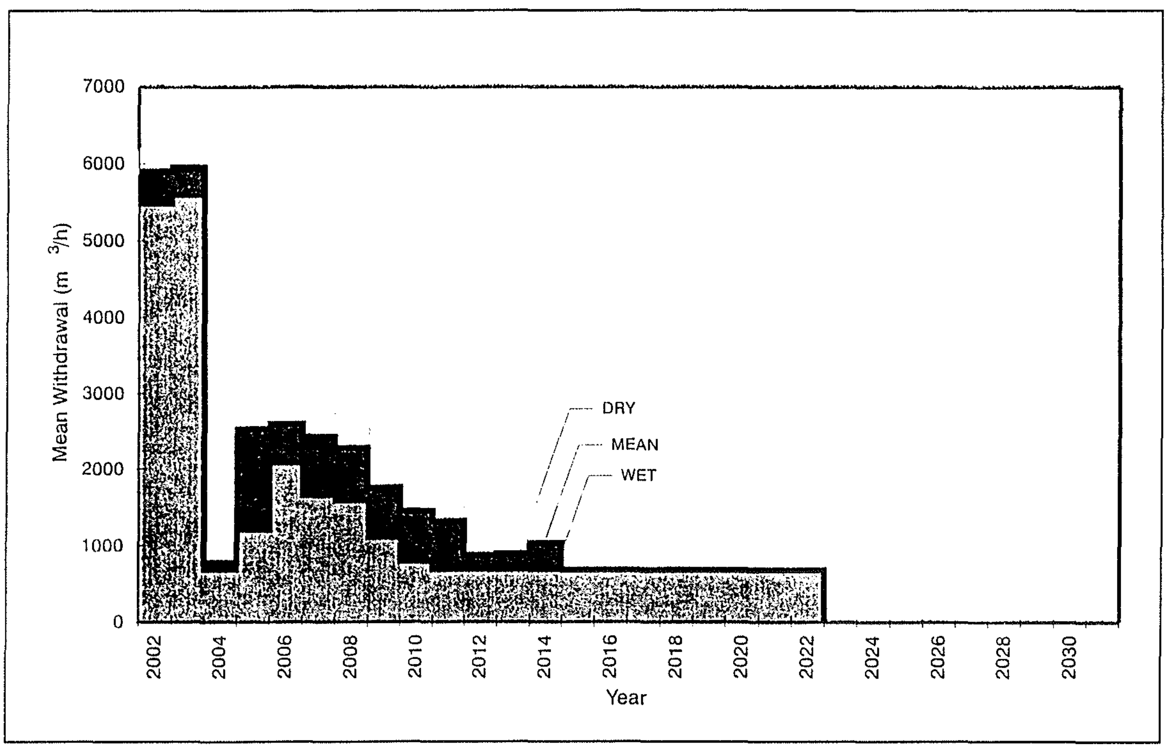
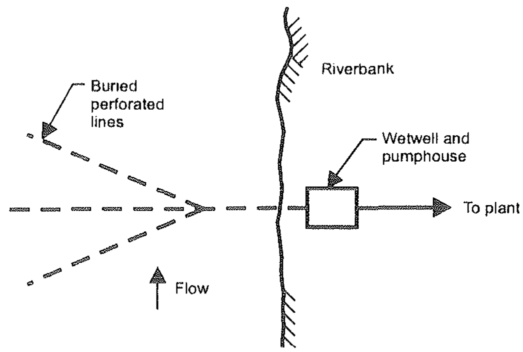
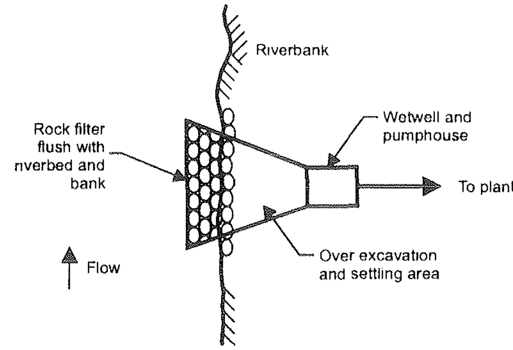


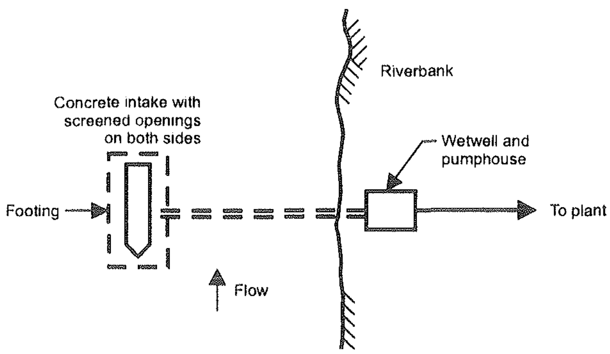
Figure 8-6: Mean Annual Raw Water Requirements for Three Weather Scenarios



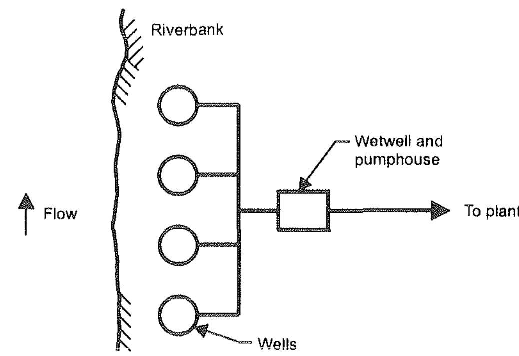
Infiltration Gallery



Rock Filter Bank Intake



Instream Concrete Intake



Floodplain Wells

FACTOR/ISSUE AFFECTING PERFORMANCE	INFILTRATION GALLERY	INSTREAM CONCRETE INTAKE	ROCK FILTER BANK INTAKE	FLOODPLAIN WELLS
1. Suspended Sediment and Bedload	H	M	L	N
2. Ice Forces	N	H	L	N
3. River Channel Stability	L	H	M	L
4. Bank Height/Slope	M	M	H	L
5. Instream Work Required	H	H	L	N
RECOMMENDED FOR THIS REACH OF THE ATHABASCA?	**NO** - due to high silt load (Maximum, mean and minimum sediment concentrations at Fort McMurray are 4110 mg/L, 350 mg/L and 4mg/L respectively as per Water Survey of Canada).	**NO** - due to ice forces and impact on navigation	**YES** - at bank location with good access, relatively flat bank profile and where main channel impinges into the bank - the barge landing area meets these requirements.	**YES** - in buried gravel/ sand channel in Mills Island (potential as identified from Alsands Project borehole locations).
DEGREE OF IMPORTANCE - **H** = High impact on performance and cost, **M** = Medium, **L** = Low, **N** = No impact				

Figure 8-7: Alternative Intake Types Evaluated

Intake Location

Sites Considered

Two water intake sites along the eastern bank of the Athabasca River (see Figure 8-8) were considered:

- a site near the existing barge landing (see Figure 8-9), using a rock filter intake structure excavated into the river bank. The conceptual design of this intake is shown in Figure 8-10.

- a sand bar, known as Mills Island, between Isadore's Lake and the Athabasca River (see Figure 8-11), using induced water wells from thick sand deposits

Selected Intake Location

The rock filter intake located near the barge landing was selected as the preferred intake location. The rock filter will be designed to prevent clogging from sediments and the possible entry of fish into the pump intake.

Access to the site will be via the existing barge landing access road connecting with Highway 63. The pipeline from the intake will follow the barge landing access road and will cross Highway 63 to connect with the Lease 13 utility corridor.

Alternative Intake

A field investigation conducted as part of the Alsands Project discovered a unique sand deposit up to 75 m thick beneath Mills Island, adjacent to Isadore's Lake (see Figure 8-12). This site is ideally suited for locating water wells which, though induced filtration, can access sediment-free water from the Athabasca River. Because of the thickness and nature of the sand deposit and its proximity to the Athabasca River, five wells might be capable of supplying the total quantity of fresh water required over the life of the project.

This location has additional benefits, because:

- river navigation is not affected
- fisheries are not affected
- pumping sediment-free water is energy efficient
- a sedimentation pond is not required

Shell considers the Mills Island well intake near Isadore's Lake to be a superior location from both an environmental impact and cost perspective. However, some concerns have been raised through stakeholder consultation because of the sensitivity of this area to traditional land use and possible archaeological resource. Shell will continue to evaluate this option and to discuss and resolve outstanding issues with stakeholders.

GROUNDWATER FROM BASAL AQUIFER

Groundwater will be produced ahead of the mining operation during the depressurization of the basal aquifer and will be used to supplement water from the Athabasca River for process water supply. However, high concentrations of chloride in the water, if present, could preclude its use as process water.

Groundwater from muskeg drainage and from surficial aquifers will be discharged to the natural streams.

Groundwater produced from the basal aquifer will be conveyed by manifold pipes to the onsite water storage for process use, or conveyed to the Athabasca River.

The basal aquifer flow is estimated to range between 90 m^3/h to 459 m^3/h. The process water demand will use this supplemental source to reduce the withdrawal from the Athabasca River.

The presence of hydrogen sulphide (H_2S) has been reported in the basal groundwater in other oil sands leases. In October 1997, a program to determine the technical status and water sampling of 15 project area basal aquifer piezometers was initiated. Eight piezometers were found in good condition and seven required some minor repair. Hydrogen sulphide was not recorded in any of the groundwater samples collected from this aquifer in 1997.

The water quality monitoring program will be continued in 1998 to check for the presence of H_2S in the basal groundwater.

RUNOFF

Runoff from the developed area around the extraction plant, tailings and mining areas will be collected and conveyed to the plant area storage pond and used as process water. The estimated flows from these sources range between 190 to 1,065 m^3/h. The water withdrawal from the Athabasca River will be reduced by these amounts.

CONNATE WATER

The laboratory assay of oil sands quantifies the volume of connate water at 488 m^3/h from the oil sands throughput to produce 23,850 m^3 (150,000 bbl) of bitumen per calendar day.

WATER QUALITY

CANMET completed a detailed study of the water quality of various process water sources. The results of the CANMET study, together with other available information, are summarized in Table 8-2.

Table 8-2: Quality of Water Sources

		pH	Ion Concentration (mg/L)							
			HCO_3	Ca	Na	K	Mg	Cl	SO_4	TDS
Athabasca River	Typical	7.75	130	32	13	1	10	11	22	219
Connate	Worst case	7.60	1,670	31	1,120	310	15	870	110	4,126
	Typical	7.46	540	4	270	50	4	130	40	1,038
Recycle (after 14 years)	Worst case	N/A	879	84	531	146	12	429	1,917	3,998
	Typical	N/A	329	81	133	24	7	69	1,883	2,527
Basal Aquifer	High	8.6	451	126	9	3	20	2,793	90	7,404
	Low	7.4	368	101	5	1	16	81	3	815
Surficial Aquifer	High	7.9	108	26	15	3	4	134	300	1,729
	Low	6.7	6	8	5	1	2	1.6	2	249
Surface Water	Muskeg River	7.7	313	67	14	1.6	18	5.5	6	270

WATER USE AND DISPOSAL

The mine and the extraction plant use water for:

- processing oil sands to extract bitumen
- fire protection
- vehicle and plant cleaning and flushing
- culinary and consumptive uses, such as drinking and showers
- boiler feed water
- equipment gland water

PROCESS WATER SUPPLY AND DISTRIBUTION

The water supply and distribution system, which is designed to be a closed loop circuit, is shown in Figure 8-13.

Water from the Athabasca River will be pumped into a pond with an effective capacity of 105,000 m^3, equivalent to the plant requirement for one half-day. The depth of this raw water pond, as well as other ponds at the plant, will include:

- 1 m for free board
- 1 m for silt accumulation
- 1 m for ice cover

PROCESS WATER SUPPLY AND DISTRIBUTION (cont'd)

Clean water from this pond will feed the water distribution systems to meet the mine and extraction plant's requirements for process and other uses. The system is designed to maximize the energy efficiency by recycling and reusing the water to a maximum, thereby minimizing the environmental impact.

RECYCLE WATER POND

The recycle water pond near the plant will collect:

- waste water from the plant flush and cleaning
- developed area surface runoff
- utilities water for reuse
- water reclaimed from the tailings settling pond
- treated sewage

The effective capacity of the recycle water pond will be 411,000 m^3, equivalent to the plant requirement for two days. The conceptual design of the recycle pond is shown in Figure 8-14.

DISTRIBUTION CIRCUITS

The water supply system will draw water for the project needs either from the clean water pond or from the recycle pond.

Clean Water Pond

The clean water pond will supply water in two distribution circuits:

- a fire water circuit with an instantaneous capacity of 1,365 m^3/h

- a second circuit with an instantaneous capacity of 1,030 m^3/h, which will supply water to meet all other uses

Recycle Water Pond

The recycle water pond will supply water to two distribution circuits:

- a process water circuit with an instantaneous capacity of 7,420 m^3/h. Water from this circuit will be mixed with the utility cooling water and water from the:
  - solvent recovery unit
  - froth treatment unit
  - tailings solvent recovery unit

Recycle Water Pond (cont'd)

- a plant and tailings flush and density control circuit with an instantaneous capacity of 1,700 m^3/h. Water from this circuit will be used to:
  - flush the plant and the tailings line, when required
  - control the rheology of the tailings if the solids content exceeds the design level

All water supplied by these two circuits will eventually become part of the tailings.

INDUSTRIAL USES

Water required for industrial uses, such as fire protection, vehicle and plant washing, will be drawn from the clean water circuit. Water required for flushing the plant and tailings line will be drawn from the recycle water pond circuit.

The discharge water from these activities will be collected in the recycle water pond.

POTABLE WATER TREATMENT PLANT

Potable water is required during the construction and operating phases of the project. During the construction phase, a water well will be drilled in the Quaternary aquifer near the camp to provide potable as well as other water for construction. The construction work force will range from a minimum of 300 people to 800 at peak.

The potable water requirement is expected to range from 100 to 450 m^3/d when the camp population peaks.

Groundwater from the Quaternary aquifer will be aerated, chlorinated, then directed to an iron and manganese filtration system before it is sent to the water distribution system.

Figure 8-15 shows the construction camp water treatment system.

During the operations phase of the project, raw water from the Athabasca River will be the permanent source of potable water. The potable water requirement is estimated at 100 m^3/d for employees and visitors.

Because the river water is laden with sediment and the quality is different from the groundwater quality, a separate treatment system is proposed. Figure 8-16 shows the required treatment steps before the water is sent to the facility reticulation system.

BOILER FEED WATER TREATMENT

The demand for boiler feed water is estimated at 80 m^3/h. The treatment process (see Figure 8-17) involves passing the softened water through a sequence of reverse osmosis and deionization resins to remove any possible remaining organic material that passed through the reverse osmosis membrane.

On average, the boiler feed water will have:

- less than 0.1 mg/L hardness
- less than 1 mg/L of total dissolved solids

GLAND WATER

Clean water is required for the glands of the plant equipment. The required supply will come from the clean water circuit. The water will be reused as many times as possible until it is discharged to the recycle pond.

WASTE WATER TREATMENT

Domestic sewage flow from the construction camp is estimated to range between 75 to 500 m^3/d.

Treatment will consist of screening, followed by storage in a mechanically aerated facultative lagoon. The sewage treatment system will be designed and operated following all applicable environmental regulations and guidelines for such facilities. The quality criteria for the final effluent will be consistent with its intended reuse, because it will not be discharged to the receiving stream.

During the operating phase of the project, domestic sewage will be screened and pumped via pipeline to the aerated lagoon used previously for the construction camp. The treated effluent will be discharged to the recycle pond for reuse in the processing plant.

WATER TREATMENT, CHEMICAL SUPPLY AND STORAGE

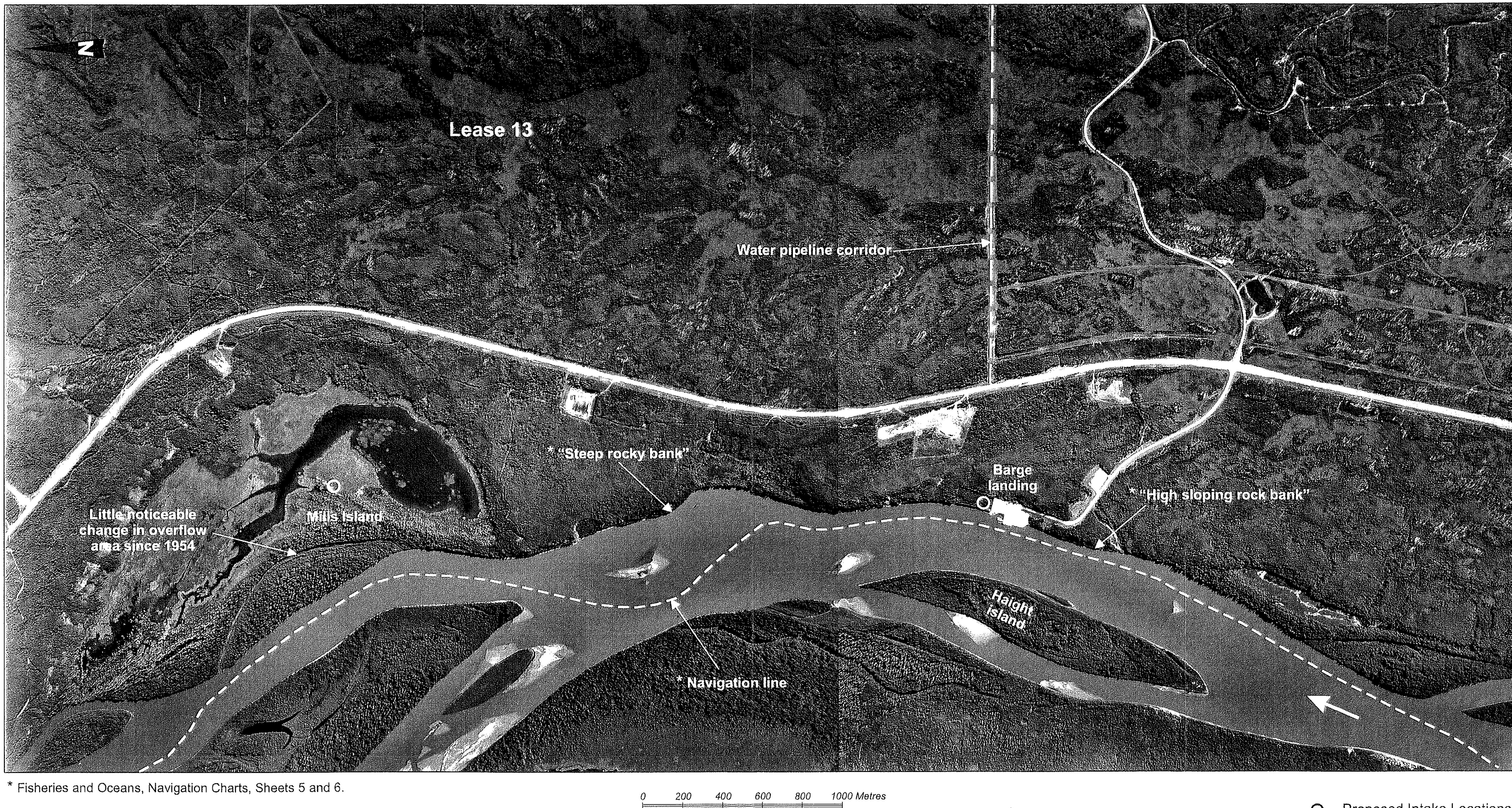
All solid or liquid chemicals used in water treatment will be transported to the project site in sufficient quantities by truck.

The following chemicals are expected to be used in the water treatment systems:

- sodium hypochlorite — 6 L/d
- lime consumption — 20 kg/d
- alum — 1 kg/d
- sulphuric acid — 10 kg/d
- caustic soda — 0.5 kg/d

WATER TREATMENT, CHEMICAL SUPPLY AND STORAGE (cont'd)

All chemicals will be stored in a covered facility. To control spills or leaks, perimeter dykes with concrete curbs will be provided for the storage area. Storage floor drains will be provided with valves to prevent spilled chemicals from entering the domestic sewage system. Vacuum trucks will collect any spilled chemicals. Chemical spills will either be recycled or disposed of according to regulatory requirements and corporate practices.



* Fisheries and Oceans, Navigation Charts, Sheets 5 and 6.

Figure 8-8: Intake Structure Sites

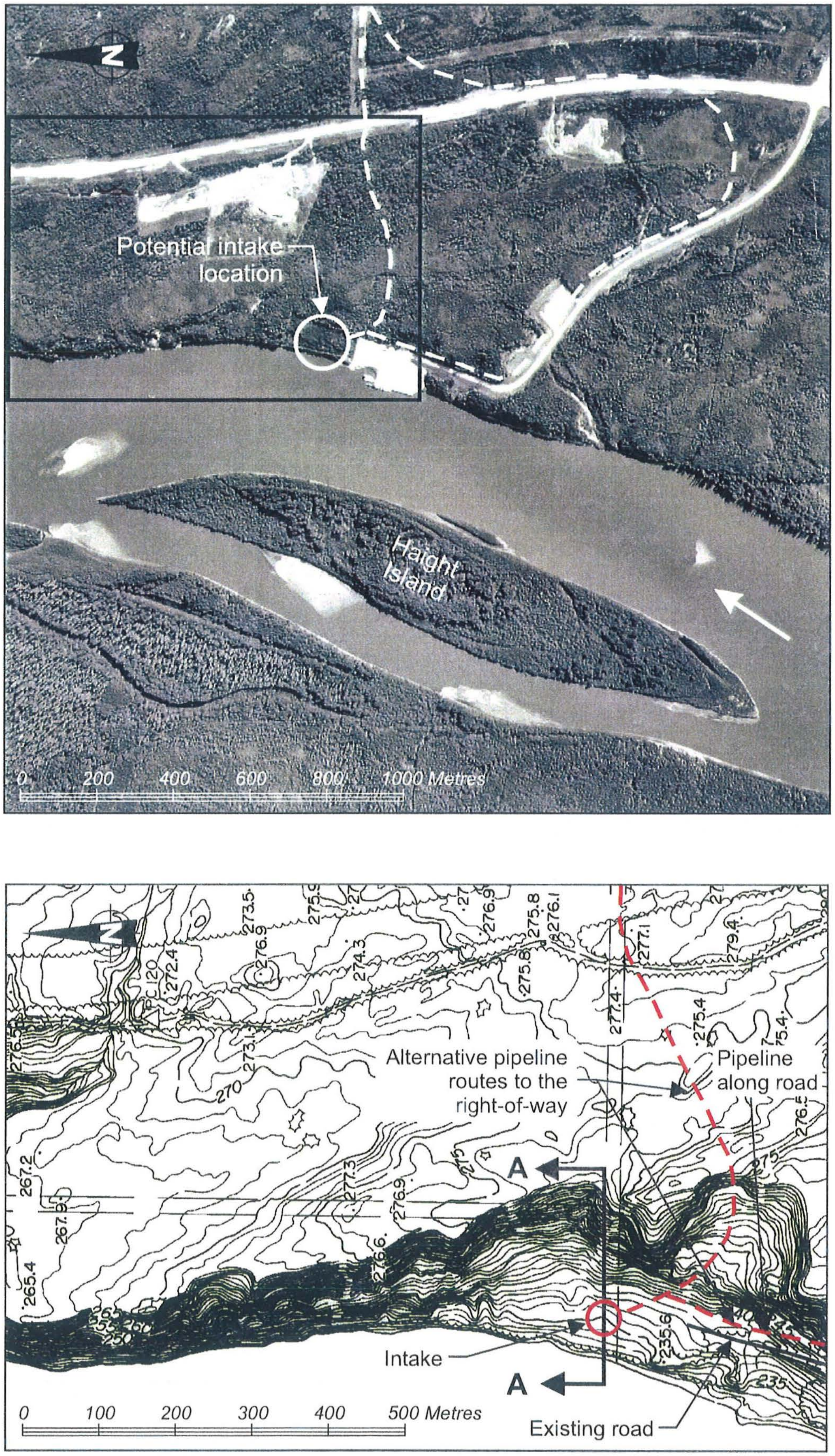


Figure 8-9: Location of Proposed Barge Landing Water Intake

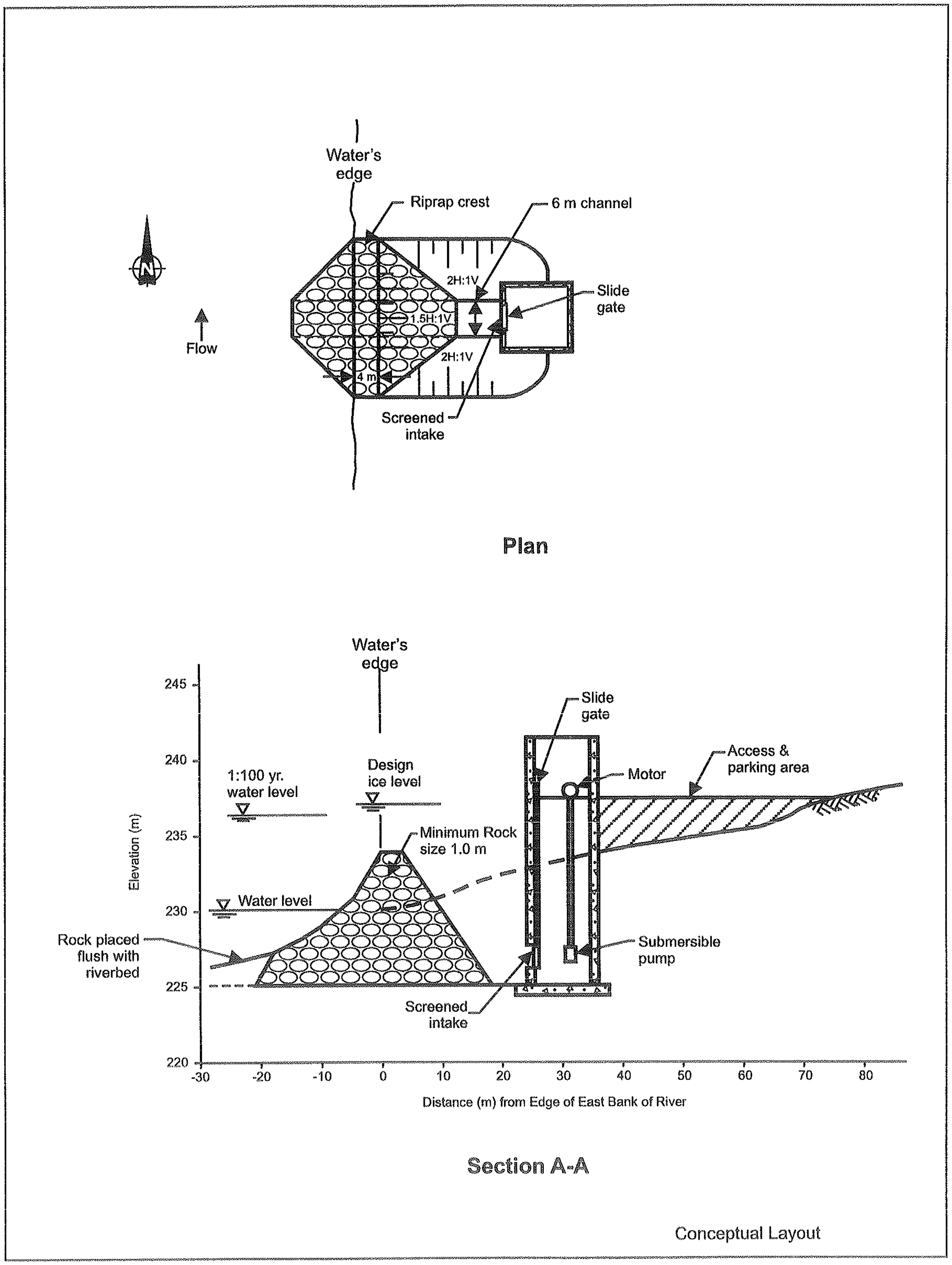
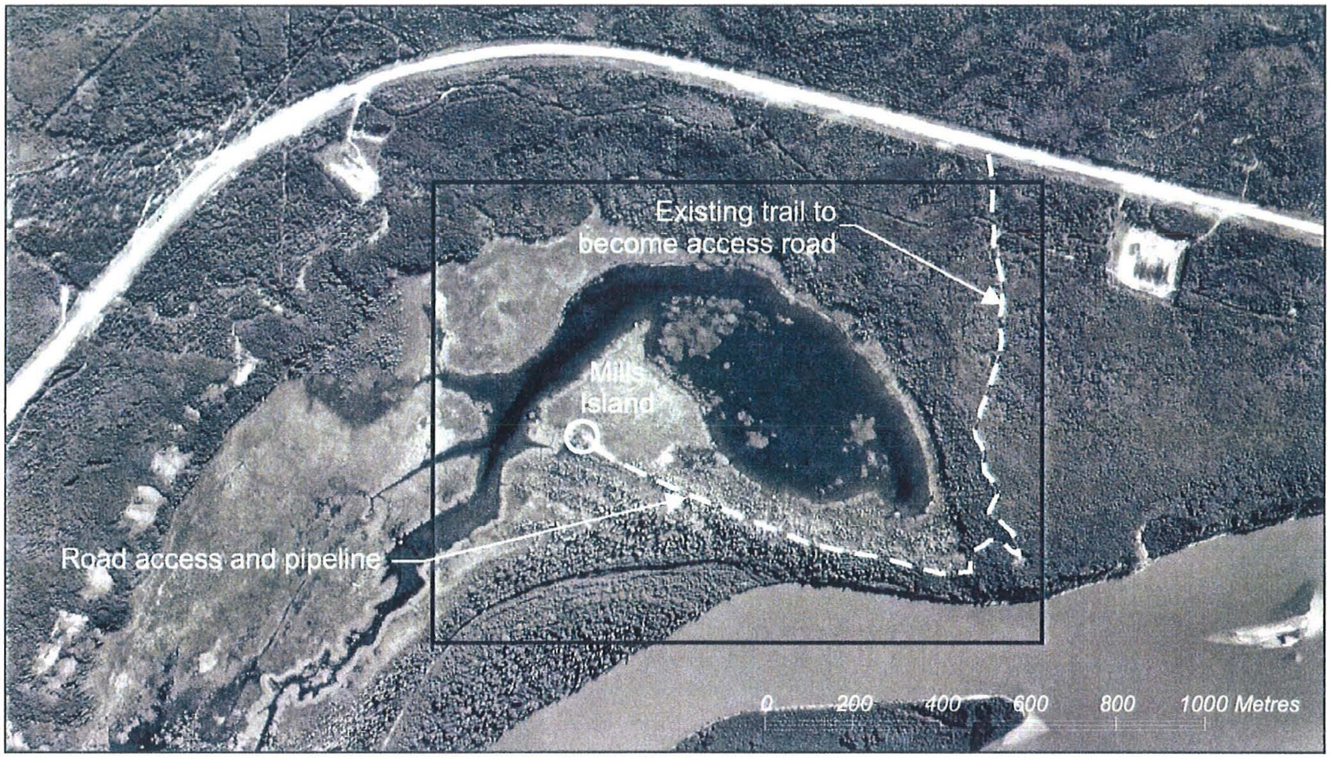


Figure 8-10: Conceptual Layout of Intake Structure



1994 Air Photo

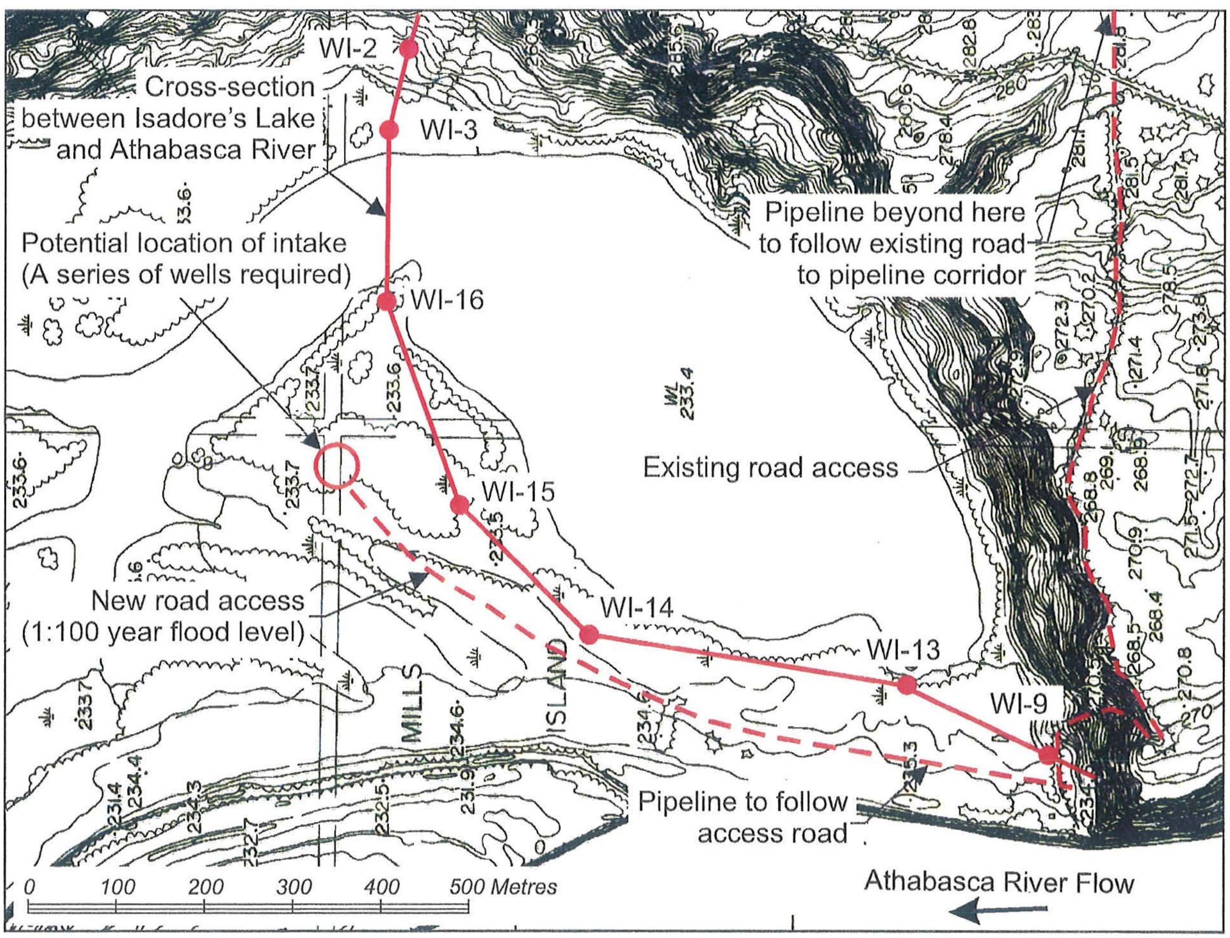


Figure 8-11: Location of Athabasca River Water Intake Alternative

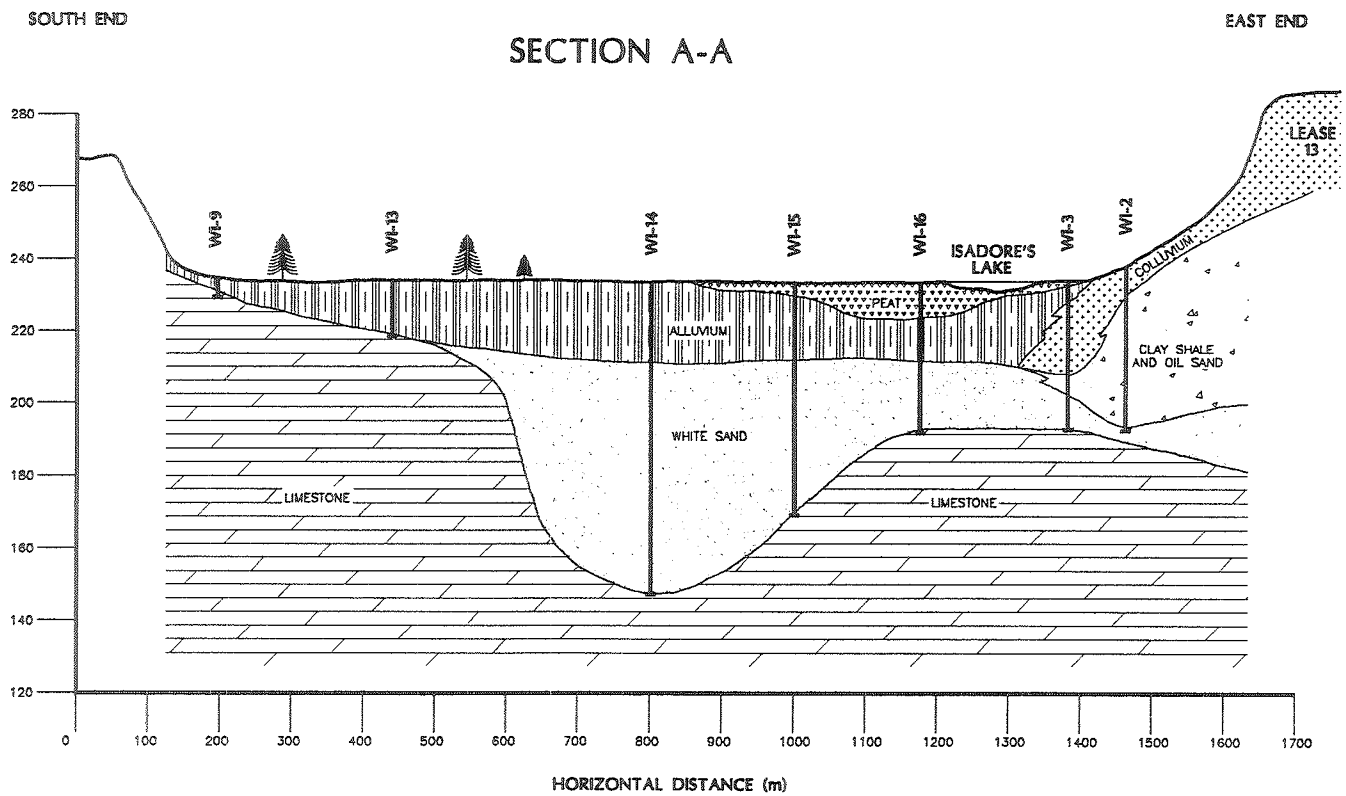


Figure 8-12: Cross-Section of Sand Deposit Beneath Mills Island

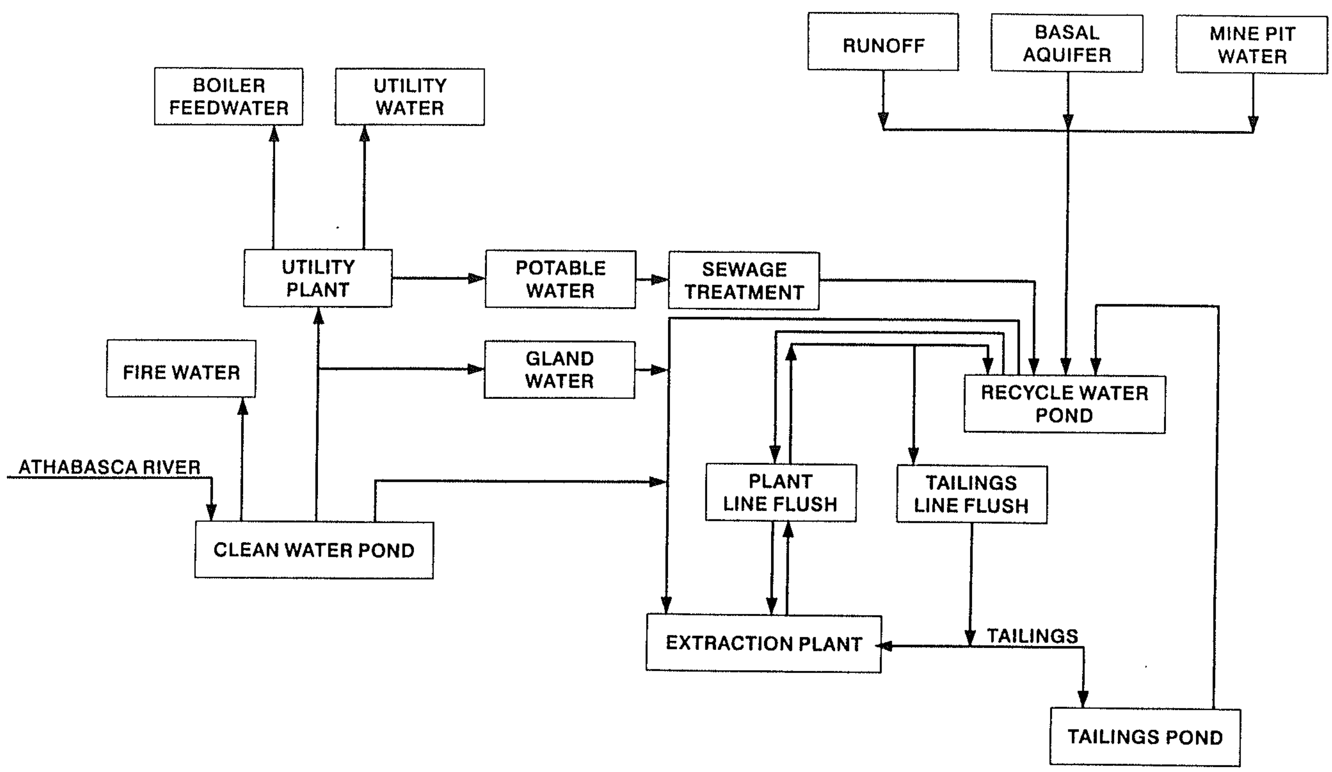
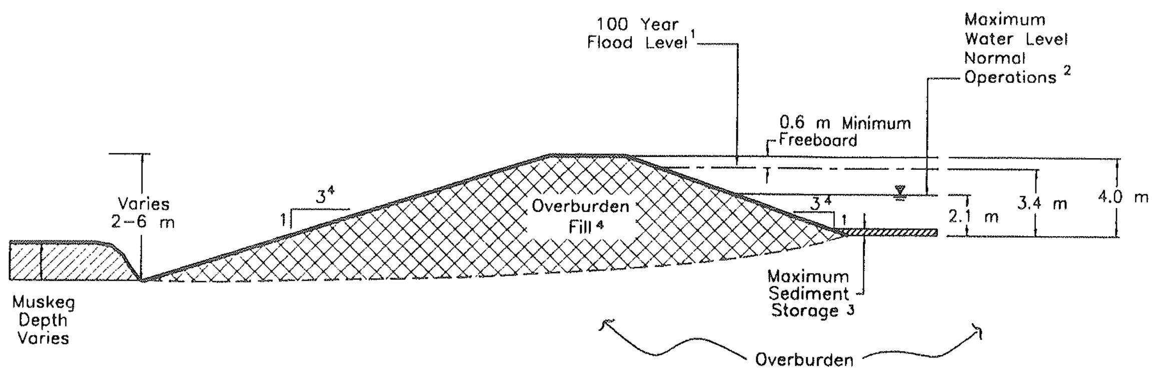


Figure 8-13: Water Supply Flow Chart



NOTES

1. In accordance with dam safety requirements, and based on the operating conditions for a period of maximum inflows and minimum outflows
2. Includes winter ice conditions of 1.0 m thickness
3. Assumed storage is 0.5 m
4. Maximum slope and the requirement for an impermeable core and toe drains will depend on the results of soil investigations

Figure 8-14: Recycle Pond Containment Dyke Cut and Fill Construction

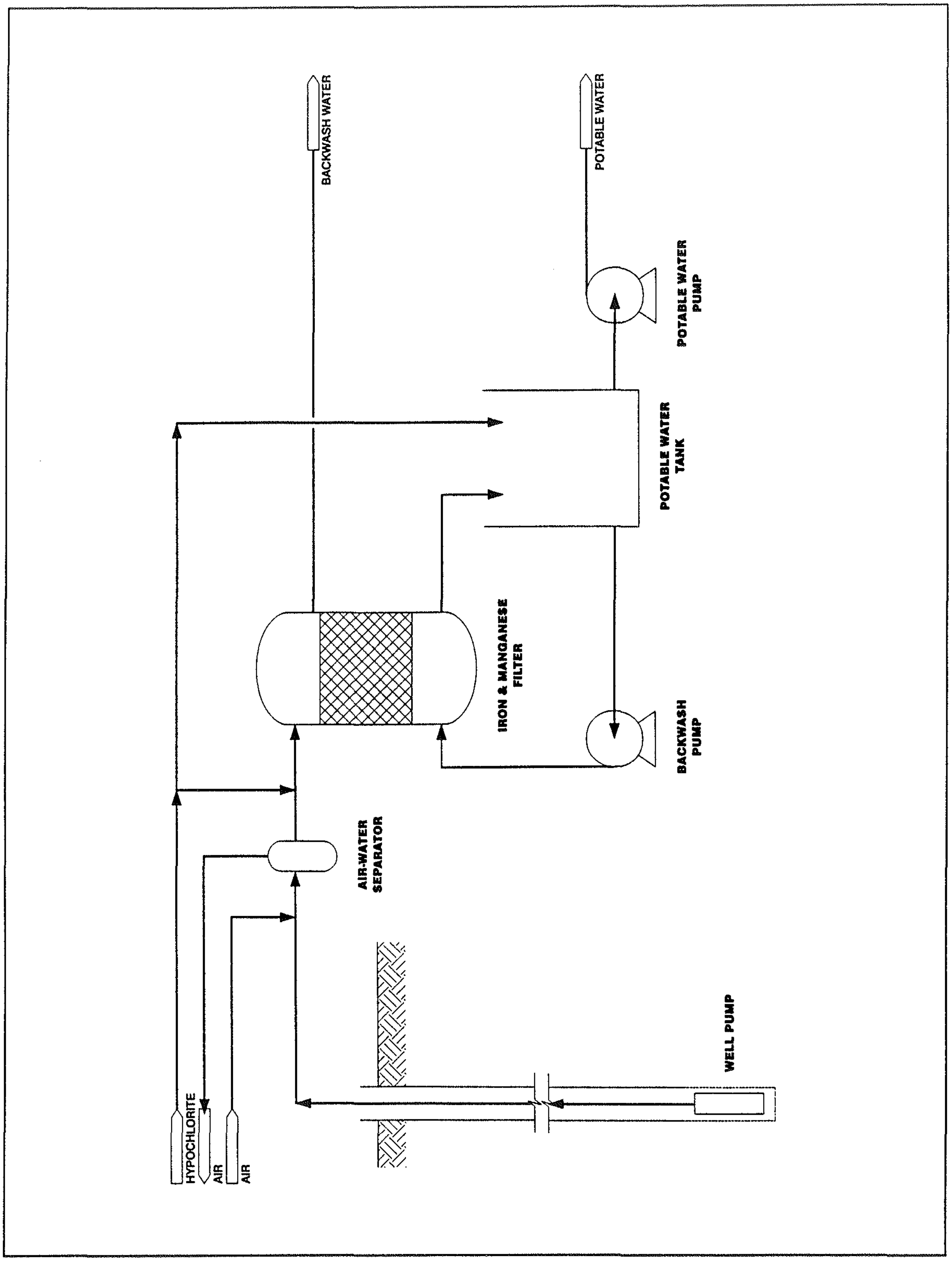


Figure 8-15: Camp Water Supply Water Treatment Process Flow Diagram

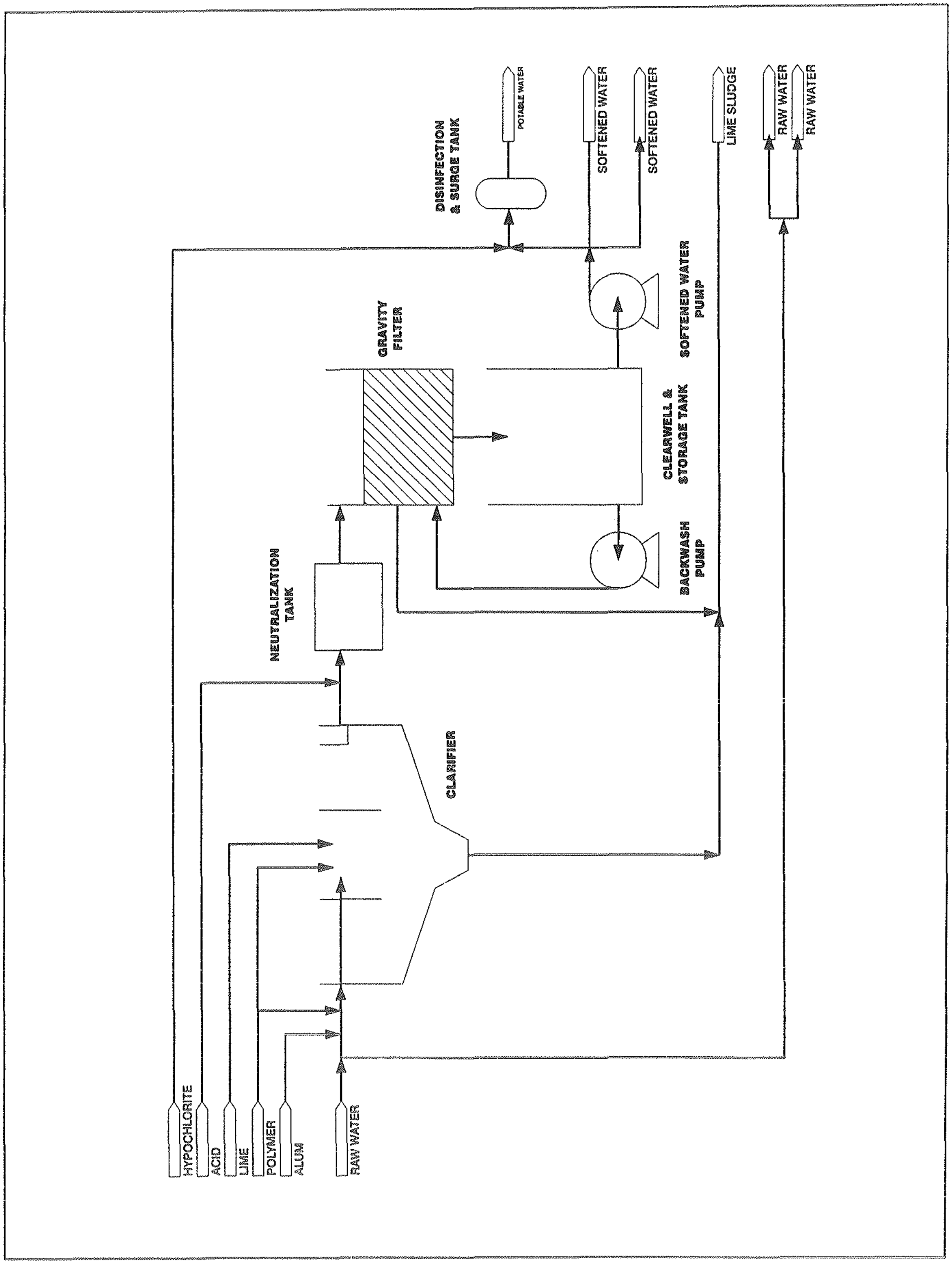


Figure 8-16: Water Supply Water Softening Process Flow Diagram

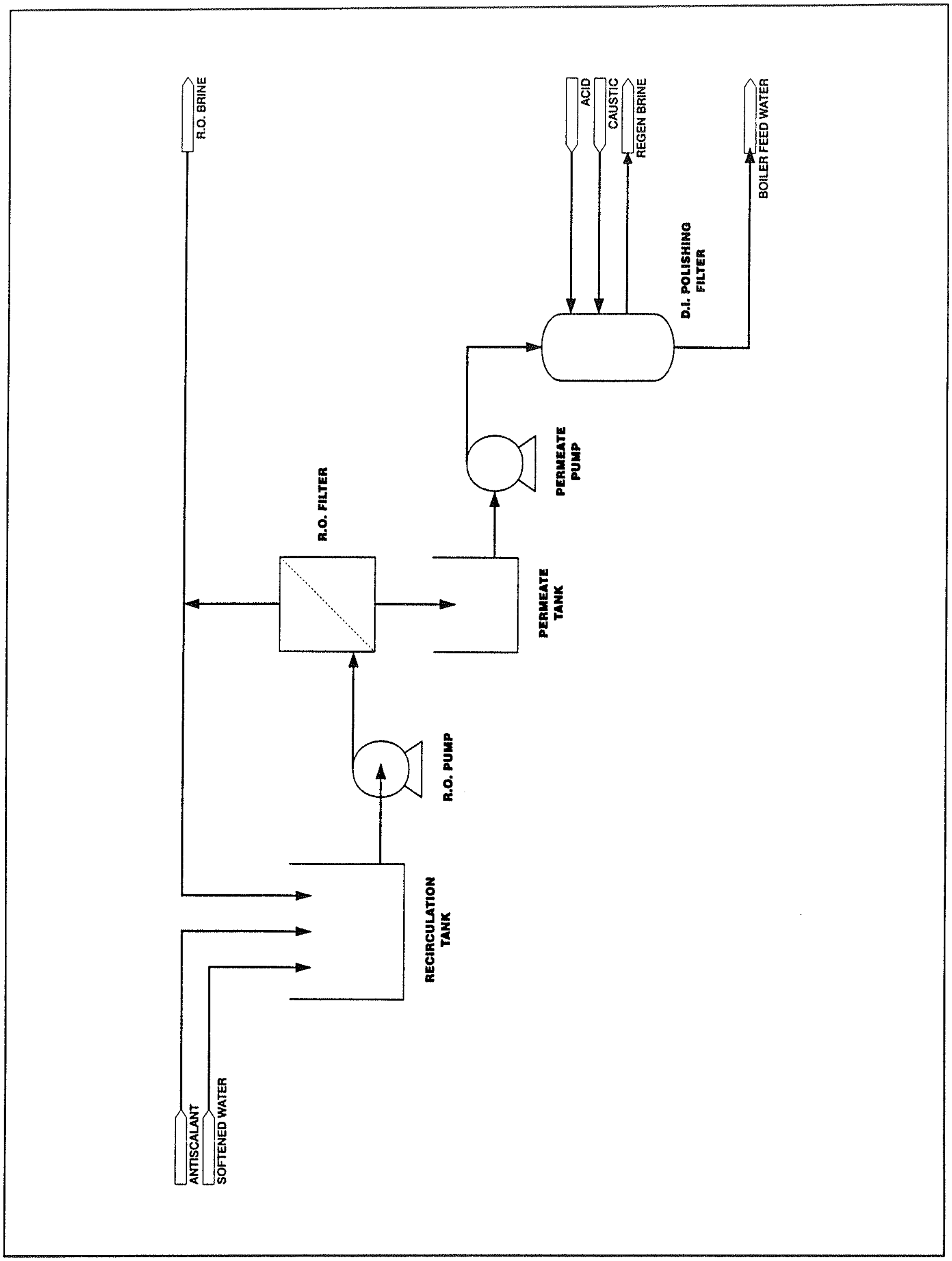


Figure 8-17: Water Supply Boiler Feed Water Process Flow Diagram

WATER BALANCE

The water balance analysis and calculations show that water conservation objectives will be achieved. The calculations are based on the annual accumulation being equal to the annual inflow, less the annual outflow on the project area.

Inflows

The inflows include:

- makeup water from the Athabasca River
- connate water
- basal aquifer water
- surficial aquifer water
- surface runoff from the disturbed lease area

Outflows

The outflows include:

- evaporation losses from waterbodies
- groundwater seepage
- atmospheric losses in the process
- consumptive domestic uses

Accumulation

Water accumulates in the pores of:

- rejected ore
- coarse tailings
- fine tailings
- consolidated tailings

Water is also found as:

- free-standing water in the tailings settling pond for recycling
- stored water in the water system, ponds and sumps
- water in the end-pit lake

Accumulation (cont'd)

Table 8-3 summarizes the water balance components of the project.

Table 8-3: Summary Water Balance Analysis for Average Conditions

(Flows in m^3/h)

	INFLOWS								OUTFLOWS					CHANGES IN STORAGE								RECYCLE FLOWS				
Period Starting:	Athabasca Intake	Net Connate Water	Basal Aquifer Depressurizatio	Plant Area Runoff	Mine Pit Runoff	Tailings Dyke Runoff	CT Disposal Area Runoff / Recycle	Total Inflows	Boiler Feed Losses	Net Pond Evaporation	Seepage	Flows to Natural Receiving St	Total Outflows	Raw Water Pond	Recycle Pond	MFT Porewater in Tailings Pond	Free-water in Tailings Pond ar	Sand Porewater	CT Porewater	Water in End-Pit Lake	Total Storage (million m3)	Net Runoff	CT Porewater Recycle	Basal Aquifer Depressurizatio	MFT Porewater Recycle	Total Recycle
Jan-99																										
May-00				18				18				18	18													
Nov-00				56				56				56	56													
May-01				109		221		329		10		88	98				232				232					
Nov-01	93			109		210		411		20		88	107	68	24		211				304					
Jul-02	5900	488	326	109	-2	165		6986	4	57			61		0	2533	2300	2092			6925	105		326		431
Jan-03	5950	488	250	109	25	101		6923	4	111			115		0	2134	2581	2092			6808	132		250		382
Jan-04	771	488	216	109	52	102		1738	4	110			113		0	1582	-1992	2034			1625	159		216	5005	5380
Jan-05	2534	488	216	109	80	104		3530	4	108			112			1396	-23	2044			3418	186		216	3246	3649
Jan-06	2599	488	216	109	107	105		3623	4	107			111		0	1288	-23	1615	632		3512	214	574	216	2828	3832
Jan-07	2429	488	233	109	2	103	140	3503	4	109	9		122		0	1061	41	1270	1010		3381	108	1125	233	2508	3975
Jan-08	2284	488	176	109	7	100	169	3331	4	112	10		125			930	41	1285	950		3206	114	1232	176	2669	4190
Jan-09	1759	488	151	109	13	97	197	2813	4	114	11		129		0	487	41	1289	867		2684	119	1309	151	3053	4632
Jan-10	1456	488	151	109	18	95	225	2541	4	116	13		132		0	274	41	838	1255		2408	125	1809	151	2537	4621
Jan-11	1319	488	151	109	23	92	254	2435	4	118	14		136		0	131	41	698	1428		2299	130	2107	151	2481	4869
Jan-12	872	488	459	109	31	93	292	2343	4	117	16		137			217	-17	722	1285		2206	138	2396	459	2552	5545
Jan-13	890	488	359	109	38	94	331	2309	4	116	17		138		0	138	-17	543	1507		2171	145	2546	359	2343	5393
Jan-14	1029	488	313	109	46	95	370	2449	4	116	19		139	0		135	-17	561	1631		2310	152	2597	313	2423	5485
Jan-15	678	488	313	109	53	96	409	2145	4	115	21		139			-173	4	575	1601		2006	160	3081	313	2457	6011
Jan-16	678	488	313	109	61	97	444	2189	4	114	23		140			-315	419	538	1407		2049	167	2978	313	2101	5560
Jan-17	678	488	233	109	67	99	463	2136	4	113	25		142			-289	368	532	1383		1994	173	2528	233	2539	5473
Jan-18	678	488	177	109	71	100	402	2023	4	112	31		146			-266	142	532	1469		1877	178	2591	177	2527	5473
Jan-19	678	488	153	109	77	101	385	1989	4	111	35		149			-256	220	532	1344		1840	184	2697	153	2440	5473
Jan-20	678	488	153	109	83	102	368	1980	4	110	39		152			-243	189	532	1350		1827	190	2798	153	2332	5473
Jan-21	678	488	153	109	89	103	372	1991	4	109	41		154			-241	618	532	927		1836	196	2690	153	2457	5496
Jan-22	678	488	90	109	91	105	269	1830	4	107	48		159			-198	83	526	1261		1671	198	2776	90	2354	5418
Jan-23					111	107	630	848		167	35		202	-46	-16	-1525	-1452		-1002	4686	646					
Jan-24					111	103	630	843		171	35		206			-608	-195		-859	2300	638					
Jan-25					111	99	630	839		174	35		209			-307	-504		-607	2048	630					
Jan-26					111	103	630	843		171	35		206			-142	-661		-542	1983	638					
Jan-27					111	112	630	852		163	35		198			-1326	-786		-347	1787	-671					
Jan-28					111	121	630	861		156	35	2470	2661			-1326	-542		-284	-973	-3125					
Jan-29					111	138	630	878		65	35	3214	3314			-1913	-9		-204	-2223	-4349					
Jan-30					111	138	630	878		65	35	3143	3244			-1913			-143	-2223	-4278					
Jan-31					111	138	630	878		65	35	921	1021						-143		-143					
Jan-32					111	138	630	878		65	35	874	974						-96		-96					
Jan-33					111	138	630	878		65	35	874	974						-96	0	-96					
Jan-34					111	138	630	878		65	35	828	929						-50		-50					
Jan-35					111	138	630	878		65	35	828	929						-50		-50					
Jan-36					111	138	630	878		65	35	809	909						-31	0	-31					
Jan-37					111	138	630	878		65	35	809	909						-31		-31					
Jan-38					111	138	630	878		65	35	809	909						-31	0	-31					
Jan-39					111	138	630	878		65	35	809	909						-31		-31					
Jan-40					111	138	630	878		65	35	809	909						-31	0	-31					
Jan-41					111	138	630	878		65	35	809	909						-31		-31					
Jan-42					111	138	630	878		65	35	809	909						-31	0	-31					
Jan-43					111	138	630	878		65	35	809	909						-31		-31					
Jan-44					111	138	630	878		65	35	778	878													
Jan-45					111	138	630	878		65	35	778	878							0	0					

(data from Agra, September 24, 1997)

Source: Agra Earth & Environmental, September 24, 1997

Accumulation (cont'd)

Figure 8-18 shows a schematic water balance for water withdrawal during an average year with the amounts of the water balance components influenced by the weather.

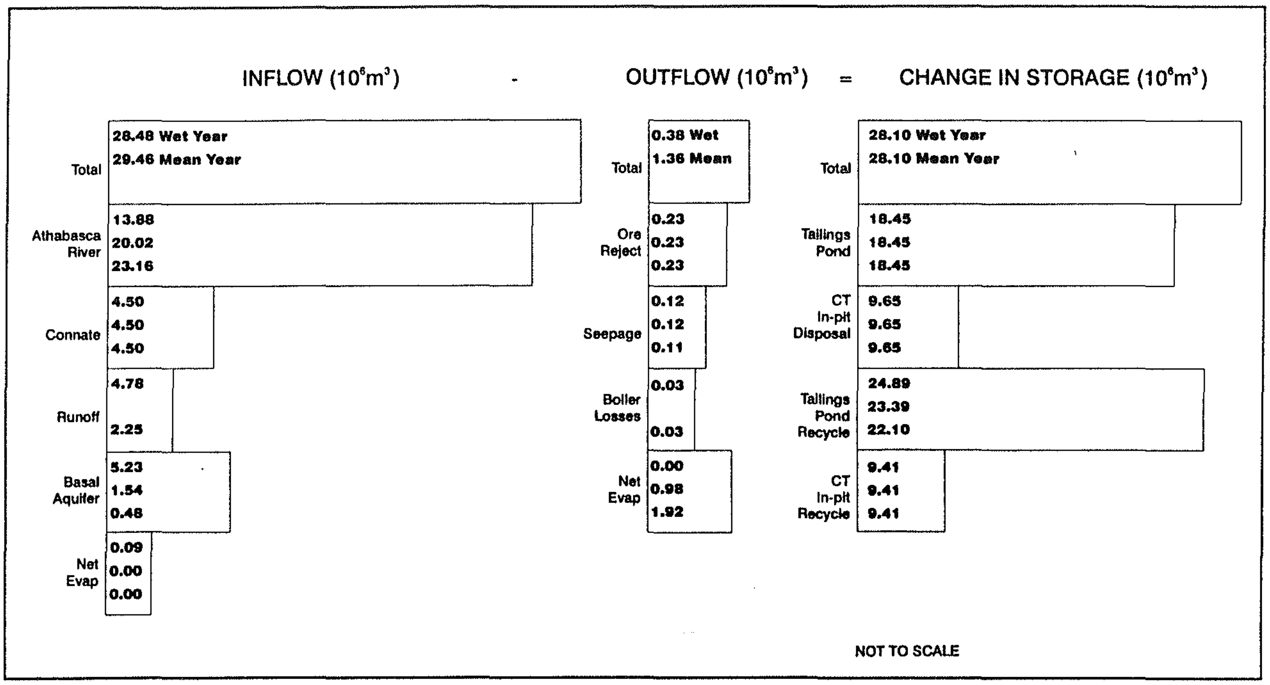


Figure 8-18: Water Balance During 2008, an Average Year for Raw Water Requirements

MASS BALANCE

Figure 9-1 shows the overall mass balance on a tonnes per hour calendar day basis for a production level of 3.4 million m^3/a (5.5 million bbl/yr). Figure 9-2 shows the overall mass balance on a tonnes per hour stream day basis for the same production level.

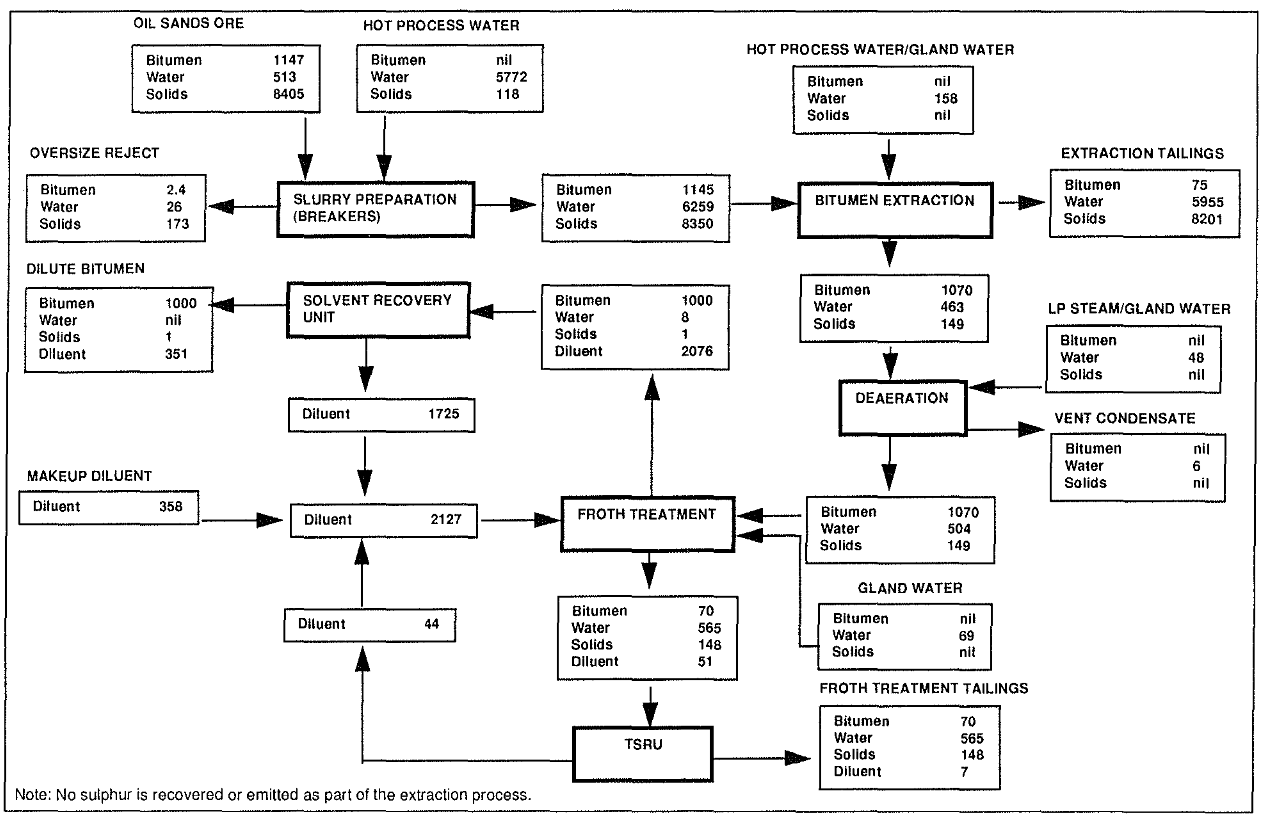


Figure 9-1: Overall Mass Balance Tonnes per Calendar Day

MEASUREMENTS

The necessary process measurement systems and instrumentation will be installed in the Muskeg River Mine extraction plant to ensure that:

MEASUREMENTS (cont'd)

- operations are effective
- licence requirements are met

The primary emphasis will be on process stream measurements that will enable the key performance parameters in the following areas to be controlled and monitored:

- products and production
- bitumen extraction and hydrocarbon recovery
- water intake, disposal and recycle
- waste processing and disposal
- energy consumption
- air emissions

The systems and equipment used to obtain operational data for regulatory reporting will be based on sound engineering practices and will meet or exceed the:

- regulatory requirements
- American Petroleum Institute (API) *Manual of Petroleum Measurement Standards*
- recognized industry recommended practices and standards

Operational information will be reported to the EUB through the *Monthly Oil Sands Processing Plant Statement,* S-23.

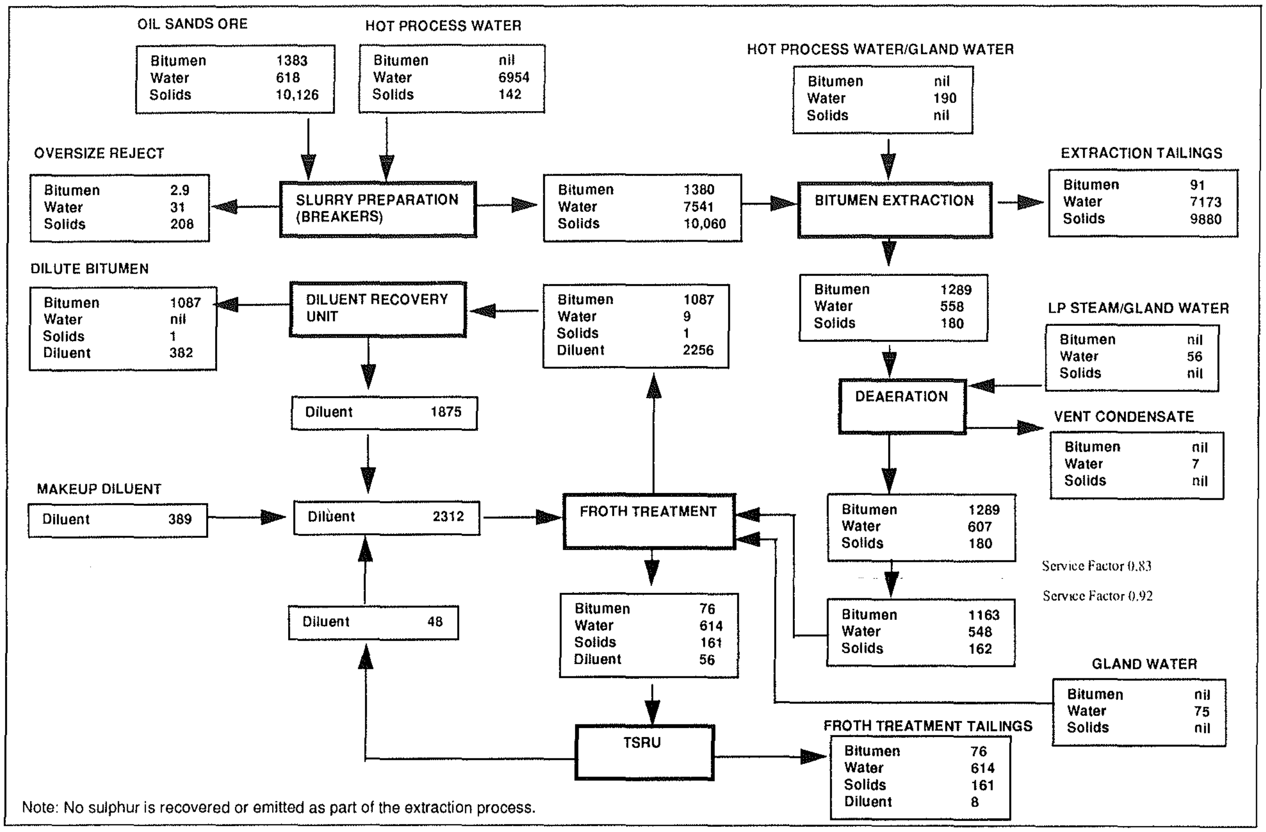


Figure 9-2: Overall Mass Balance Tonnes per Stream Day

ANNUAL AVERAGE ENERGY BALANCE

Figure 9-3 shows the annual average energy balance, including the heat balance, for the Muskeg River Mine Project.

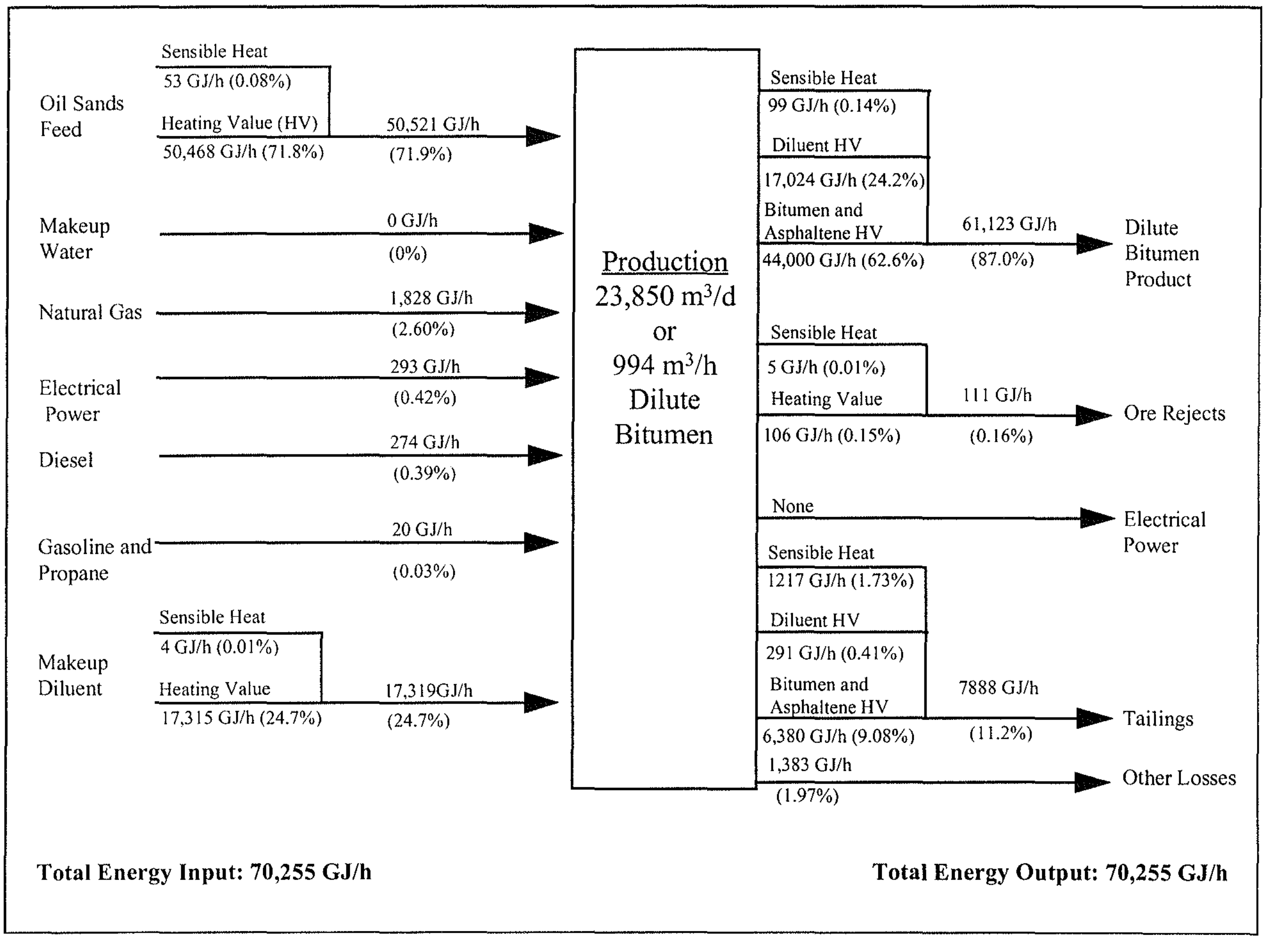


Figure 9-3: Annual Average Heat and Energy Balance

WINTER ENERGY BALANCE

Figure 9-4 shows the winter energy balance, including the heat balance.

WINTER ENERGY BALANCE (cont'd)

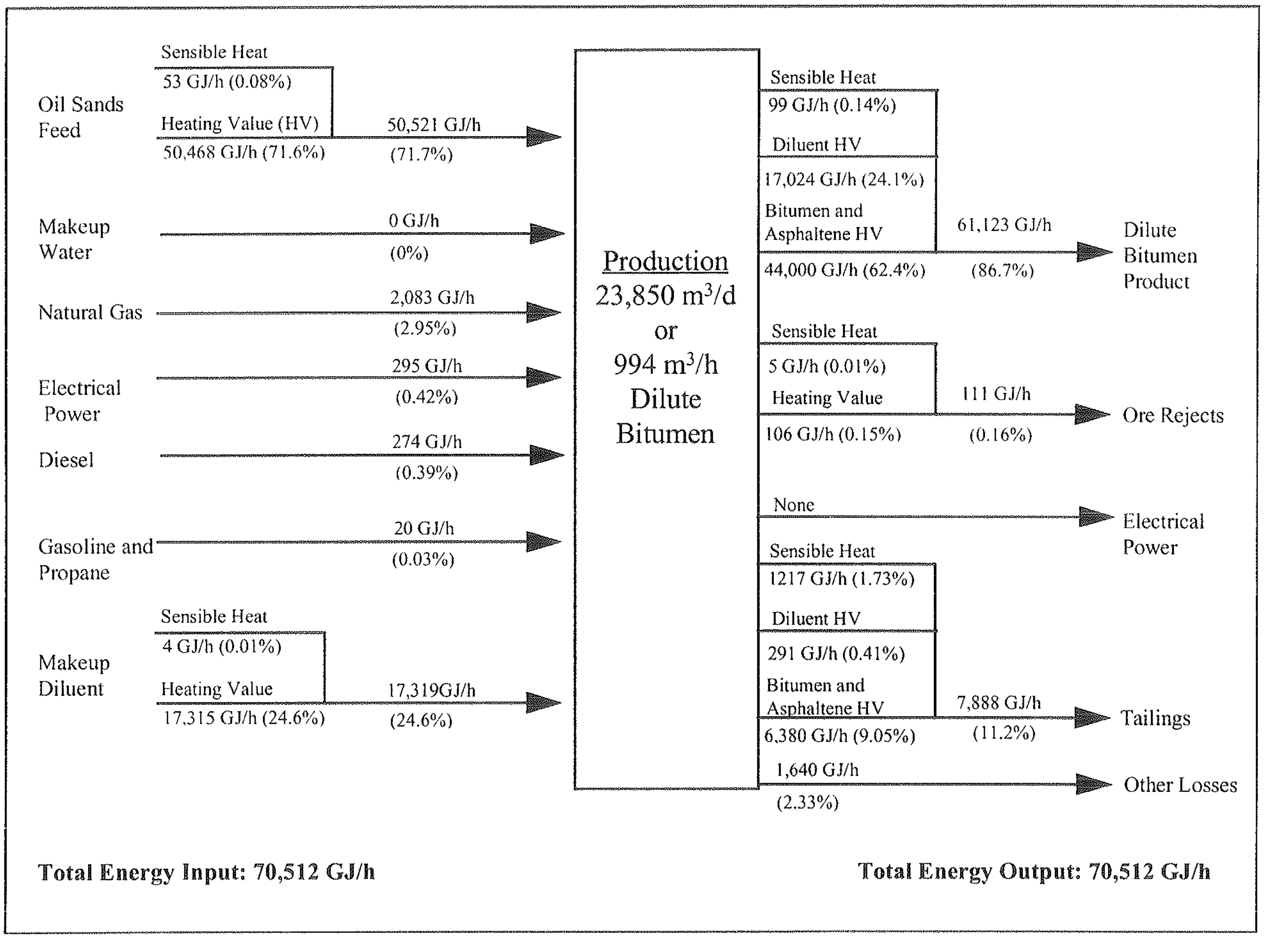


Figure 9-4: Winter Heat and Energy Balance

SUMMER ENERGY BALANCE

Figure 9-5 shows the summer energy balance, including the heat balance.

MAJOR ENERGY INPUTS

Major energy inputs include:

- electrical power
- sensible heat and heating value from the inlet oil sands
- heating value from burning natural gas
- heating value from diesel fuel
- heating value from gasoline and propane
- sensible heat and heating value from makeup diluent

MAJOR ENERGY INPUTS (cont'd)

Sensible heat is the heat absorbed or evolved by a substance during a change of temperature that is not accompanied by a change of state.

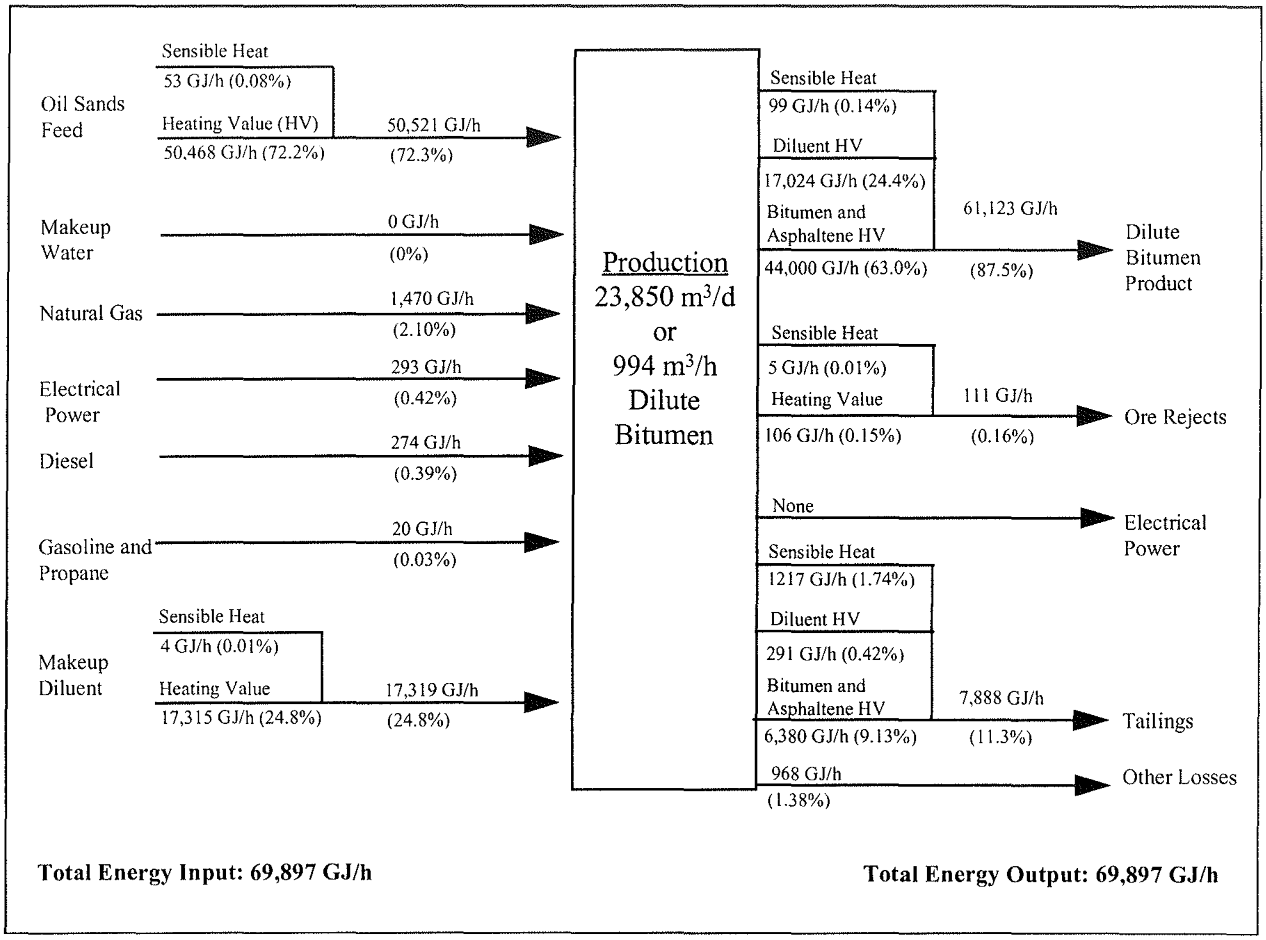


Figure 9-5: Summer Heat and Energy Balance

MAJOR ENERGY OUTFLOWS

Major energy outflows include sensible heat and heating value in the:

- diluted bitumen to the upgrader pipeline
- ore rejects and tailings

Discounting the heating value of bitumen and diluent, the overall mine and extraction unit energy consumption is:

- 2.13 GJ/m^3 in summer
- 2.75 GJ/m^3 in winter
- 2.49 GJ/m^3 as an annual average

MASS FLOW BALANCES

Figure 9-6 shows the mass flow balance of the major process streams for the Muskeg River Mine and associated stream temperatures for summer conditions. The mass flow balance for winter conditions is shown in Figure 9-7. For comparison:

- Figure 9-8 shows summer operation using the Clark hot water extraction process
- Figure 9-9 shows winter operation using the Clark hot water extraction process
- Figure 9-10 shows summer operation using a low temperature extraction process
- Figure 9-11 shows winter operation using a low temperature extraction process

Table 9-1 compares the summer, winter and average unit thermal energy requirement. This is a measure of the energy required to heat process water and create process stream, at 100% efficiency, as a function of bitumen produced.

Table 9-1: Comparison of Thermal Energy Requirements for Various Processes

Extraction Process	Summer (GJ/m^3)	Winter (GJ/m^3)	Average (GJ/m^3)
Clark hot water	2.36	2.74	2.55
Muskeg River Mine	1.53	2.04	1.79
Low temperature	1.02	1.05	1.04

The unit thermal energy requirement differs from the overall mine and extraction unit energy consumption, as it expresses the thermal energy requirements for conditioning, separation and froth treatment only, without regard for the source of the required heat. For example, the use of heat exchange reduces the overall mine and extraction unit energy consumption by reducing the natural gas usage, but does not change the thermal energy requirements for the process.

To reduce load on the downstream water heating system, waste heat will be contributed to extraction water by exchanging extraction water with:

- tailings to the tailings pond (preheat)
- product and tailings diluent recovery units
- froth in the froth treatment

The process design will make significant use of heat exchangers to ensure that the highest practical heat efficiency is obtained. Exchanging extraction water with product and tailings diluent recovery units, and with froth in the froth treatment unit, will all impart waste heat to the extraction water to reduce the load on the downstream water heating system.

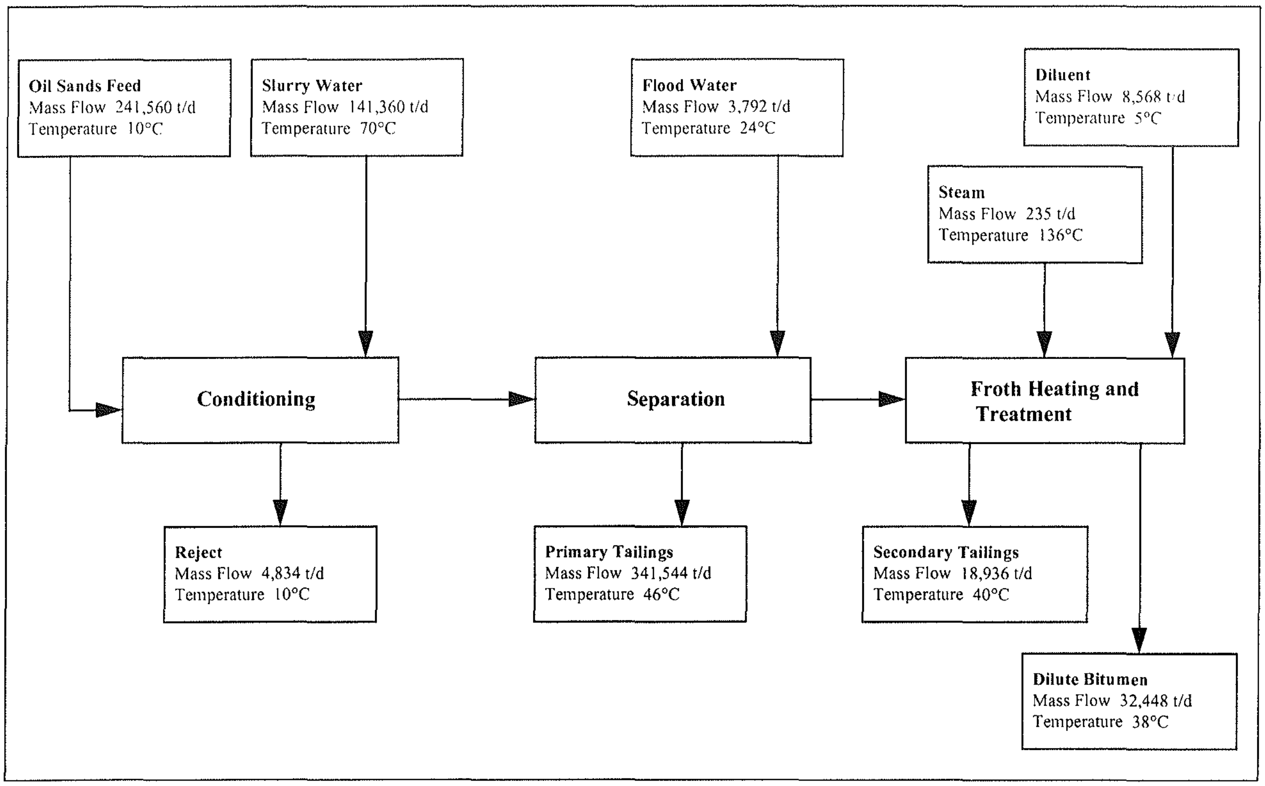


Figure 9-6: Extraction Mass Balance - Summer Operation on 11.4% Grade

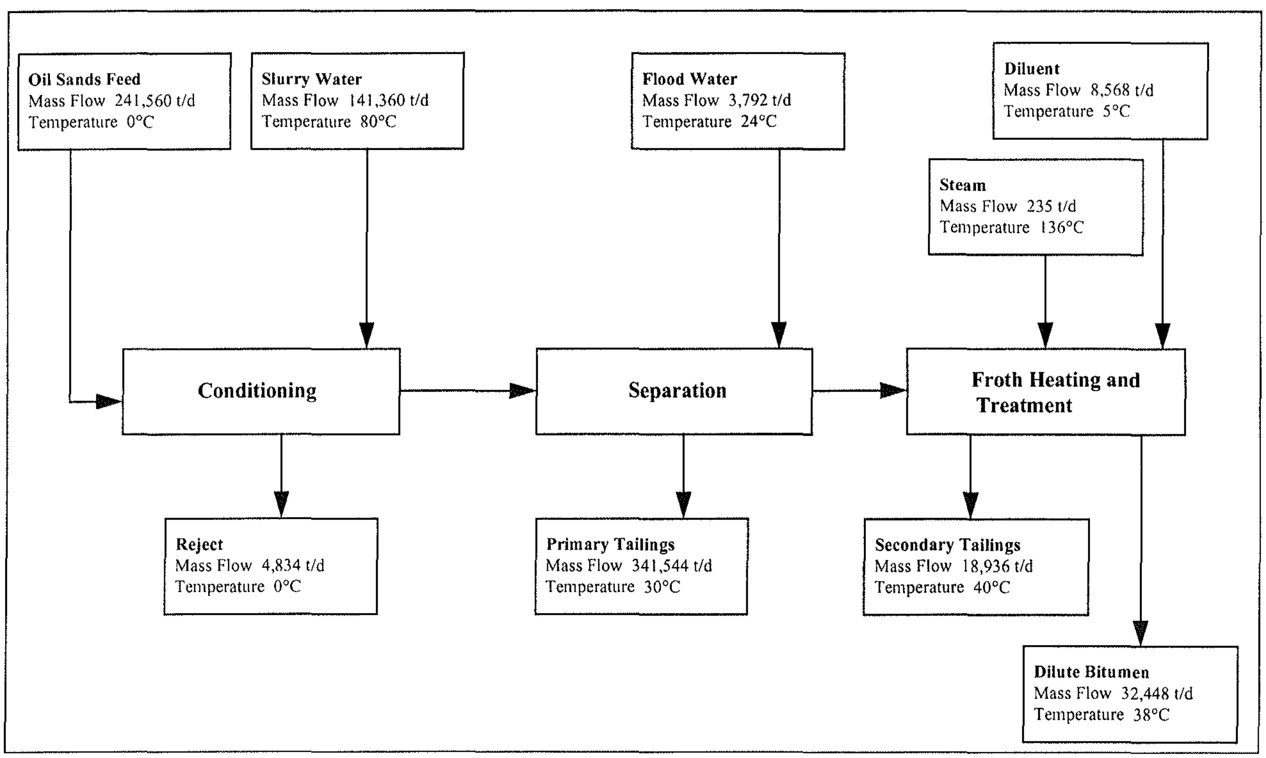


Figure 9-7: Extraction Mass Balance - Winter Operation on 11.4% Grade

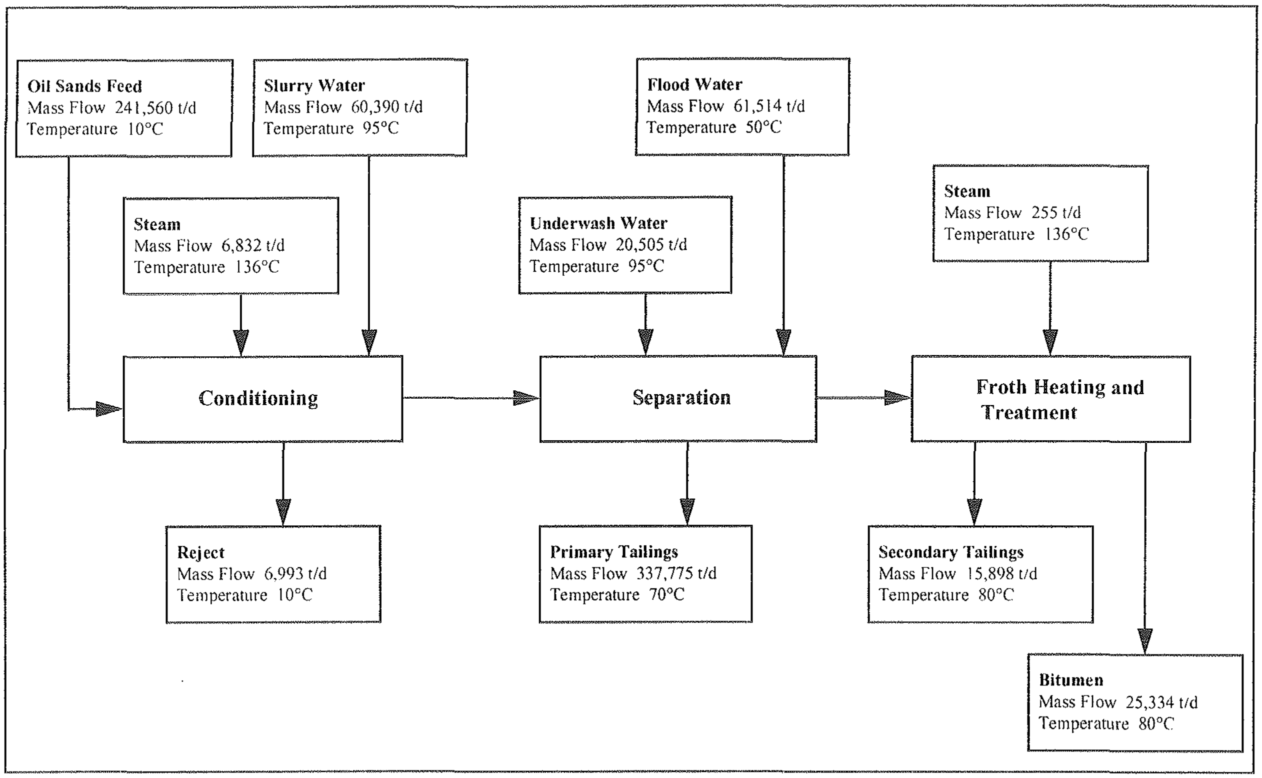


Figure 9-8: Clark Hot Water Process - Summer Operation on 11.4% Grade

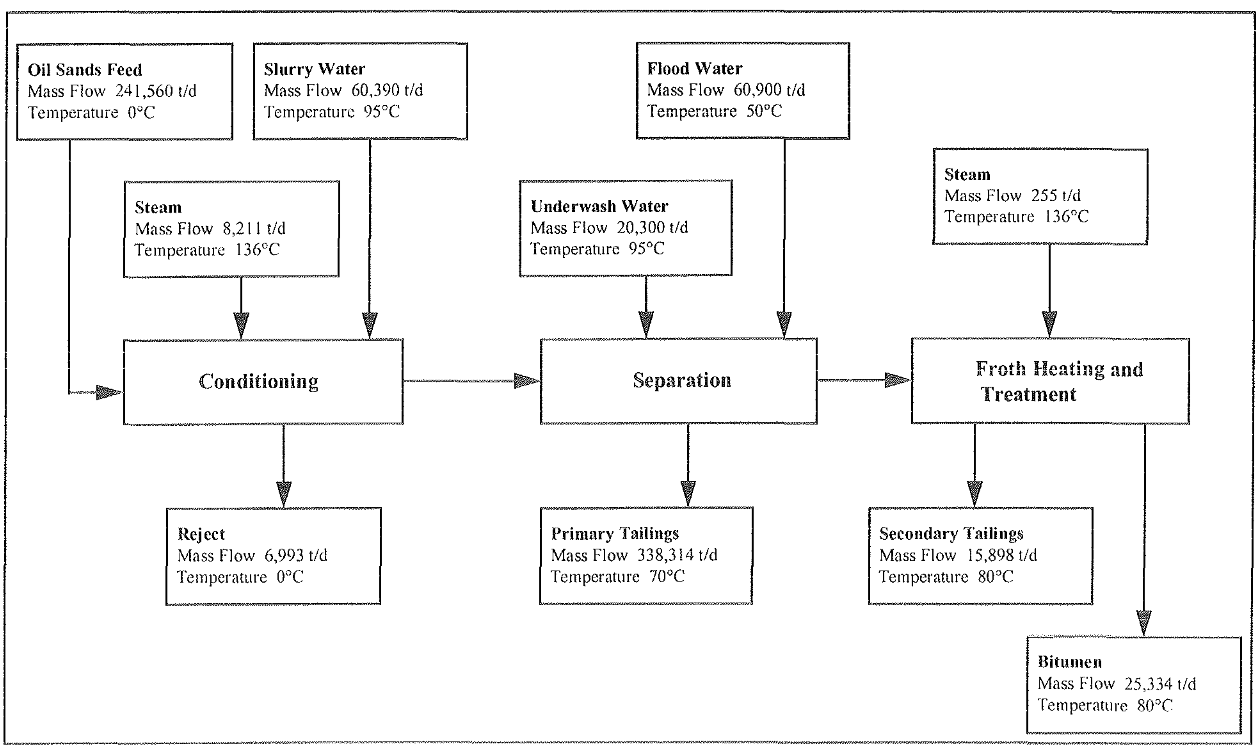


Figure 9-9: Clark Hot Water Process - Winter Operation on 11.4% Grade

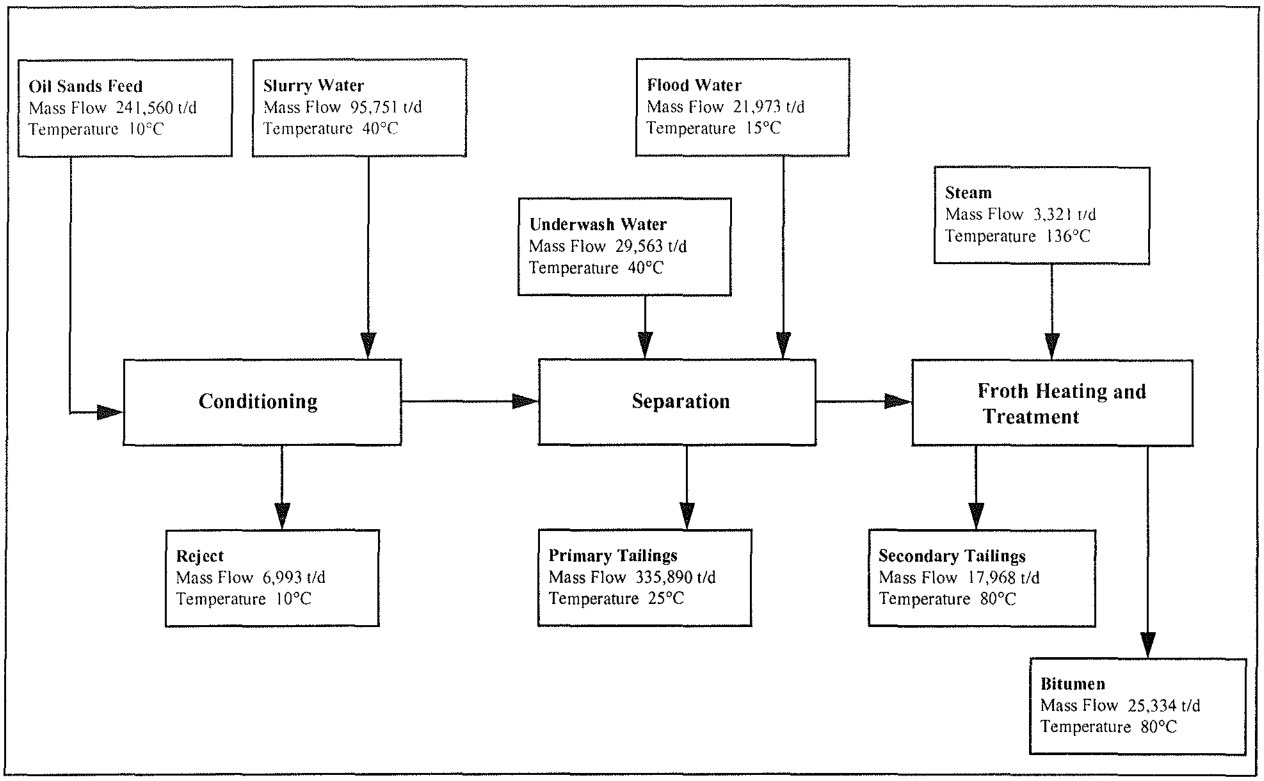


Figure 9-10: Low Temperature Extraction Process - Summer Operation on 11.4% Grade

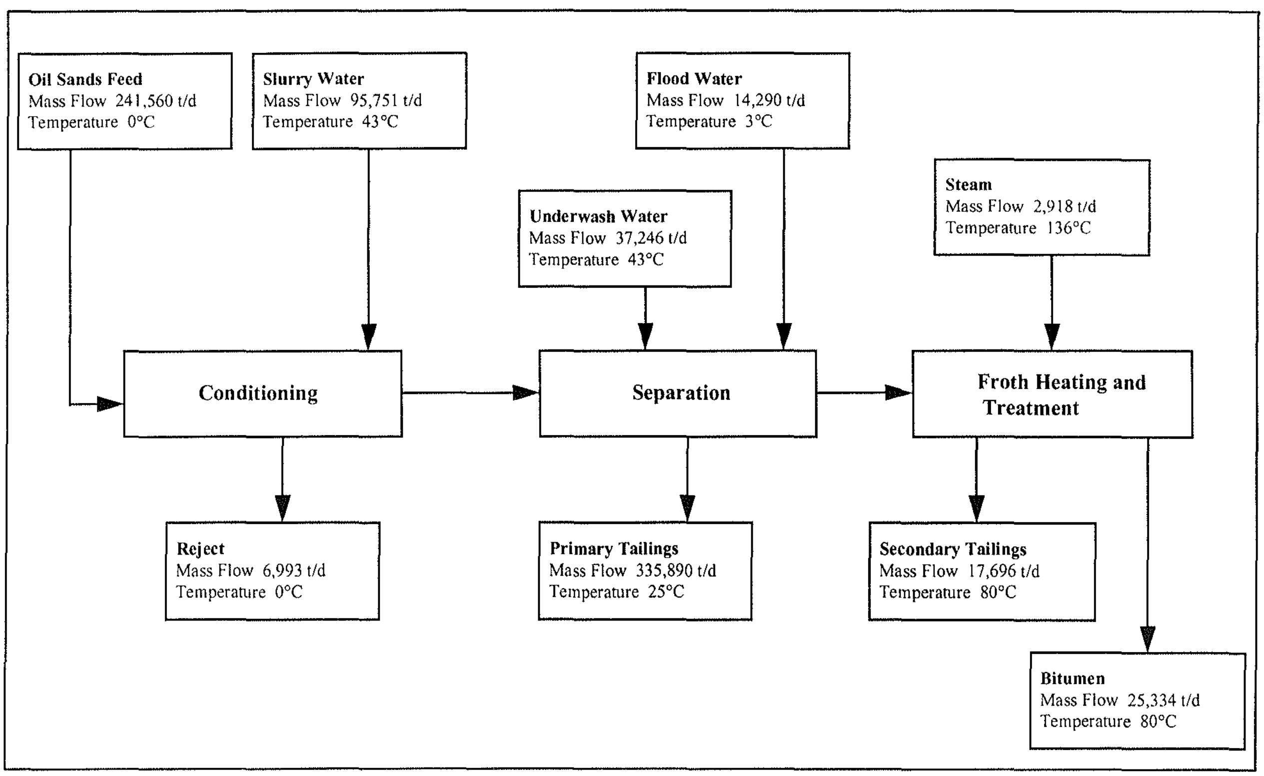


Figure 9-11: Low Temperature Extraction Process - Winter Operation on 11.4% Grade

INTRODUCTION

SCOPE OF EIA

The Environmental Impact Assessment (EIA) for the Muskeg River Mine was completed in accordance with AEP's Final Terms of Reference for the project. Therefore, the EIA:

- predicts the biophysical and historical resource impacts that could result from the project's development, operation and reclamation, including their direction, magnitude, frequency, duration, reversibility and geographic extent
- identifies measures to prevent or mitigate impacts, and to monitor environmental protection measures and residual and cumulative impacts
- evaluates the residual effects of the project
- outlines proposed research programs and other follow-up activities related to the proposed project

This section summarizes the basis and results of the biophysical and historical resources portion of the EIA. The socio-economic portion of the EIA is summarized in Section 11.

RESULTS OF ASSESSMENT

The predicted biophysical and historical resource impacts identified for the Muskeg River Mine Project are acceptable. The predicted impacts will have no significant long-term effects on the environment, provided that the recommended mitigation is undertaken.

KEY ENVIRONMENTAL CONCERNS

The EIA focuses on addressing key concerns identified by both the public and regulators, taking into account the:

- Alberta land use guidelines (Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan)
- draft guidelines produced by the Oil Sands End Land Use Committee

KEY ENVIRONMENTAL CONCERNS (cont'd)

- Aurora EUB decision report
- Steepbank EUB decision report
- public consultation
- government consultation

The key environmental concerns identified include the:

- health protection of local and regional residents and employees of the Muskeg River Mine Project
- effects on traditional land use and historical resources
- impacts of surface disturbance on the terrestrial ecosystem (terrain, soils and vegetation), especially within the Athabasca and Muskeg river valleys
- cumulative effects on wildlife populations
- impacts on water quality
- health of the aquatic ecosystems in the Athabasca and Muskeg rivers
- impacts on local and regional air quality

For further details on the biophysical and historical resources impacts, see:

- Volume 2 (Biophysical and Historical Resources Baseline Conditions)
- Volume 3 (Biophysical and Historical Resources Impact Assessment)

The cumulative effects assessment and the Regional Development Review for the biophysical and historical resources components of the EIA will be provided in Volume 4 when it is issued in early 1998.

CONSERVATION AND RECLAMATION

The Conservation and Reclamation (C&R) Plan developed for the Muskeg River Mine Project (see Section 16.4) is based on fundamental project conservation and reclamation objectives, such as that:

- Reclaimed landforms will be geotechnically stable.
- Reclaimed areas will be capable of developing as self-sustaining ecosystems with an acceptable degree of biodiversity.

CONSERVATION AND RECLAMATION (cont'd)

- Forest capability will be equal to, or greater than, predevelopment conditions.
- Drainage systems will have an acceptable level of impact on erosion rates and contaminant loading.
- On-site public health and safety will be protected.
- Offsite impacts will meet regulatory requirements.
- End land use objectives will be developed in consultation with stakeholders.

The C&R plan provides:

- the basis for the project's C&R activities
- details of the first 10 years of C&R operations
- a conceptual closure plan for the Muskeg River Mine Project

SCOPE

The EIA provides information on the environmental resources and resource use that could be affected by the project. The baseline conditions for the project development area provide the foundation upon which biophysical and historical resources impacts were predicted. The biophysical and historical resources baseline conditions are described in EIA Volume 2.

The EIA baseline conditions represent different components of the environment:

- air quality
- hydrogeology - groundwater
- surface water hydrology
- surface water quality
- aquatic resources
- ecological land classification
- terrain and soil
- terrestrial vegetation
- wetlands
- wildlife
- human health
- historical resources
- traditional land use
- resource use

Included within each baseline discussion is a review of the information available from the literature, previous oil sands EIA reports and environmental studies. Additional information from current oil sands operations, industry study groups, traditional knowledge and government sources was also used in the baseline. The final source of baseline information for the project came from studies completed in 1997 as part of the Muskeg River Mine Project EIA.

LOCAL AND REGIONAL CONSIDERATIONS

The information on baseline conditions collected for the EIA included considering local and regional study areas. The local study areas centred around the project development area on the western portion of Lease 13. The regional area extended from south of Fort McMurray, north toward Lake Athabasca.

RESULTS OF THE EIA

Results of Assessment

The predicted impacts of the Muskeg River Mine Project are acceptable and will have no significant long-term impacts on the environment within all three scenarios considered, provided that the recommended mitigation is undertaken.

Scope of Assessment

The environmental impact assessment was completed on the project activities and design, as described in this volume of the application.

The impact assessments of environmental resources and historical resources focused on issues identified by regulatory agencies, local communities and other stakeholders in the oil sands development area. The impact assessments included the construction, operation and closure of the project.

The impacts that are identified and assessed are post mitigation. These are impacts that are expected after mitigation, not potential impacts. These residual impacts are identified and assessed under three scenarios:

- The first scenario is the Muskeg River Mine impact assessment. It focuses on the baseline conditions, which include the existing environmental conditions within the project region, and the addition of the Muskeg River Mine Project to those conditions.
- The second assessment scenario (the Muskeg River Mine Cumulative Effects Assessment) considers the potential impacts of the project, plus currently approved oil sands projects within the regional study area.
- The third assessment scenario (the Regional Development Review) considers the potential impacts of the project, plus the approved and publicly disclosed oil sands projects and planned oil sands projects in the region.

Mitigation

Enhancement and mitigation plans are incorporated into the project design to prevent or restrict potential environmental impacts related to the project. Details on the mitigation are summarized in each of the environmental component areas.

Monitoring

The proposed monitoring programs for each of the environmental component areas provide a means of verifying the predicted environmental effects of the project, as well as the effectiveness of mitigation plans and environmental protection plans.

AIR QUALITY

Results of Assessment

The maximum ambient NO_2 and PM_{10} concentrations will be less than the ambient air quality guidelines. The primary deposition of acid-forming precursors is predicted to result from the dry deposition of NO_2 from the mine fleet. Values in excess of the 0.25 keq/ha/a target loading for sensitive ecosystems are predicted for a small area in the vicinity of the project from existing sources.

For limited periods during the summer, there is the potential for ozone concentrations to exceed provincial guidelines at some locations. This is primarily because of naturally occurring ozone concentrations that already reach or exceed the guidelines.

Scope of Assessment

The air quality impact assessment focused on the project's potential effects on:

- oxides of nitrogen (NO_x) emissions from the mine fleet and extraction plant combustion sources. These emissions can result in ambient air quality changes, deposition of acidic precursors and the photochemical production of ozone.
- hydrocarbon emissions, including volatile organic compounds (VOCs) from the mine fleet exhaust, mine pit area and tailings settling pond area. These emissions can result in ambient air quality changes and the photochemical production of ozone.
- fugitive total reduced sulphur (TRS) emissions from the mine pit and tailings settling pond area. These emissions have the potential to cause odours.
- particulate matter (PM) emissions from site clearing, mining activities and combustion sources. PM and associated polycyclic aromatic hydrocarbons (PAHs) can have adverse effects on human health.
- greenhouse gas emissions, mainly carbon dioxide (CO_2) from emission sources

The impact assessment for air quality considered the potential effects from the project on:

Scope of Assessment (cont'd)

- exceeding ambient concentration guidelines
- human health
- acidification potential
- photochemical production of ozone
- greenhouse gases

Mitigation

Mitigation strategies to reduce NO_x emissions include selecting:

- low NO_x burners for the plant site
- mine fleet vehicles with emission control technology

The tailings solvent recovery unit will reduce VOC and TRS losses to the tailings settling pond. A vapour control system will reduce VOC and TRS emissions from the solvent and product storage tanks.

PM emissions during site clearing will be reduced by controlled burning procedures. Fugitive PM emissions during operation of the mine will be controlled through road maintenance, such as watering in dry weather, and progressive reclamation activities.

Energy efficiency objectives, such as an optimized mine plan for minimizing material handling and travel distances, coupled with a warm water extraction process, will help manage CO_2 emissions.

Monitoring

Source monitoring for the project will include:

- the ongoing estimation of NO_x and CO_2 emissions
- periodic monitoring to assess fugitive PM and VOC emissions

Ambient monitoring will include a single trailer to measure NO_2 and PM_{10} in the vicinity of the mine. Participation in the Southern Wood Buffalo Zone airshed monitoring program will address regular monitoring needs.

HYDROGEOLOGY - GROUNDWATER

Results of Assessment

Groundwater levels and flow patterns will be altered from their natural state only in the local study area. The impact is acceptable, given that the effect is reversible after mining is completed.

Results of Assessment (cont'd)

Groundwater quality in the basal aquifer beneath the mine and tailings settling pond, in the oil sands and lean oil sands, possibly surficial sediments to the east of the pond, and on both sides of the tailings settling pond will be altered in varying degrees from their natural state. The impact on groundwater quality in the local area will be long term. The change in water quality is not significant.

Scope of Assessment

The hydrogeology – groundwater impact assessment focused on the potential effects of the project on:

- local and regional groundwater systems
- groundwater quality
- re-establishing groundwater systems following closure of the project

The groundwater impact assessment considered the potential influence of the project on water levels in area lakes, including Kearl Lake, McClelland Lake and Isadore's Lake, as well as on the Muskeg and Athabasca rivers.

Mitigation

Mitigation strategies to minimize potential impacts on groundwater resources include constructing a ditch around the tailings settling pond.

Monitoring

Monitoring wells will be located by the mine pits and reclaimed tailings structure to identify any changes or trends in groundwater quality. Wells will also be installed to monitor the performance of the overburden dewatering and basal aquifer systems and to monitor the magnitude of drawdown in the adjacent unmined overburden and basal aquifers.

SURFACE WATER HYDROLOGY

Results of Assessment

The project will have a negligible effect on the:

- flows and water levels in the Athabasca River, Isadore's Lake and Kearl Lake
- channel regimes of both Mills Creek and the Muskeg River

The project will cause a negligible to small increase in sediment concentrations in Mills Creek and the Muskeg River.

The project will have negligible effects on the flows and water levels in the Muskeg River and Mills Creek during construction and most of the time during operation. It will moderately increase the Muskeg River flows for two years

Results of Assessment (cont'd)

during the end-pit lake management period, and moderately increase the Mills Creek flows during the period of muskeg drainage and overburden dewatering discharge to the creek. The project will moderately reduce the Mills Creek flows after closure, but it will have only a small effect on the Muskeg River flows after closure.

The reclaimed landscape and drainage systems will provide larger open-water areas of streams, wetlands and lakes, replacing the open-water areas lost during construction and operation. A conceptual and feasible reclamation drainage plan was developed to design and predict long-term sustainability of the closure reclamation landscape and drainage systems.

Scope of Assessment

The surface water hydrology impact assessment focused on the potential project effects on receiving and nearby waterbodies including streams, lakes, ponds and wetlands. The potential effects evaluated included:

- changes in flows and water levels in waterbodies
- changes in basin sediment yields and sediment concentrations in waterbodies
- changes in the regime or geomorphic condition of receiving streams
- changes in open-water areas
- sustainability of the reclaimed landscape and reclamation drainage systems.

Mitigation

In addition to following regulatory guidelines and best management practices, mitigation measures to minimize impacts on the surface water hydrology include:

- using tailings porewater releases, basal aquifer water and process-affected water to reduce raw water withdrawal from the Athabasca River

- distributing muskeg drainage and overburden dewatering evenly throughout the mine life to avoid a large increase in flows to receiving streams

- routing drainage water and runoff from cleared areas to polishing ponds to settle sediments before discharging to receiving streams

- providing erosion protection measures

- reducing sediment loadings to receiving streams during construction of access roads and stream crossings

- developing a sustainable closure landscape and drainage systems by:

    - vegetating reclaimed surfaces to minimize surface erosion

Mitigation (cont'd)

- building drainage networks and regime channels to minimize gully and channel erosion
- constructing wetlands and lakes to reduce flood peak discharges and sediment loadings to receiving streams

Monitoring

The impacts on surface water hydrology will be monitored by:

- monitoring flows, water levels and sediment concentrations at the Alsands Drain, Muskeg River, Mills Creek and Isadore's Lake
- participating in the Regional Hydrology Program

SURFACE WATER QUALITY

Results of Assessment

The background levels of several metals in the Muskeg and Athabasca rivers exceed the Environmental Protection Agency (EPA) water quality guidelines for the protection of human health. However, the project, in combination with existing developments in the local or regional study areas, will not cause water quality or toxicity guidelines for aquatic life to be exceeded. Exceedances of human health water quality for two polycyclic aromatic hydrocarbon (PAH) compounds were predicted to occur during initial high end-pit lake discharges. These exceedances are expected to be mitigated through various means. Follow-up risk analysis (see EIA Volume 3, Sections E11 and E12) rejected these compounds as being of concern to wildlife and human health.

Temperature fluctuations in the Muskeg River, as a result of changing flow regimes, would remain within acceptable ranges. Dissolved oxygen impacts from muskeg drainage waters are not expected to occur. The accumulation of PAHs on sediments is not expected to occur, because of limited available pathways. Acidification of waterbodies as a result of air emissions is unlikely, although questions remain about possible spring runoff acidification.

Scope of Assessment

The surface water quality impact assessment focused on the potential effects of the project on:

- compliance with water quality guidelines in the Athabasca and Muskeg rivers, and Isadore's Lake
- compliance with toxicity guidelines in the Athabasca and Muskeg rivers, and Isadore's Lake

Scope of Assessment (cont'd)

- changes in water temperature of the Muskeg River from operational and reclamation water releases
- changes in the dissolved oxygen levels in the Muskeg River from muskeg and overburden dewatering activities
- accumulation of PAHs in sediments in the Muskeg River from operational and reclamation water releases
- compliance with toxicity guidelines in the end-pit lake before discharge to the Muskeg River
- accidental releases occurring and affecting the water quality of the Muskeg and Athabasca rivers
- changes in water quality from acidifying emissions

Mitigation

Mitigation strategies to minimize impacts include:

- constructing a ditch around the tailings settling pond
- timing the release of the end-pit lake discharges, such as to open water periods, for the first few years of discharge
- depositing consolidated tailings below ground level to minimize seepage
- developing wetland systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of process-affected streams

Monitoring

Monitoring will include:

- monitoring the muskeg drainage and sedimentation ponds for dissolved oxygen concentration
- monitoring the end-pit lake for PAHs and other constituents
- participating in the Regional Aquatic Monitoring Program

AQUATIC RESOURCES

Results of Assessment

The project, in combination with existing developments in the local or regional study areas, is not expected to cause tainting or bioaccumulation of chemicals in fish tissue or acute and chronic effects on fish.

No habitat for sports fish will be disturbed during the life of the project or after closure. A small amount (1.7%) of available forage fish habitat will be disturbed during construction and operations but it will be replaced through reclamation. At closure, the reclamation drainage system, which consists of wetlands, streams and an end-pit lake, will provide additional habitat for sports and forage fish.

Scope of Assessment

The assessment of aquatic resources impact focused on the potential effects of the project on:

- changes in fish habitat because of:
    - changes in watercourse flows and stream morphology
    - changes in thermal regime
    - direct losses
    - effects on spawning habitat
    - increased erosion
    - increased suspended solids in streams
- acute and chronic toxicity effects on fish through release of process-affected waters
- changes in the quality of fish flesh
- abundance of fish

The impact assessment also considered the potential for the end-pit lake to support a viable aquatic ecosystem.

Mitigation

Mitigation strategies to minimize effects on aquatic resources include those summarized in surface water hydrology and surface water quality, i.e.:

- using tailings porewater releases, basal aquifer water and process-affected water to reduce raw water withdrawal from the Athabasca River
- distributing muskeg drainage and overburden dewatering evenly throughout the mine life to avoid a large increase in flows to receiving streams

Mitigation (cont'd)

- routing drainage water and runoff from cleared areas to polishing ponds to settle sediments before discharging to receiving streams
- providing erosion protection measures
- reducing sediment loadings to receiving streams during construction of access roads and stream crossings
- developing a sustainable closure landscape and drainage systems by:
  - vegetating reclaimed surfaces to minimize surface erosion
  - building drainage networks and regime channels to minimize gully and channel erosion
  - constructing wetlands and lakes to reduce flood peak discharges and sediment loadings to receiving streams
- constructing a ditch around the tailings settling pond
- timing the release of the end-pit lake discharges, such as to open water periods, for the first few years of discharge
- depositing consolidated tailings below ground level to minimize seepage
- developing wetland systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of process-affected streams

Design features for preventing or minimizing sediment loading, changes in dissolved oxygen, water temperature fluctuations and water quality changes will minimize effects on aquatic resources. Effects on critical sports fish habitat will be avoided by setting project facilities back at least 100 m from the Muskeg River and Jackpine Creek.

Monitoring

Benthic invertebrates will be monitored, in conjunction with water quality monitoring, to assess the effects on aquatic resources from the end-pit lake discharge.

All other monitoring for the Muskeg and Athabasca rivers will be done as part of the Regional Aquatics Monitoring Program (RAMP), which will include monitoring for bioaccumulation in fish tissue, water quality, benthic invertebrates and fish populations.

TERRESTRIAL RESOURCES

Results of Assessment

Terrestrial resources within the local study area will be significantly disrupted by the activities associated with developing and operating the mine. Wildlife will be displaced, vegetation communities will be disrupted and biodiversity will decline. However, these effects will be localized and, for the most part, will be reversible. After closure of the mine, self-sustaining vegetation communities will evolve to productive ecosystems similar to those existing before the mine development.

The project, in combination with existing developments in the local and regional study areas, is not expected to have an adverse affect on wildlife or human health from ingesting water, aquatic prey or plants during the operation or after mine closure.

Scope of Assessment

The terrestrial resources impact assessment included considering the project's effects on terrain and soils, terrestrial vegetation, wetlands, ecological land classification units and wildlife. The impact assessment focused on the:

- loss or alteration of terrain and soils, vegetation communities and wetlands
- changes in soils, vegetation communities or wetlands because of air emissions or water releases
- changes in biodiversity
- changes in wildlife habitat
- impacts to wildlife health caused by air emissions or water releases

The impact assessment also considered the potential for landscape reclamation and closure activities to replace terrain, soils, vegetation, wetlands and wildlife habitat.

Mitigation

During the construction and operation of the project, the terrain, soils and vegetation will be temporarily disturbed. About 40% of the local study area will be affected. However, the phased mine development plan will result in mine construction and reclamation proceeding in sequence, to minimize the amount of disturbed land at any one time.

Wildlife habitat will be progressively altered during the mine construction phases. Clearing and reclamation will be phased to minimize the area of habitat disturbed at any one time. Major activities adjacent to the Athabasca and Muskeg rivers will be completed outside the critical winter period, consistent

Mitigation (cont'd)

with Alberta Fish and Wildlife guidelines. Wetland habitat will be affected the most. However, the disturbed areas will be reclaimed to produce a mosaic of landforms and early to middle successional vegetation types. The increase in better drained habitat will improve habitat for some species, such as moose and western tanager, but will be less favourable for species such as beaver.

Landforms will be altered to allow access to the orebody, resulting in the removal of overburden and reclamation materials that will be stored on site. The reclamation materials and some of the overburden will be reused during reclamation to provide a variety of landscapes, topography and slope conditions. The landforms re-established in the development area will be similar to pre-existing landforms, but with an overall increase in the amount of better drained land. Some new landforms will also be created during land reclamation, such as an end-pit lake, the overburden disposal areas and the reclaimed tailings settling pond area.

Land capabilities might be temporarily decreased through soil mixing, burial, compaction, erosion and temporary storage. In the poorly drained areas of the lease, dewatering of soils in preparation for mine development will affect Organic and Gleysolic soils within the local study area. Although the natural soil conditions will be permanently altered, the reclaimed soils will have a higher capability for a variety of end land uses, such as commercial forestry and wildlife habitat.

A significant loss of the existing vegetation communities will occur within the local study area, primarily as a result of site clearing and mine dewatering. Wetlands vegetation, such as fens and bogs, will be the most affected, with lesser impacts on upland vegetation, such as jack pine, aspen and white spruce dominated communities. Following reclamation, there will be an overall increase of commercial forest lands within the local study area, for example, aspen-white spruce communities. The effects on old growth forests and plants used for traditional purposes is expected to be minimal. A total of three rare plants that are known throughout the local study area are known to be directly affected by the project.

Biodiversity will be temporarily reduced during construction and operation of the project. However, phased reclamation and the re-establishment of vegetation communities on a variety of reclaimed landscapes will provide the basis for a functionally diverse reclaimed landscape.

Monitoring

The impact of air emissions on soils and vegetation (primarily NO_x) are expected to have localized effects immediately around the plant site. The existing environmental effects monitoring program, part of the Regional Airshed Monitoring Plan of RACQQ, will evaluate the impacts of air emissions on vegetation.

Monitoring (cont'd)

During the excavation of muskeg for direct placement on reclamation sites or salvaging for future use, monitoring will take place to ensure that the correct amount of overstripping is taking place. When the reclamation site has been revegetated, monitoring will take place to document the development of the reclamation soils and the extent of vegetation cover. The established growth of trees and shrubs will also be monitored. CT deposits will form much of the new landforms. The impact of CT release water on vegetation and soils will be monitored.

HUMAN HEALTH IMPACTS

Results of Assessment

The project will not result in unacceptable chemical exposures for people who live or work in the area. This conclusion is based on a conservative analysis of predicted exposures that might arise from:

- contacting or ingesting surface waters
- ingesting local plants and animals
- inhaling airborne chemicals

Because of a lack of chronic toxicity data for mammals, no conclusion could be reached on the potential exposure to naphthenic acids in surface water. However, limited acute toxicity data and subchronic toxicity data suggest that this group of chemicals is low in toxicity and unlikely to present an adverse health risk. Efforts within the oil sands industry are currently being initiated to collect new toxicity data and resolve this uncertainty.

Scope of Assessment

The human health impact assessment included considering the project's effects on humans from:

- water releases
- air emissions
- consumption of local plants and animals
- combined exposures to water releases, air emissions, plants and animals
- working at the plant during project construction and operation
- releases of chemicals from the reclaimed landscape

Mitigation

Mitigating chemical exposures potentially arising from chemical releases to surface waters will involve mitigation previously identified in the surface water quality section, i.e.:

Mitigation (cont'd)

- constructing a ditch around the tailings settling pond
- maintaining and enhancing the perimeter ditch system with wetlands at closure
- timing the release of the end-pit lake discharges, such as to open water periods, for the first few years of discharge
- depositing consolidated tailings below ground level to minimize seepage
- developing wetland systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of process-affected streams

Chemical exposures arising from air emissions will be mitigated by the same measures as for air quality, i.e., reducing NO_x emissions by:

- selecting low NO_x burners for the plant site
- equipping mine fleet vehicles with emission control technology

The tailings solvent recovery unit will reduce VOC and TRS losses to the tailings settling pond. A vapour control system will reduce VOC and TRS emissions from the solvent and product storage tanks.

PM emissions during site clearing will be reduced by controlled burning procedures. Fugitive PM emissions during operation of the mine will be controlled through road maintenance, such as watering in dry weather, and progressive reclamation activities.

Energy efficiency objectives, such as an optimized mine plan for minimizing material handling and travel distances, coupled with a warm water extraction process, will help manage CO_2 emissions.

Monitoring

Monitoring includes:

- monitoring water, plants and animal tissue residues to validate estimated exposures and health risks, and how they might vary spatially and temporally
- monitoring air quality, including conventional parameters, organic substances and odour detection of $PM_{10}/PM_{2.5}$ at various regional nodes to validate estimated exposures and health risks, and how they vary spatially and temporally

TRADITIONAL LAND USE AND NON-TRADITIONAL RESOURCE USE

Results of Assessment

The project, in combination with other projects in the local or regional study areas, will not cause significant long-term impacts to surface or mineral materials. Timber resources will be adequately salvaged and forest capability will be equivalent to, or greater than, predisturbance levels. Non-consumptive resource use will be reduced during construction and operations. Hunting and trapping potential will be reduced during construction and operations as a result of access restrictions and habitat disruption. Sports fish species will not be affected by the construction and operation of the project.

Overall impacts to the non-traditional land uses in the area will be affected during the construction and operational phases of the project. However, reclamation and closure plans will mitigate the adverse impacts and, in some cases, improve the land use capability.

Scope of Assessment

The assessment of the project's effects on traditional land use and non-traditional resource use included considering changes in:

- surface and subsurface minerals
- environmentally significant areas
- forestry
- use of local plants for food or spiritual and medicinal purposes
- hunting
- trapping
- fishing
- non-consumptive recreational use

Mitigation

Long-term mitigation measures to reduce impacts to traditional land use include designing a closure plan that accommodates traditional land uses. Shell will consult with local aboriginal communities in preparing a final mine closure plan that will optimize landscape productivity and ensure ongoing capability to support traditional land use practices.

Shell has initiated a process to compensate registered trapline owners.

More general effects will be managed by:

- limiting vegetation cover removal, where possible

- staging activities to provide a transition period for both resources and traditional users

Mitigation (cont'd)

Strategies to minimize impacts to non-traditional resource use include:

- salvaging surface materials, such as gravel, during site clearing
- minimizing site clearing
- revegetating to improve protective cover and browse for wildlife species
- reclamation to return forestry potential to equivalent or greater capability
- developing timber salvage and end land use plans, in consultation with government agencies and Forest Management Agreement quota holders
- reforesting using forest species proven to revegetate successfully
- salvaging all merchantable timber during site clearing
- including berry producing shrubs in reclamation plans
- avoiding altering the Athabasca and Muskeg rivers

Monitoring

Resource uses in the project area will be monitored by:

- monitoring for plant species and community type re-establishment
- establishing plots to examine species composition, community structure, forest growth and shrub productivity
- establishing water quality monitoring programs to minimize or eliminate adverse impacts to fish habitat and, thus, fishing capability

HISTORICAL RESOURCES

Results of Assessment

The historical resources within the local study area will not be significantly impacted by the project. The positive effects of the mitigation program will effectively compensate for the residual effects of the project.

Scope of Assessment

The assessment of the project's effects on historical resources included considering the:

- changes in identified historical resource sites
- exposure of additional historical resources sites

Mitigation

Mitigation strategies involve plans to limit land surface disturbances and archaeological studies to locate, recover and preserve significant resources and information that would otherwise be lost during construction.

Mitigation strategies implemented will be based on the significance of the resources to be affected, will take place in direct impact zones and focus on information recovery. Activities include:

- completing information recovery requirements previously established by Alberta Community Development
- completing similar requirements for significant resources identified in the impact analysis
- recovering sample information from sites representative of typical prehistoric land use patterns identified within the local study area
- examining areas recently cleared of forest to identify significant and atypical resources not previously recognized
- conducting sample recoveries from these sites before overburden is removed
- recovering significant palaeoenvironmental information exposed in muskeg and overburden removal
- analyzing and interpreting information recovered in a cohesive study that makes a substantive contribution to regional history and prehistory

INTRODUCTION

STUDY AREA

This section summarizes the socio-economic impacts of the Muskeg River Mine Project. For this analysis, the study area is defined as the Regional Municipality of Wood Buffalo, containing:

- the urban service area of Fort McMurray, including Saprae Creek (referred to as the Fort McMurray area)
- the outlying communities of:
    - Fort McKay
    - Fort Chipewyan
    - Conklin
    - Janvier
    - Anzac
    - Gregoire Lake

The full socio-economic assessment is provided in the EIA, Volume 5.

Only summary information on the outlying communities is presented here. Additional information is being prepared by community-based groups and will be available in early 1998.

ASSESSMENT METHOD

The socio-economic impacts of the Muskeg River Mine Project were assessed by comparing scenarios of the socio-economic conditions in the region with the project, and without the project. The difference between these scenarios is the impact of the project.

The base case (the scenario without the project) is defined as the socio-economic situation that would exist, assuming ongoing operation of the Syncrude and Suncor plants, the Suncor Steepbank Mine, and Trains 1 and 2 of Syncrude's Aurora North Mine.

The Shell Development Scenario (the scenario with the project) includes the base case and the Muskeg River Mine Project.

ASSESSMENT METHOD (cont'd)

The cumulative regional development scenario includes the baseline, the Muskeg River Mine and announced projects that have not yet received regulatory approval.

ECONOMIC ACTIVITIES

The study area encompasses a range of economic activities, including:

- forestry
- mineral exploration
- conventional oil and gas development
- tourism

However, the economic backbone of the region is the oil sands industry.

FORT MCMURRAY AREA

The 1997 population of the urban service area of Fort McMurray is 38,700, an estimated 13% increase over the 1996 population. This growth reflects proposed projects by Shell, Mobil, Suncor, Gulf, Syncrude and others. It is in contrast to the stable population level in the area between 1986 and 1996.

Fort McMurray offers a full range of social services. Most service agencies are coping with the increased demand associated with the recent population growth.

The physical infrastructure of the Fort McMurray area is adequate. The water and sewer utilities, except the solid waste system, have sufficient capacity for the current and expected near-term population.

ISSUES

Fort McMurray Area Issues

Issues of particular concern to Fort McMurray residents are the:

- shortage of housing, particularly affordable housing
- rising cost of living, especially as it affects housing
- in-migration of people with low skills and limited resources looking for employment
- additional demands on many service providers

Fort McMurray Area Issues (cont'd)

- disparity between the rural and urban service area of the municipality
- transportation, including highway traffic safety

Outlying Community Issues

The outlying communities are small hamlets, which have a limited range of social services. They depend on the Fort McMurray area for most secondary health care services and, except for Fort Chipewyan, for secondary education beyond the primary grades.

The issues of particular concern to residents in the outlying communities are:

- employment, training and business opportunities
- transportation to oil sands plants
- inadequate municipal and recreational facilities
- inadequate youth programs
- limited school system resources (human and physical)
- housing shortage and inadequacy
- municipal infrastructure inadequacy
- potential health problems from environmental pollution
- social issues, including:
    - family and child care
    - substance abuse
    - gaming

EMPLOYMENT

Construction Employment

The Muskeg River Mine Project will be mainly constructed between 1998 and 2002. Construction of the plant and associated infrastructure is expected to generate 1,900 work-years of work, excluding engineering. The number of workers is expected to peak at 1,300. Mine construction will require an estimated 500 work-years.

Long-Term Operations Employment

Based on preliminary estimates, the Muskeg River Mine Project will have a work force of about 800. Of these, about:

- 50% will work in the mine
- 40% will work in the extraction plant
- 10% will work in managerial, professional and administrative positions

Employment in the oil sands industry is the key determinant of population levels in the region, especially in the Fort McMurray area.

POPULATION IMPACTS

Urban Service Area

The long-term population of Fort McMurray, assuming the Shell Development Scenario, is estimated at:

- 37,900 in 2011
- 38,300 in 2016

This is similar to the mid-1997 population estimate (see Figure 11-1).

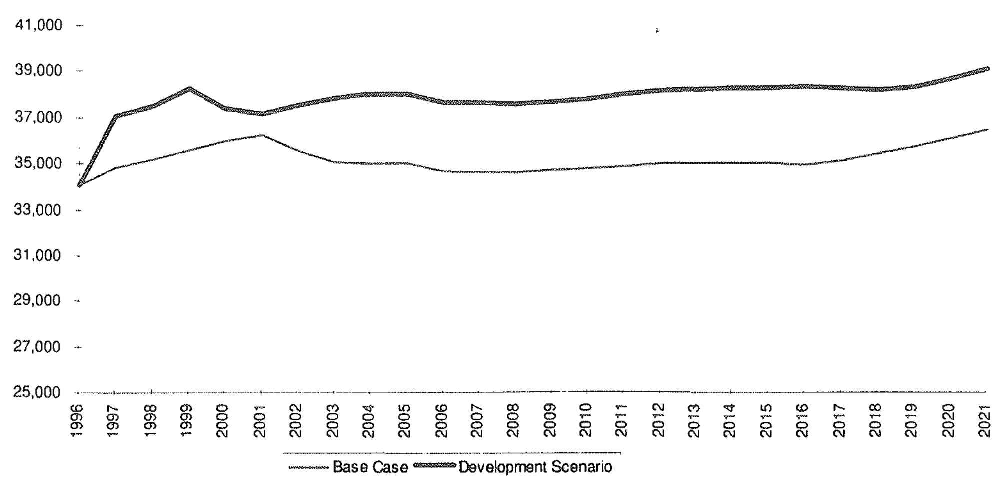
The population is expected to increase during the construction period, peaking at 38,200 in 1999. This is about the same as the long-term population estimate.

Outlying Communities

Outlying communities might experience some in-migration, as community members who now live in Fort McMurray return, to avoid the increasing housing

Outlying Communities (cont'd)

costs. However, community members who become employed at the Muskeg River Mine Project might move to Fort McMurray to take advantage of commuter services.



Note: Base case includes existing oil sands plants, plus Steepbank and Aurora North mines.
The 1997 actual population is estimated at 38,700 and includes impact of expected projects.

Figure 11-1: Baseline Population Forecast in Fort McMurray Area

REGIONAL ECONOMIC BENEFITS

During the construction period between 1998 and 2002, Shell will invest about $1.2 billion. An estimated $230 million or almost 20% will accrue to local area people and businesses. During operations, the Muskeg River Mine Project is estimated to augment the labour and business income in the region by between $3 billion and $3.9 billion ($1997).

Fort McMurray Area

Much of the construction income will accrue to people and businesses in the Fort McMurray area, where most people live and where most businesses are located.

Outlying Communities

The outlying communities will also benefit from local spending during construction, through:

- employment of community members
- business income to community-based contractors

IMPACTS ON LOCAL AND REGIONAL SERVICE PROVIDERS

Housing

The population increase associated with the Shell Development Scenario translates into a demand for about 1,050 housing units. In the base case there are about 550 vacant dwellings, which, together with the almost 350 new housing starts in 1997, account for an estimated 900 dwellings. This suggests that most of the Shell-related housing demand will be met in the near future. No new rental accommodation construction has been announced, so rental accommodation will remain in short supply in the near term.

Mitigation

Shell plans to locate a full-service camp on Lease 13 during construction and will consider keeping part of the camp open during the operations phase.

Shell is working with the municipality on housing issues through the Mayor's Housing Task Force.

Education

The number of school-aged children associated with the Shell Development Scenario is expected to be between 800 and 900 students higher than the base case.

The school systems are expected to be able to deal with this increase by:

- re-opening a currently empty school
- adding temporary facilities, especially to schools in the Timberlea area, where most new houses are being built
- increasing busing for high school students

Mitigation

Shell has cooperated with other oil sands developers and the Regional Municipality of Wood Buffalo in developing an Urban Population Impact Model. This model estimates the population by age group, providing detailed planning input to the school boards in the area.

Shell is participating in the careers preparation program and is a member of the Training and Education Working Group.

Social Service Agencies

The long-term stable population of 38,000 to 39,000 associated with the Shell Development Scenario is expected to have less impact on social agencies than

Social Service Agencies (cont'd)

the current population. Part of the current demand is from unqualified job seekers coming to the region, anticipating employment from the new projects.

Mitigation

Shell's key proposed mitigative measure is using a full-service camp throughout the construction period. For operations-phase workers, Shell is proposing an orientation program and a company-sponsored employee assistance plan.

To help individual agencies, Shell will develop a corporate charitable donations policy. Shell will consider establishing a 'days of caring program' to encourage employees to become active community volunteers.

Health Services

The impact of the population growth implied by the Shell Development Scenario is not expected to increase health service demands beyond those that are currently experienced. However, additional medical personnel need to be attracted to the area. Additional funds made available by Alberta Health for recruiting and retaining doctors in rural areas will help, but should be viewed in the context of the current physician deficit.

Mitigation

Shell will provide basic medical services for workers on site during the project's construction and operations phases. Four medical technicians with the appropriate facilities will ensure that those working at the mine have continuous basic emergency health service coverage.

Shell and the other oil sands developers have established the Athabasca Oil Sands Facilitation Committee, which coordinates regional cooperation. This committee has a full-time resource person, who will work with the Regional Health Authority to identify issues and potential solutions.

Emergency Services

The Shell Development Scenario is not expected to increase the expected population levels beyond the 38,700 level estimated for 1997. This scenario does not imply service demands beyond those currently experienced. However, a new fire and ambulance station in the area or an expansion of the existing station in Thickwood Heights might be required.

Mitigation

Shell will provide full-time emergency health services for workers on site. Medical personnel will have a fully equipped Advanced Life Support (ALS) ambulance for transporting patients.

Mitigation (cont'd)

The mine will have on-site fire-fighting equipment and trained personnel. An emergency response plan will also be developed and implemented.

Shell will explore the possibility of a mutual aid agreement with the fire department of the Regional Municipality of Wood Buffalo and the emergency units of Syncrude and Suncor.

Highway Transportation

The Muskeg River Mine will require an average of five to eight trucks daily to deliver major equipment and materials during construction. Diesel fuel delivery will account for about 16 truck movements daily during operations. Additional traffic will be generated by the movement of people and materials during operations.

Mitigation

The measures Shell proposes to take to mitigate the impact of the Muskeg River Mine on traffic includes:

- using a camp for construction workers
- scheduling delivery of fuel, construction materials and equipment in off-peak periods
- considering alternative ways of delivering fuel
- busing workers
- discouraging construction workers from using private vehicles
- cooperating with other oil sands developers in scheduling shifts and work hours

Shell is working with other oil sands industry developers and the Regional Municipality of Wood Buffalo to define traffic issues further and to suggest remedial action. Shell, as a sponsor and member of the Athabasca Oil Sands Facilitation Committee, will support any of the committee's traffic issue recommendations.

Other Infrastructure

The population estimates associated with the Shell Development Scenario do not reach any critical municipal infrastructure thresholds. The change from a stable population to one of population growth, partly from the Muskeg River Mine development, has brought general infrastructure needs more into focus. The municipality is currently reviewing its infrastructure planning.

Mitigation

Shell will provide all necessary infrastructure on Lease 13, and is cooperating with other oil sands developers, the municipality and provincial politicians to identify infrastructure requirements and to formulate viable options.

MUNICIPAL FISCAL IMPACTS

The Muskeg River Mine will have a positive impact on the fiscal position of the municipality. The mine will contribute an estimated $1.25 million per year in municipal property taxes. In addition, new housing will add about $800,000 a year to municipal property tax revenue.

PROVINCIAL AND NATIONAL ECONOMIC IMPACTS

Income and Employment Impacts

Construction Phase — Income Impacts

An estimated $730 million (60%) of the construction expenditures will accrue directly to the provincial economy. Of the balance, $140 million (12%) is estimated to accrue to the rest of Canada and $370 million (38%) to foreign suppliers.

The income that will accrue to Alberta and the rest of Canada from the construction of the Muskeg River Mine will be compounded through the subsequent spending and re-spending of the new direct-income stimulus. The project will increase the province's gross domestic product (GDP) by an estimated cumulative $980 million, and increase household income by $680 million between 1998 and 2002.

Construction Phase — Employment Impacts

Design and construction of the Muskeg River Mine will require an estimated 3,000 work-years of direct employment. In addition, the construction expenditures will generate employment among suppliers (indirect employment) and across other sectors of the provincial economy (induced employment). The total direct, indirect and induced employment impacts to the province will equate to 6,600 work-years. Those employment impacts will be largely concentrated between 1998 and 2002.

Operations Phase — Income Impacts

An estimated $180 million to $240 million annually (80%) of the $225 million to $300 million operating costs, will be spent in Alberta. The total direct, indirect and induced income impacts to Alberta associated with operating the Muskeg River Mine are estimated at between $220 million and $280 million annually in terms of the province's GDP and between $110 million and $145 million annually in labour income.

Operations Phase — Employment Impacts

The operation of the Muskeg River Mine will require about 800 work-years annually. The direct, indirect and induced employment impacts in the province are estimated at 1,700 work-years annually.

Net Social Benefits

The undiscounted net social benefits of the Muskeg River Mine for the project's life are estimated to be $3.8 billion. Therefore, the project is of significant economic benefit to the provincial and national economies.

Between 1997 and 2025, $1.2 billion (33%) of the undiscounted net social benefits will accrue to the Alberta government and $850 million (22%) to the federal government — a total of 55% of all net social benefits. An estimated $30 million will accrue to the municipality as property taxes. The balance will go to the owners as a return on investment.

The estimated net social benefits do not account for additional municipal and government spending on infrastructure. These expenditures would decrease the net social benefits.

Other Impacts and Benefits

The development of the Muskeg River Mine will have other provincial economic benefits that are not reflected in the income and employment impact assessment or the net social benefit analysis. For example, the project will:

- support the province's goals to attract new investment and to diversify and sustain the economy
- contribute directly to the provincial resource revenue
- increase personal, corporate and other tax revenue through induced employment and economic activity
- contribute to the revised outlook on oil sands industry in the region. The industry would offset declines in the province's conventional oil industry.
- provide opportunities for Shell to apply new approaches and technologies in oil sands mining and bitumen extraction. These research and development initiatives are expected to yield increasing returns.

These qualitative economic benefits reinforce and augment the quantitative economic benefits.

CUMULATIVE CONSTRUCTION AND OPERATIONAL EMPLOYMENT

The cumulative assessment considers the Muskeg River Mine Project in the context of several other proposed projects. In addition to those assumed in the baseline, projects that have been announced, but that do not yet have regulatory approval, include:

- Suncor's Millennium Project
- Mobil Oil's Kearl Mine
- Gulf's Surmont Commercial Oil Sands Project
- Syncrude's Syncrude 21 suite of projects

Other in situ developments are planned, including projects by Petro-Canada and Japan Canada Oil Sands.

The estimated construction work force associated with these projects will peak at 7,500 workers in 2000. As several projects are in the early stages, these work force estimates are provisional. Cumulative new and additional operational work forces are estimated at about 2,700.

CUMULATIVE POPULATION IMPACT

Assuming that all the planned projects proceed, the cumulative population estimate for the Fort McMurray area is 47,100 by 2016. This estimate implies a 22% increase over the 1997 estimate. However, this estimate needs to be interpreted with caution, because all projects might not proceed, or other projects might be proposed.

During the construction period of most projects, the Fort McMurray area will have marginally higher population levels. The population is expected to peak at 48,900 in 2006, a 26% increase over the 1997 estimate.

The Fort McMurray area will also be influenced by the project site construction camps. The camps will draw on some central services. The total annual camp population is expected to peak at 6,300 in 2000.

The outlying communities are expected to grow, based on natural population dynamics. This includes the possibility that people will return to their communities to avoid the increasing cost of housing in the Fort McMurray area.

IMPACTS ON LOCAL AND REGIONAL SERVICE PROVIDERS

Housing

The regional housing demand is estimated at 3,800 dwelling units. Meeting this demand at current levels of building activity would take 11 years.

This imbalance in the housing market means that housing will remain in short supply during this 11-year period. Therefore, part of the population will continue to rely on basement suites and rental accommodation.

Education

The number of school-aged children is expected to increase from 8,300 in 1996 to 11,000 by 2002 and 11,300 by 2005. This increase of between 2,700 and 3,000 represents a 30% to 35% increase over eight years. Enrollments are expected to decline marginally as children graduate from secondary school.

This increase in school-aged children translates roughly to a need for 100 to 125 classroom teachers and associated facilities. The magnitude of the population increase is known. However, the timing of the impact depends on the age and family profile of the new workers attracted to the region.

Social Service Agencies

Social service agencies are already experiencing some impact from the population changes associated with regional development. If the expected regional development proceeds, the population will increase at 6.5% annually for the next five years and at 1% for the following five years. This population growth will have further impact on the demand for social services.

Several agencies expect a linear relationship between population and service demands. Others will experience impacts in the near-term construction phase, from speculative workers moving to the region.

Health Services

The total service population of the health region will likely increase by 2005 to 52,000, including:

- the Fort McMurray area
- outlying communities
- construction camps

The camp population might peak at 6,300 in 2000. The long-term stable population might reach 49,000 between 2016 and 2018, an increase of 7,000 (17%).

Without adjusting the analysis to the demand for individual services, the expected population level of 49,000 will require 60 to 65 physicians to keep the

Health Services (cont'd)

number of patients per physician within the provincial average of 700 to 750. This implies an increase of at least 30 physicians more than the current 32.

Emergency Services

The expected population growth will increase demands for emergency services. Emergency resources will need to expand to meet these demands.

Highway Transportation

New jobs will increase the total number of vehicles on the highway north of Fort McMurray by an estimated 15% to 17% during the operations phases of the projects. Highway use will increase by up to 35% in 2000, when several projects will be in full construction. Much of this projected increase will conform to the current highway-use profile, thus increasing rush hour congestion.

Other Infrastructure

The population impact from regional development will remain below the critical level of 55,000 to 60,000, beyond which major municipal infrastructure expenditure is expected. However, projects included in the regional development will have some impact on the municipality. Some of these impacts are already being felt, such as a marked increase in development permit applications for residential, commercial and industrial construction.

MUNICIPAL FISCAL IMPACTS

A preliminary review of the fiscal impacts of the proposed projects suggest that they will lead to improvements in the municipal fiscal situation. The plants and mines are major contributors to the assessment base, although conveying relatively little direct cost to the municipality. This beneficial impact depends on the way the municipality wants to develop. Although still in an early stage of discussion, some major infrastructure options are being considered, including:

- a bridge over the Clearwater River
- opening up the area to the east of the Clearwater for development

These options could have a significant impact on the municipal fiscal position.

APPROACH

CONSULTATION FRAMEWORK

Shell believes in the benefits of public consultation and that the public should be aware of, and have an opportunity to input into, decisions which affect them. Consultation helps to establish trust and build cooperative working relations with individuals and groups. It also enables Shell to benefit from the public's input and expertise.

Shell developed Principles of Consultation based on accepted industry principles. These principles (see Figure 12-1) cover:

- shared process
- respect
- timeliness
- relationships
- communication
- responsiveness
- accountability

These principles provided a framework for designing and implementing the Muskeg River Mine public consultation program.

CONSULTATION DEVELOPMENT PROCESS

In early 1997, individuals and groups that might be affected by, or demonstrated an interest in, plans for the Muskeg River Mine began to be identified. A consultation team was then formed to:

- Consult closely with communities, interested parties affected by the project, and regulatory agencies.
- Keep interested parties well informed as the project progresses.
- Gather and listen to feedback and work with people to resolve any concerns that might be identified.
- Work closely with the communities located near the project.

CONSULTATION DEVELOPMENT PROCESS (cont'd)

Initial consultations through specific work programs were initiated during the 1996-1997 winter drilling program. After the Lease 13 Project Public Disclosure was distributed in March 1997, a direct consultation program was implemented.

The public consultation plan was based on the community's preferred methods of communication. Senior members of Shell's oil sands division were assigned to work with specific stakeholder groups, which allowed the team to establish and maintain long-term relationships with their stakeholders. Key areas of concern were identified in the initial consultations, to ensure that they were being addressed from the outset of the project.

Stakeholder needs were evaluated, and an effort was made to put in place the most effective forums for exchanging information. For example, Shell staff participate in many working groups and committees.

Shell has also focused on keeping the public informed of plans and activities through meetings, open houses, workshops, mailouts and speaking engagements. In addition, the public has an opportunity to ask questions, voice concerns, or provide input through such mechanisms as:

- a 1-800 number
- project updates with self-addressed and stamped feedback forms
- an e-mail address

Shell is dedicated to ongoing consultations with stakeholders on activities surrounding the development of the Muskeg River Mine and, later, through ongoing operations. Support from Shell's neighbours is essential to successfully establishing the project and to ensuring success throughout operations.

Key issues will continue to be addressed through ongoing participation in stakeholder committees, workings groups and individual meetings, as required. Updates on Shell's activities will also continue to be provided regularly to residents of the Regional Municipality of Wood Buffalo, as well as regulators and other identified interested parties.

- **Shared Process** — Design consultation programs based on public input, taking into consideration their knowledge, in areas where Shell operates or plans to operate.
- **Respect** — Respect individual values. Consultation recognizes the legitimacy of peoples' concerns and the valuable input they can provide.
- **Timeliness** — Start consultation early. Provide social and environmental information and resources to ensure that the public and regulators are informed when participating in the consultation process. (Disclose all relevant information, as long as it does not affect Shell's competitive position.) Use appropriate methods of communication to proactively provide frequent updates to all stakeholders, and respond to questions and requests for information in a timely way.
- **Relationships** — Establish and maintain long-term relationships with key stakeholders through interaction, working teams and general involvement in the project. Meet and work with stakeholders face-to-face, whenever possible.
- **Communication** — Consult closely with communities and interested parties affected by the project and regulatory process. Gather and listen to feedback and work with people to resolve any concerns that might be identified.
- **Responsiveness** — Adapt plans based on stakeholder input and provide feedback on how input has affected plans and decisions. Establish feedback mechanisms to ensure that input is being captured and concerns addressed on an ongoing basis.
- **Accountability** — Trust that representatives of interest groups are accountable to the organizations they represent.

Figure 12-1: Shell's Principles of Consultation

STAKEHOLDER IDENTIFICATION

Shell's consultation program began with the identification of individuals and groups that might be affected by, or have demonstrated an interest in, plans for the development of the Muskeg River Mine, including:

- adjacent lease holders
- contractors and suppliers
- educational institutions, including:
    - Fort McMurray public schools
    - Fort McMurray Catholic schools
    - Keyano College
    - Northland School Division
- environmental groups, including the:
    - Canadian Parks and Wilderness Society
    - Clearwater Heritage River Committee
    - Cree Burn Lake Preservation Society
    - Environmental Resource Centre
    - Fort McMurray Environmental Association
    - Fort McMurray Field Naturalist Society
    - Fort McMurray Fish and Game Association
    - Pembina Institute
    - Toxics Watch Society
- federal government, including:
    - the Canadian Coast Guard
    - the Canadian Environmental Assessment Agency (CEAA)
    - the Department of Fisheries and Oceans (DFO)
    - the Department of Indian and Northern Affairs
    - Environment Canada
    - Finance Canada
    - Industry Canada
    - Natural Resources Canada
- Fort Chipewyan community:
    - Athabasca Chipewyan First Nation

STAKEHOLDER IDENTIFICATION (cont'd)

    - Fort Chipewyan Metis Local 124
    - Mikisew Cree First Nation

- Fort McKay community:
    - Fort McKay First Nation
    - Fort McKay Metis Local #122

- Fort McMurray community:
    - Alberta Government Organization and Office of the Commissioner of Services for Children and Families
    - Fort McMurray Chamber of Commerce
    - Oil Sands Interpretive Centre
    - Salvation Army

- general public and residents of the Regional Municipality of Wood Buffalo

- industry

- industry associations:
    - Alberta Chamber of Resources
    - Canadian Association of Petroleum Producers
    - Fort McMurray Construction Association
    - Northeastern Alberta Aboriginal Business Association

- media

- municipal government, including:
    - Emergency Services
    - Fire Department
    - Northern Lights Regional Health Authority
    - Planning Department
    - Regional Municipality of Wood Buffalo (RMWB)
    - the Royal Canadian Mounted Police (RCMP)
    - Standing Committee on Oil Sands Development

- oil sands operators

- other Wood Buffalo First Nation and Metis communities:
    - Anzac Metis Local 334

STAKEHOLDER IDENTIFICATION (cont'd)

- Chipewyan Prairie Dene First Nation
- Conklin Metis Local 193
- Fort McMurray First Nation
- Fort McMurray Metis Local 1935 and Local 2020
- Janvier Metis Local 214

- provincial government, including:
  - Alberta Community Development - Historic Sites Service
  - Alberta Economic Development and Tourism
  - Alberta Energy
  - Alberta Energy and Utilities Board (EUB)
  - Alberta Environmental Protection (AEP)
  - Alberta Treasury
- trappers

GOOD NEIGHBOUR POLICY

While Shell's Principles of Consultation serve as an internal guideline to direct plans and activities, a Good Neighbour policy (see Figure 12-2) was also drafted to guide Shell's actions and help Shell's neighbours understand its position, expectations and objectives.

Good Neighbour Policy

Shell's proposed Muskeg River Mine is located in the Regional Municipality of Wood Buffalo. Shell's objective is to develop a mutually prosperous, long-term relationship with the people living in the local area, particularly our neighbours — the First Nations and Metis people living close to the Muskeg River Mine.

Shell will use the following principles as a guide in developing such a relationship:

- Shell will establish trust, respect and understanding at an early stage – through honest, open and proactive communication.
- Shell will, on an ongoing basis, involve its neighbours in decisions which impact them – with the objective of finding solutions which both parties view as positive over the long term.
- Shell will construct and operate the Muskeg River Mine in an environmentally responsible – and economically robust – manner.
- Shell will use and encourage local businesses – including First Nation and Metis businesses – where they are competitive and can meet Shell's requirements.
- Shell will ensure that the jobs created by the Muskeg River Mine are filled by its neighbours whenever possible – but always on a strictly merit basis. To help make this happen, Shell will work with its neighbours, contractors, educational institutions and other producers to develop the skills Shell requires.

Figure 12-2: Good Neighbour Policy

COMMUNITY UNDERSTANDING

Some consultation was undertaken before Shell's 1996-1997 winter drilling program. Formal consultation was initiated after the Lease 13 Project Public Disclosure was distributed in March 1997, to ensure that all interested parties had an opportunity to become familiar with the project.

The public consultation plan is based on that input, which includes assigning senior members of Shell's oil sands division to work with specific stakeholder groups. Assigning specified representatives to work with each group allows the team to establish and maintain long-term relationships with their stakeholders. Specified points of contact also help to provide continuity when following through on issues and commitments. As the project evolves, experts and new team members are brought in as needed.

Key areas of concern were also identified through early public input to ensure that they were being addressed from the outset of the project.

PROJECT PUBLIC DISCLOSURE

On March 14, 1997, the Lease 13 Project Public Disclosure was distributed to identified stakeholders. The availability of the public disclosure was communicated through newspaper and radio advertising, and a news release describing the project was distributed to key media outlets. A project-related 1-800 telephone number and e-mail addresses were also introduced through the advertisements and public disclosure to request input and facilitate information sharing.

The preliminary stakeholder list was expanded as Shell received and responded to enquiries for additional information and copies of the public disclosure. Distribution was followed with numerous meetings to describe the project and respond to questions.

ENVIRONMENTAL IMPACT ASSESSMENT TERMS OF REFERENCE

On May 17, 1997, the proposed Terms of Reference for the Environmental Impact Assessment (EIA) was made available for public review at the:

- Fort McMurray Public Library
- Oil Sands Interpretive Centre
- Fort Chipewyan Regional Municipal Contact Office
- Environmental Assessment Division Registry

The availability of the proposed EIA Terms of Reference was communicated through newspaper advertisements. In addition, copies were distributed to stakeholder groups with a cover letter offering to discuss the content of the proposed EIA Terms of Reference, as well as environmental concerns.

The proposed EIA Terms of Reference were revised based on input obtained through numerous stakeholder meetings and workshops. The final Terms of Reference were issued by AEP on November 7, 1997.

MEETINGS AND WORKING GROUPS

Meetings continue to be held with stakeholders to provide project updates, discuss concerns and opportunities, and develop plans for future activities. As consultations progress, opportunities for Shell to participate in committees and

MEETINGS AND WORKING GROUPS (cont'd)

working groups are identified. Stakeholder needs are also continuously evaluated and additional meetings, phone calls or correspondence are scheduled as required. More formal consultation processes are implemented, as appropriate.

Community of Fort Chipewyan

Shell has been meeting regularly with the Athabasca Chipewyan First Nation, the Mikisew Cree First Nation and Metis Local 124. These groups have expressed their concern about being downstream of the Athabasca River and about the socio-economic opportunities and impacts of Shell's project.

On November 24, 1997, an open house in Fort Chipewyan was attended by a cross-section of the community.

Community of Fort McKay

Fort McKay is the closest community to the proposed development on Lease 13 and is located on the west bank of the Athabasca River, several kilometers south of Lease 13. This community has the greatest potential to be affected by the Muskeg River Mine Project. For this reason, a detailed consultation process was undertaken with the community of Fort McKay.

An integrated team, called the Shell McKay Application Review Team (SMART), was formed with members from the Fort McKay First Nation, Fort McKay Metis Local 122 and Shell. The committee has the mandate to review Shell's proposed development by:

- involving the community in the review of development plans before filing the application
- obtaining feedback and incorporating it, where possible
- considering local environmental impacts
- considering socio-economic impacts, including employment and local business opportunities

Other consultation activities with the community of Fort McKay include:

- elder workshops
- an open house
- participation in a business day
- meetings with community members

Consolidated Metis Locals (CML)

Shell has been meeting regularly with Metis locals participating in the consolidated Metis locals of Wood Buffalo. Project updates and other

Consolidated Metis Locals (CML) (cont'd)

information, such as employment opportunities and required skills, has been provided. The major interest from the group has been socio-economic benefits, including jobs and business opportunities.

Education

Project staff have met with representatives of local school boards and Keyano College to provide project updates and employment forecasts to help them plan their future courses and facilities. Shell is also participating in the Joint Industrial Education Working Group, which is made up of industry, municipal government, Keyano College and First Nations representation to provide a cooperative approach to prepare interested residents of the RMWB for employment opportunities in oil sands projects.

Environmental Groups

The environmental groups interested in oil sands development have formed a coalition, called the Oil Sands Environmental Coalition (OSEC), to review the proposed oils sands developments. The coalition members include the:

- Environmental Resource Centre
- Fort McMurray Environmental Association
- Pembina Institute
- Toxics Watch Society

Shell has been meeting with OSEC or its delegated representatives to provide information on the Muskeg River Mine Project and to get feedback on the environmental concerns and issues raised by OSEC. This consultation process is ongoing and will continue after the application for approval has been filed.

Industry

Numerous meetings have been, and continue to be, held with other oil sands operators. Discussions included both commercial and consultation issues.

As outlined in Regional Cooperation Approach in Section 1.5, Shell is committed to promoting ongoing and effective working relationships with other industry members. These have included Syncrude, Suncor, Mobil, Birch Mountain, Alberta-Pacific, Northlands and others.

The recent announcement of a number of proposed developments for the Athabasca oil sands region has resulted in an increased focus on cumulative effects and regional development. A Cumulative Effects Assessment (CEA) Working Group was established in response to the need for both a shared view of development in the region over the next 10 to 15 years, and a common methodology for cumulative environmental effects analysis. Shell has been participating in the working group, which to this point has comprised oil sands operators and proponents. The group has been developing and implementing a

Industry (cont'd)

strategy on how the issue of CEA for individual projects and long-term planning should best be managed. Efforts are being made to ensure that regulators, non-governmental groups and the public are given an opportunity to participate in this process.

If the Muskeg River Mine Project is approved, Shell will join the Regional Air Quality Coordinating Committee (RAQCC) as an official member. The committee evolved as a result of conditions to operating approvals for Suncor and Syncrude, and is now at the point where the existing Syncrude, Suncor and AEP air monitoring networks will be combined and realigned to form the new Southern Wood Buffalo air monitoring zone. Members include companies with existing operating permits, AEP, Fort McKay, the RMWB and the Fort McMurray Environmental Association. Until granted full membership, Shell staff attend meetings as observers.

Shell is a member of the End Land Use Planning Committee, which was formed to assist in the policy decision-making process regarding final land uses of mined oil sands areas. The committee is advisory to both AEP and the oil sands mining companies. Members include representatives from EUB, AEP, RMWB, oil sands operators, environmental groups, industry operators, and First Nation and Metis communities.

Shell is a participant in the newly formed Regional Aquatic Monitoring Program (RAMP), a committee organized to assess regional trends and cumulative impacts to aquatic resources (water quality, sediment, vegetation, benthic invertebrates and fish) of portions of the Athabasca River and its tributaries.

Other First Nations and Metis Groups

Shell has provided project updates to representatives of the Fort McMurray First Nation and the Chipewyan Prairie Dene First Nation.

Project staff also met with representatives of Wood Buffalo First Nations and Metis to provide project updates and overviews, and discuss concerns and issues.

Regional Municipality of Wood Buffalo

Shell has been working with the RMWB and local service agencies to obtain planning information for the Muskeg River Mine. Shell is also an active participant in the Regional Infrastructure Working Group (RIWG), which was formed in June 1997, to support the Regional Municipality of Wood Buffalo in addressing infrastructure planning in light of the prospects for increased oil sands activity in the area. The RIWG consists of representatives from the RMWB and from Gulf Canada, Imperial Oil, Mobil, Petro-Canada, Shell, Suncor, Syncrude and Japan Oil Sands Canada, with other oil sands developers expected to join.

Regional Municipality of Wood Buffalo (cont'd)

To enhance planning for services and infrastructure, an urban population prediction model was developed and representatives from key service agencies and the Municipality have been trained in its use. Model results will be updated periodically and made available to interested agencies and businesses.

In addition to this planning tool, the RIWG identified priorities for immediate attention. These include:

- rural community assessment
- housing
- transportation
- work force training

Recognizing that there are other groups and initiatives in the region, the RIWG will not duplicate work but will serve as an interim industry window. To enhance focus on the management of the identified interest areas, a senior level Facilitation Committee, made up of industry and provincial and municipal representatives, was formed in October 1997. The committee sponsored the provision of a full-time coordinator who works closely with developers, the municipality and other agencies to improve planning.

Shell is aware of the increased demand for housing that is associated with the more optimistic outlook for oil sands developments. Shell has been actively participating in the Mayor's Housing Task Force, which is focusing on identifying barriers and potential solutions to improve the supply of housing in the region. The task force includes representatives from federal and provincial agencies responsible for providing affordable housing, as well as local developers and agencies concerned with housing. Shell and others have worked to identify new approaches to housing development to accommodate future growth, and project staff have met with social service, emergency service and education agencies.

REGULATORS

Working Groups

In addition to ongoing meetings and regular contact with the EUB and AEP, two working groups involving Shell, EUB and, later, AEP staff were established to provide ongoing reviews and input to the mine and extraction process scope development. The mandate was to establish a clear set of regulatory expectations for the Muskeg River Mine application and EIA, specifically as it relates to the project scope component. Working in this proactive manner has supported the efficient use of people, time and resources in the regulatory process for all parties involved.

Project Overview Sessions

Project overview sessions were held in Edmonton in September 1997 and Fort McMurray in October 1997 with a broad range of provincial and federal government regulators and interested stakeholders. The purpose of the sessions was to describe development plans and environmental issues to be considered for the Muskeg River Mine. The sessions also provided the necessary background to support a series of more detailed environmental review workshops that followed in fall 1997.

Participants attending the Edmonton and Fort McMurray sessions included representatives from the following groups:

- AEP
- Chipewyan Prairie Dene First Nation
- EUB
- Environment Canada
- Fort McKay Environmental Services
- Fort McMurray Environmental Association
- Natural Resources Canada
- Pembina Institute
- RMWB

Environmental Review Workshops

Regulatory agencies and other non-government organizations (NGOs) were invited to help to identify environmental issues. Five workshops were conducted to gain additional feedback on topics of specific interest, including:

- air
- terrestrial (vegetation, wildlife, soils, land use and historic resources)
- water
- human and ecological health
- socio-economics

Working group participants were provided with a project overview and update, an overview of key issues, methods and approaches to be used to address the issues and, where possible, an outline of expected results. Environmental issues and concerns raised by working group participants have been incorporated in this application and EIA.

Participants included representatives from

- AEP
- Alberta Community Development
- Athabasca Chipewyan First Nation
- Alberta Health

Environmental Review Workshops (cont'd)

- Chipewyan Prairie Dene First Nation
- Environment Canada
- EUB
- DFO
- Fort McKay Environmental Services
- Mikisew Cree First Nation
- Northern Lights Regional Health Authority
- Pembina Institute
- RMWB

GENERAL CONSULTATION ACTIVITIES

Shell ensures that the public is kept apprised of plans and encourages input regularly through various means of communication, such as:

- advertisements
- news releases
- speaking engagements
- mailouts
- open houses
- public disclosures

Public Disclosures

In addition to consultation, a number of announcements related to the Muskeg River Mine Project have been disclosed and made available to the public through advertisements, including the:

- Lease 13 Public Disclosure on March 14, 1997
- Corridor Pipeline Public Disclosure on July 31, 1997
- Scotford Upgrader Public Disclosure on September 30, 1997

Following each of these announcements, Shell also published news releases, and spokespeople responded to all requests for interviews and general enquiries.

Information and Updates

Information and project updates have been distributed directly to the public in a variety of formats. For example:

- The 1997-1998 winter drilling program information package, including a fact sheet and letter outlining service requirements and business opportunities, was distributed to the Fort McMurray Chamber of Commerce and local operators and suppliers on August 8, 1997.

Information and Updates (cont'd)

- A project update was mailed to 16,350 RMWB residents on October 20, 1997.

Open Houses

To date, three open houses have been held in the RMWB, including:

- Fort McMurray
- Fort Chipewyan
- Fort McKay

Shell will continue to provide opportunities for open houses in other communities.

Fort McMurray

About 750 RMWB residents attended the November 6, 1997 open house. About 500 of these attendees attended the formal project overview presentation, which was followed by a question and answer session.

Two hundred and fifty-five feedback forms were returned, providing input on the effectiveness of the open house and communication methods employed by Shell. The open house helped 254 of the 255 respondents gain a better understanding of the project, and 253 individuals felt their questions were answered satisfactorily. Mailouts proved to be the most effective form of communication for informing the public about the open house, followed closely by radio and newspaper advertising. Mail and newspaper are the two most preferred sources of information.

Fort Chipewyan

About 180 residents attended the November 24, 1997 Fort Chipewyan open house and project overview presentation, and participated in the question and answer session. Ten project representatives were present to meet with the attendees.

Forty-five feedback forms were returned. The open house helped 32 of the 45 respondents understand more about the project, and 25 felt their questions were answered satisfactorily. Mailouts and newsletters are the preferred sources of information, followed by television and radio.

Fort McKay

About 90 residents attended the open house and project overview presentation in Fort McKay on December 9, 1997. Attendees participated in a question and answer session after the presentation. Ten project representatives were present to meet with the attendees.

Fort McKay (cont'd)

Nine feedback forms were returned. The open house helped six of the nine respondents understand more about the project, and seven felt their questions were answered satisfactorily. Mail and meetings are the preferred sources of information.

Open House Resource Materials

At all three open houses, information and maps were prominently displayed to illustrate and clarify project details, and information pieces were available including:

- Shell's Lease 13 Public Disclosure
- a fact book entitled Sharing Our Plans – Our Athabasca Oil Sands Development
- the proposed EIA Terms of Reference
- Shell's 1996 Annual Report and Sustainable Development Report
- BHP's Environmental Report and corporate materials

FEEDBACK MECHANISMS

In addition to meetings and workshops with key stakeholders, a number of other mechanisms have been used to provide the public with an opportunity to ask questions, voice concerns, or provide input.

Telephone

A 1-800 telephone number was established in March 1997 and has been promoted through advertising and information updates. Over 1,000 calls were received up to the end of November 1997. Questions and requests for additional information have been responded to, and feedback on project-specific issues has been forwarded to appropriate project staff for consideration and resolution. Most callers were interested in employment opportunities.

Project Update and Open House Announcement

The project update and open house announcement that was distributed to 16,350 RMWB residents in October 1997, included a self-addressed, stamped comment card. Interested parties were encouraged to provide input on:

1. Communication: How can we ensure a two-way flow of information?
2. Jobs and opportunities: What are your expectations?
3. The environment: What are your concerns?
4. Other areas of interest to you.

Project Update and Open House Announcement (cont'd)

More than 520 cards have been received to date. Respondents were included in the project mailing list, if requested, and Shell is responding to questions and requests for additional information.

Primary areas of interest included:

- employment opportunities
- impact on the RMWB
- housing
- transportation
- environmental issues, including:
  - protection initiatives
  - cumulative effects
  - emissions
  - impact on waterways
- education and training

In addition to sending letters of response and additional information to individuals who expressed concern or requested information, these areas of interest will be addressed in future information updates.

E-Mail

An e-mail address has been promoted through advertising and information updates. All enquiries are responded to as they are received.

ONGOING PLANS

Shell is dedicated to ongoing consultations with stakeholders on activities surrounding the development of the Muskeg River Mine and later through ongoing operations. Support from Shell's neighbours is essential to successfully establish the project and to ensure success throughout operations.

Key issues will continue to be addressed through ongoing participation in stakeholder committees and working groups, and individual meetings, as required. Updates on Shell's activities will also be provided to residents of the RMWB.

Issues and questions raised at the three open houses will be addressed in future communication plans.

Table 12-1 lists the consultations Shell has had with stakeholders. Consultations with regulators are listed in Table 12-2.

Table 12-1: Stakeholder Consultations

February 1997	Activity	Stakeholder
26	Meeting to review business services the Band has to offer, training programs, employment opportunities and open houses.	Fort McMurray First Nation
27	Meeting to discuss the Muskeg River Mine and regional cooperation.	Mobil
March 1997		
13	Meeting to introduce the Muskeg River Mine and discuss other projects.	End Land Use Planning Committee
14	Distribution of the Lease 13 Project Public Disclosure.	General public
29	Project overview and review of potential work, and upcoming contract opportunities.	Fort McKay Metis Local 122
April 1997		
17	Presentation to provide an overview of the project and answer questions (300 attendees).	Fort McMurray Chamber of Commerce, business people and general public
28	Discussion regarding the cultural and archaeological significance of the Cree Burn Lake area, summary of Shell's plans and discussion of a historical site.	Cree Burn Lake Preservation Society (CBLPS)
29	Meeting to discuss the mandate and role of the Regional Infrastructure Working Group.	Oil sands developers and RMWB
29	Meeting to provide a project overview.	Fort McMurray First Nation
29	Meeting to introduce the project and provide an overview.	Chipewyan Prairie Dene First Nation
30	Meeting to introduce the project and provide copies of the disclosure.	Fort McKay First Nations and Metis
May 1997		
5	Meeting to provide a project overview.	Athabasca Chipewyan First Nation
5	Meeting to provide a project overview.	Mikisew Cree First Nation
7	Project overview and potential socio-economic benefits for the local economy.	Fort McMurray Chamber of Commerce
7	Meeting to discuss end land use issues.	End Land Use Planning Committee
7	Meeting to introduce consultation approaches and discuss a cooperative industry approach to development.	RMWB department heads

Table 12-1: Stakeholder Consultations (cont'd)

May 1997 (cont'd)	Activity	Stakeholder
7	Meeting to discuss the project, a First Nations and Metis community outreach program, review learnings from Syncrude and Suncor experiences and a defined sponsorship strategy.	Keyano College
7	Meeting to provide a project update and discuss EIA and employment opportunities.	Consolidated Metis Locals of Wood Buffalo
7	Presentation and project overview to the Standing Committee on Oil Sands Development.	Standing Committee on Oil Sands Development (SCOSD)
7	Meeting to discuss educational opportunities, meeting facilities, partnerships, displays and funding opportunities.	Oil Sands Interpretive Centre
9	Meeting to review and ensure common understanding of existing information and analysis, define a draft scope for a Regional Socio-economic Review, define a Go-Forward Plan and address regional coordination of a supporting infrastructure.	Oil sands developers and municipality
15	Meeting to review the letter and Terms of Reference for the Shell McKay Application Review Team (SMART) agreement.	Fort McKay First Nations and Metis
16	Meeting to review a report on the archaeological significance of Cree Burn Lake Site and draft document supporting nomination of a historical site.	Syncrude
22	Meeting to determine a process for working with the Pembina Institute.	Pembina Institute
26	Ongoing work on planning model and key issue follow-up plans.	Regional Infrastructure Working Group
28	Meeting with local Forestry Office to provide a project overview and determine key contacts.	AEP Fort McMurray
29	Meeting to discuss end land use issues.	End Land Use Planning Committee
June 1997		
3	Meeting to introduce new team members, finalize SMART agreement, provide a project update and provide nomination information on the Cree Burn Lake area.	Fort McKay First Nations, Metis and Environmental Services

Table 12-1: Stakeholder Consultations (cont'd)

June 1997 (cont'd)	Activity	Stakeholder
10	Meeting to provide an update on the Muskeg River Mine as input to a Regional Health Authority Needs Assessment.	Northern Lights Regional Health Authority
10	Meeting to provide a project overview, discuss the mandate of the Alberta Government Organization and Office of the Commissioner of Services for Children and Families in the region, and request assistance with the identification of additional stakeholder groups.	Alberta Government organizations and Office of the Commissioner of Services for Children and Families
13	Meeting to discuss and review EIA Terms of Reference.	Fort McKay First Nations, Metis and Environmental Services
16	Socio-economic workshop, sponsored by Regional Infrastructure Working Group, to provide a consolidated view of socio-economic information, discuss how the existing information is used and focus on how to move forward.	Social Services, RCMP, Public Works, RMWB, Chamber, Fire Chief, Keyano College
16	Meeting to discuss the new Southern Wood Buffalo air monitoring zone.	Regional Air Quality Coordination Committee
19	Meeting to discuss Metis Corp. Campsite on the Muskeg River Mine and Shell's winter 1997-1998 requirements.	Fort McKay First Nations, Metis and Environmental Services
19	Meeting to discuss utility access corridor for the Aurora Project.	Syncrude
20	Meeting to provide a project update and discuss the EIA Terms of Reference, and employment and business opportunities.	Consolidated Metis Locals of Wood Buffalo
20	Meeting to clarify Shell's position with regard to historical site, Special Places 2000, and recreational facilities.	Cree Burn Lake Preservation Society
25	Meeting to provide a project update and seek input into the EIA Terms of Reference; discussion on potential business opportunities and participation in Socio-Economic Impact Assessment work.	Mikisew Cree First Nation
25	Meeting to provide an update of the project and discuss any comments regarding the EIA Terms of Reference.	Fort Chipewyan Metis
25	Meeting to discuss the socio-economic baseline model.	Regional Infrastructure Working Group

Table 12-1: Stakeholder Consultations (cont'd)

June 1997 (cont'd)	Activity	Stakeholder
26	Meeting with public affairs team to discuss public consultation activities.	Mobil
26	Meeting to discuss the need and approaches for industry coordination related to regional infrastructure issues.	Regional Infrastructure Working Group
July 1997		
2	Discuss primary needs from Shell and programs that require industry support.	School boards: public and separate
2	Meeting to provide a project overview to the Northeastern Alberta Aboriginal Business Association.	Northeastern Alberta Aboriginal Business Association
3	Meeting to review the EIA Terms of Reference.	Athabasca Chipewyan First Nation
3	Meeting to discuss environmental review and ongoing water monitoring, socio-economics, and Cree Burn Lake report.	Athabasca Chipewyan First Nation
8	Meeting to discuss public consultation plans and activities.	Suncor
8	Meeting to provide an update on the project.	Fort McMurray radio station
10	Meeting to provide an update on the project and to introduce BHP.	Fort McMurray City Manager
10	Meeting to introduce BHP, sign the SMART agreement and provide an update on the project.	Fort McKay First Nations and Metis
10	Meeting to discuss different approaches for developers to involve First Nation and Metis communities in both employment and business opportunities.	Millennium II Inc.
10	Meeting to provide a project update and introduce BHP.	Athabasca Chipewyan First Nation
10	Meeting to provide a project update, introduce BHP and review Mikisew Cree business capabilities and direction.	Mikisew Cree First Nation and Mikisew Cree Corp.
11	Meeting to understand Birch Mountain Mineral lease position and opportunities regarding cooperation.	Birch Mountain Minerals
11	Meeting to review proposals for a Regional Socio-Economic Planning Model and set contract.	Regional Infrastructure Working Group

Table 12-1: Stakeholder Consultations (cont'd)

July 1997 (cont'd)	Activity	Stakeholder
16	Meeting to provide a project update and discuss EIA and cumulative effects study document.	Fort McKay First Nations and Metis
22	Meeting with Clearwater Heritage River Committee members to discuss the project and product pipeline plans.	Clearwater Heritage River Committee
22	Meeting to provide a project overview and identify concerns.	Northlands Forest Products
31	Distribution of Pipeline Public Disclosure.	General public
August 1997		
21	Meeting to discuss end land use options.	End Land Use Planning Committee
22	Meeting to provide a project update and discuss the EIA, training and CML employee liaison.	Consolidated Metis Locals of Wood Buffalo
25	Meeting to review the project and discuss the pipeline disclosure.	Fort McMurray First Nation
25	Meeting to provide a project update and identify issues.	Salvation Army
25	Meeting to discuss Keyano's needs and expectations.	Keyano College
28	Meeting to discuss the Muskeg River Mine and define the function of the Athabasca Tribal Council (ATC).	Athabasca Tribal Council
28	Meeting with oil sands operators and project proponents to discuss the need for agreement on the methodology used for cumulative environmental effects analysis.	Suncor, Syncrude and Mobil
28	Meeting with Fort McMurray Mayor Doug Faulkner to introduce Shell and the project, and to obtain feedback with respect to the consultation work to date with the RMWB.	Mayor Faulkner
28	Meeting to discuss the status of the project, information requirements, and speaking opportunities with interested member businesses and associations.	Fort McMurray Chamber of Commerce
September 1997		
5	Meeting to discuss key issues and provide a project update.	Pembina Institute
10	Discuss the progress of the SMART team and consultation with Fort McKay.	Chief Jim Boucher and Bonnie Evans

Table 12-1: Stakeholder Consultations (cont'd)

September 1997 (cont'd)	Activity	Stakeholder
11	Meeting to discuss SMART agreement issues and provide a mining overview.	Fort McKay First Nations, Metis and Environmental Services
12	Participation and brief presentation and project overview at a Fort McKay Industry and Government Industrial Development session.	Fort McKay, Alberta-Pacific, Petro-Canada, Mobil, Suncor and Syncrude
15	Meeting to provide a project update and discuss procurement policies and other issues.	Northeastern Alberta Aboriginal Business Association
16	First meeting of the Housing Strategies Task Force to define how affordable housing in Fort McMurray can be achieved.	Housing Stakeholder Representatives (RMWB, Industry, Associations and AB Government)
16	Meeting to provide Fort McMurray and Area School Boards (Public, Separate and Northlands) with a project update and assess the Boards' needs.	School Boards: Public, Separate and Northlands
16	Meeting to discuss the Regional Socio-Economic Model, review the development work to date, the remaining work program, and discuss the associated roll-out.	Regional Infrastructure Working Group
17	Meeting to provide a project update and discuss how Keyano can provide assistance.	Keyano College
17	Meeting to provide a general update.	Consolidated Metis Locals of Wood Buffalo
18	Meeting to discuss Socio-Economic Model roll-out.	Suncor re: Regional Infrastructure Working Group
19	Presentation to the Canadian Institute of Mining, Metallurgy and Petroleum conference in Fort McMurray.	Fort McMurray, mining and business representatives
23	Meeting to discuss the proposed Cree Burn Lake historic site area, buffer zones and other facilities.	Alberta Community Development, Cree Burn Lake Preservation Society, Syncrude, Mobil, Birch Mountain, RMWB, Lifeways and Fort McKay Environmental Services
24	Meeting to introduce new SMART team members, provide a project update, and discuss Socio-Economic Planning Committee issues.	Fort McKay First Nations and Metis
24	Meeting to discuss framework for Cumulative Effects Analysis.	Suncor, Syncrude, Mobil and Petro-Canada

Table 12-1: Stakeholder Consultations (cont'd)

September 1997 (cont'd)	Activity	Stakeholder
25	Meeting to discuss Memorandum of Understanding for involvement in the review of the proposed Muskeg River Mine and Upgrader developments.	Pembina Institute
25	Presentation at Purchasing Management Association of Canada Conference and Fort McMurray's Business Associate's Day to provide an update of the project and encourage input.	Industry, Business and supplier representatives
26	Meeting to discuss framework for Cumulative Effects Analysis.	Fort McKay, Pembina Institute and industry consultants
26	Cumulative Effects Workshop # 2.	CEA working group
29	Meeting to discuss end land use options.	End Land Use Planning Committee
29	Meeting to discuss the proposed project.	Clearwater Heritage River Committee
30	Distribution of Upgrader Public Disclosure.	General public
October 1997		
2	Kick-Off Meeting to provide a project overview, review workshops and discuss issues.	RMWB, Natural Resources Canada and Chipewyan Prairie Dene First Nation
3	Meeting to discuss socio-economic impact analysis for Fort Chipewyan.	Mikisew Cree First Nation
3	Working group to provide a project update, share the upgrader public disclosure document, employment communication needs, employment targets, and preliminary estimates of manpower numbers and job types.	Fort McKay First Nations, Métis and Environmental Services
6	Meeting to discuss the development of a plan to work together to address Fort McMurray's housing needs.	Mayor's Housing Task Force (RMWB, Industry, Associations, Alberta Government and CMHC)
7	Water Workshop to provide a project overview and address issues related to hydrogeology, hydrology, aquatics and water quality.	DFO, Environment Canada, AEP and EUB
8	Discussion to arrange meeting regarding compensation issue and winter drilling program.	Trapper (M. Tourangeau)
9	Air Quality Workshop to provide a project overview and address related issues.	Environment Canada, AEP, EUB and Pembina Institute

Table 12-1: Stakeholder Consultations (cont'd)

October 1997 (cont'd)	Activity	Stakeholder
10	Meeting to discuss letter of interest forwarded to Shell re: communication activities with trappers.	Trapper (J. Gauthier)
10	Meeting to provide an update on the project, including timing and approvals, cost, how it relates to other projects and pipelines; Shell requested input on current issues such as housing, camps, pipeline routes, public services, etc.	RMWB representatives and department heads
10	Meeting to provide a project update, regulatory update and timeline, discuss their issues and expectations, open house, socio-economic impact modelling and regional cumulative effects work.	Mayor Faulkner, Councilors, Regional Manager
15	Meeting to review Shell's Good Neighbor policy.	Consolidated Metis Locals of Wood Buffalo
15	Terrestrial Workshop to provide a project overview and address issues related to vegetation, wildlife, soils, land use and historic resources.	Environment Canada, Alberta Community Development, AEP and EUB
16	Meeting to discuss drilling program; follow-up meeting to be scheduled upon review of the program.	Trapper (M. Tourangeau)
16	Meeting to provide an overview of the proposed extraction process; tour of the CANMET facilities at Devon with an overview of the Shell pilot plant.	Fort McKay First Nations, Metis and Environmental Services
16	Meeting to review project status, tentative employment numbers and timing; discussed Good Neighbour policy, and participation in school program.	Athabasca Tribal Council
16	Human and Ecological Health Workshop to provide a project overview and address related issues.	Environment Canada, AEP, Alberta Health, Northern Lights Regional Health Authority and Pembina Institute
17	Discussion regarding compensation.	Trapper (M. Tourangeau)
19	Meeting to discuss the Socio-economic Impact Assessment, Good Neighbour policy, education and hiring processes.	Athabasca Chipewyan First Nation

Table 12-1: Stakeholder Consultations (cont'd)

October 1997 (cont'd)	Activity	Stakeholder
20	Meeting to discuss options for coordinating employee selection and training activity and the college's ability to facilitate the development of a local industry assessment of required skills and professions.	Keyano College
20	Meeting to provide a project update, discuss Good Neighbour policy and identify concerns.	Fort McMurray First Nation
21	Meeting with industry and stakeholders to discuss cumulative effects methodology.	Fort McKay, Fort Chipewyan, Pembina Institute, Suncor, Syncrude, Mobil, Petro-Canada, Gulf, Gibsons and JAPEX.
22	Meeting to attempt to resolve Northlands Forest Products concerns regarding loss of annual timber quota because of Aurora project.	AEP Waterways, Northlands and Syncrude
23	Meeting to provide a project update and discuss pilot plant.	Athabasca Chipewyan First Nation
23	Socio-Economic Workshop to provide a project overview and address related issues.	AEP, Pembina, Athabasca Chipewyan First Nation, EUB, Fort McKay, Mikisew Cree First Nation and RMWB
30	Meetings to finalize compensation details.	Trappers (R. Boucher and M. Tourangeau)
30	Meeting to provide project update and discuss mine planning and pilot plant options.	Fort McKay First Nation and Metis
31	Meeting to roll out urban population impact model.	Standing Committee on Oil Sands Development
November 1997		
3	Discussion regarding public consultation activities and coordination of key messages.	Suncor, Syncrude and Mobil
3	Meeting to give presentation on the population impact model.	Mayor's Housing Task Force
6	Open House in Fort McMurray for about 750 attendees.	General public
6	Meeting to discuss historical preservation, recreational areas, zoning and other issues.	Cree Burn Lake Preservation Society
7	Presentation of recent work of CEA working group to CEAA, DFO, AEP, EUB, and Environment Canada.	CEA Working Group
10	Meeting to discuss project update.	Fort McMurray First Nation - Chief and Council

Table 12-1: Stakeholder Consultations (cont'd)

November 1997 (cont'd)	Activity	Stakeholder
11	Meeting to review business services the band has to offer, training programs, employment opportunities and open houses.	Fort McMurray First Nation
11	Meeting to discuss project update and review request for oil sands executive participation in a First Nations Economic Development Workshop.	ATC - Economic Development
12	Tour of Lease 13 pilot plant project area in association with development permit review.	Marga Betz, RMWB Planning
13	Meeting to go over the 1997-1998 winter evaluation drilling program for Lease 13.	Northlands Forest Products
14	Telephone conversation to discuss Cree Burn Lake Historical Site Nomination.	Alberta Community Development
14	Telephone conversation to discuss Open House.	Cree Burn Lake Preservation Society
16-18	Trip to BHP Navajo coal mine in New Mexico and mine tour to see aboriginal involvement in the BHP facility and mine tour.	Fort McKay First Nations and Metis
17	Meeting to review Lease 13 mine plan and any boundary issues concerning Lease 30.	Gulf Canada
18	Meeting to assess main oil sand operators' expected use of Susan Lake gravel deposits	Syncrude, Suncor and AEP
18	RIWG meeting.	Regional Infrastructure Working Group
19	Meeting to discuss 1997-1998 winter drilling program.	AEP Lands and Forests
19	Meeting to discuss 1997-1998 winter drilling program.	Fort McKay Group of Companies
19	Meeting to discuss 1997-1998 winter drilling program.	Northeastern Alberta Aboriginal Business Association
20	Meeting with Fort McKay elders to provide a project overview and listen to their concerns and issues.	Fort McKay Elders
20	Meeting to update on pilot plant plans and discuss Shell's future hiring plans.	Consolidated Metis Locals of Wood Buffalo
24	Fort Chipewyan open house	Fort Chipewyan
25	Fort McKay business day	Fort McKay

Table 12-1: Stakeholder Consultations (cont'd)

November 1997 (cont'd)	Activity	Stakeholder
25	Meeting to discuss various issues concerning the project.	Mobil
25	Meeting to discuss project update.	Consolidated Metis Locals - Employment Coordinator
25	Meeting to discuss proposed historical site and the Society's objectives and goals.	Cree Burn Lake Preservation Society
27	Industry discussion on Cumulative Effects Assessment.	Suncor, Syncrude and Mobil
28	Meeting to discuss a plan for crossing of the Clearwater River.	Rick Arthur (Clearwater River Heritage Committee)
December 1997		
2	Meeting to discuss long and short-term salvage plans.	Alberta-Pacific
9	Fort McKay open house.	Fort McKay
9	Meeting to give project update and discuss issues.	Pembina Institute, Toxics Watch, Environmental Resource Centre
9	Meeting to discuss project and employment plans.	Fort McKay Employment Coordinator
9	Meeting to discuss project update.	Fort McKay Junior High School Students
10	Joint meeting with industry, municipal government, educational institution, and community representatives to discuss area resource needs versus education provisions.	Subcommittee of Regional Infrastructure Working Group
10	Meeting to discuss project update.	First Nations - Employment Coordinator
10	Meeting to discuss project update.	Fort McMurray First Nation - Chief
10	Meeting to explain to non-industry representatives the initiatives to standardize cumulative effects approaches.	Industry, Pembina Institute, Toxics Watch, First Nations and Metis

Table 12-2: Regulatory Consultations

January 1997	Activity	Stakeholder
16	Meeting to update EUB staff on the status of the Muskeg River Mine and review Shell and Syncrude cooperation approach.	EUB
16	Define the process for initiating development of Shell's EIA.	AEP
20	Meeting of Mine Working Group.	EUB, AEP and Syncrude
February 1997		
19	Meeting to facilitate introductions and provide an overview of the project.	DFO and AEP
20	Meeting to discuss application schedule.	EUB
25	Presentation by EUB of its needs and issues for Shell to consider in developing the application.	EUB
March 1997		
20	Meeting to discuss approach to the mine planning process and development of a set of cost criteria to assist with resource evaluation.	EUB
26	Meeting to provide a project update.	Alberta Energy
April 1997		
10	Meeting to provide a project overview and obtain feedback on federal communication and information needs.	CEAA, Environment Canada, DFO, Indian and Northern Affairs
11	Meeting to review the overall approach for application and EIA.	EUB
16	Meeting to review the scope and timing for application preparation and review.	AEP and EUB
17	Meeting of the Mine Working Group.	EUB
25	Meeting to preview the proposed target dates and phasing for the application.	AEP and EUB
27	Meeting to preview proposed target dates and phasing for the Application.	EUB and AEP
May 1997		
13	Meeting to discuss regional cooperation, tailings ponds and technology and end-pit lakes.	EUB
14	Meeting to provide an overview on work done in the extraction area and agree on next steps and a working proposal.	EUB
28	Meeting to provide a project overview, discuss the Susan Lake gravel pit, and Alberta-Pacific and Northlands overlapping timber salvage rights.	AEP and Forestry

Table 12-2: Regulatory Consultations (cont'd)

June 1997	Activity	Stakeholder
4	Meeting to provide a project update, discuss regulatory principles and define areas of AEP and EUB input.	AEP (Air Emissions, Wastewater, Waste Management, Conservation and Reclamation) and EUB
5	Review and discuss the application scope, preliminary application schedule, EIA draft Terms of Reference and public consultation activities.	EUB
5	Meeting to discuss the scope of the integrated application and EIA Terms of Reference.	AEP
12	Meeting to discuss EIA methodology.	AEP
15	Meeting to review approval guidelines and government requirements.	AEP and EUB
17	Meeting to review the EIA Terms of Reference.	CEAA, DFO, Environment Canada, Indian and Northern Affairs
19	Meeting to discuss the status of the Susan Lake granular resource.	AEP Waterways
19	Meeting on cumulative effects methodology.	AEP, EUB and CEAA
20	Meeting to discuss land disposition strategy.	AEP Waterways
26	Meeting to discuss application process for pilot plant.	EUB
26	Meeting to review provincial and federal regulatory process.	CEAA, DFO, AEP and EUB
July 1997		
7	Meeting to review regulatory process and provide a project overview to senior officials.	CEAA, DFO and Environment Canada
7	Meeting of Extraction Working Group.	EUB and AEP
11	Meeting to provide an update on Ottawa meeting with CEAA, DFO and others, and discuss upcoming pipeline disclosure.	EUB
15	Meeting to provide a project overview and update.	Alberta Economic Development and Tourism
16	Meeting of the Mine Working Group.	EUB and AEP
August 1997		
12	Discussion regarding scheduling regulator workshops, EIA Terms of Reference and cumulative effects.	AEP
21	Meeting to discuss EUB findings following review of Shell TV/BIP mapping .	EUB
27	Meeting to discuss the mine plan, mine design, tailings criteria and cut-off grade selection	EUB

Table 12-2: Regulatory Consultations (cont'd)

August 1997 (cont'd)	Activity	Stakeholder
28	Meeting of the Mine Working Group.	AEP, EUB, CEAA and DFO
29	Review scheduling of environmental workshops.	CEAA and DFO
September 1997		
5	Meeting to provide an update on the project.	AEP
8	Teleconference to provide an update on the status of the application and discuss how Shell plans to resolve outstanding issues.	EUB, AEP and DFO
15	Discussion regarding flow of information and mechanisms to address concerns and issues.	EUB
22	Meeting of the combined Mine Working Group and the Extraction Working Group.	EUB and AEP
23	Meeting to review federal involvement and provide an overview of cumulative effects methodology with CEAA.	CEAA
26	Meeting to discuss outstanding issues and review expectations.	EUB
30	Meeting to review project scoping, federal triggers and project overview.	CEAA and DFO
30	Meeting to provide a detailed overview of scope and environmental issues.	CEAA, DFO, Environment Canada, Indian and Northern Affairs
30	Kick-Off Meeting to provide a project overview, review workshops and discuss issues.	Provincial and federal government representatives
October 1997		
5	Discussion regarding access through the Muskeg River Mine.	AEP Waterways
6	Follow-up discussion regarding access through the Muskeg River Mine and gain feedback on AEP's position.	AEP Waterways
8	Review of utilities.	EUB
15	Meeting with Coast Guard to discuss Navigable Waters Act.	Coast Guard
17	Meeting of Extraction Working Group	EUB
20	Discussion regarding mining and extraction working sessions and pilot plant application.	EUB
22	Meeting to discuss methodology for assessing cumulative environmental effects.	EUB, AEP and CEAA
22	Meeting to provide an update on cumulative environmental effects assessment.	CEAA, DFO, AEP and EUB

Table 12-2: Regulatory Consultations (cont'd)

October 1997 (cont'd)	Activity	Stakeholder
26	Meeting to discuss impact of federal and provincial regulations.	EUB, CEAA and AEP
28	Meeting of Extraction Working Group	EUB
November 1997		
9	Meeting to discuss the Regional Infrastructure Working Group activities, the population impact model and Shell's SEIA approach.	EUB
19	Meeting to discuss 1997-1998 winter drilling program.	AEP - Land and Forest
December 1997		
4	Meeting to discuss review of project.	CEAA, Coast Guard, DFO

MANAGEMENT PROCESS

Shell's consultation program includes the use of a database to track issues, questions, responses, commitments and resolutions. Issues with a high degree of concern or interest are typically addressed through working groups or committees to ensure that in-depth discussions occur and comprehensive feedback and recommendations are received. Issues are then resolved by modifying policies, socio-economic and environmental impact mitigation steps, where appropriate, and other relevant project components. Key issues are being addressed on an ongoing basis as the project evolves.

Table 12-3 summarizes key issues and responses by category.

Table 12-3: Response to Key Issues

Category	Issue	Response and Status	Stakeholders
Socio-Economic	How is Shell planning to assist with impacts on RMWB communities, services and agencies that will result from your project?	Shell is participating in a Regional Infrastructure Working Group that was formed to address growth issues and provide a sound base of information for planning purposes. During the fall of 1997, a population impact prediction model for assessing the impacts of oil sands projects on the urban service area was developed. Presentations on model use have been made to stakeholder groups, including the Standing Committee on Oil Sands Development, the Mayor's Housing Task Force and the EUB. The model will be provided to key stakeholders to support their ongoing planning needs. In addition, Shell, along with other oil sands industry representatives and provincial and municipal leaders, formed a senior level Facilitation Committee in October 1997 to provide direction, facilitation and support on the resolution of defined issues.	• RMWB • public, separate and Northland school boards • Keyano College • First Nation and Metis communities • provincial and federal government • Regional Health Authority • general public

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Socio-Economic (cont'd)	What will Shell be doing with respect to Highway 63?	The RIWG is addressing transportation issues as one of its priorities. As a member of RIWG, Shell wants to understand traffic patterns and transportation needs during the construction and operating phases of projects, to ensure that safe, reliable transportation is available. The transportation assessment is in its early stages so it is too early to judge what the outcome might be.	• RMWB • general public
	How is Shell supporting housing development in the RMWB, both during construction and in the operating phase?	Shell is participating in the Mayor's Housing Task Force meetings to identify actions stakeholders can take to support the development of required housing on a timely basis. Group participants include representatives from the RMWB, industry, Metis community, provincial government, Canada Mortgage and Housing Corporation, Construction Association and Homebuilders' Association, and others. Shell will develop camp facilities during construction to reduce the pressure on local housing.	• RMWB • general public
	Who will have input into the SEIA?	Shell contracted Nichols Applied Management, Fort McKay Environmental Services and Mikisew Cree First Nation to conduct SEIA studies, which have been compiled by Nichols. Key agencies in Fort McMurray, as well as Fort McKay, Fort Chipewyan and other outlying communities had input into the study.	• Athabasca • Chipewyan First Nation • Mikisew Cree First Nation • Fort McKay (First Nation and Metis)

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Environment Cumulative Effects	Will the ecosystem be able to withstand the high levels of development proposed for the Athabasca oil sands?	The predicted impacts identified for the Muskeg River Mine Project are acceptable and will have no significant long-term effects on the environment, provided the recommended mitigation is undertaken. Shell is working with oil sands operators, regulators and environmental groups regarding the models and methodology used for assessing cumulative environmental effects analysis.	• Industry • ENGOs • AEP • EUB • OSEC • Pembina Institute • Fort McMurray • Fort McKay • Fort Chipewyan • Environment Canada • CEAA
		Several Cumulative Effects Assessment (CEA) workshops have been held to establish a regional development scenario, a common approach for assessment and sharing of environmental information. Shell has used this common framework, methods and modelling in its CEA work on the project. ENGOs and other stakeholders have been invited to participate in industry meetings to discuss the issue.	
	Are all of these projects being undertaken in response to a growing hydrocarbon product demand in North America?	The demand for hydrocarbon products has remained relatively flat over the past five years. Oil sands development is being driven by a demand for cheaper, heavier crude oils and replacement for the decline in conventional oil reserves.	• Pembina Institute

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Air Emissions	How will this project impact CO_2 levels?	Shell has been evaluating this issue and can show that oil sands are no greater producers of CO_2 than producers of heavy imported oils, on a full-cycle analysis of emissions from a barrel of oil. In addition, lower levels of energy are contemplated with the proposed processes, thereby reducing the levels of CO_2 produced compared with those of the original oil sands technologies. The energy efficiency of the oil sands has improved by more than 35% in the last 15 years. Shell and BHP plan to build upon these improvements and attempt to further optimize them over time.	• Pembina Institute • the public
	What technology will Shell use to keep SO_2 emissions under legislated guidelines?	The Muskeg River Mine has minimal SO_2 emissions because there is no upgrader located on site. Shell's intent is to upgrade in Edmonton, using hydroconversion technology rather than coking (carbon removal) technologies. This technology does not result in coke as a byproduct of production, and produces significantly lower levels of sulphur dioxide (SO_2) emissions than conventional upgraders.	• Pembina Institute
Water Resources	Will waste effluent from industrial development have an impact on the Athabasca River and Lake Athabasca?	The EIA findings indicated that the Shell development will have no impact on the Athabasca River and Lake Athabasca. A key component of the EIA will be a detailed assessment of the project on the Muskeg and Athabasca Rivers and the drainage basins. The work will be shared with interested parties as it progresses. Water workshop materials were forwarded to the Athabasca Chipewyan First Nation and other key stakeholders for review, and experts were asked to attend meetings to address concerns.	• Athabasca Chipewyan First Nation • CEAA • Environment Canada • DFO • Indian and Northern Affairs • general public

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Water Resources (cont'd)	How will discharge or seepage from the tailings settling pond be managed?	Seepage will be collected in perimeter ditches and returned to the pond during operations, or treated in wetlands and released to the Athabasca River after reclamation and closure.	• Fort Chipewyan Metis
	If the project attracts people wanting to build in the Gregoire Lake area, will development have an impact on Gregoire Lake, a source of drinking water?	Zoning and permitting for residential development will be the responsibility of the RMWB. The Muskeg River Mine Project does not include mining of the Muskeg River.	• Fort McMurray First Nation
	Will the ore beneath the Muskeg River be mined?	Shell has assessed the potential for mining the ore under the Muskeg River. There are significant economic risks associated with a protracted regulatory process to consider the larger environmental impact of mining through the river. The Muskeg River Mine was designed to avoid sterilizing the ore from future consideration. (This is discussed further in Mine Plan Layout in Section 4.2.)	• EUB • Fort McKay • Pembina Institute • DFO
Reclamation	When will reclamation commence?	Shell, the End Land Use Planning Committee, Fort McKay and other NGOs are planning for staged ongoing reclamation. Shell intends to minimize effects on wildlife, vegetation and local land uses by conserving soils, using evolving reclamation technologies, and returning disturbed land to a state of equal or greater productive capacity.	• Fort McKay Northlands Forest Products • AEP • EUB
Historic Sites	What is Shell's position regarding the Cree Burn Lake Preservation Society's application for a Historic Site designation on a portion of Lease 13?	Shell supports the historical site nomination, and continues to work with the Cree Burn Lake Preservation Society and Alberta Community Development to define the boundaries. There is no intention to develop mining operations on the proposed historical site. Sponsorship is being provided for part of a historical research project which is based on interviews with Elders in the Wood Buffalo region.	• Cree Burn Lake Preservation Society • Alberta Community Development • Syncrude

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Education	What is Shell doing to address needs for adult upgrading and education requirements in outlying First Nation and Metis communities?	Shell will be working with Keyano College to support First Nation and Metis training, upgrading and distance education programs. Feedback on skill-sets has been requested from First Nation and Metis communities in order to identify gaps, and provide recommendations on how they can be filled. Dialogue on this issue is ongoing between Shell and community employment coordinators and Chiefs.	• Keyano College • First Nation and Metis communities • RMWB
	What are Shell's long-term education and training requirements?	Shell is defining the skill-sets required for future employment, and informing the community about future opportunities and educational requirements.	• Keyano College • First Nation and Metis communities •school boards
	Will Shell support training and apprenticeship programs?	Shell will encourage an apprenticeship program for trades and work with Keyano College and employment officers to develop training programs. Long-term activities that will help educate local people and contribute towards a future resource base are being identified.	• Keyano College • First Nation and Metis communities • Consolidated Metis Locals • RMWB
	Does Shell support local education initiatives?	Shell currently supports programs and initiatives that will help children stay in school, such as the local Junior Achievement Program, and the Career Preparation program. This new educational program integrates academic and applied knowledge, motivating students to stay in school and realize the relevance of their education to the work world. Shell is supporting Keyano College's cooperative education program, both by providing input into the curriculum, and supporting the cooperative education program.	• School boards • Keyano College • RMWB • general public • First Nation and Metis communities

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Employment	What is Shell's policy for local hiring and employment of First Nation and Metis peoples? What are Shell's employment targets and target percentage of First Nation and Metis hires?	Shell will ensure that the jobs created are filled by area residents wherever possible, but always on a merit basis. To help make this happen, Shell will work with its neighbors, contractors, educational institutions and other producers to develop required skills. Currently, Shell does not intend to set employment targets. However, aboriginal employment levels will be measured and reported.	• First Nation and Metis communities
	How is Shell managing the hiring process?	Assuming regulatory approvals are received, mine preparation and construction work will begin in early 1999. Most of this work will be contracted. Staffing for operation jobs will begin in 2000, continue in 2001, and peak in 2002. In the interim, Shell is working with Keyano College to determine the most efficient means for an employee selection process, potentially using Keyano's services to facilitate that process. Shell's current practice is to accept and respond to résumés, which are being incorporated in a human resources database.	• General public • Keyano College • First Nation and Metis communities
	What transportation options will be available to Shell employees?	Shell is aware of the issues and interests related to transporting workers to the site. A complete assessment of options will be done before start-up, with input from stakeholders. A camp will be used during construction.	• First Nation and Metis communities • RMWB • general public
Industry	What is the cooperation potential regarding minerals above and below the oil sands horizon?	Shell has an agreement with Birch Mountain which sets out ongoing mechanisms for cooperation in information sharing and planning.	• Birch Mountain Resources
Compensation	Will development activities affect traplines?	Shell has negotiated agreements to compensate for disruption to traplines resulting from activities related to the development of the Muskeg River Mine.	• Trappers

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Compensation (cont'd)	Will Shell participate in equity partnerships?	Shell supports long-term business relationships through alliance partnerships for support contracts for ongoing business operations, e.g., maintenance contracts. Shell is not considering other equity partners at this time, other than BHP, which is providing mining expertise.	• Mikisew Cree First Nation
Contracts	How will Shell's operations affect allowable cuts for Northland Forest Products, a quota holder in the Muskeg River Mine area?	Shell discussed the availability of additional quota areas with AEP-Forestry. AEP confirmed there is no additional land available for allotment. Timber will be salvaged.	• Northlands • AEP
	What is Shell's criteria for awarding business contracts?	Shell has a formal purchasing policy which addresses how it deals with vendors and contractors. The general process is that the scope of the work is identified, the local community is advised that the work is available, and qualified suppliers and contractors are invited to bid on the work. Shell will encourage and use local businesses, including First Nation and Metis businesses, where they are competitive and qualified.	• Northeastern Alberta Aboriginal Business Association • Consolidated Metis Locals • Mikisew Cree First Nation • Athabasca Chipewyan First Nation • Fort McKay First Nation and Metis
Technology and Economics	How was the site for the tailings pond selected? Why is the tailings pond going to be situated on a site where the ore has some economic potential?	The tailings settling pond was selected after evaluating two options — one in the current site and one at the southeast corner of Lease 13. It was determined that it would be substantially more expensive to have the tailings settling pond so far from the plant site (compared to the selected site). (See Mine Plan Layout in Section 4.2 for more information on the site selection.)	• EUB
	When is the geological data Shell is using in their plans going to be updated?	Shell will be updating the information after the 1998 winter drilling program and data analysis are complete.	• EUB

Table 12-3: Response to Key Issues (cont'd)

Category	Issue	Response and Status	Stakeholders
Technology and Economics (cont'd)	Was paste technology considered as a tailings technology option?	Shell assessed tailings technology options with AGRA as a prime consultant for the review. A peer review with industry representatives and academics was also conducted to ensure no options were missed or inadequately represented. Specifically, paste technology, while of interest, is not adequately proven to support inclusion in a commercial application at this time. (For more details on the technology evaluated, see the Evaluation of Tailings Management Methods in Section 6.2.)	• EUB • AEP
Cooperative Development	Are oil sands operators working cooperatively in the development of their projects?	Industry has indicated an interest in pursuing opportunities for cooperation in development. A number of initiatives are already under way, (see Regional Cooperation Approach in Section 1.5).	• Oil sands industry: - Syncrude - Suncor - Mobil

BACKGROUND

The hydrocarbon material found in the Athabasca oil sands is a heavy bitumen product with an API gravity of less than 10° before blending and a sulphur content of about 5%. By comparison, conventional heavy oil has an API gravity of 22° or less. The Athabasca oil sands have a more limited market scope or range of potential buyers because of the incremental effort and cost associated with transporting and processing them into refined petroleum products. Bitumen properties preclude ready absorption of large new increments of supply into existing market areas.

Both of the existing oil sands mining operators in Alberta have had integrated upgrading facilities since their mines started up. These upgraders take the heavy bitumen and convert it to a synthetic crude — a crude oil equivalent, which has a broader range of market outlets.

Defining the type and quantity of the product from a new mineable oil sands project and the associated market disposition are fundamental to the scope and scale of the development. The marketing plan and outlook will help establish the product specifications, transportation and pricing premises.

MARKET ASSESSMENT

Until the 1980s, only relatively small volumes of bitumen were transported by truck from in situ piloting operations to manufacturing operations in Alberta. As volumes grew, the local asphalt markets could not sustain the degree of production and steps were taken to provide transportation of the bitumen to high conversion refineries in the Northern U.S. and Ontario. This involved diluting the bitumen with natural gas condensate or refinery diluent to reduce the viscosity and density to make a pumpable product. The availability of this lower cost feedstock motivated investment in upgrading capacity in both the Midwestern United States and Canada. In 1992, Husky Oil's bi-provincial upgrader came online and provided an additional market for bitumen from the oil sands and Canadian conventional heavy oil. The Newgrade upgrader in Regina is tailored more to processing heavy oil.

The early to mid-1990s was a period of great opportunity for bitumen and heavy oil producers. With access to low-cost feedstock, an over-investment in upgrading capability took place in North America, which resulted in a higher relative market value for heavy oil and bitumen. Figure 13-1 shows the range of

MARKET ASSESSMENT (cont'd)

light to heavy oil price differentials from 1985 to the present. Higher prices subsequently led to higher production of both conventional heavy crudes and bitumen with 75% of Canada's output flowing into the U.S. Midwest (PADD II) (see Figure 13-2).

The increased production of bitumen and conventional heavy crude over the past several years has resulted in an important shift in market dynamics placing a downward pressure on heavy oil and bitumen prices. Two key features that directly affect investment decisions in oil sands bitumen production are:

- upgrading capacity
- diluent supply

The recent trend has been a tightening of both the upgrader excess capacity and of diluent supply for bitumen transportation. These trends suggest directionally lower bitumen prices and increased competition for upgrader capacity. For a new oil sands development, a prudent strategy is to either secure third-party upgrading capacity or consider an integrated development that includes new upgrading capability.

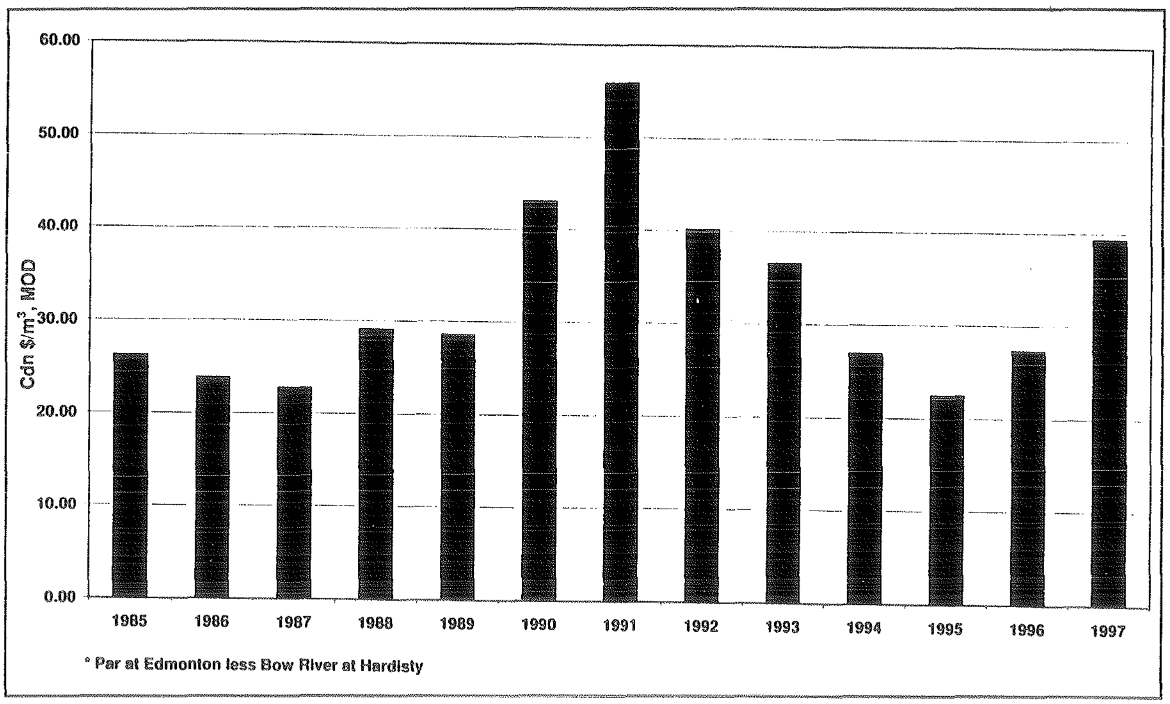


Figure 13-1: Canadian Light versus Heavy Oil Differentials

MARKET ASSESSMENT (cont'd)

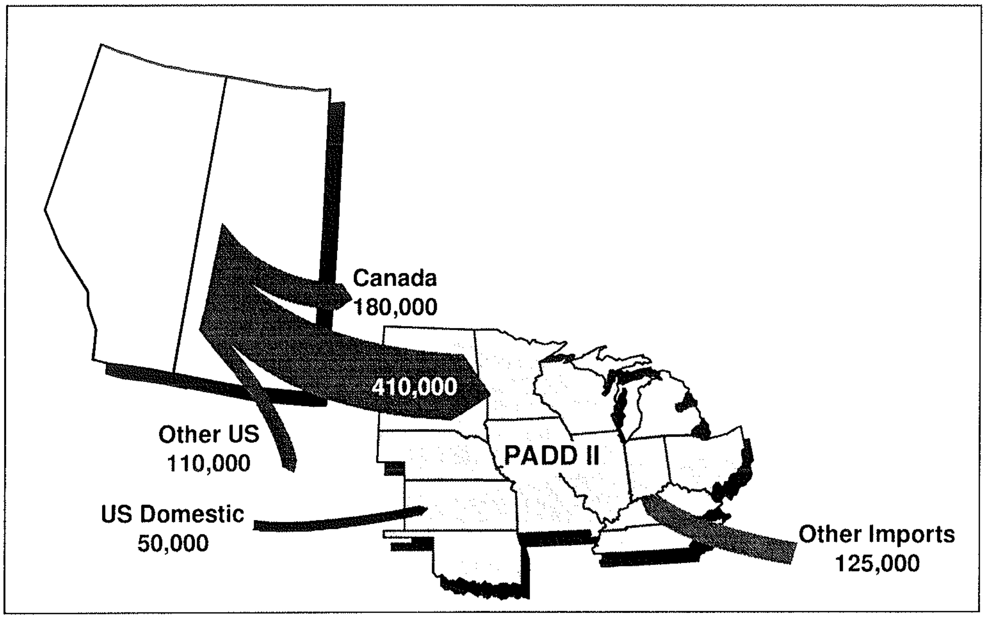


Figure 13-2: Heavy Oil and Bitumen Market

UPGRADING CAPACITY

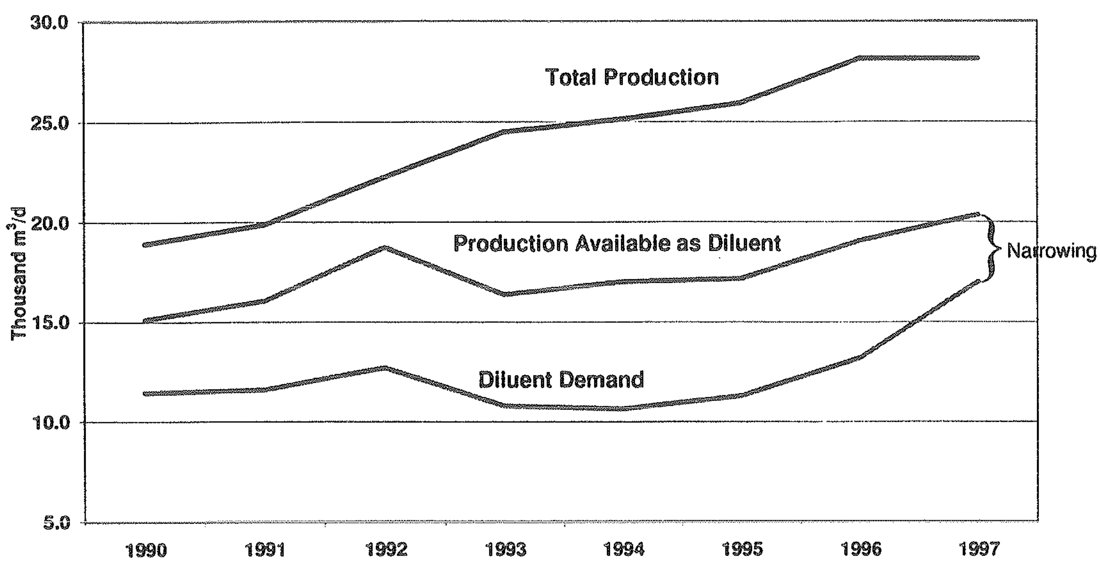
As a result of increases in production, the market upgrading capacity to absorb heavy oil and bitumen is being outstripped by supply. This has resulted in a downward pressure in heavy oil and bitumen prices and differentials have begun to widen since late 1995. In this environment, existing upgrader operators are contemplating additional capacity investment by taking advantage of low-cost facility debottlenecking opportunities. However, further downward pressure on heavy oil and bitumen prices will be necessary to bring about new, higher cost investment in grassroots upgrading facilities.

DILUENT SUPPLY

To facilitate transportation of the heavy bitumen material, the viscosity and density is usually reduced by adding a lighter hydrocarbon diluent. Until now, natural gas condensate and refinery diluent have been used. Although the production of condensate has been steadily increasing, the supply and demand balance in the diluent market has become much tighter during the last year, especially on a seasonal basis. This is the result of rapidly rising diluent demand, which led to a substantial increase in condensate prices relative to light crude during 1997. Although there have been no shortages of diluent so far, expected future heavy oil and bitumen production increases might result in a need to look for alternatives (see Figure 13-3). Alternatives to natural gas condensate as diluent all tend to be more expensive. Higher diluent cost will, in turn, put additional pressure on heavy oil and bitumen producers' price netbacks.

DILUENT SUPPLY (cont'd)

The scale and scope of the Muskeg River Mine Project is driven by the options available for downstream product disposition. The lack of availability of markets (upgrading capacity) and diluent presents a concern and a development risk that must be managed. In this regard, Shell is in a position to advance a new oil sands development because it can take advantage of its existing downstream business assets to address the serious market constraints that are arising for bitumen production.



Source: Purvin & Gertz, World Crude Oil and Refining to 2015, 1997.

Figure 13-3: Diluent Production Supply and Demand

UPGRADING OPTIONS

Recognizing the marketing challenges that will confront new bitumen producers, particularly when looking at the volume required to advance a new oil sands mining development, Shell assessed the potential to bring strategic value from its existing refining assets. Both the Scotford and Sarnia refineries have latent capacity that could be accessed for processing the lighter components of the bitumen product when considered on an integrated basis. Some refinery modifications will be required, but the investment is significantly leveraged relative to a project involving totally new facilities. The remaining challenge was to separate and process the heavier component of the produced bitumen. Several options were explored, including:

- providing dedicated new upgrading capability
- making commercial processing arrangements
- a combination of both

UPGRADING OPTIONS (cont'd)

In September 1997, Shell announced its intention to invest in new upgrading capability at the Scotford refinery to take advantage of the site integration opportunities. Although this does not preclude other optimization or development opportunities, such as alternative feedstocks and alternative bitumen disposition, it does provide a solid market outlet option for bitumen production from the Muskeg River Mine. This decision also supports the long-held industrial strategy of the Province of Alberta to maximize the upgrading of primary products in Alberta.

Shell's Scotford refinery is one of the newest and most efficient refineries in North America. Although it currently processes synthetic crude oil, with minor modifications the refinery has the ability to process other feedstocks. The new upgrader will be built next to the Scotford refinery to process the bitumen produced from Lease 13 into a range of upgraded refinery feedstocks that take full advantage of the refinery's existing configuration. By customizing the upgrader to produce upgraded feedstocks that meet specific refinery capabilities, capital costs will be reduced relative to producing synthetic crude oil for general sale. Synthetic crude oils will also be shipped to central Canadian refineries, including Shell's Sarnia Manufacturing Complex, and refined there to meet the needs of the central Canadian market.

The Scotford upgrader will be based on an innovative application of commercial upgrading technologies. Hydroconversion (hydrogen addition) technology will provide the basis for the upgrader. This technology base:

- maximizes the yield per m^3 of bitumen processed
- reduces emissions and byproducts
- enables refiners to produce clean, high-quality refined products

The quality of the bitumen produced at the Muskeg River Mine will allow Shell or others to upgrade the material using hydroconversion technology. The low-solids feedstock with a portion of the heavy hydrocarbon waste stream rejected from the bitumen at Lease 13 enables the upgrader to capture economies in operational design and has reduced exposure to solids fouling the process units.

The use of hydroconversion (hydrogen addition) technology, rather than coking (carbon removal) technologies, has a number of significant advantages. For example, it:

- makes best use of the bitumen resource, yielding a higher proportion of upgraded crude oil for each cubic metre of bitumen processed. In Shell's case, the hydrogen addition process yields more than 100 m^3 of upgraded crude oil for every 100 m^3 of bitumen processed, compared to less than 85 m^3 for coking technologies.

- produces lower levels of sulphur dioxide (SO_2) emissions

UPGRADING OPTIONS (cont'd)

- does not produce coke (carbon) as a byproduct
- produces upgraded refinery feedstocks that enable refiners to produce clean, high quality refined products, such as gasoline and diesel fuel, which have low levels of aromatics and sulphur

The overall significant hydrocarbon recovery advantage of the Muskeg River mine and extraction process, in combination with the hydroconversion upgrading scheme, is illustrated in Figure 13-4. The values will be validated with the technology development and front-end engineering and design in 1998.

Carbon Rejection

	Ore Conditioning & Primary Extraction	Froth Treatment and Product Clean-Up	Upgrading	Overall Carbon Rejection (wt%)
Conventional Oil Sands Process	7% bitumen	2% bitumen	16% bitumen loss (12% coke/4%OC)	25%
Muskeg River Mine Process	7% bitumen	2% bitumen 4% heavy hydrocarbon asphaltene	no coke production	13%

Note: OC = own consumption

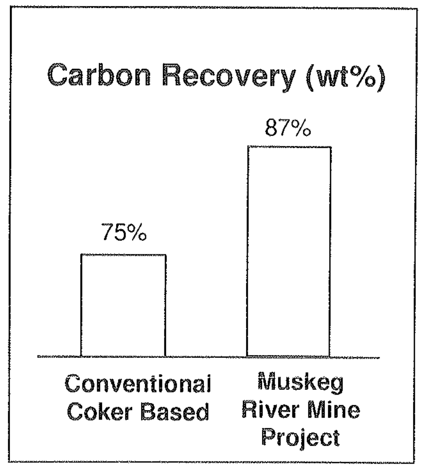


Figure 13-4: Enhanced Overall Recovery

OPTIONS EVALUATED

The Muskeg River Mine development involves producing bitumen product for transportation to upgrading facilities in Fort Saskatchewan and other market outlets.

Two options for transporting the bitumen product to the Edmonton area have been assessed:

- a diluted bitumen pipeline
- a heated pipeline

The results of Shell's analysis showed that the diluted bitumen pipeline was the most cost effective option when accounting for the capital and operating costs for transporting the material about 500 km from Lease 13 to the Fort Saskatchewan area.

DILUTED BITUMEN TRANSPORTATION

Transporting diluted bitumen is a proven means of bitumen transportation, as illustrated by the Alberta Energy Company (AEC) system which transports diluted bitumen from Cold Lake to the Edmonton area, then returns the diluent via a separate pipeline in the same right-of-way. For the Muskeg River Mine Project, this would mean a:

- 610 mm (24-inch) pipeline for diluted bitumen
- 323 mm (12-inch) diluent return pipeline

A number of diluted bitumen pipeline projects have been proposed in the last year. These proposals are focused on moving bitumen and other products to the Lloydminster and Hardisty areas. The plan for the Muskeg River Mine Project is to move diluted bitumen directly to Scotford for further processing. The direct pipeline route to Fort Saskatchewan is more cost effective than participating in a common carrier system taking product to the eastern part of the province. The bitumen pipeline is a strategic asset for the Muskeg River Mine Project because it forms the vital link with the upgrader and other market outlets. These factors support the decision to proceed with plans for the Corridor Pipeline to provide a controlled and secure outlet for production from the Muskeg River Mine.

HEATED PIPELINE

The Shell Group has experience with heated pipelines in other parts of its worldwide operations, such as for transporting heavy oil in California. For the Muskeg River Mine Project, this would result in a 500 mm (20-inch) product line with a number of heating stations. The current assessment is that this would present a higher cost system than diluted bitumen transportation.

CORRIDOR PIPELINE PLAN

Lease 13 to Scotford Routing

The mine and extraction facilities on Lease 13 will produce up to 23,800 m^3/d (150,000 bbl/d) of premium quality bitumen. This bitumen will be transported directly to the new upgrader at Shell's Scotford refinery and markets in the Edmonton area.

Several product transportation options were assessed on key criteria, such as cost, and environmental and operational performance. The preferred option is the proven technology of pipeline transportation for diluted bitumen. Diluted blended bitumen would be moved south down a 610 mm (24-inch) diameter line. A complementary 323 mm (12-inch) diameter line would carry the required diluent north. The final size of these two pipelines will depend on many factors, such as the:

- pumping horsepower
- product temperature
- selected diluent

Final design details will be set out in the regulatory application for the pipeline.

The length of the system, from Lease 13 to the Scotford refinery and any required interconnection points to Edmonton, will be about 500 km. The system will have an initial capacity to ship about 31,800 m^3/d (200,000 bbl/d) of blended bitumen south, and send about 9,500 m^3/d (60,000 bbl/d) of diluent north.

This line will be developed in the most cost effective, environmentally responsible manner possible. The route outlined in Figure 13-5 is the initial view of how this might be achieved and follows the route selected by the Province of Alberta and set out in the *Athabasca Oil Sands Multiple Use Corridor Study* (1986). The route follows the multiple use corridor through the forested area of the province, and follows existing pipeline rights-of-way along the balance of its course to Edmonton. This route limits environmental and resource development impacts.

The timing of the proposed corridor pipeline is related to the projected production plans for bitumen from the Muskeg River Mine. Construction of the pipeline system is expected to begin in 2000, about 18 to 21 months before the

Lease 13 to Scotford Routing (cont'd)

planned date of first bitumen production. Filing of the formal regulatory application for the pipeline is planned for the spring of 1998. Regulatory approvals will be sought under the following Alberta legislation:

- the Pipeline Act
- the Environmental Protection and Enhancement Act
- the Public Lands Act

The pipeline is expected to be completed and commissioned in early 2002.

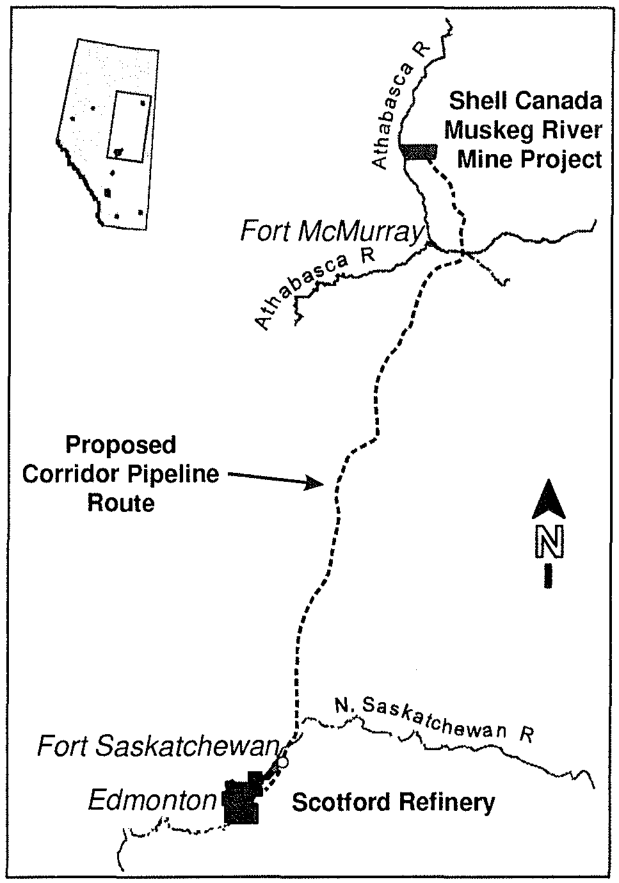


Figure 13-5: Corridor Pipeline Route - Lease 13 to Scotford

Routing Within Lease 13

Athabasca Oil Sands Multiple Use Corridor Study Route Alignment

The recommended pipeline routing set out in the *Athabasca Oil Sands Multiple Use Corridor Study* (1986) ends at the Lease 13 boundary. The study did not identify potential routes for a product pipeline within the Lease 13 boundary.

Routing Options Considered on Lease 13

Four potential pipeline routes within the Lease 13 boundary were considered. These options (A through D) are shown on Figure 13-6. Route C was selected as the preferred route after balanced consideration of the potential economic, resource conservation, design risk, historical resource and environmental impacts (see Table 13-1). The intent was also to select a route that would not require future relocation of the pipelines.

The route also requires an alignment from the Lease 13 boundary with a point just to the east of Jackpine Creek, which is the recommended location for connection from the *Multiple Use Corridor Study* routing.

Route C is the recommended route. In addition to being the shortest distance, it also:

- minimizes sterilizing economic ore
- has a lower exposure for both potential historical resource and environmental impacts

As the Corridor Pipeline Project advances, this route will be considered in more detail. The ultimate location of the pipeline will be addressed as part of the regulatory approval submission for the Corridor Pipeline Project.

Screening Criteria

The criteria for screening the pipeline route alternatives within Lease 13 included:

- pipeline distance — The pipeline distance has physical as well as cost and economic impacts. All other factors being equal, the distance should be minimized.
- resource conservation — The routing should minimize the potential for ore sterilization. As the geology and resource placement on Lease 13 is well understood, this can be done with a high degree of confidence.
- terrain design — The routing should minimize any impairments resulting from the terrain, such as
  - major obstacles
  - unstable soil conditions
  - difficult approach trajectories
  - slopes for any water crossings
- historical resources — The potential for historical resources disturbance was considered in an assessment conducted by Golder Associates.

Screening Criteria (cont'd)

- environmental factors — Consideration was given to the potential for other environmental impacts, with emphasis on the encroachment of wetlands areas and riparian corridors. Golder Associates conducted this assessment.

Route C has the shortest length, minimizes sterilizing economic ore and also has a low potential for affecting both historical resources and riparian areas and wetlands.

The application for AEP's Conservation and Reclamation Approval, which is the subject of a separate application, will address the entire pipeline corridor in detail.

Table 13-1: Corridor Pipeline Route Assessment

Route	Distance	Pipeline Cost	Resource Conservation	Terrain Design Considerations	Historical Resources	Environmental Impact
A	20 km	Highest	Follows lease boundary and has no ore sterilization	No major obstacles Scattered muskeg areas and larger section because of length Two water crossings	Highest potential to impact archeological sites	Lowest potential to impact riparian areas and wetlands
B	14 km	Medium	Limited potential for ore sterilization	No major obstacles Scattered muskeg Two water crossings	Second highest potential to impact archeological sites	Highest potential to impact riparian areas and wetlands
C	10 km	Lowest	Intersects a small section of uneconomic ore	No major obstacles Scattered muskeg Two water crossings	Second lowest potential impact	Second lowest potential impact
D	11 km	Low	Largest sterilization of economic ore	No major obstacles Scattered muskeg One water crossing	Lower potential, due mainly to the distance from Jackpine Creek	Second highest potential impact

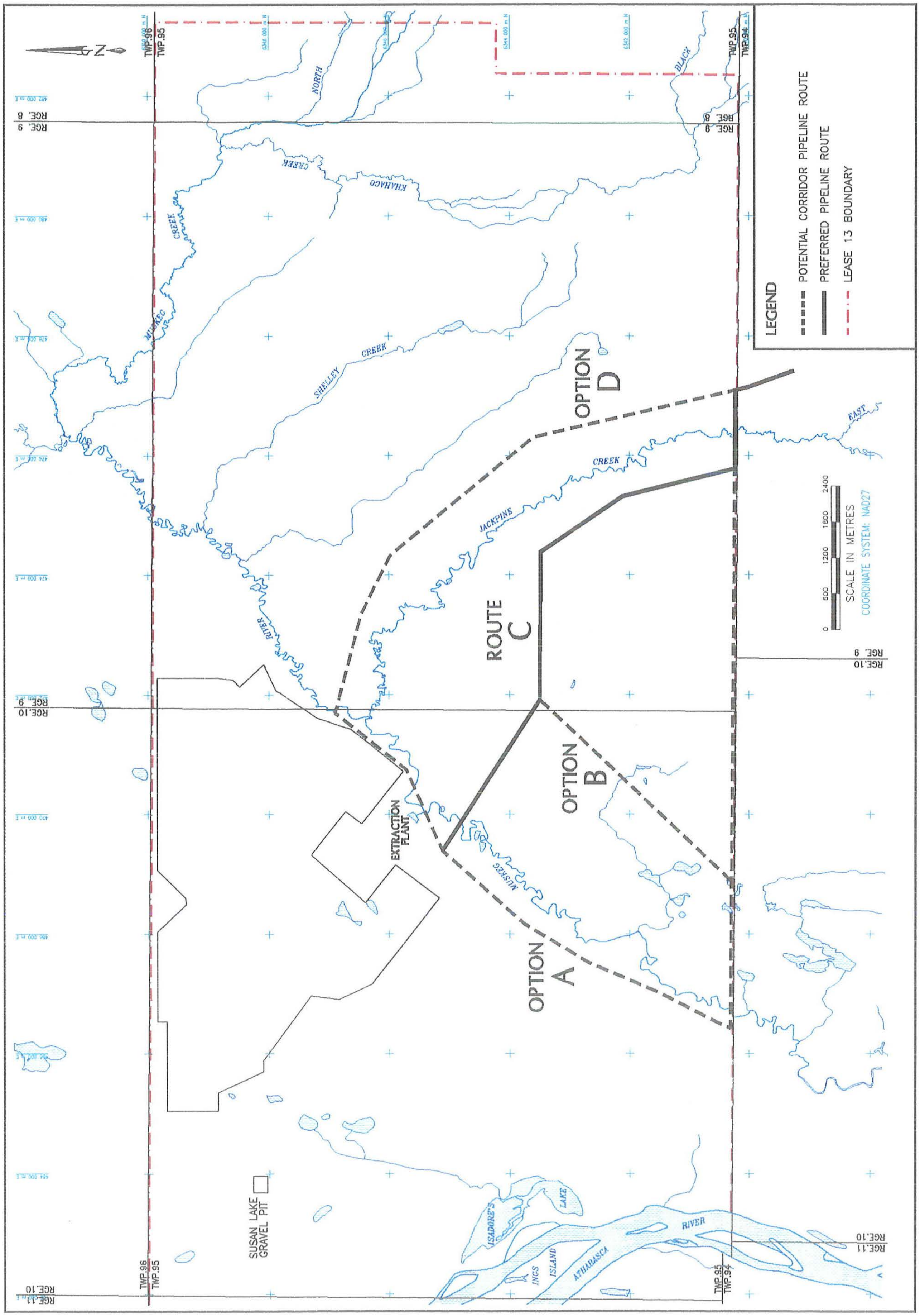


Figure 13-6: Corridor Pipeline Route Within Lease 13

BACKGROUND

Recently, the Government of Alberta and the Government of Canada have provided a clear and directionally supportive fiscal framework to encourage economic oil sands development.

On its own, the existence of an attractive royalty regime will not create a high level of investment activity. However, a stable system that is structured to reduce barriers to development, underpins this type of capital intensive project.

GOVERNMENT OF ALBERTA

Royalty Objectives

In 1996, the Government of Alberta established a new royalty regime that supports:

- ongoing development of the oil sands
- competitiveness of oil sands development relative to alternative supply options
- a standard royalty framework for new projects to ensure a clear, consistent system

Resource Rent Royalty

Working with industry, the government developed a resource rent royalty. Under this scheme, the government allows the developer to earn a set rate of return while paying a 1% royalty on gross revenue. When a modest return on capital (the federal long-term bond rate) has been achieved, the royalty increases to 25% of net project revenues. The system recognizes the high capital cost and risks of oil sands development.

GOVERNMENT OF CANADA

Mining Tax Regime

Canada's income tax provisions for mining projects are designed to recognize the high capital costs and significant risks associated with mining project

Mining Tax Regime (cont'd)

development. Provisions allow the developer to claim all capital costs before the project pays income tax.

The Muskeg River Mine Project will qualify as a new mine for the purposes of these tax provisions.

CAPITAL COST

The initial capital cost for the Muskeg River Mine Project is estimated at about $1.2 billion (1997$). The approximate breakdown of this capital cost is:

- lease evaluation, engineering, environmental and project management - 7%
- mine, extraction and utilities facilities - 93%

CAPITAL AND OPERATING COSTS

The estimated maintenance capital and operating costs are $9.3 billion (1997$) to 2025. This does not include expansion potential on the lease. Cash costs are estimated initially in the range of $40/m^3 ($6.25/bbl) of bitumen in 1997$.

COMMERCIAL VIABILITY

The performance of the existing Fort McMurray oil sands operations and proposed expansions demonstrate the viability of mineable oil sands development. The economic viability has been enhanced through a successful, dedicated effort to reduce costs through new technology and other efficiencies.

The Muskeg River Mine Project return is calculated as being positive at an oil price of $18 U.S. per barrel of West Texas Intermediate. On this basis, to 2025, the project would contribute about:

- $850 million in taxes to the federal government
- $1,225 million in taxes and royalties to the provincial government

The Municipality of Wood Buffalo will also benefit from the project. For example, 800 permanent positions are expected to be created by the Muskeg River Mine Project. To 2025, about $30 million is expected to be contributed in local municipal taxes.

For additional information on socio-economic benefits, see Section 11.

POTENTIAL COMMERCIAL ARRANGEMENTS

Currently, commercial arrangements are being contemplated for the following:

- contract mining for removing overburden material
- agreements for supplying natural gas commodity and infrastructure
- agreements for utility services, as an alternative to owner-supplied facilities and services for electrical power and heat. The current project basis assumes that electrical power will be supplied from the Alberta electrical grid.

At this stage, a number of options are being considered. The terms of these arrangements are confidential.

Commercial arrangements for the supply of goods and services in support of the project will follow established Shell contracting and purchasing protocols.

DEVELOPMENT PLAN

REQUIREMENTS

The Muskeg River Mine Project represents the first development step for Lease 13. As such, the economics have to support not only the mine and extraction elements, but also the establishment of extensive new infrastructure to support the production operations. This includes:

- roads
- utility supply
- product pipelines
- operations administration facilities
- support services

Consequently, the development approach must be cost-effective and performance-oriented to be able to cross the economic threshold for a new grassroots development.

PROJECT SCALE CONSIDERATIONS

The current Lease 13 development focus was motivated from an internal Shell strategic review of oil sands potential in late 1995. This resulted in the initiation of a scoping review in 1996. The scoping studies undertaken in 1996 focused on a design capacity of 9,500 m^3/d (60,000 bbl/d) of bitumen. This was viewed as the smallest production level that could be cost-effectively contemplated with the size and capability of current mining equipment. The strategy assessed was Shell's ability to advance a mineable oil sands business entry or anchor project that would be the smallest scale possible, in order to minimize shareholder risk and capital exposure. The conclusions from this were that:

- an oil sands mining development would be suboptimal and noncompetitive at this production level

- to overcome the economic hurdles, a grassroots project has to be of a scale large enough to support the establishment of a new production facility and infrastructure

Generally, production levels in excess of 15,900 m^3/d (100,000 bbl/d) of bitumen are considered a minimum threshold for a mineable oil sands development. At this level, the volumes are sufficiently large to also support a dedicated pipeline for product transport, if required. This removes the risk of having to rely on

PROJECT SCALE CONSIDERATIONS (cont'd)

third-party volumes and commercial arrangements to achieve an acceptable transportation cost.

The target volume for the Muskeg River Mine Project was established based on the downstream processing capacity for upgrading the material. Through work done in 1997, it has been established that the base case of constructing a new upgrader at Scotford and linking product disposition to Shell's existing refining assets and network can accommodate up to 23,850 m^3/d (150,000 bbl/d) of bitumen. This established the upstream production target and the basis for the definition of the mine and extraction facilities and plans.

SUSTAINING PRODUCTION LEVELS

An area of high-quality, low-stripping ratio ore on the western extent of Lease 13 is optimal for the opening cut on the mine (see the Mine Development Plan in Section 4.5). The area west of the Muskeg River can support a mine plan with sustained production levels of up to 23,850 m^3/d (150,000 bbl/d) of bitumen for over 20 years. This is the same location that was contemplated for the Alsands project in the late 1970s. It has been the focus of potential development for a number of years and has the highest degree of resource understanding to support a commercial project. All plans for the Muskeg River Mine Project are based on a development plan for 23,850 m^3/d (150,000 bbl/d) of bitumen from the area west of the Muskeg River on Lease 13. Beyond this, Shell will look to reserves in the eastern part of Lease 13 to sustain production over the longer term.

Shell views the development of oil sands in the Fort McMurray region as a strategic opportunity. In addition to Lease 13, Shell acquired four mineable oil sands leases from Amerada Hess in 1996 (see Section 1.2), to ensure a solid reserve base for the long term. Although the focus of efforts has been on defining and advancing an anchor development in the western part of Lease 13, the long-term opportunities include:

- sustaining production levels
- debottlenecking base operations
- investigating expansion opportunities

Once an operational base has been established, Shell will give first priority to investigating the opportunity for profitably debottlenecking the existing facilities.

EXPANSION OPPORTUNITIES

Shell intends to explore options for expanded production, first with the eastern part of Lease 13 and, ultimately, with Leases 88 and 89. A conceptual 31,800 m^3/d (200,000 bbl/d) development in the eastern part of Lease 13 was advanced to help assess the potential impacts of regional development. This

EXPANSION OPPORTUNITIES (cont'd)

conceptual development plan assumed that a new processing plant would be required for the eastern development. When the operating infrastructure for the Muskeg River Mine Project is established, the intent is to explore opportunities for access to, and use of, that infrastructure before developing any new facilities. The Muskeg River Mine plant site is centrally located on the lease and well suited to future reserve replacement and expansion.

The Muskeg River Mine Project is viewed as an anchor project for entry into the oil sands business. It is designed at a sufficient scale to achieve acceptable unit costs for a competitive and commercially viable initial development. Both Shell and BHP are taking this step to provide the operating base from which further development and growth of the business can be contemplated. The option value and potential of future oil sands development is attracting these new major industry participants to what is a large-scale and capital-intensive business.

PROJECT EXECUTION PLAN

OBJECTIVES

The project will be developed and operated to meet world-class standards. The objectives for all work carried out are to:

- provide safety for the work force
- provide a challenged and satisfied work force
- protect the environment
- provide high-quality, fit-for-purpose facilities
- be cost competitive
- maintain an aggressive project schedule

ORGANIZATION

Key members of the project execution team (see Figure 15-1) will be drawn primarily from the experienced ranks of Shell and BHP. When people with the required skills are not available internally, they will be hired from outside the organization.

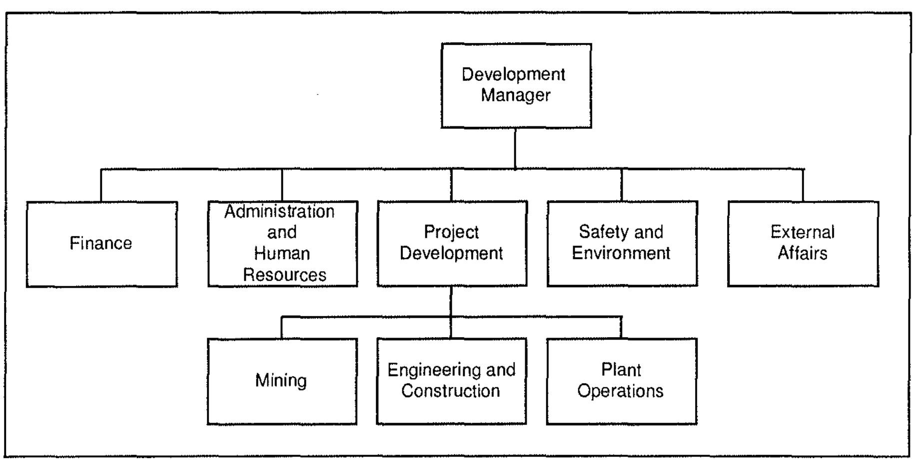


Figure 15-1: Project Execution and Operations Organization

The engineering and construction group will develop the process plant and infrastructure at the Lease 13 site from initial concept through to initial operation. The facilities will then be handed over to the extraction plant operations group, which will operate and maintain the facilities for the life of the mine.

ORGANIZATION (cont'd)

The mining group will be responsible for all of the mining activity from initial concept to mine closure. This will include planning, engineering, procurement, project development and subsequent operations.

SCHEDULE BASIS

A preliminary schedule has been developed for the overall project development (see Background in Section 1.1). In parallel with the regulatory review and approval process in 1998, Shell will continue with the front end engineering and design (FEED) phase of the project. This phase will provide the definition needed to support the advancement into detailed engineering. A key element of the FEED phase is the development of more detailed project schedules and execution plans. In 1998, during the FEED phase, and concurrent with the extraction pilot operation, a feasibility study will be conducted.

Regulatory and corporate approvals for the project are targeted for the end of 1998. By then, the prime engineering, procurement and construction management (EPCM) contractor will be hired to support the development of the detail required to thoroughly assess all risks and opportunities and put appropriate execution strategies and plans in place. Engineering will continue until the end of 2000.

General site preparation and construction of the camp and some infrastructure will take place in 1999. Construction of the major process facilities will begin in the second quarter of 2000 and continue until early 2002. Work on the mine and extraction plant at Lease 13 will be timed to enable commissioning of the extraction plant to start in late 2001. The plant will start up in mid 2002 and approach full production in late 2002. For a detailed schedule of the phasing of mine activities, up to and including reclamation, see Mining Operations in Section 4.4.

RISK ANALYSIS

Currently, no unmanageable risks have been identified. Shell is confident in its understanding of the resource and in the plans required to efficiently and effectively develop the mine. Data from the 1997 and 1998 winter field program will further enhance this knowledge base.

The design and subsequent construction of the processing facilities could present some resourcing challenges because of the high level of industry activity currently projected in Alberta. However, with proper planning and use of the broad resource base that includes Fort McMurray, Alberta, Canada and foreign resources, as needed, Shell is confident that the project can be executed effectively. The technology development work, which includes a field extraction pilot in 1998, will provide design information for the FEED phase and subsequent detailed engineering phase.

RISK ANALYSIS (cont'd)

The key risk area in the timing for detailed engineering is having the regulatory approvals in hand to support the corporate project approval process and detailed engineering. For this reason, Shell has put a major focus on proactive consultation with the regulators, local communities, non-governmental groups and other stakeholders throughout the development of the Muskeg River Mine plans.

ENGINEERING AND CONSTRUCTION

Owners' Team

The first engineering and construction members of the project execution team will be assembled for the FEED phase. The team will be increased as the work proceeds and the level of activity increases. The key personnel will be well experienced in large mining and mineral processing projects. This team will manage the activities of the EPCM contractor and maintain a global view of the project.

EPCM Contractor

In early 1998, proposals will be requested from qualified engineering companies to engineer, procure, and manage the construction and commissioning of the process facilities and infrastructure at the Muskeg River Mine site. The work will be performed in two stages:

- the feasibility study and cost estimating in 1998, as part of the front-end engineering phase

- the remainder of the work, starting after the project has received regulatory and corporate approvals in 1999, including detailed engineering, procurement, construction and commissioning of the process facilities and infrastructure

The EPCM contractor will be responsible for:

- project management
- process and project engineering
- detailed design
- procuring equipment and materials
- health, safety and environmental management
- construction management and quality control
- planning and scheduling
- cost estimating and cost control
- accounting
- commissioning the facilities up to initial operations

EPCM Contractor (cont'd)

Specialty areas, such as tailings, might be subcontracted to other engineering firms. Construction will most likely be done by Canadian contractors experienced in this type of work.

Pilot Plant

A 20 t/h extraction pilot plant will be designed and constructed in modules in late 1997 and early 1998. The plant will be operated by experienced Shell and BHP technical staff until the end of 1998, to confirm commercial process conditions and bitumen and solvent recoveries, as well as to provide information for front-end engineering and design. The extraction pilot plant is the subject of a separate regulatory application and approval.

Front-End Engineering

The selected EPCM contractor will start front-end engineering in the second quarter of 1998 and finish by the end of 1998. The purpose of this program is to provide sufficient process engineering and plant design to produce a sound feasibility study and cost estimate. Much of the value improvement process will also be performed at this stage. Between 5% and 10% of the total engineering effort will be completed during this period, including:

- process flow sheets
- material balances
- a water balance
- preliminary process and instrumentation diagrams (P&IDs)
- an equipment list
- a plot plan
- general arrangements of the facilities
- electrical single-line diagrams
- general specifications for each of the engineering disciplines
- major equipment specifications
- procurement standards
- a contracting plan
- a construction plan
- a detailed project execution schedule
- a detailed operating cost estimate
- a capital cost estimate, accurate to within 15%
- sketches of civil, structural, piping and electrical work for estimating purposes

Bids will be solicited for major equipment items so that accurate prices can be obtained for the estimate. Purchase orders will be released for these items as soon as regulatory and corporate approvals for the project have been received.

Detailed Engineering

Detailed engineering will begin as soon as regulatory and corporate approvals have been received. This major effort will require a peak of about 150 engineers and other professionals for two years. The owners team will also be resident in the EPCM contractor's office and will approve all work. All basic and detailed engineering for all disciplines will be completed to the level required for successful installation. All equipment and materials will be specified to the appropriate standards.

When engineering is about 60% complete and most of the major purchase orders and contracts have been awarded, a cost estimate with an accuracy of between 5% and 10% will be prepared.

Procurement

The procurement services provided by the EPCM contractor will include:

- selecting qualified bidders
- purchasing
- inspections
- expediting
- traffic management
- customs clearance and import services
- warehousing

An approved vendors' list will be developed early in the project and all equipment and materials will be sourced from reputable and proven local, provincial, national and international suppliers. Final selections will be made on the basis of quality, cost and schedule, and safety and environmental track records. Most of the smaller orders for bulk material and services will be supplied by firms in Fort McMurray, because of proximity to the mine. Most of the bulk materials will come from Canada, unless the suppliers have reached their capacity or the materials are not competitively priced. Most of the major equipment will come from North America, Europe and the Far East. A stringent shop inspection and expediting program will be implemented to ensure the quality and timely completion of fabricated items.

Construction

Safety is of paramount importance in all construction activities. Quality, cost and schedule will be the other criteria driving the construction program. Innovative methods, such as modularization, will be encouraged to increase efficiency.

The project will be constructed by a number of contractors, which will be selected on the basis of cost and capability, including demonstrated safety performance. Only highly qualified and proven contractors will be invited to bid on work. The EPCM contractor will manage these contractors and inspect their work.

Construction (cont'd)

The current plan is for construction workers to be housed at a new camp on Lease 13. The camp will be located near the extraction plant, to minimize transportation of the work force.

Commissioning

A commissioning manager and team from the EPCM contractor's organization will be appointed well before commissioning starts. The selected manager will be experienced in commissioning and will have an intimate knowledge of the processes and equipment used.

The commissioning team will implement a commissioning program for each area of the project as construction nears completion. A thorough punchlist, checkout and start-up sequence will be performed with a system of sign-offs to ensure that every element is carefully checked. Initially, every piece of equipment, structure, pipeline, cable and instrument will be checked and commissioned with water, followed by each system, module and area. Feed will be introduced to the process only when the entire facility has been run successfully on water and all deficiencies have been corrected.

Plant operations personnel will be involved in each step of the commissioning program to ensure that they are knowledgeable and satisfied with the completed facilities.

ORGANIZATION

The Muskeg River Mine will be managed from the mine site under the control of a general manager. Functional responsibilities will be delegated to line managers for:

- environment, health and safety (EH&S)
- human resources
- finance
- regulatory affairs
- public affairs

As soon as the project has been approved, a project manager, a mine operations manager and an extraction plant operations manager will be appointed. During the project's execution phase, the project manager will coordinate the overall project engineering and design activities, as well as the construction activities on the lease, including construction of the extraction plant, tailings, utilities and offsite and mine operations. The mine and extraction plant managers will organize two teams of operating superintendents who will be responsible for:

- mining, including:
    - site works and stripping
    - mining
    - tailings
    - mine maintenance
    - engineering
- extraction, including:
    - ore conditioning
    - froth treatment
    - utilities and offsites
    - the laboratory
    - plant maintenance

The key individuals will be drawn from Shell, BHP and outside sources.

The managers will each develop and train their organizations in time for plant commissioning. When the mine and extraction plant have been commissioned,

ORGANIZATION (cont'd)

the mine and extraction plant managers will report directly to the general manager.

PRE-OPERATIONS ACTIVITIES

The mining and extraction plant operations managers and their teams of superintendents will be resident either on site or in the engineering office with the EPCM contractor for between 12 to 18 months to provide input into the design and to ensure that the facilities will be fit for purpose and operable. Their experience will be a valuable addition to the engineering effort and their participation will ensure their ultimate acceptance of the facilities.

In addition to their participation in engineering work, the mine and extraction plant operations managers and superintendents will be responsible for:

- preparing operating manuals
- developing training programs
- recruiting and training the work force
- planning and implementing the activities in readiness for a successful operation

They will have between 12 and 18 months to ensure that their organizations are thoroughly prepared to commission and operate the mine and extraction plant.

COMMISSIONING AND START-UP

Plant operations personnel will work closely with the commissioning team during the commissioning and start-up of the facilities. They will observe and formally accept each of the commissioning steps throughout the water testing program. When feed is introduced into the plant, the operating staff will begin their hands-on work, assisted by the commissioning team.

Ownership of the facilities will be transferred from the engineering and construction team to the operations team upon successful introduction of feed to the plant.

OPERATING AND PRODUCTION PLAN

During front-end engineering, an operating and production plan will be developed, using standard Shell, BHP and oil sands industry practices. This plan will be based on necessary mine and extraction plant production and feed targets. Equipment, major supplies, staffing and contract service needs will be determined to support this plan.

ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT

Environmental, health and safety management during the construction and operation phases of the project will include:

- developing annual plans to ensure that the sustainable development, health and safety policies are effectively implemented
- staffing with experienced personnel to help implement and inspect EH&S-related activities and facilities
- training all project and contractors' staff to the appropriate levels
- developing, implementing and improving EH&S-related operational practices
- conducting annual audits to identify areas of success, areas for improvement, and to ensure that corporate and regulatory compliance has been achieved
- participating in regional cooperative initiatives, such as joint environmental and health management programs
- maintaining an effective level of communication with the public, regulatory agencies and other stakeholders

The environmental management system for the project is described more fully in Section 16.1.

OPERATIONS STAFFING PLAN

A highly trained work force with solid technical skills will be required to support the use of increased mechanization and advanced control systems for this grassroots mine and extraction development. Many of these people will be recruited from the Fort McMurray area. Others will be recruited from elsewhere in Alberta or the rest of Canada.

Salaries and working conditions will be competitive in order to secure and maintain a stable and motivated work force. This will be a long-term operation, and all personnel, operating standards and procedures must be established with a long-term view.

HOUSING AND TRANSPORTATION

The current plan assumes that most full-time employees and contractors will live within the Regional Municipality of Wood Buffalo. Shell and BHP staff will work with the Regional Infrastructure Working Group and the Mayor's Housing Task Force to confirm the viability of this premise. If the infrastructure cannot

HOUSING AND TRANSPORTATION (cont'd)

support the expected staffing levels, other housing alternatives, such as full or partial operating camps, will be considered.

Transportation options for local staff will be developed with consideration to Syncrude and Suncor schedules, to try to minimize the impact and optimize the benefits.

CONSUMABLE SUPPLIES

All of the consumables required for operations are expected to be supplied from Canadian suppliers. Suppliers will be selected based on quality, reliability, cost and schedule. Local suppliers will be preferred if they provide competitive services. Long-term agreements will be developed for most supplies and services after the capabilities of the various vendors have been identified.

EMERGENCY RESPONSE PLAN

Emergency Response Management Approach

Both Shell and BHP staff have extensive backgrounds in emergency response planning. With worldwide operations and the high levels of regulatory and public expectation associated with organizations of this scale and stature, emergency response has long been a high priority.

Emergency response management involves developing a site-specific response plan for every operating location. A key feature of Shell and BHP's emergency response planning is that the site-specific plan is backed up by a corporate emergency response plan. This affords a depth of resources and expertise that enhances any given location's ability to manage a specific incident, if such assistance is required.

Shell and BHP's emergency response management systems are modelled after the Incident Command System. The value of this approach is the incorporation of emergency response roles and a management process that is used internationally and is constantly being drilled and upgraded with learnings. It provides a solid blueprint for success in emergency response planning and management.

For the Muskeg River Mine, Shell and BHP will build from their existing experience base, but also work with local industry representatives and regulators to enhance the development of a comprehensive Muskeg River Mine Emergency Response Plan.

Scope of Muskeg River Mine Emergency Response Plan

The plan will address:

- Standards — The Emergency Response Plan will follow the Incident Command System Model as well as the relevant features of CSA Z-731, Emergency Planning for Industry.

- Resources — The Emergency Response Plan will be developed to take full advantage of the resources associated with a 24-hour, seven-day a week operation. The objectives will be to build a capable base of emergency responders within the organization.

- Mutual Aid — To support the Emergency Response Plan, Shell will approach the existing industry operators and Regional Municipality of Wood Buffalo representatives to participate in a Mutual Aid arrangement. Shell and BHP staff have broad experience in being value-adding contributors to Mutual Aid organizations of many types and structures.

- Oil Spill Cooperative — Shell intends to join the Wood Buffalo Region Area Y Cooperative oil spill response organization.

Consistent with Shell's belief in continuous improvement, the Muskeg River Mine Emergency Response Plan will be tested via planned drills and audited throughout the life of the mine. A specific standard, setting out the expectations for this testing and review process, will be part of the Emergency Response Plan.

INTRODUCTION

SCOPE

This section describes the activities for which approvals are being sought for the Muskeg River Mine Project under the Alberta Environmental Protection and Enhancement Act (EPEA) and the Water Resources Act. The facilities associated with the project are described in previous sections of this application. This section also briefly describes the Environmental Management System that is being developed and the management objectives that will be implemented to minimize environmental impacts.

AEP APPROVALS

EPEA Approvals Requested

AEP approvals for the following activities are being applied for under EPEA:

- construction, operation and reclamation of the Muskeg River Mine
- construction and operation of the extraction plant and utilities
- management of pesticides
- construction and operation of a potable water system
- management of wastewater and stormwater
- construction and operation of a Class II landfill
- release of non-process-affected water into the Muskeg River

Water Resources Act

The following activities require AEP approval under the Water Resources Act and are being applied for in this application:

- withdrawal and diversion of surface water and groundwater for process use
- impoundment of surface water and groundwater for process water use
- diversion of natural surface waters around or away from the project site
- muskeg dewatering
- process water ditching
- mine depressurization
- construction, operation and reclamation of the tailings settling pond
- construction and operation of the Muskeg River crossing

Water Resources Act (cont'd)

Additional information on the landfill and Muskeg River crossing will be provided by May 31, 1998.

ENVIRONMENTAL MANAGEMENT SYSTEM

Managing environmental issues is an integral and important component of the business management strategy for the Muskeg River Mine Project. A formal environmental management system, based on the best features of the environmental management systems currently in place for Shell and BHP, will be developed to address site- and project-specific issues. Developing, implementing, monitoring and continuously improving the environmental management system will provide an effective tool for self-regulation of environmental issues.

The environmental policy for the project will be developed according to the existing environmental policies of Shell and BHP. The policy will be applicable to all employees, contractors and joint venture partners.

Shell is committed to achieving a high standard of environmental care in conducting its oil sands project throughout all phases of the development, operation and closure. The project's approach to environmental management is to seek continuous improvement in performance by taking into account the following commitments:

- compliance with all applicable laws, regulations and standards
- applying self-imposed standards and guidelines
- communicating with all stakeholders, including government and communities
- implementing an environmental management system to identify, control and monitor environmental risks arising from its operations
- setting targets for measuring, appraising, reporting and improving performance
- conducting ongoing research to improve environmental performance
- integrating environmental protection with traditional business decision-making

The effectiveness of an environmental management system relates directly to how it is implemented and monitored. All management, employees and contractors share responsibility for ensuring that the work being done reflects the spirit and intent of the system. Implementing the management system involves:

ENVIRONMENTAL MANAGEMENT SYSTEM (cont'd)

- establishing performance indicators
- developing and documenting applicable project site management plans
- staffing with experienced personnel and providing continuous training
- monitoring compliance with the environmental management system
- monitoring, recording and reporting performance
- developing and taking corrective action as necessary
- conducting incident reporting, investigation, analysis and follow-up according to standards and guidelines
- communicating significant learnings

ENVIRONMENTAL MANAGEMENT OBJECTIVES

The project includes several fundamental environmental management objectives designed to minimize environmental impacts. These include:

- progressive mining and reclamation operations to ensure more efficient resource recovery and environmental protection
- improved energy efficiency through lower process temperatures
- a non-caustic extraction process resulting in improved tailings settling and reduced tailings disposal footprint
- a waste minimization and management strategy that incorporates waste reduction, reuse, recycle and recovery
- participation in regional cooperative research and monitoring programs for air, water and reclamation
- ongoing research and development of new technology to conserve resources, minimize waste and protect the environment
- a water management plan that minimizes raw water imports through recycling and engineering design to minimize losses to seepage and evaporation

SCOPE

Waste management is an integral component of the Muskeg River Mine Project environmental management system. The objective is to manage waste in a manner that is environmentally responsible and complies with all corporate standards and regulatory requirements. Identification, characterization, minimization, reuse, recycling and recovery of waste are key to effective waste management.

Waste management will adhere to the waste management process and procedure guidelines currently used at other Shell facilities. These processes involve:

- identifying, measuring and controlling waste generation
- handling, storage and disposal
- performance tracking and reporting
- offsite disposal of hazardous waste
- onsite disposal of non-hazardous waste
- recycling as appropriate

As detailed engineering for the mine and extraction plant is firmed up, a more site-specific waste management plan will be developed for the project. The standards, guidelines and procedures developed will apply to all types of wastes generated, handled, stored, and disposed of at the Muskeg River Mine. These activities will be closely monitored to ensure compliance with environmental regulations, and to encourage the most effective and efficient use of resources through the waste management principles of reduction, reuse, recycle and recover, where practical. Table 16-1 summarizes the waste management strategy for the project.

SOURCES OF WASTE

Waste will be generated from several sources during the construction and operation phases of the project. Waste management processes and procedures will be structured according to the following sources of waste:

- sanitary sewage

- solid and liquid waste from the:

SOURCES OF WASTE (cont'd)

  - construction camp
  - administration offices
  - laboratory
  - kitchens
  - first aid room

- utilities and services

- maintenance shops

- process waste, excluding liquid effluent and tailings

Where applicable, the construction camp and operations components of these waste streams have been separated.

LANDFILL

A Class II industrial landfill will be constructed to dispose of the solid waste from the Muskeg River Mine. The landfill will meet Alberta's regulations and guidelines for a Class II industrial landfill. Supplemental information required for approval of the landfill will be submitted to AEP by May 31, 1998.

HAZARDOUS WASTE MANAGEMENT

A hazardous waste storage area will be developed to provide interim storage for wastes that are unsuitable for the Class II landfill. This area will be operated according to the standards set out in the EPEA Waste Control Regulation and the Hazardous Waste Storage Guidelines and will be fully secured to control access.

Appropriately trained personnel will:

- control the area
- conduct waste inventories and yard inspections regularly

Wastes leaving this area will be taken to either:

- a regulated and recognized hazardous waste disposal facility

- a recycler of such items as oil filters and lead acid batteries

- the on-site landfill, if analytical testing verifies the acceptability of disposing of the material there

For further information on the management and operation of the hazardous waste storage area, see Hazardous Waste Management in Section 7.5.

Table 16-1: Muskeg River Mine Waste Management Strategy

Area	Waste	Storage Method and Location	Disposal Method and Location
Sanitary Sewage	Sewage	Screened and treated in an aerated facultative lagoon system and stored for 30 days	• Lagoon
	Treated wastewater	• Recycle Pond	• Used in process
	Screenings	• Stored in marked containers	• Landfilled
Solid and Liquid Waste	Camp waste: • Domestic solid waste • Leachate • Recyclables	 • Stored in marked bins • Sewage lagoons • Marked bins	 • Landfilled • Recycle pond • Recycled
	Office waste: • Recyclable • Non-recyclable	 • Marked containers • Marked containers	 • Recycled • Landfilled
	Laboratory Waste: • Non-hazardous wastewater • Hazardous	 • Lime sludge pond • Marked containers	 • Recycle pond • Offsite disposal
	Kitchen and cafeteria waste: • Recyclables • Non-recyclables • Grease	 • Marked containers • Marked containers • Grease traps	 • Recycled • Landfilled • Offsite disposal
	First aid room waste	• Marked containers	• Offsite disposal
Utilities and Services	Steam boiler blowdown	• Lime sludge pond	• Recycle pond
	Heating boiler sludge and blowdown	• Marked containers	• Offsite disposal
	Equipment and vehicle wash: • Clarified water • Settled solids and skimmed oil	 • Recycle pond • Oil-water-solids separator	 • Used in process • Tailings settling pond
	Waste oil	Dedicated above ground tanks	Offsite disposal
Maintenance Shops	Scrap metal	• Marked containers	• Recycled or landfilled
	Recyclable materials	• Marked containers	• Recycled
	Batteries	Hazardous waste storage area	Offsite disposal
	Tires	Mine area or yard	Recycled or landfilled
Process Waste	Empty chemical containers	None	Rinsed, compacted and landfilled
	Water treatment waste: • Sediments • Lime sludge • Grit and rocks	 • Sedimentation Pond • Lime sludge pond • Quick lime slaker	 • Landfilled • Landfilled or tailings • Landfilled
	Filters and strainers	• Marked containers	• Recycled or landfilled
	Piping and equipment waste water	• Recycle pond	• Used in process
	Commissioning and start-Up waste water	• Recycle pond	• Used in process

SANITARY SEWAGE

Construction Camp Sewage

Sanitary sewage from the construction camp will come from:

- living quarters
- kitchen
- cafeteria
- laundry

The current estimated sewage flow range for design is 75 m^3/d to 500 m^3/d.

Sanitary sewage will be treated in a lagoon system before discharge to a large storage pond that will later become the recycle pond after construction activities are complete and mine operations have begun. This pond is expected to be about two-thirds full by the time operations begin. The effluent will not be discharged to any receiving stream or natural body of water.

The sewage treatment lagoon system will not be decommissioned at the end of the construction camp activities. It will be reused to provide sewage treatment for the operating facilities.

Treatment before discharge to the storage pond will consist of screening followed by mechanical aeration in a facultative lagoon (see Figure 16-1). The screenings will be drained, bagged and disposed of with domestic solid refuse.

The sewage treatment system will be designed and operated to comply with regulations and guidelines for facilities of this size. However, as this water will not be discharged to the environment, the quality criteria for the final effluent will be consistent with its intended reuse. The long-term storage (over two years) for this effluent, and the fact that it will not be discharged to the environment, makes disinfection unnecessary.

Table 16-2 lists the expected characteristics of the treated sewage effluent, as monthly averages.

Operations Sewage

The sewage treatment system developed for the construction camp will continue operations when the mine and extraction plant are put into operation.

The average sewage produced during operation, including flows from hygiene facilities, the kitchen, cafeteria and laundry, will be about 100 m^3/d. The instantaneous peaking factor is estimated to be about three times the average.

The sanitary sewer will not receive any contaminated discharges, such as those from the laboratory. Sanitary sewage will be screened and pumped through a pipeline to the aerated lagoon system used previously for the camp. The final effluent will have characteristics similar to those indicated for the camp, but with

Operations Sewage (cont'd)

lower concentrations of coliform bacteria because of the extended treatment time. The treated effluent will be discharged to the recycle water pond for reuse in the extraction process. The screenings at each site will be dewatered, bagged and disposed of with domestic solid waste.

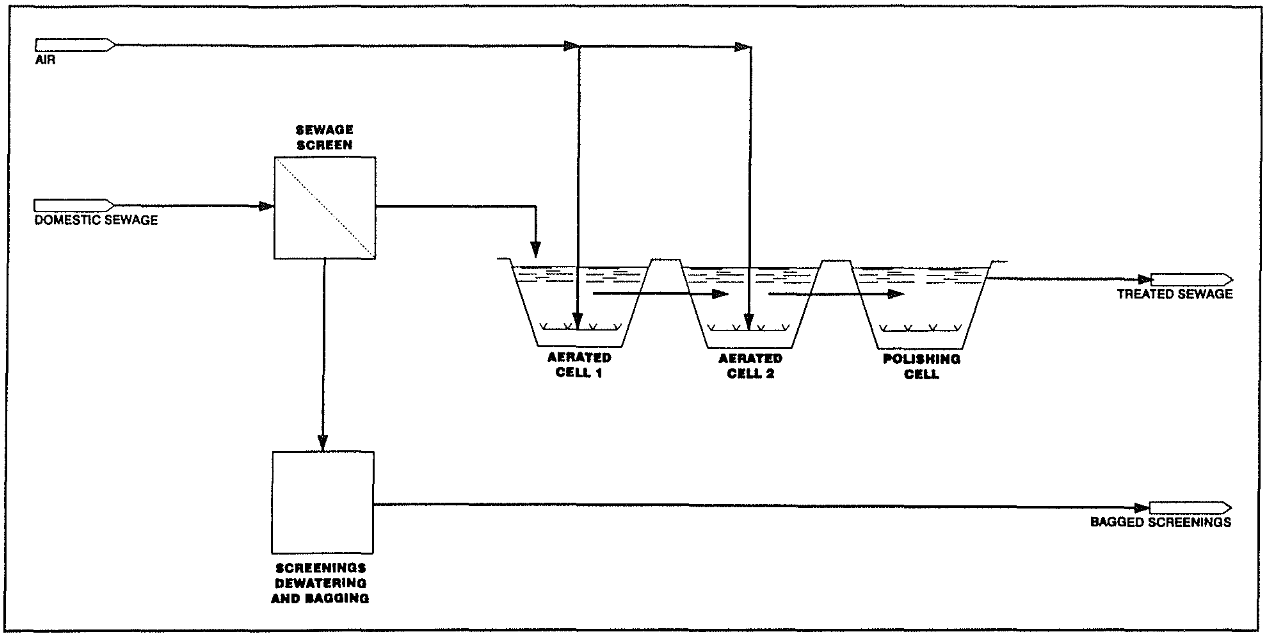


Figure 16-1: Sewage Treatment System Process Flow Diagram

Table 16-2: Expected Characteristics of Sewage Effluent

Parameter	Concentration Units
Flow rate	500 m^3/d
Biochemical oxygen demand (BOD)	50 mg/L
Total suspended solids (TSS)	100 mg/L
Total phosphorus as P	15 mg/L
Total nitrogen as N	15 mg/L
Ammonia nitrogen as N	15 mg/L
Total coliform bacteria	10^4 colony forming unit/mL
Fecal coliform bacteria	10^2 colony forming unit/mL
Note: BOD = five-day test.	

SOLID AND LIQUID WASTE

Construction Camp

Domestic Solid Waste

Domestic solid waste will be stored in marked bins and hauled to the landfill. Between 300 and 1,000 kg/d of solid waste, including sewage screenings, is expected to be generated during the construction camp's peak period. This expectation is based on about 1 kg of domestic solid waste being generated per person in the camp.

Leachate

Leachate will be collected from the landfill according to applicable regulations. Any leachate collected during the construction period will be transferred to the sewage treatment lagoon system. The landfill will not be decommissioned at the end of the camp activities. It will be used for waste disposal from the operating facilities.

Recycling Bins

Marked bins will be available for recycling paper, plastics, glass and metals.

Offices

The administration and other offices are expected to generate about 100 m^3/a of waste. Most of this will be paper products, which will be segregated in marked bins and removed from the site by a recycling contractor.

The offices will use recycled printer and photocopying ink cartridges.

Office waste that is not recycled will be placed in marked solid waste containers and disposed of in the landfill.

Laboratory

Non-hazardous wastewater generated by the laboratory is expected to be about 100 m^3/a. This wastewater will be directed to the lime sludge pond. Lime sludge will provide neutralization, as necessary. The supernatant will be sent to the process water recycle pond.

Samples collected during normal operations will be disposed of appropriately, according to the type of waste. Other wastes, such as chemicals and containers, will be removed from the site by a licensed hazardous waste management company for recycling or for environmentally safe disposal.

Kitchen and Cafeteria

About 100 m^3/a of solid waste is expected to be generated from the kitchen and cafeteria.

Kitchen and Cafeteria (cont'd)

Where economically feasible, marked bins will be available for recycling glass, metallic cans, cardboard and plastics. These recyclable wastes will be removed from the site by a licensed contractor.

Kitchen sewers will have grease separators. A recycler will periodically clean these grease traps and remove the grease from the site.

Other waste generated in this facility will be placed in marked domestic solid waste containers. This solid waste will be hauled to the landfill.

First Aid Room

Occasionally, small amounts of biohazards and other materials, such as needles and broken glass, will be discarded from the first aid facility. These wastes will be stored in appropriate containers and removed from the site by a licensed waste management contractor.

UTILITIES AND SERVICES

Blowdown

Process steam boilers and glycol heaters will produce different wastes, which will be handled according to their characteristics.

Steam boiler blowdown will be discharged into the lime sludge pond. Some of the phosphates will precipitate by adsorption on the lime sludge particles. The supernatant will be directed to the process water recycle pond for reuse.

The sludge blowdown and the fluid changes in the heating glycol boilers will be collected in appropriate containers. This waste material will be removed from the site by a recycling company.

Equipment and Vehicle Wash

A vehicle and equipment washing facility will produce a maximum instantaneous flow of 150 L/min, and an average of 100 m^3/d (100,000 L/d). These flows assume two 70 L/min large-volume washers operating about 12 hours a day.

The wastewater will be screened and received in an oil-water-solids separator with an oil skimmer. The clarified wastewater will be pumped to the process water recycle pond for reuse. The settled solids and the skimmed oil will be disposed of onsite.

Waste Oil and Related Waste

Waste oil from vehicles and from equipment, such as compressors and pumps, will be stored in marked, separate, above-ground tanks. These tanks will have a

Waste Oil and Related Waste (cont'd)

monitored, double-containment and roof-vent connection for oil removal. An oil recycling company will remove the waste oil from the site.

Waste antifreeze, and other recyclable vehicle and equipment fluids, will be stored either in tanks similar to the waste oil or in 200-L drums at the maintenance shop. The area will be dedicated to the storage of these materials and provided with a concrete curb to contain potential spills. A licensed recycling contractor will remove these fluids from the site.

Filter elements that cannot be recycled, including air, diesel, water and oil, will be stored in appropriate containers at the maintenance shop. Small elements will be stored in 200-L drums and crushed before disposal.

Chemical containers will be recycled through supply-and-recycle contracts with the chemical vendors, where appropriate. Containers that are not recyclable will be rinsed, compacted and will be hauled to the landfill periodically.

MAINTENANCE SHOPS

The maintenance shops will generate several different waste streams, including:

- scrap metal
- recyclable materials
- batteries
- tires

Scrap Metal

Metals and parts that cannot be reused will be stored in marked containers and removed from the site by a scrap-metal recycler. Parts that are not recycled will be compacted, if possible, and hauled to the landfill. A drum compactor will be available at the maintenance shops for these and other materials.

Recyclable Materials

Marked containers will be provided for materials such as rags, paper and plastics. These containers will be removed from the site by a recycling contractor.

Batteries

Used vehicle batteries will be recycled by the vendors or a battery recycling contractor. The batteries awaiting recycling will be stored in the hazardous waste area.

Tires

The large vehicles used in the mine operation will generate about 200 used tires a year. The tires will be recycled through the tire supplier, and removed from the site by a recycling company or hauled to the landfill.

PROCESS WASTE

Chemical Waste

Construction Camp Chemical Use

The only chemical expected to be required at the construction camp is sodium hypochlorite. Use will vary, depending on the iron concentration in the well water. Consumption will vary from 1.3 L/d initially to 6 L/d of hypochlorite solution at peak camp activity. This estimate assumes a total dosage of 5 mg/L and a hypochlorite concentration of 80 g free chlorine per litre of solution.

Operations Chemical Use

Chemicals used in significant volumes in the Muskeg River Mine facilities are summarized in Table 16-3.

Table 16-3: Chemicals Used at Muskeg River Mine

Chemical	Amount	Application	Container
Sodium hypochlorite	475 L/a	Water disinfectant or biocide	200-L drums
Lime	7,300 kg/a	Water softening or clarifying	Bulk
Alum	370 kg/a	Water clarifying	200-L drums
Sulphuric acid	3,700 kg/a	Water antiscalant or resin regeneration	Bulk
Caustic soda	185 kg/a	Resin regeneration	200-L drums
Gypsum	20,000 to 40,000 t/a	Tailings consolidation	Bulk

Liquid chemicals will be delivered in 200-L drums and stored in indoor tanks. Tank capacity will be determined by usage rate and delivery volumes. Secondary containment will be provided for all tanks to control leaks or spills. Vacuum trucks will collect any spilled chemicals for disposal or recycle, as appropriate.

Hypochlorite consumption is expected to be 1.3 L/d. This is based on a dosage of 2 mg/L. Chlorine will not be used as part of the iron-removal system.

Lime consumption is expected to be 15 to 20 kg/d. This is based on dosages of 80 to 120 mg/L, varying seasonally. It is also assumed that quick lime will be used. If hydrated lime is used, consumptions will be about one third higher.

Operations Chemical Use (cont'd)

Alum consumption will vary seasonally. This variation will be confirmed following further water studies. On average, a dosage of 10 mg/L can be expected. This would result in a consumption of 1 kg of alum per day, or 1.6 L of alum solution per day.

Acid will be used:

- for adjusting the pH of softened water
- as an antiscalant in the reverse osmosis process
- as a regenerant for the polishing deionization resins for the boiler feed water system

Assuming that sulphuric acid is used, the total consumption will be about 10 kg/d, or about 6 L/d of 98% acid.

Caustic soda will be used to regenerate the deionization resins in the boiler feed water system. Consumption is expected to be about 0.5 kg/d, or about 1 L/d of 40% to 50% solution.

Gypsum consumption varies from 20,000 t/a in 2006 to 40,000 t/a in 2015. Gypsum is used in the production of consolidated tailings.

Chemical-Related Waste

No waste is expected from the bulk delivery and storage of chemicals.

Empty chemical containers associated with non-bulk deliveries are a source of solid waste. These containers might be 200-L drums or tote bins up to 1,000 L. The containers will be stored in appropriate areas and segregated according to compatibility. Generally, these containers will be recycled through supply-and-recycle contracts with chemical vendors. A few empty chemical drums might not be recyclable. These will be rinsed thoroughly, compacted and hauled to the landfill.

Water Treatment Waste

The source of water for the operating facilities will be the Athabasca River. River water will be pumped through a pipeline to a sedimentation pond. Sediment will accumulate in this pond over the years and eventually have to be removed to recover storage capacity. When this is necessary, a contractor will dredge the pond and dewater the sludge. The river sediment sludge produced in this operation will be hauled to the landfill or applied to land if it is environmentally acceptable and approved by AEP.

Raw water will be pumped from the sedimentation pond to a water treatment plant. The water treatment plant will consist of a conventional lime-softening

Water Treatment Waste (cont'd)

clarifier followed by gravity filters and sulphuric acid neutralization. The water treatment plant will produce lime sludge from the clarifier bottoms and from the discharge of filter backwash water.

The lime sludge will be directed to two settling tanks operated in alternate years. While one tank is filling up with solids, the other will be draining. A winter freezing-and-thawing cycle will be used to improve the solid dewatering. Every summer, the lime solids from the bottom of the drained tank will be removed using a front-end loader and dump trucks. The lime solids removed will consist mostly of calcium carbonate, magnesium hydroxide, alum, small amounts of organic water-treatment polymers and river solids. Any lime solids that cannot be reused at the site, such as for acid waste neutralization, will be hauled to the tailings settling pond.

The annual production of lime solids will be about 440 tonnes on a dry basis, or about 880 tonnes of wet material. This is estimated to represent 650 m^3/a of dewatered lime solids. This estimate is based on removing an average of about 120 mg of hardness as $CaCO_3$ per litre of water. Higher dry solid concentrations and, therefore, smaller solid volumes, might be achieved if alum dosages can be kept low.

Grit and rocks from the quick lime slaker will be received in a bin and hauled to the landfill.

Filters and Strainers

About 1,000 m^3/a of filter cake will be produced at process filters and strainers. The cake will be stored in appropriate marked containers and hauled to the landfill.

Filter and strainer elements that cannot be reused will be stored in appropriate marked containers and removed from the site by a licensed scrap-metal recycler. Those elements that cannot be recycled will be compacted and hauled to the landfill.

Piping and Equipment

Wastewater from piping and equipment flushing, in-place cleaning, draining and pigging is estimated to be 100,000 m^3/a. This wastewater will be directed to the process water recycle pond for reuse. Screened solids will be drained, stored in appropriate and marked containers and removed either by a licensed recycling company or hauled to the landfill.

Commissioning and Start-up

Flushing and testing wastewater produced during the testing, commissioning and start-up of the facilities will be directed to the recycle pond for reuse.

Commissioning and Start-up (cont'd)

Screened solids will be drained, stored in appropriate and marked containers and hauled to the landfill.

Similar procedures will be followed during maintenance shutdowns and start-ups.

MONITORING

Shell is committed to monitoring waste management activities at the Muskeg River Mine Project. This will include routine inspections of the landfill and storage locations. An inspection checklist, based on an AEP checklist routinely used for sanitary landfill inspections, will be used. A waste inventory will be devised to ensure that only suitable materials are being sent to the landfill site.

Groundwater monitoring at the landfill sites is an integral component of the groundwater monitoring program for the Muskeg River Mine Project (see Groundwater Monitoring in Section 16.3)

Operating procedures, location and site design, regular inspections and frequent visits to the waste storage locations will be implemented to ensure that they are secure and environmentally protected.

Only appropriately licensed contractors will remove waste from the site for recycling, reuse or disposal. Contractor performance monitoring is an integral component of the site environmental management system (see Section 16.1).

AIR EMISSIONS

Types of Emissions and Impacts

Air emissions from the Muskeg River Mine Project include:

- total hydrocarbon compounds (THC)
- volatile organic compounds (VOCs)
- oxides of carbon
- oxides of nitrogen
- sulphur-containing compounds
- particulate emissions

For a summary of the impacts of these emissions, see Section 10.

Sources of Emissions

Air emissions result from:

- mining operations, including:
    - clearing and slash burning
    - fleet exhaust and vehicular activity
    - exposed mine surfaces
- extraction plant and utility operations, including:
    - stationary combustion sources
    - potential fugitive plant emissions
    - tailings settling pond surfaces

Extraction plant stationary combustion sources include:

- six, natural-gas-fired heaters
- two boilers
- space heating
- the flare pilot

Each of the six natural-gas-fired heaters and the two boilers will be routed to a 25 m high stack with an exit temperature of 182°C.

EMISSION CONTROL MEASURES

Table 16-4 outlines the air emissions and control mechanisms to be used for the Muskeg River Mine Project.

Table 16-4: Air Emissions and Control Measures

Substance Released	Mitigation Measures	Effect of Mitigation
Nitrogen Oxides (NO_X)	Mine fleet vehicles with effective emission control technology will be selected. Low NO_x burners will be used when appropriate.	Reduces combustion source NO_X levels
Carbon Monoxide (CO)	Improved energy efficiency, minimizing flaring and reducing process temperature. Efforts will be made to optimize the mine fleet to reduce unnecessary travel.	Reduces combustion and fugitive CO production
Carbon Dioxide (CO_2)	Improved energy efficiency and minimizing flaring.	Reduces combustion source CO_2 production
Particulate Matter (PM_{10})	Minimizing amount of organic material burned. Minimizing smouldering, revegetating overburden, and watering roadways.	Reduce particulate emissions
Particulate Matter ($PM_{2.5}$)	Minimizing amount of organic material burned, minimizing smouldering, revegetating overburden, and watering roadways.	Reduces particulate emissions
Total Hydrocarbons (THC)	Using a vapour recovery unit on closed consolidated tailings (CT) mixing tank.	Reduces THC emissions
Volatile Organic Compounds (VOC)	Lowering process temperature, nitrogen blanketing tanks and froth treatment, capturing and flaring HC from froth treatment plant, and using floating roofs on storage tanks.	Reduces combustion and process source VOC emissions

Stack and Emission Parameters

Table 16-5 lists stack and emission parameters for normal winter project operations as a maximum case scenario. Summer emissions are predicted to be lower than the levels shown. The flare stack includes air assist for smokeless flaring.

Table 16-5: Source and Emission Parameters for Winter Operations

Source	Fired Heaters						Boilers		Space Heating	Flare Pilot	Total
	1	2	3	4	5	6	1	2			
Energy input (GJ/h)	283	283	283	283	283	283	93	93	196	2	2084
Fuel consumption (m^3/s)	2.24	2.24	2.24	2.24	2.24	2.24	0.73	0.73	1.55	0.01	16.49
Stack height (m)	25	25	25	25	25	25	25	25	-	-	-
Stack diameter (m)	1.986	1.986	1.986	1.986	1.986	1.986	1.136	1.136	-	-	-
Total flow (m^3/s)	29.79	29.79	29.79	29.79	29.79	29.79	9.76	9.76	20.59	0.18	-
Velocity (m/s)	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	-	-	-
Temperature (°C)	182	182	182	182	182	182	182	182	-	-	-
NO_2											
Emission factor (ng/J)	40	40	40	40	40	40	26	26	26	26	-
Concentration (ppmv)	54	54	54	54	54	54	35	35	35	35	-
Emissions (g/s)	3.15	3.15	3.15	3.15	3.15	3.15	0.67	0.67	1.42	0.01	-
Emissions (t/d)	0.272	0.272	0.272	0.272	0.272	0.272	0.058	0.058	0.122	0.001	1.87
CO											
Emission factor (ng/J)	17	17	17	17	17	17	15	15	15	9	
Concentration (ppmv)	38	38	38	38	38	38	34	34	34	20	-
Emissions (g/s)	1.34	1.34	1.34	1.34	1.34	1.34	0.39	0.39	0.82	0.00	-
Emissions (t/d)	0.116	0.116	0.116	0.116	0.116	0.116	0.033	0.033	0.071	0.00	0.83
CO_2											
Emissions (t/d)	415	415	415	415	415	415	136	136	287	3	3049

Source: Conor Pacific Environmental

Table 16-5: Source and Emission Parameters for Winter Operations (cont'd)

Source	Fired Heaters						Boilers		Space Heating	Flare Pilot	Total
	1	2	3	4	5	6	1	2			
THC											
Emission factor (ng/J)	0.73	0.73	0.73	0.73	0.73	0.73	2.4	2.4	2.4	3.4	-
Concentration (ppmv)	2.9	2.9	2.9	2.9	2.9	2.9	9.4	9.4	9.4	13.3	-
Emissions (g/s)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.13	0.00	-
Emissions (t/d)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.011	0.0001	0.05
VOC											
Emission factor (ng/J)	0.6	0.6	0.6	0.6	0.6	0.6	1.1	1.1	1.1	2.2	-
Concentration (ppmv)	2.3	2.3	2.3	2.3	2.3	2.3	4.3	4.3	4.3	8.6	-
Emissions (g/s)	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.06	0.00	-
Emissions (t/d)	0.004	0.004	0.004	0.004	0.004	0.004	0.002	0.002	0.005	0.0001	0.03
PM_{10}											
Emission factor (ng/J)	5.3	5.3	5.3	5.3	5.3	5.3	5.8	5.8	5.8	5.1	-
Emissions (g/s)	0.42	0.42	0.42	0.42	0.42	0.42	0.15	0.15	0.32	0.002	-
Emissions (t/d)	0.036	0.036	0.036	0.036	0.036	0.036	0.013	0.013	0.027	0.0002	0.27

Source: Conor Pacific Environmental

Stack and Emission Parameters (cont'd)

Mobile fleet exhaust emissions (see Table 16-6) were estimated from expected fuel consumption and the application of appropriate emission factors for vehicles. For the vehicles used in the mine fleet, see Mining Operations in Section 4.4.

Table 16-6: Mobile Fleet Exhaust Emissions

Emission Type	Emission Level (t/d)
Nitrogen oxides (NO_X)	10.0
Carbon monoxide (CO)	3.4
Carbon dioxide (CO_2)	616.0
Particulate matter (PM_{10})	0.5
Particulate matter ($PM_{2.5}$)	0.3
Total hydrogen compounds (THCs)	0.88
Methane (CH_4)	0.07
Volatile organic compounds (VOCs)	0.81
Polycyclic aromatic hydrocarbons (PAH)	0.001

Volatile Organic and Total Hydrocarbon Compounds

Volatile organic compound (VOC) emissions of 2.54 t/d are predicted from:

- vehicle exhausts (0.81 t/d)
- mine surfaces (0.60 t/d)
- stationary sources (0.03 t/d)
- tailings settling pond (1.10 t/d)

Mine surface and tailings settling pond emissions for VOCs are only for C_5 to C_{10} compounds.

Total hydrocarbon compound (THC) emissions of 3.96 t/d are predicted from:

- vehicle exhausts (0.81 t/d)
- mine surfaces (1.60 t/d)
- stationary sources (0.05 t/d)
- tailings settling ponds (1.50 t/d)

THCs and VOCs from slash burning and other fugitive emission sources have not been quantified. Emissions from traffic and road surfaces are not expected to contribute large quantities of VOCs or THCs.

Volatile Organic and Total Hydrocarbon Compounds (cont'd)

Potential fugitive emissions from the facilities include steam vents, storage tank vents and building exfiltration. These emissions will be minimized by using:

- an extraction process temperature of 50°C, compared to 75°C for existing operations
- nitrogen blanketing of separation processes with vapour recovery and flaring of emergency releases
- nitrogen blanketing and floating roofs on diluent and diluted bitumen tanks

Oxides of Carbon

Emissions of carbon monoxide (CO) and carbon dioxide (CO_2) are estimated from the following sources:

- vehicle emissions:
  - 3.4 t/d CO
  - 616 t/d CO_2
- stationary sources in winter:
  - 0.83 t/d CO
  - 3,049 t/d CO_2
- stationary sources in summer:
  - 0.59 t/d CO
  - 2,150 t/d CO_2

Oxides of Nitrogen

Emissions of nitrogen oxides (NO_X) are predicted to be 11.9 t/d from:

- vehicle exhausts (10.0 t/d)
- stationary sources (1.9 t/d)

Emission estimates for vehicle exhausts were based on expected fuel consumption for diesel and gasoline or propane-fueled vehicles.

TRS Emissions

Emissions of 0.043 t/d of total reduced sulphur compounds (TRS) from the mine surface and tailings settling pond have been predicted. These emissions will consist of:

TRS Emissions (cont'd)

- 0.013 t/d from the mine surface
- 0.03 t/d from the tailings settling pond

Particulate Emissions

Particulate emissions are expected to arise from:

- burning cleared vegetation
- road and plant site construction
- fleet exhaust emissions
- stationary sources
- mine activities, such as loading, unloading and hauling
- wind erosion of exposed mine surfaces and tailings settling pond dykes

Mitigation measures for particulate emissions from slash burning include:

- salvaging timber, to minimize the amount of fuel to be burned
- burning when fine fuel material has a low moisture content and large fuel material has a high moisture content
- keeping burn piles clean to minimize the smouldering phase of burns
- cleaning up burn piles immediately after burns to minimize smouldering

Only the particulate emissions from the mine fleet exhaust and stationary combustion sources were estimated for the project.

Particulate emissions from fleet exhaust are expected to be about:

- 0.5t/d for PM_{10}
- 0.3 t/d for $PM_{2.5}$

These rates are based on the highest fuel use and assume that the level of mine activity is uniform over 354 operating days a year.

Particulate emissions from stationary sources include exhaust from the water system, utilities plant, space heaters and the flare pilot. Total PM_{10} emissions from these sources are estimated to be:

- 0.27 t/d in winter
- 0.19 t/d in summer

The total average emissions from stationary sources, based on winter levels as a maximum case, are estimated to be:

Particulate Emissions (cont'd)

- 0.3 t/d for PM_{10}
- 0.3 t/d for $PM_{2.5}$

For the purposes of evaluation, all PM emissions from the plant stacks were assumed to be in the $PM_{2.5}$ size fraction.

Total emissions from estimated sources are expected to be:

- 0.8 t/d for PM_{10}
- 0.6 t/d for $PM_{2.5}$

Particulate emissions from loading and unloading ore in mining activities are not expected because of the moisture and hydrocarbon content of the oil sands.

Table 16-7 summarizes the emissions from the Muskeg River Mine. The effects of these emissions are discussed in detail in EIA Volume 3, Section E2. The more significant effects are summarized in Section 10.

Table 16-7: Summary of Emissions from Muskeg River Mine

	Emission (t/d)							
Source	NO_x	CO	CO_2	PM_{10}	$PM_{2.5}$	THC	VOC	TRS
Mining:								
• Clearing and slash burning	NQ[1]	NQ	NQ	NQ	NQ	NQ	NQ	NQ
• Fleet exhausts	10.0	3.4	616	0.5	0.3	0.9	0.8	NQ
• Fugitive mine sources	0	0	0	NQ	NQ	1.6	0.6[2]	0.013
Extraction:								
• Stationary plant sources[3]	1.9	0.8	3,049	0.3	0.3	0.05	0.03	NQ
• Fugitive plant site sources	0	0	0	NQ	NQ	NQ	NQ	NQ
Tailings Management:								
• Tailings settling pond	0	0	0	NQ	NQ	1.5	1.1[2]	0.03
• Consolidated tailings	0	0	0	0	NQ	NQ	NQ	NQ
Total	11.9	4.1	3,665	0.8	0.6	4.0	2.5	0.01

Notes: 1. NQ - not quantified.
2. C_5 to C_{10}.
3. Worst-case winter conditions.
Source: Conor Pacific Environmental

AIR MONITORING

Air quality monitoring associated with the mine site will be designed and implemented so that it will be compatible with the work of the RAQCC.

Regional air quality issues of primary importance, as defined by RAQCC, are:

- human health
- odours
- acid deposition
- ozone

Data quality and integrity are critical for all of these. The monitoring system is designed to obtain quality data for research and monitoring.

The air monitoring program will include measurement of emissions and the collection of meteorological ambient air measurements at a monitoring trailer.

Measurement at Source

Air quality for the project will be measured by a combination of:

- simultaneous limits
- maximum hourly or daily emission rates
- rolling average limits for specific sources
- a maximum plant-wide rolling average

Air emission sources for which approval is being requested are:

- six natural-gas-fired heaters
- two boilers
- space heaters
- one flare stack with associated pilot

Ambient Air Quality Monitoring System

A program for ambient air quality monitoring will be prepared, based on the Regional Airshed Monitoring Plan for the Southern Wood Buffalo Zone. The program might include a monitoring station in the vicinity of the project as a component of the human health, ecosystem health and compliance monitoring network currently operating in the region.

The monitoring data that will be collected and recorded will include:

- continuous data
- intermittent data
- passive data
- wet and dry deposition rates

Ambient Air Quality Monitoring System (cont'd)

Parameters that will be measured include:

- SO_2
- H_2S
- THC
- O_3
- NO_X
- $PM_{2.5}$
- PM_{10}
- TRS
- VOCs
- PAHs
- metals
- wet and dry deposition
- meteorological conditions

The data will be transferred into a database management system for effective and efficient storage and retrieval. The system will:

- have an automated phone-in system
- store five-minute average data
- have an alarm system
- provide fixed-format and special reports

WATER RELEASES

Application for the Muskeg River Mine Project under EPEA is for the first 10-year operating period. The EIA provides details on water quality predictions related to substance releases and reviews how the reclaimed mine at closure will continue to have minimal impact on water quality, aquatic resources, wildlife and human health.

The approach to mine water management and, therefore, management of water-related releases, is based on the objectives to:

- minimize raw water imports
- minimize water inventory
- develop practical reclamation drainage facilities
- supply minimum required storage for fresh water and recycle water
- minimize costs for capital work, maintenance and operations

Table 16-8 summarizes the water releases and control mechanisms for the Muskeg River Mine Project.

Table 16-8: Project-Related Waters and Control Measures

Substance Release	Mitigation Measures	Result of Mitigation
Pre-Mine Releases (1999-2002)		
Catchment diversions	Catchment diversions will be designed to avoid channel erosion	Natural water diversions will not result in sedimentation impacts
Muskeg and overburden drainage	Sedimentation ponds will receive all muskeg and overburden drainage before release to natural receiving streams	Suspended sediments will be controlled during dewatering activities
Basal aquifer dewatering	Basal aquifer depressurization water will be pumped to the recycle pond	Used for process water requirements
Operations Releases (2003-2030):		
Basal aquifer dewatering	Basal aquifer depressurization water will be pumped to the recycle pond	Used for process water requirements
Muskeg and overburden drainage	Sedimentation ponds will receive all muskeg and overburden drainage before release to natural receiving streams	Suspended sediments will be controlled during dewatering activities
CT deposit water	CT water formed when CT is deposited in mined-out pits will be used for process water	No CT water releases
Seepage from tailings settling pond and deposited CT	Perimeter ditch around tailings settling pond will intercept seepage from sand dykes Depressurization wells during operation will intercept any CT seepage from CT deposits in mined-out pits	All process-related seepage will be intercepted and pumped back into a closed circuit system during construction and operations No process-related seepage will reach natural waterbodies
Tailings settling pond water and MFT at end of operation, before closure	MFT and aged, non-acutely toxic tailings pond water will be pumped to the bottom of the end-pit lake starting in 2023 at such a rate that the end-pit lake discharge to the Muskeg River will be non-toxic	Discharge of end-pit lake water to the Muskeg River will be non-toxic
End-pit lake release	MFT transfer to the end-pit lake during the last years of reclamation activities before closure will be carried out at a rate that ensures releases from the end-pit lake to the Muskeg River will be non-toxic	Discharge of end-pit lake water to the Muskeg River will be non-chronically toxic
Accidental releases	Prevented and controlled through best management practices and emergency spill response planning	Spill prevention and control of spills if they occur

Pre-Mine Releases (1999 to 2002)

Water that does not come into contact with oil sands will be released to natural receiving streams. Such water will not be treated, except for settling suspended sediment. Included in this category is water from:

- catchment diversions
- muskeg and overburden drainage
- basal aquifer dewatering

Process-affected operational waters will not be released during the life of the mine. Muskeg and overburden waters are the only operational waters to be released.

Catchment Diversions

Catchment diversions will divert natural drainage to natural receiving streams from:

- undisturbed areas surrounding disturbed mine areas
- pre-construction drainage areas

Catchment diversions will not require sediment removal as they drain natural waters and will be designed to avoid channel erosion. Catchment diversions will be constructed in stages to accommodate mine pit expansion.

Muskeg and Overburden Dewatering

The near-surface zone of muskeg is composed of highly pervious fibrous peat. Muskeg drainage is required to remove most of the free-draining water from this zone. Previous field tests near the Muskeg River Mine area, such as for the Alsands and OSLO projects, and the experience of current oil sands operators, indicates that shallow (1 m to 2 m deep) muskeg drainage ditches at about 100 m spacing are effective and economical, where the underlying soil (overburden material) is composed of relatively impervious soils. Where the overburden materials are composed of pervious sand and gravel, the optimum drainage scheme will involve deep ditches with wider spacing. Based on previous studies, a depth of 7 m (measured from the surface of the muskeg) and a spacing of 300 m is proposed for these conditions.

Muskeg drainage and overburden dewatering will be directed to sedimentation ponds, then discharged to receiving streams. An analysis of the water quality of muskeg drainage and overburden dewatering will be completed to confirm the acceptability of these waters for discharge to receiving streams. The water quality issues and predictions associated with the release of these waters, as well as the monitoring of these waters, is discussed in EIA Volume 3, Section E5. BOD, TSS, metals and temperature will be monitored.

Basal Aquifer Dewatering

The basal aquifer dewatering will be contained in the mine closed circuit. Available water quality data indicates that basal aquifer dewatering will likely be of acceptable quality for discharge to natural receiving streams. Basal aquifer water will be released to natural receiving streams if its quality:

- is acceptable to AEP
- can be made acceptable by mixing with muskeg drainage flows

Depending on the outcome of water quality analysis, Shell requests the option of either:

- releasing basal aquifer water to natural receiving streams
- using basal aquifer water for process water

Operations Discharges (2003 to 2030)

Process affected operational waters will not be released during the life of the mine. Muskeg, overburden and, if suitable, basal aquifer waters are the only operational waters to be released.

The mine water management system is based on the criterion that all water in contact with oil sands will be contained in the mine closed circuit. Accordingly, all of the following will be contained in the mine closed circuit:

- mine surface drainage
- plant site drainage
- process water
- recycle water
- tailings porewater
- recoverable tailings seepage

The diversion system will progress, as required, to eliminate the flow of water into the closed circuit operation from the surrounding undisturbed areas. This system will include the diversion of water around the temporary oil sands storage area and crusher site throughout the period that these activities exist. Because runoff from these areas will have been in contact with oil sands, the water will continue to be collected from these areas throughout the mine life and be used in the recycle water system.

Basal Aquifer Dewatering

Basal aquifer dewatering will continue throughout mining operations.

Muskeg and Overburden Drainage

Muskeg and overburden drainage waters will be released throughout the operation as new areas are prepared for mining. Sedimentation ponds will

Muskeg and Overburden Drainage (cont'd)

receive all muskeg and overburden drainage before release to natural receiving streams. Suspended sediments will be controlled during dewatering activities.

CT Deposit Water

CT water, which develops as CT is deposited in mined-out pits, will be used as process water. CT deposit water will not be released to the environment.

Seepage from Tailings Pond and Deposited CT

Seepage will be prevented from reaching natural waterbodies during the life of the operation. A drainage collection ditch will ring the tailings settling pond dyke to collect seepage from the pond and route it back to one of three sumps. The water in the sumps will be pumped back into the tailings settling pond. A diversion ditch will run in parallel to the ring ditch along the northeast edge of the tailings settling pond to keep natural flows separate from the seepage. Depressurization wells operated during mining will intercept any CT seepage from CT deposits in mined-out pits.

Most reclamation waters will be treated in wetlands or the end-pit lake before reaching natural waterbodies. Sand seepage from the reclaimed tailings settling pond and CT deposits not intercepted by wetlands or directed to the end-pit lake will eventually reach the Muskeg River after hundreds of years or report to the basal aquifer and eventually reach the Athabasca River. Seepage that might reach the Muskeg River would be non-toxic after decaying while travelling through the land. Any seepages that are not intercepted by the perimeter ditch will be detected during the monitoring program and mitigated, if necessary.

Tailings Settling Pond Water and MFT at End of Operation, Before Closure

MFT and aged, non-acutely toxic tailings pond water will be pumped to the bottom of the end-pit lake starting in year 2023, at such a rate that the end-pit lake discharge to the Muskeg River starting in 2028 will be non-toxic.

End-Pit Lake Release

MFT transfer to the end-pit lake during the last years of reclamation activities before closure will be carried out at a rate that ensures releases from the end-pit lake to the Muskeg River will be non-toxic. The end-pit lake is scheduled to release water to the Muskeg River in 2028.

Accidental Releases

Accidental releases will be prevented and controlled through best management practices, spill prevention procedures and emergency spill response planning.

Surface Water Monitoring

The growth in oil sands mining and related developments in the region have highlighted the need to optimize environmental monitoring activities. The intent is to coordinate information gathering for cumulative impacts so that regulatory monitoring requirements are satisfied cost-effectively. Suncor, Syncrude and Shell have initiated a Regional Aquatics Monitoring Program (RAMP) to address these issues for surface water quality. Other oil sands operators in the region might also become involved in this program. The RAMP is designed as a long-term monitoring program and will likely evolve as input is solicited from a steering committee and stakeholders and as data collection programs progress.

The objectives of the RAMP are to:

- design and execute a program which satisfies aquatic monitoring requirements detailed in environmental operating approvals
- monitor aquatic environments in the oil sands region to allow regional trends and cumulative effects to be assessed

During 1997, benthic invertebrates, sediment, sediment toxicity, water quality, fish and vegetation in lakes were monitored. A fish radiotelemetry study was also initiated in 1997.

Closure (2030 - Far Future)

Application under EPEA is for the first 10-year operating period. The EIA reviews how the reclaimed mine at closure will continue to have minimal impact on water quality. For details associated with this period, see:

- EIA Volume 3, Sections E3, E4, E5 and E6
- EIA Volume 4, Sections F3, F4, F5 and F6

GROUNDWATER

Pre-Mine Hydrogeology

The pre-mine hydrogeology has been characterized by numerous studies dating from investigations during the early 1970s to current exploratory programs. The pre-mine groundwater regime is described in Area Description in Section 8.1.

The exploration programs conducted at the Muskeg River Mine site provide sufficient information to characterize the hydrogeology. Published and unpublished literature also describe the groundwater conditions within the Muskeg River Mine Project regional study area.

Ongoing programs to advance hydrogeological understanding of the Muskeg River Mine Project include:

Pre-Mine Hydrogeology (cont'd)

- completing an inventory of remaining piezometers installed during pre-1997 exploration programs to assess their technical state and suitability for further use. Seriously damaged piezometers will be abandoned and installations requiring repairs will be upgraded.
- confirming the absence of dissolved H_2S in the basal aquifer water
- sampling selected piezometers installed in the basal aquifers to confirm water quality. The tests will include routine main ions, dissolved metals, BTEX/TPH, TEH, PAHs, naphthenic acids and total phenols. Piezometers completed in the Methy Formation will be sampled and analyzed only for inorganic compounds.
- determining the toxicity of groundwater in Quaternary sediments (overburden)
- conducting a detailed evaluation of basal aquifer hydraulic properties in the proposed mine area

Groundwater Management

Groundwater control in the basal and surficial aquifers will be implemented to ensure that mining is safe and efficient. Observations collected to date indicate that there is no hydraulic connectivity between the Methy Formation and the basal aquifer.

Mine pit dewatering will involve:

- draining the Quaternary and intra-orebody aquifers in the areas adjacent to the open pit
- depressurizing the basal aquifer

The surficial aquifer and muskeg drainage will be routed through a network of drainage ditches and interceptor channels, according to current practice in the region. The basal aquifer drainage will be discharged via a network of groundwater wells and directed to the process water recycle pond. The location, flow directions and schedule for basal aquifer drainage are described for the pre-mine and operations phases in Area Description in Section 8.1.

Groundwater Monitoring

A number of groundwater exploration and monitoring wells have been installed in the regional study area for industrial purposes. There are no records on file with AEP of domestic groundwater users in either the regional or the local study area.

Groundwater Monitoring (cont'd)

Observation wells will be installed to monitor water level changes and groundwater quality within the local study area. This monitoring program will address the geological, hydrogeological and hydrochemical characteristics of the various stratigraphic units, i.e., La Loche, Methy, basal aquifer and Quaternary. These wells will be installed both downstream and upstream of the tailings settling pond and process water recycle pond areas, the mining area and the landfill. Additional wells will be installed along the Athabasca and Muskeg rivers for background conditions. The exact locations of these wells and the timing of their installation will be determined during the detailed engineering stage of the project.

The analytical parameters to be reviewed from the samples taken from the groundwater monitoring wells are listed in Table 16-9. This represents a full analytical suite of parameters, which is in agreement with the current practices of the other operating oil sands companies in the region.

Table 16-9: Groundwater Monitoring Program Analytical Parameters

Description	Parameters
Index parameters	Total dissolved solids, total suspended solids, hardness, carbonate, bicarbonate, pH, conductivity
Nutrients	Nitrate, nitrite, total kjeldahl-nitrogen, ammonia, phosphorus
Major ions	Sodium, chloride, fluoride, bromide, sulphate, alkalinity ($CaCO_3$)
Dissolved metals	Al, Ba, Be, B, Ca, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mg, Hg, Mo, Ni, P, K, Ag, Na, S, Si, Sr, Ti, U, V, Zn
Phenols	Total phenols
Organics	Oil and grease Total petroleum hydrocarbons (IR) Total extractable hydrocarbons (GC/FID) Naphthenic acids
Oxygen demand	BOD_5, COD, TOC
Others	Sulphide
Toxicity	Microtox

Sampling equipment will include:

- bladder pumps
- inflatable packers, as required
- bailers

Groundwater Monitoring (cont'd)

Samples will be taken twice a year, in late spring and early winter. Detailed sampling and handling protocols will be developed to maintain sample integrity and allow for direct comparison between sampling events. If results of the sampling program illustrate consistent results from specific sampling locations, a reduced sampling frequency, such as once a year, and suite of parameters will be considered, i.e., major ions, including inorganic and organic carbon. This reduced suite of parameters should be enough to detect changes in basic chemistry and hydrocarbon content. If changes in basic chemistry are detected in any of the wells which have a reduced analytical frequency or suite, a full analytical suite and standard sampling frequency will be reinstated.

A groundwater model will be developed as additional data is added to the existing database. This model will allow groundwater flow paths to be identified and quantified. This model is expected to be three dimensional and will incorporate all stratigraphic units. The ongoing data collection will also be used to update the regional model.

PLANNING

Approach

The conservation and reclamation (C&R) plan developed for the Muskeg River Mine Project is based on the extensive database and experience in oil sands reclamation as well as details of the proposed development area and the mine plan. Knowledge of these issues comes primarily through Shell's involvement in cooperative environmental programs with regional oil sands industry operators, regulators, aboriginal groups and other stakeholders. This collaboration included participating in the:

- Regional Air Quality Coordinating Committee (RAQCC), under Clean Air Strategic Alliance - Southern Wood Buffalo Zone
- Regional Aquatic Monitoring Program
- Canadian Oil Sands Network for Research and Development (CONRAD)
- Oil Sands Mining End Land Use Committee

As a result of this involvement, stakeholder consultation and participation, a variety of C&R issues have been identified and addressed in the C&R plan developed for the Muskeg River Mine. For the conceptual basis of reclamation and closure planning, see EIA Volume 3, Section E16.

Key Issues

The key issues associated with C&R activities in the oil sands region include:

- end land use
- the reclamation of consolidated tailings deposits
- optimizing the use of mineral and organic soils
- developing self-sustaining wetlands ecosystems as components of reclamation landscapes
- evaluating the performance of developing reclamation ecosystems

Key Issues (cont'd)

- assessing and maintaining regional biodiversity
- designing and evaluating the self-sustainability of end-pit lakes

Stakeholder Consultation

Shell will maintain an effective stakeholder consultation and participation program as an integral component of its C&R program. This consultation program, coupled with active participation in oil sands reclamation studies and research, will enable the Muskeg River Mine Project C&R plan to effectively achieve end land use goals.

10-YEAR C&R PLAN

Objective

Soil capability is a principal determinant for many terrestrial environmental characteristics, including vegetation and wildlife and their sustainability and biodiversity. The reclamation objective is to provide equivalent (or better) soil capability as the mine is developed and reclaimed. Annual detailing of areas for soil stripping and reclamation, using a recently developed soil classification system for the oil sands area, enables gains and losses in equivalent capability to be quantified.

Mining and Reclamation

The progression of clearing, reclamation material salvage and storage, overburden removal and storage, and reclamation are shown in:

- Figure 16-2 for the end of 1999
- Figure 16-3 for the end of 2000
- Figure 16-4 for the end of 2001
- Figure 16-5 for the end of 2002
- Figure 16-6 for the end of 2003
- Figure 16-7 for the end of 2004
- Figure 16-8 for the end of 2005
- Figure 16-9 for the end of 2006
- Figure 16-10 for the end of 2007
- Figure 16-11 for the end of 2008
- Figure 16-12 for the end of 2009
- Figure 16-13 for the end of 2010
- Figure 16-14 for the end of 2020
- Figure 16-15 for the end of 2022
- Figure 16-16 for the final vegetation classification following reclamation

Mining and Reclamation (cont'd)

Two major reclamation material storage areas will be established to temporarily store material for future reclamation use. About 6.9 million bcm of reclamation materials will be stored in these areas, providing a ready supply for planned progressive reclamation activities. On closure, these storage areas will also be reclaimed. Table 16-10 shows the reclamation materials salvage and use schedule. The muskeg materials identified are in addition to the overburden materials. For details on the overburden storage and materials movement, see Mining Operations in Section 4.4.

Table 16-10: Reclamation Materials Balance

Year	Mine Component	Area (ha)	In Situ Reclamation Material (bcm)[1]	Reclamation Material Destination			
				Left in Place (bcm)	Direct Placement (bcm)	Reclamation Material Storage Areas (bcm)[2]	Overburden Disposal Area (bcm)
pre-2001	Plant site	260	2,223,211	0	0	0	2,223,211
	Access and utility corridor	87	311,090	0	0	0	311,090
	Tailings settling pond	1,039	6,870,637	6,870,637	0	0	0
	South disposal area	174	2,405,812	2,405,812	0	0	0
2001	Pit advance	191	932,899	0	0	0	932,899
2002	Pit advance	101	574,257	0	87,000	0	487,257
2003	East reclamation storage area	69	730,700	0	0	730,700	0
2004	Pit advance	239	1,193,413	0	343,400	0	850,013
2005	-	0	0	0	0	0	0
2006	Pit advance	158	1,217,854	0	142,000	0	1,075,854
2007	Northeast disposal area	81	600,948	600,948	0	0	0
2008	Pit advance	92	504,830	0	0	0	504,830
2009	West disposal area	293	1,545,107	1,357,107	188,000	0	0
2010	-	0	0	0	0	0	0
2011-2020	pit advance	1,190	11,931,421	0	0	4,961,944	6,969,477
	West reclamation storage area	121	1,125,047	0	0	1,125,047	0
2021-2022	Pit advance	136	1,325,713	0	0	0	1,325,713
Total		4,231[3]	33,492,939	11,234,504	760,400	6,817,691	14,680,344

Notes:
1. All volumes are listed in bank cubic metres. No allowance has been made for material swell or compaction.
2. This total represents the amount of soil that must be stored to meet reclamation requirements. There will be no outstanding soil inventory at mine closure.
3. Excludes 17 ha for pipeline construction and 95 ha for constructed wetlands around the tailings settling pond.

Mining and Reclamation (cont'd)

The areas of development will yield significantly more reclamation materials than are required for the reclamation for the development area (33,492,939 bcm versus 7,578,091 bcm). Some of this excess material will be covered by facilities constructed for the project, such as the tailings settling pond and overburden disposal areas. Additional excess materials will be placed within the overburden disposal areas.

Reclamation Activities

The reclamation program designed for the Muskeg River Mine Project is consistent with the draft *Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region*, issued by the Oil Sands Vegetation Reclamation Committee in 1997. Reclamation of disturbed project areas will be limited during the first 10 years of operation because of the lack of areas prepared for reclamation activities.

Areas that will be reclaimed in the initial 10 years of activity include:

- roadway ditches
- the utility corridor
- the pipeline rights-of-way
- overburden disposal area lower slopes
- tailings settling pond lower slopes

Activities planned during the first 10 years of C&R activity include:

- applying reclamation material amendments to prepared seed bed areas
- applying appropriate seed mixtures (see Table 16-11)
- monitoring reclamation

Table 16-11: Seed Mixes for Infrastructure Areas

Grass Types	Mixes	Hydric Forests, Bogs and Fens	Mesic Forests and Shrublands
Fowl bluegrass	40	20	20
Creeping red fescue	30	-	30
Alsike clover	20	-	-
Red top	10	-	-
Northern wheat grass	-	20	-
Slough grass	-	20	-
Manne grass	-	20	-
Tufted hairgrass	-	10	-
American vetch	-	10	10
Awned wheatgrass	-	-	20
Slender wheat grass	-	-	20

Reclamation Activities (cont'd)

Vegetation from the seed mixture will protect the soil from wind and water erosion. Seeding rates will vary. Hydroseeding and broadcast seeding rates will be 25 kg/ha. If the areas are seed-drilled, seeding rates of 15 kg/ha are appropriate. For pipeline revegetation in hydric forests, bogs and fens, seed will be broadcast at 25 kg/ha.

Water Management

A water management plan has been prepared for the project (see Section 8). This plan is based on criteria provided by Shell and on provincial and federal project regulations and guidelines. The goal of the mine water management plan is to enable the mine to be developed economically with minimum risk to mine operations and minimum impacts on the environment. Accordingly, the plan is intended to:

- minimize the import of water
- minimize the volume of water in inventory
- provide for sustainable reclamation drainage facilities
- identify appropriate rates of fresh water and recycle water supply
- develop an operating strategy that minimizes the cost of capital expenditure, maintenance and operations

A detailed description of reclamation drainage systems is provided in EIA Volume 3, Section E4.

Plant Site and Related Facilities

The plant site will be landscaped near the office area. Other areas of disturbed soil will be seeded or stabilized mechanically to control dust.

Timber Salvage

Trees will be cleared to prepare the land for the mine area, plant site and related facilities, as well as for establishing the tailings settling pond, overburden and reclamation material storage areas.

In the pre-1999 period, these areas include the plant site, access and utility corridors, the tailings settling pond, the south overburden disposal area and the oil sands storage area. In successive years, the principal timber salvage areas will be the mining pits with some salvage needed for the northeast and west overburden disposal areas. The total potential timber salvage area (assuming that all surface areas are treed) is 4,343 ha for the entire development area (see Table 16-12).

Table 16-12: Timber Salvage Schedule

Year	Mine Component	Component Area (ha)	Cumulative Disturbance (ha)
pre-1999	Plant site	260	260
	Access and utility corridor	87	347
	Tailings settling pond	1,039	1,386
	Products pipeline	17	1,403
	South disposal area	174	1,577
1999	Pit advance	191	1,768
2000	Pit advance	101	1,869
2001	East reclamation material storage area	69	1,938
2002	Pit advance	239	2,177
2003	-	0	2,177
2004	Pit advance	158	2,336
2005	Northeast overburden disposal area	81	2,417
2006	Pit advance	92	2,509
2007	-	0	2,509
2008-2020	Pit advance	1,190	3,698
	Pit advance	136	3,834
	West overburden disposal area	293	4,127
	West reclamation material storage area	121	4,248
post 2020	Wetlands surrounding tailings settling pond	95	4,343
Total		4,343	

Soil Salvage and Reclamation

The construction of soils for reclamation activities will follow a process detailed in the draft *Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region*, issued by the Oil Sands Vegetation Reclamation Committee in 1997. Reconstruction of soils for the oil sands area follows the committee's decision tree for both soils overburden (see Figure 16-17) and tailings sand (see Figure 16-18). For the Muskeg River Mine Project, a one-lift soil replacement method will be used for both the overburden and the tailings sand areas. A 20-cm layer of muskeg-mineral soil amendment will be placed over overburden or sand material to create a Class 3 soil. This soil capability will provide equivalent or better capability compared to pre-disturbance soil conditions.

Calculations for soil salvage and reclamation are based on:

Soil Salvage and Reclamation (cont'd)

- using only organic-rich soils as suitable for the reclamation soil amendment, i.e., Muskeg (MUS) and McLelland (MLD) as identified from the baseline soil survey

- overstripping the peat and soil surface material (about 1 m) with underlying mineral soil (about 0.4 m)

- placing about 20 cm of this soil amendment mixture onto the overburden or sand capping material

Four soil types were identified as suitable soil material for use in reclaiming disturbed areas. The four soils, and the average depths associated with each, are:

- McLelland (MLD) 1.81 m
- McLelland (MLD.X) 0.72 m
- Muskeg (MUS) 1.82 m
- Muskeg (MUS.X) 0.66 m

Details of the soil conditions in the Muskeg River Project area are given in:

- EIA Volume 2, Section D8, Terrain and Soils baseline conditions
- EIA Volume 3, Section E8, Terrain and Soils impact assessment

Reclamation materials will be removed to the reclamation material storage areas. As the mine progresses, and when practical, reclamation materials will be hauled directly to areas undergoing reclamation, i.e., direct placement.

Within each area to be cleared and stripped for project development, a total area for each of the four soil types was measured. The average depth of each soil type was then added to an overstrip depth of 0.4 m and multiplied by its area to arrive at a soil volume. Overstripping is undertaken to supplement the organic soils with other important soil components, such as clay and silts, as well as other inorganic materials needed for a healthy soil ecosystem. Table 16-13 details the areas to be reclaimed and the reclamation schedule.

This system of soil salvage will be integrated with the Land Capability Classification for Forest Ecosystems in the Oil Sands Region to ensure that the desired land capabilities are achieved. The assigned ratings refer to the soil capability class for forest production for each map unit type (see Table 16-14).

Soil classes 1, 2 and 3 have the potential to support commercial timber harvesting.

Table 16-13: Reclamation Schedule

Year	Mine Component	Reclaim Area (ha)[1]	Reclaim Volume (bcm)[2]	Cumulative Volume (bcm)[2]
2002	Access and utility corridor - phase 1	43.5	87,000	87,000
2004	South disposal area slope	62.7	125,400	212,400
	Tailings settling pond slope (280-305 masl)	109.0	218,000	430,400
2005	South disposal area slope	35.2	70,371	500,771
2006	Tailings settling pond slope (305-320 masl)	71.0	142,000	642,771
2009	Tailings settling pond slope (320-335 masl)	94.0	188,000	968,771
2010-2022	Tailings settling pond surface	765.0	1,530,000	2,498,771
	South disposal area surface	76.2	152,320	2,651,091
	Northeast disposal area	81.0	162,000	2,813,091
	West disposal area	293.0	586,000	3,399,091
	East muskeg storage area	69.0	138,000	780,771
	West muskeg storage area	121.0	242,000	3,641,091
	Plant site	202.0	404,000	4,045,091
	Access and utility corridor - phase 2	43.5	87,000	4,132,091
	Cell 1	267.0	534,000	4,666,091
	Cell 2	198.0	396,000	5,062,091
	Cell 3	191.0	382,000	5,444,091
	Cell 4	362.4	724,800	6,168,891
	Cell 5	291.0	582,000	6,750,891
	Cell 6	413.6	827,200	7,578,091
		3,789.0	7,578,091	

Notes:

1. All mine component areas as per mine plans dated November 5, 1997.
2. All volumes are listed in bank cubic metres - no allowance has been made for material swell or compaction. Soil Volume = soil unit area x (soil unit average depth + overstrip depth)
3. Areas not requiring soil amendment are the end-pit lake at 442 ha, pipeline at 17 ha and constructed wetland ponds at 94 ha.
4. Excludes constructed wetlands surrounding tailings settling pond, plant site and other infrastructures.

Table 16-14: Land Capability Classifications

Capability Classification	Productivity	Limitations
1	High	None to slight
2	Moderate	Moderate
3	Low	Moderately severe
4	Currently non-productive	Very severe
5	Permanently non-productive	Extreme, e.g., wetlands

Commercial Forest

The Alberta Regeneration Survey Manual, Section 2, identifies three acceptable standards, all of which require 80% of the plots in a standard survey to be stocked with acceptable trees to a minimum height standard. The three standards are conifer, mixed wood or deciduous. The choice of standard is based on the stand and ecosite before harvest. The conifer standard requires a minimum:

- 70% stocking with conifer seedlings (white spruce, jack pine or black spruce)
- 10% conditional seedlings (aspen, balsam poplar, birch, fir)

The mixedwood standard reduces the conifer requirement to 50% and the deciduous standard does not require any conifer component.

Reclamation Activities

The first reclaimed area will be completed in 2002 when the first half of the access and utility corridor will become available for reclamation. In subsequent years, reclamation will be carried out on the slopes of the tailings pond and overburden dumps. Most of the reclamation work will be carried out after 2010 as early mine pits are exhausted, used for tailings storage and prepared for closure. The final area to be reclaimed for the Muskeg River Mine will be about 3,800 ha.

An excess of reclamation material is available on the project area. The total volume of reclamation material available from the development area is about 33.9 million bcm. A total of about 11.4 million bcm of this amount is located within the proposed tailings pond area as well as in the three overburden disposal areas and will not be salvaged. Therefore, the total volume of reclaimed soil expected to be handled is about 22.1 million bcm. In contrast, reclaimed areas through to mine closure will require a total of about 7.6 million bcm, assuming a reclamation soil depth of 20 cm.

In most cases, before 2010, reclamation areas will be completed by direct placement of soils from pit advance clearing. Most of the reclamation soil stockpiling will take place in the final 10 years of operation in preparation for reclamation of the pits, tailings settling pond, overburden disposal area surfaces,

Reclamation Activities (cont'd)

and the plant site. All excess soil above the reclamation requirement of 7.6 million bcm will be hauled to the various overburden disposal areas.

Revegetation

The primary objectives of the revegetation program are to:

- provide an erosion-resistant plant cover on tailings dyke slopes and overburden disposal area slopes
- focus on the use of woody-stemmed reclamation species common to the region
- try to establish a diverse range of plant species to re-create the level of biodiversity common to the pre-development site
- establish a viable plant community capable of developing into a self-sustaining cover of forest species suitable for commercial forest, traditional land uses, wildlife use and with possibilities for recreation and other end uses

The revegetation of reclaimed landform surfaces is dictated by the nature and type of landform structures, such as:

- dykes
- overburden
- tailings sand
- CT deposit
- slope aspect
- soil type (capability class)
- soil drainage conditions

The type of vegetation which will successfully establish and develop under various combinations of these factors has been the subject of Suncor and Syncrude research programs over more than 20 years.

Typically, the revegetation process begins with undisturbed muskeg soils being stripped and hauled to the reclamation area. This method (completed in the winter whenever possible) enhances site revegetation because dormant, in situ native seed and root fragments are transferred with the soil. Spreading the muskeg soil amendment on the reclamation site is completed in early spring with the usual result being the emergence of a variety of native, woody-stemmed species, forbs, wildflowers, and grasses.

Establishing woody plants on reclamation areas is integral to the reclamation process. The species selected and the proportion of each species in the supplemental planting mix are based on the woody-stemmed species common to

Revegetation (cont'd)

the ecosite within the region; existing field conditions; the vegetation type expected to develop on the site (based on landscape terrain features); and the expected growth of woody-stemmed species from seeds and root fragments in the soil amendment layer. The ultimate species composition is designed to accelerate the process of natural succession toward desired vegetation types. The micro-environment modifies as woody cover develops on a reclamation area, providing favourable conditions for later successional and mature species. The planting program ensures these species are present, established and capable of taking advantage of condition changes. Generally, six to eight species are planted to supplement the natural processes of woody plant establishment. Table 16-15 outlines the starter woody stemmed planting prescriptions to establish each of the ecosite phases.

Maintenance fertilizer will be applied to both the reclaimed overburden and tailings sand areas following soil application. On areas where maintenance and repair work is required, fertilizer will be included in the hydroseeder slurry mix. Maintenance fertilizer rates will be determined from soil tests, cover performance and cover objectives.

Adaptive Management

Adaptive reclamation management will facilitate and respond to the revegetation process to meet specific land capability objectives. The length of time required for developing mature ecosystems within the boreal forest eco-region means that reclamation areas will typically be assessed for certification long before the areas have fully matured. Therefore, Shell will further establish criteria and monitoring programs that will demonstrate progress toward environmentally-sound and fully-mature ecosystems. Adaptive management might be used at any point throughout the project life cycle and will facilitate decision-making on surface contouring measures and corrective action that could improve surface drainage, decrease erosion or enhance vegetation performance.

Strategies that will be investigated to enhance biodiversity in reclaimed areas will follow industry standards and include:

- habitat diversity
- ecosystem implants

Habitat Diversity

Reclaimed landscapes often exhibit a loss of the topographic variability that characterizes natural landscapes. However, within the project development area, the existing topography is subdued. As a result of the mine development, a more varied landscape in terms of aspect, slope and elevation will be produced. Recontouring overburden disposal areas and dyke slopes to produce micro and macro-scale modifications will also create a greater diversity of habitat-sites. These differences in aspect, soil moisture regime and water or snow

Habitat Diversity (cont'd)

accumulation will result in improved vegetation diversity. In turn, this will benefit wildlife by providing a greater diversity of browse and forage species.

Table 16-15: Ecosite Phase Starter Planting Prescriptions

Landscape Features	Soil Capability and Moisture Regime	Target Ecosite Phase	Tree Species 1,800-2,200 Stems/Ha Total Density	Shrub Species 500-700 Stems/ Ha Total Density
Tailings Sand Slope, South aspect	Soil Class 4-3, Subxeric, Submesic	b1 Blueberry Pj-Aw	Jack Pine Aspen White Spruce	Blueberry, Bearberry, labrador tea, Green Alder
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	b2 Blueberry Aw (Bw)	Aspen White Birch White Spruce	Blueberry, Bearberry, Labrador tea, Green Alder
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	b3 Blueberry Aw-Sw	Aspen White Spruce White Birch	Blueberry, Bearberry, Labrador tea, Green Alder
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	b4 Blueberry Sw-Pj	White Spruce, Jack Pine, White Birch, Aspen	Blueberry, Bearberry, Labrador tea, Green Alder
Overburden, South Aspect	Soil Class 3-2, Mesic	d1 Low-bush cranberry Aw	Aspen White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry
Overburden, North Aspect	Soil Class 3-2, Mesic	d2 Low-bush cranberry Aw-Sw	Aspen White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry
Near Level Overburden or Tailings Sand	Soil Class 3-2, Subhygric, Mesic	e3 Dogwood Sw	White Spruce Aspen Balsam Poplar White Birch	Dogwood, Low-bush Cranberry, Raspberry, Green Alder, Rose

Ecosystem Implants

A method of increasing the rate of recolonization is to transplant patches of soil and vegetation from natural ecosystems to reclamation areas. On reclaimed sites, topsoil and vegetation will be transplanted from equivalent ecotypes to determine the effectiveness of this method. It is not feasible to completely cover a reclamation area in this way. However, placing this material in small patches or islands across extensive reclamation areas is expected to facilitate the recovery of natural biodiversity.

Ecosystem Implants (cont'd)

The same approach will be used to develop diverse, productive wetlands habitats on reclamation areas. Transplanting topsoil or sediments from marshes into constructed wetlands will greatly accelerate wetlands development. Existing wetlands sediments contain seeds, roots and other plant propagules, which result in rapid vegetation colonization, as well as introducing a wide range of invertebrates and microorganisms that will promote the establishment of a typical wetlands detrital food chain.

Reclamation Monitoring

Soils

Performance of topsoils and subsoils is a key parameter for controlling erosion and sustaining ecosystems. Shell will monitor trends by comparing key parameters with reference soils, including:

- pH
- salt content (as indicated by electrical conductivity)
- macronutrient levels
- organic carbon content
- nitrate-nitrogen
- phosphorus
- potassium
- sulphate-sulphur

This work will evaluate and demonstrate the application of the Land Capability Classification for Forest Ecosystems in the Oil Sands Region. It will also provide supporting scientific data for the capability rating system assigned to the reclamation soil types.

Vegetation

Vegetation and soil characteristics in reclaimed areas will be monitored each year. The monitoring program will consist of an annual assessment of vegetation cover and soil sampling on areas reclaimed within the past three to four years, followed by a detailed assessment and sampling of all reclaimed areas every fifth year.

Shell's reclamation monitoring program will include an annual program specifically to assess herbaceous vegetation growth and composition as well as physical and chemical properties of soil. The reclamation program will include a routine maintenance component involving fertilization of revegetated areas, erosion repair and control, and replanting poor performance areas. Annual assessments of tree and shrub survival and growth will be conducted in areas where seedlings were planted. The results of these programs will be reported to AEP in annual Conservation and Reclamation Reports. These monitoring programs will be extended sequentially into newly reclaimed areas.

Wildlife

Assessment of the sustainability of wildlife in re-established ecosystems requires consideration of soil and vegetation development, forecasts on the evolution of revegetated areas to mature systems and re-entry of wildlife. Wildlife use of reclaimed landscapes must be monitored to provide feedback on the success of reclamation and revegetation techniques. Experience has shown that wildlife will begin using reclaimed areas as soon as a herbaceous vegetation cover is established. The diversity of wildlife using the reclamation sites will increase over time as more food and cover become available. Monitoring wildlife species representative of the various successional stages will indicate the degree to which reclaimed areas are developing into productive sustainable ecosystems.

Wildlife Habitat and Biodiversity

The design for monitoring wildlife habitat and biodiversity has not yet been established. Because the majority of reclamation will occur after 2010, details on this program will be provided in subsequent conservation and reclamation plans.

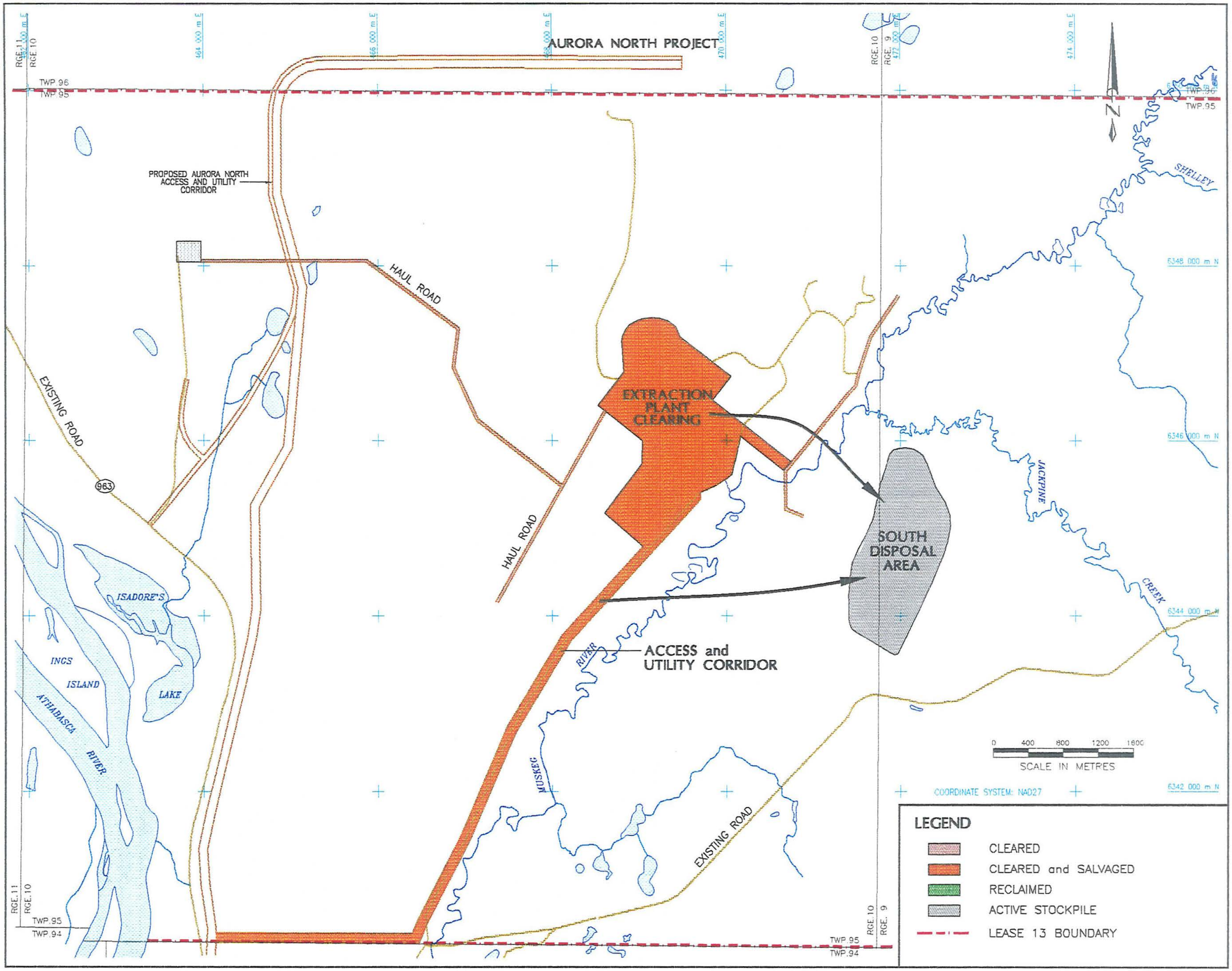


Figure 16-2: Mine Development and Reclamation Progression for Year Ending 1999

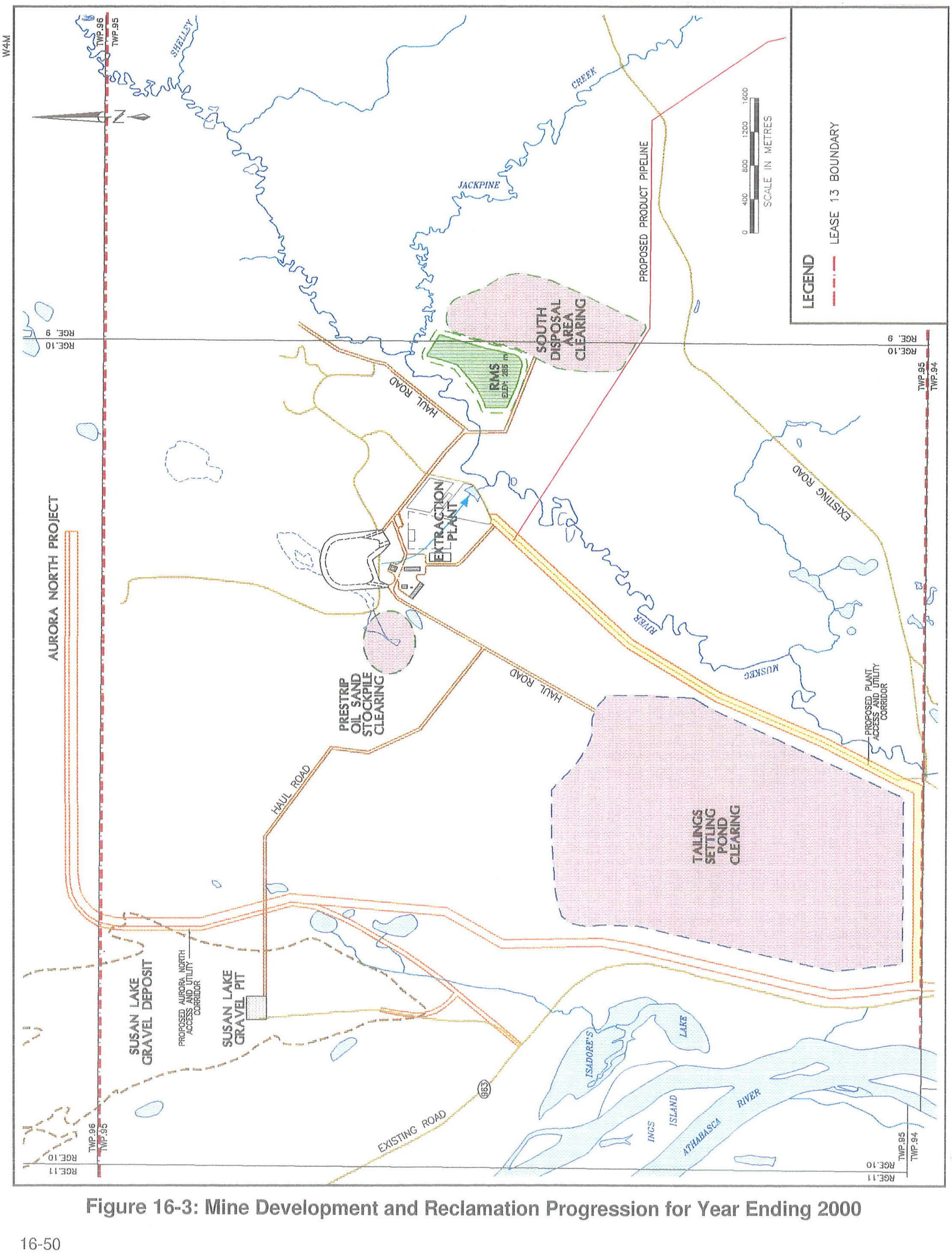


Figure 16-3: Mine Development and Reclamation Progression for Year Ending 2000

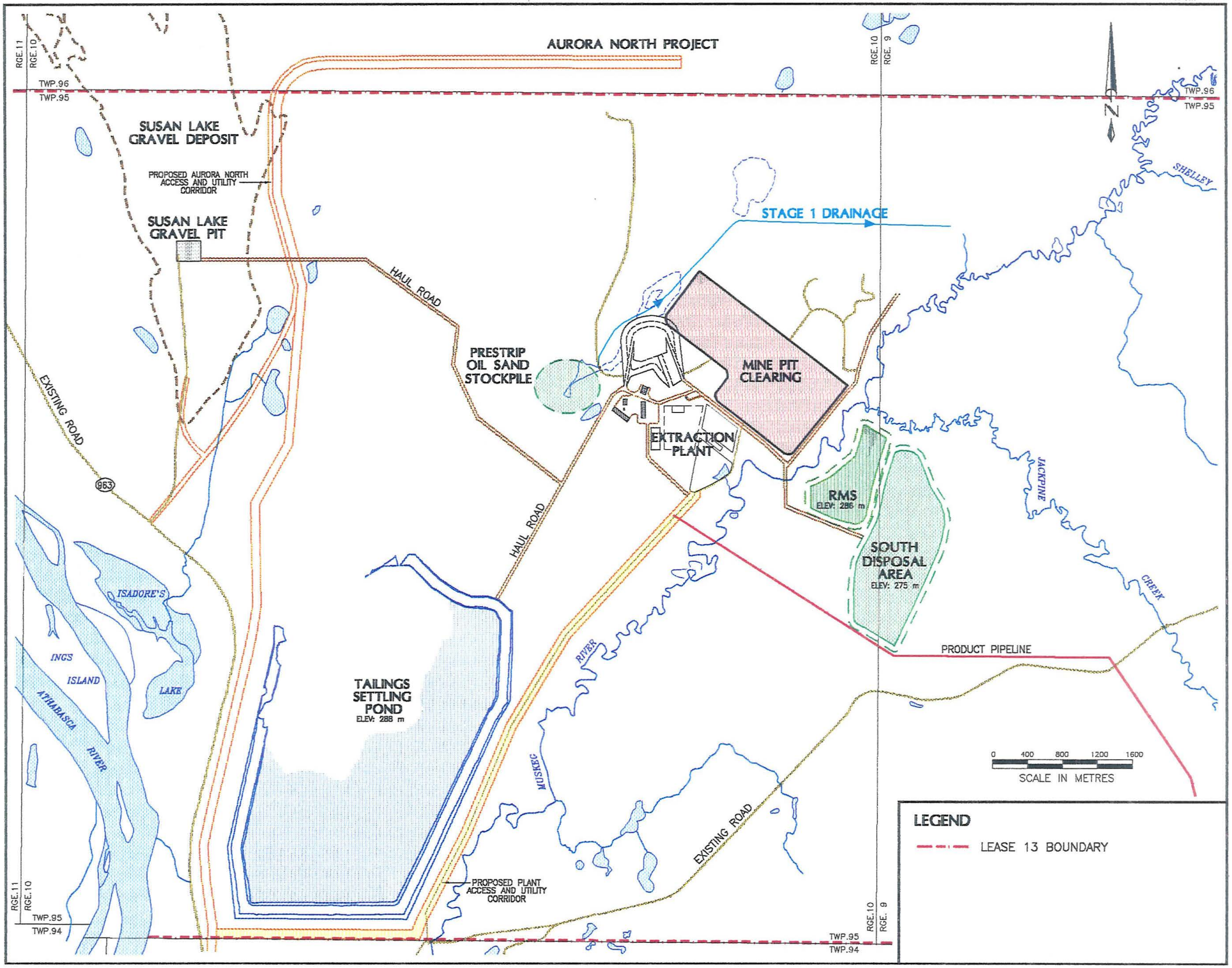


Figure 16-4: Mine Development and Reclamation Progression for Year Ending 2001

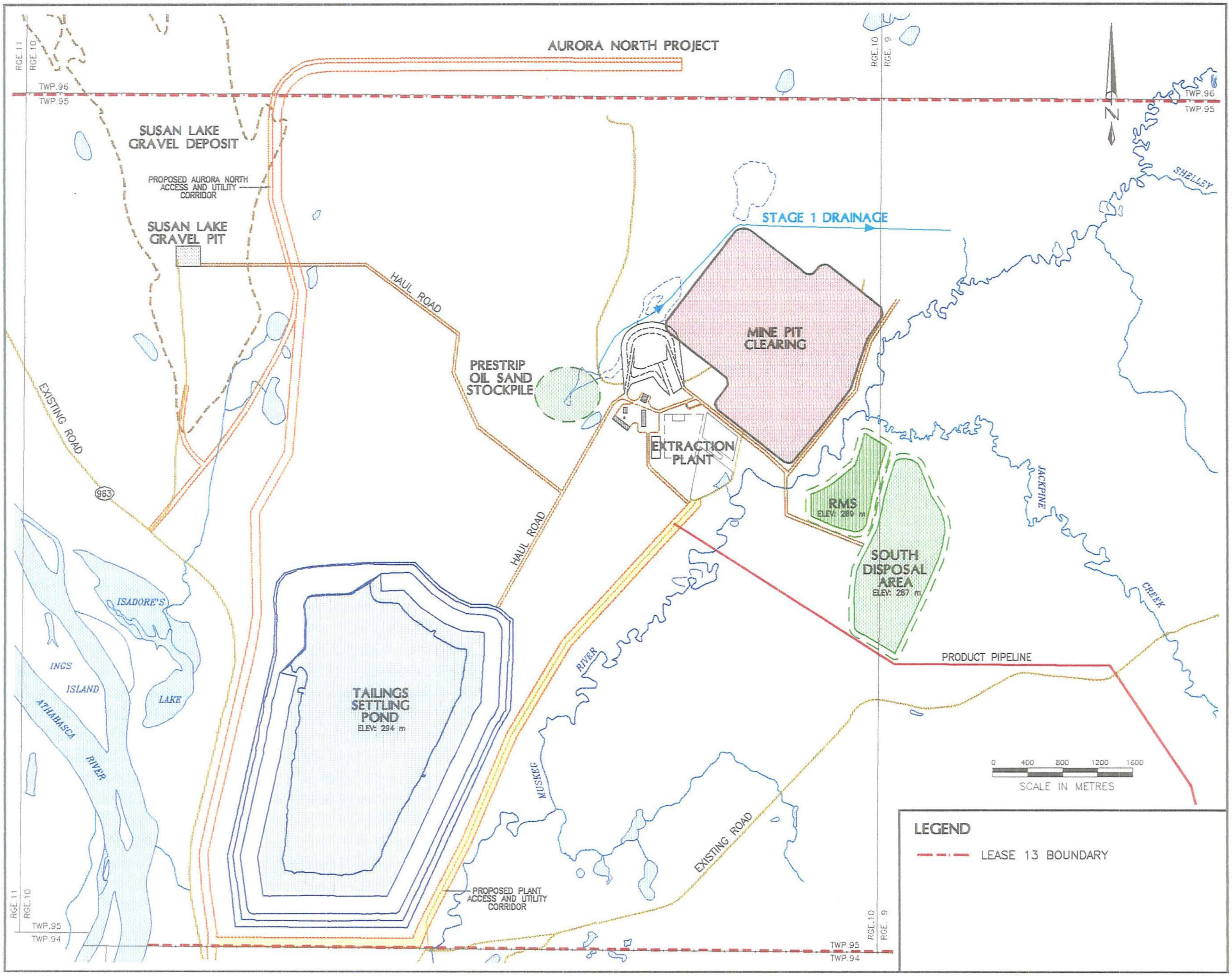


Figure 16-5: Mine Development and Reclamation Progression for Year Ending 2002

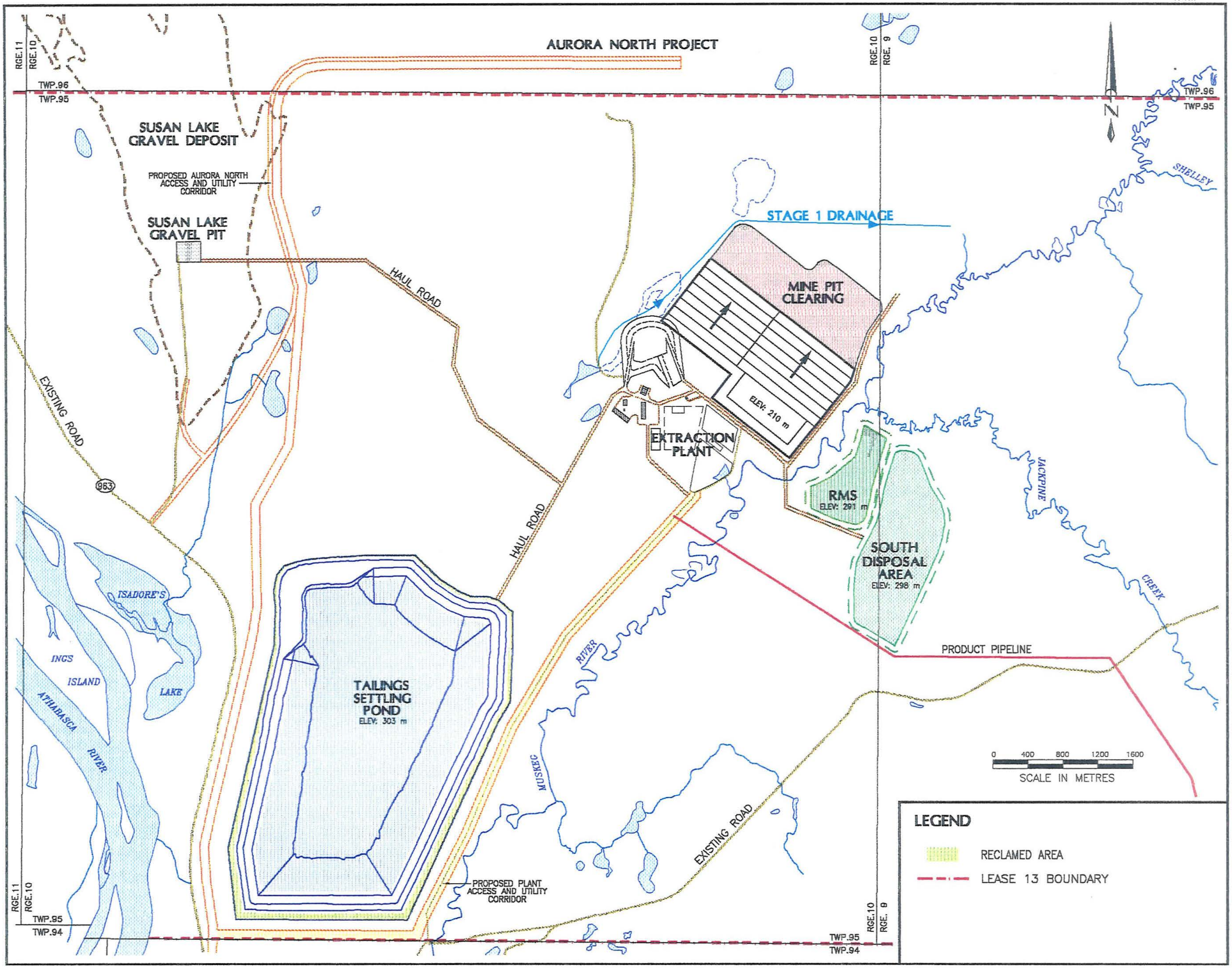


Figure 16-6: Mine Development and Reclamation Progression for Year Ending 2003

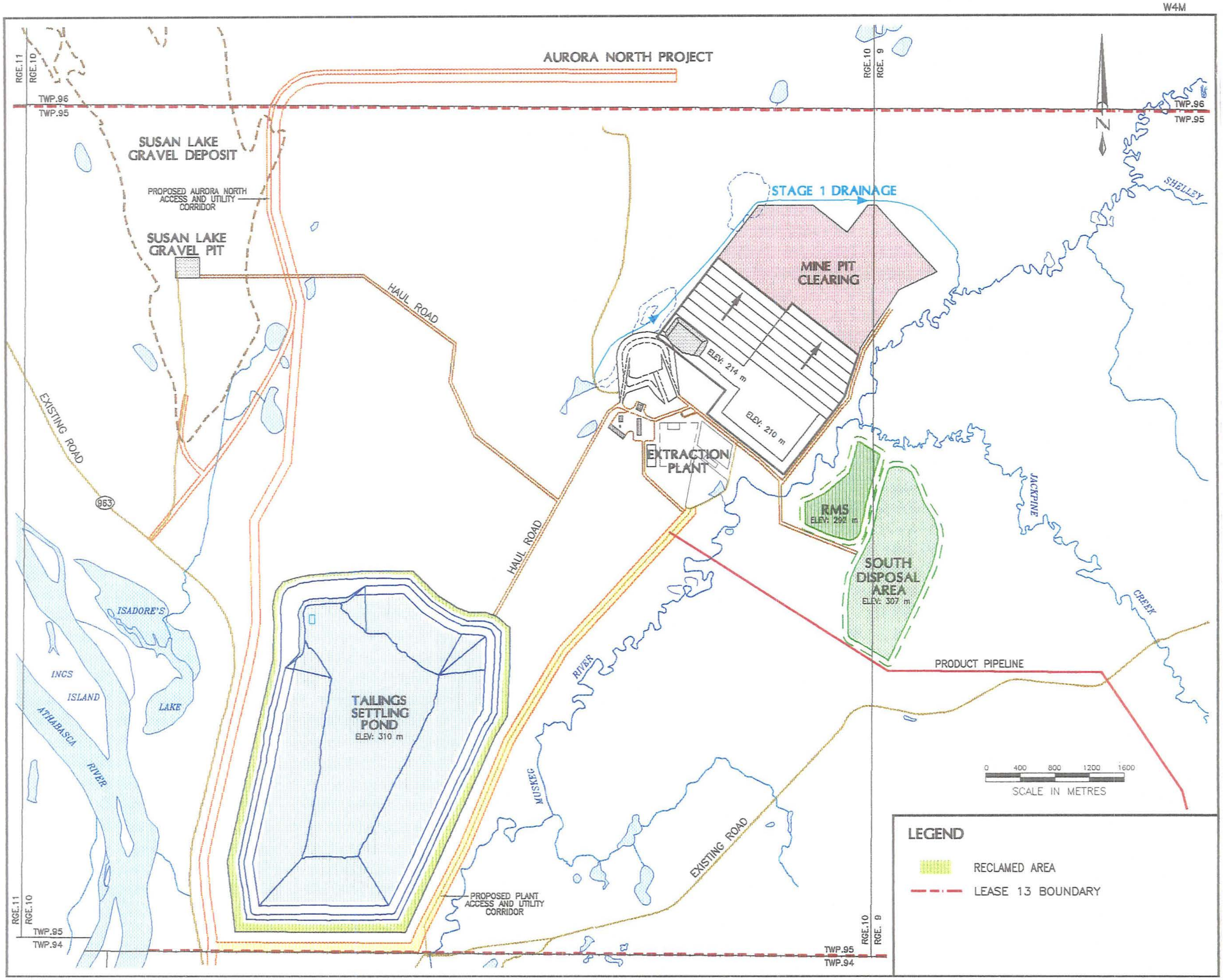


Figure 16-7: Mine Development and Reclamation Progression for Year Ending 2004

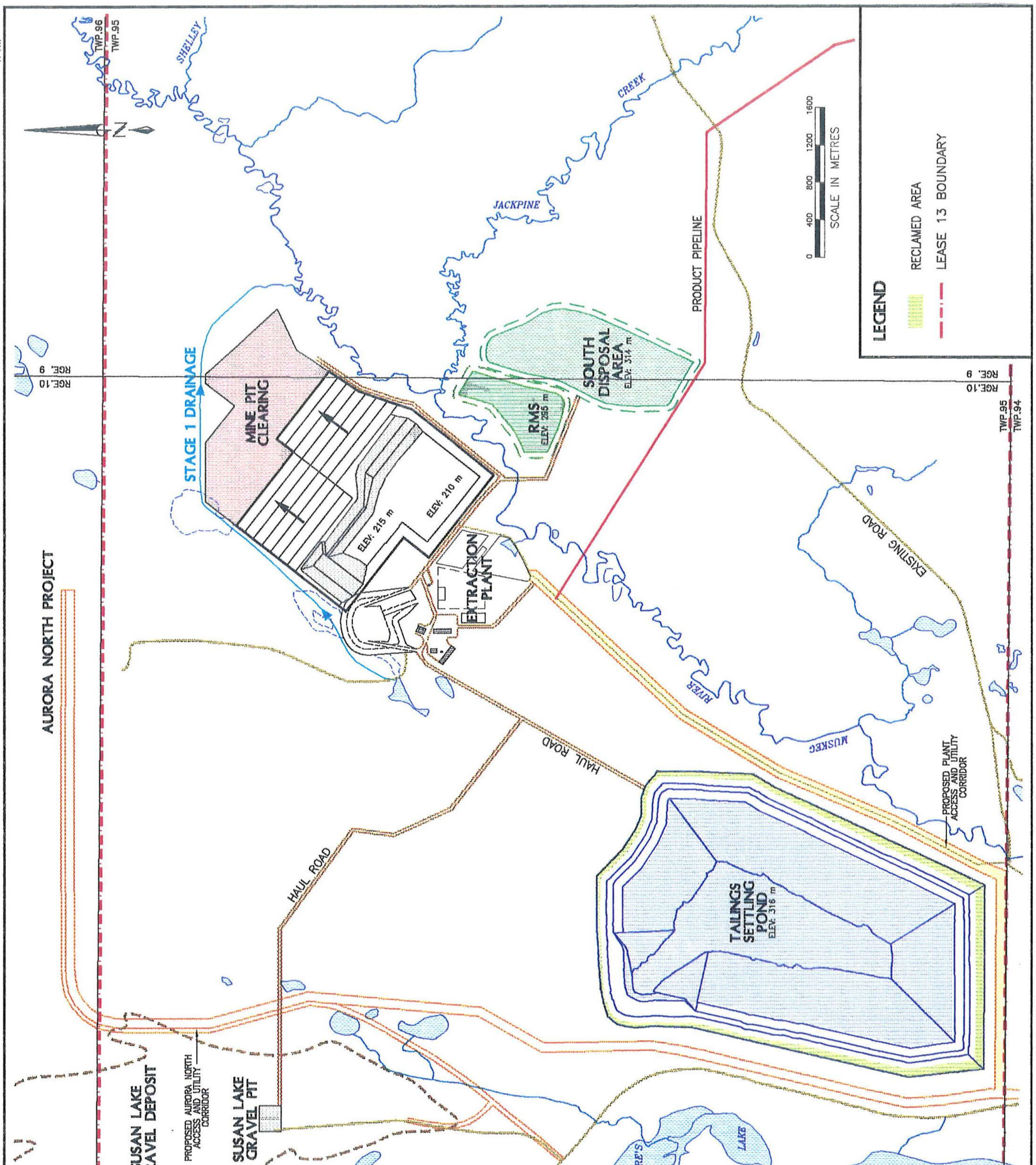


Figure 16-8: Mine Development and Reclamation Progression for Year Ending 2005

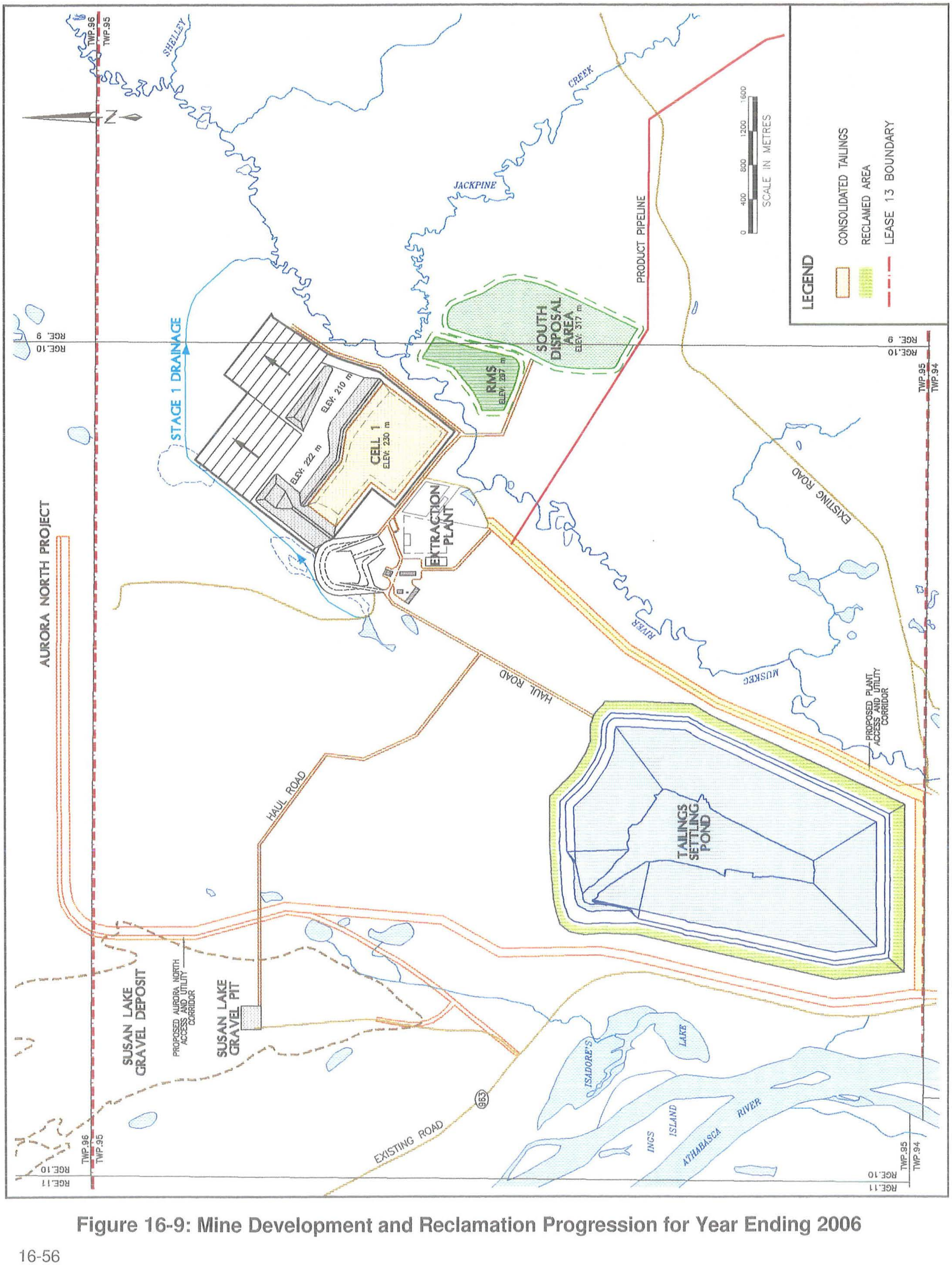


Figure 16-9: Mine Development and Reclamation Progression for Year Ending 2006

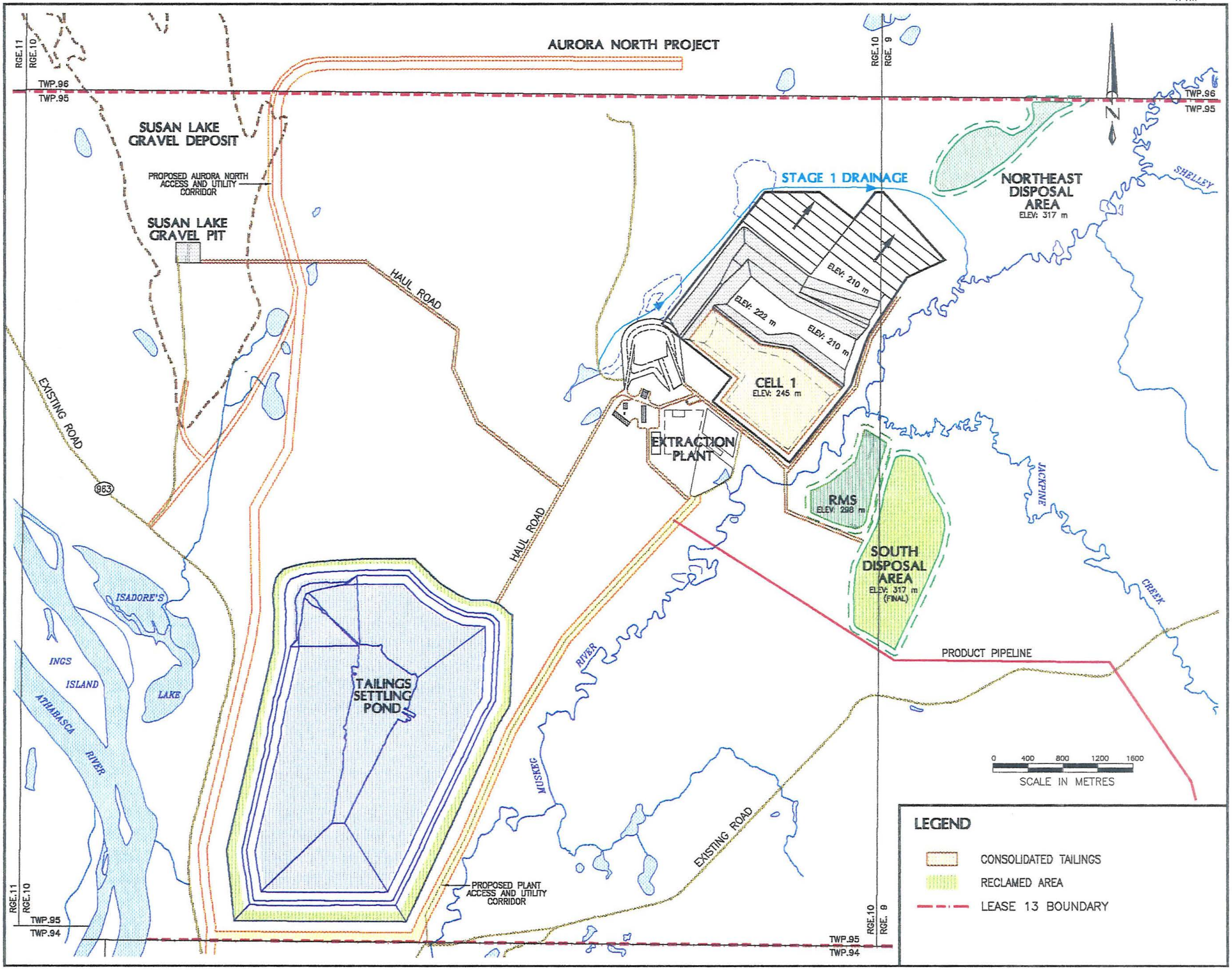


Figure 16-10: Mine Development and Reclamation Progression for Year Ending 2007

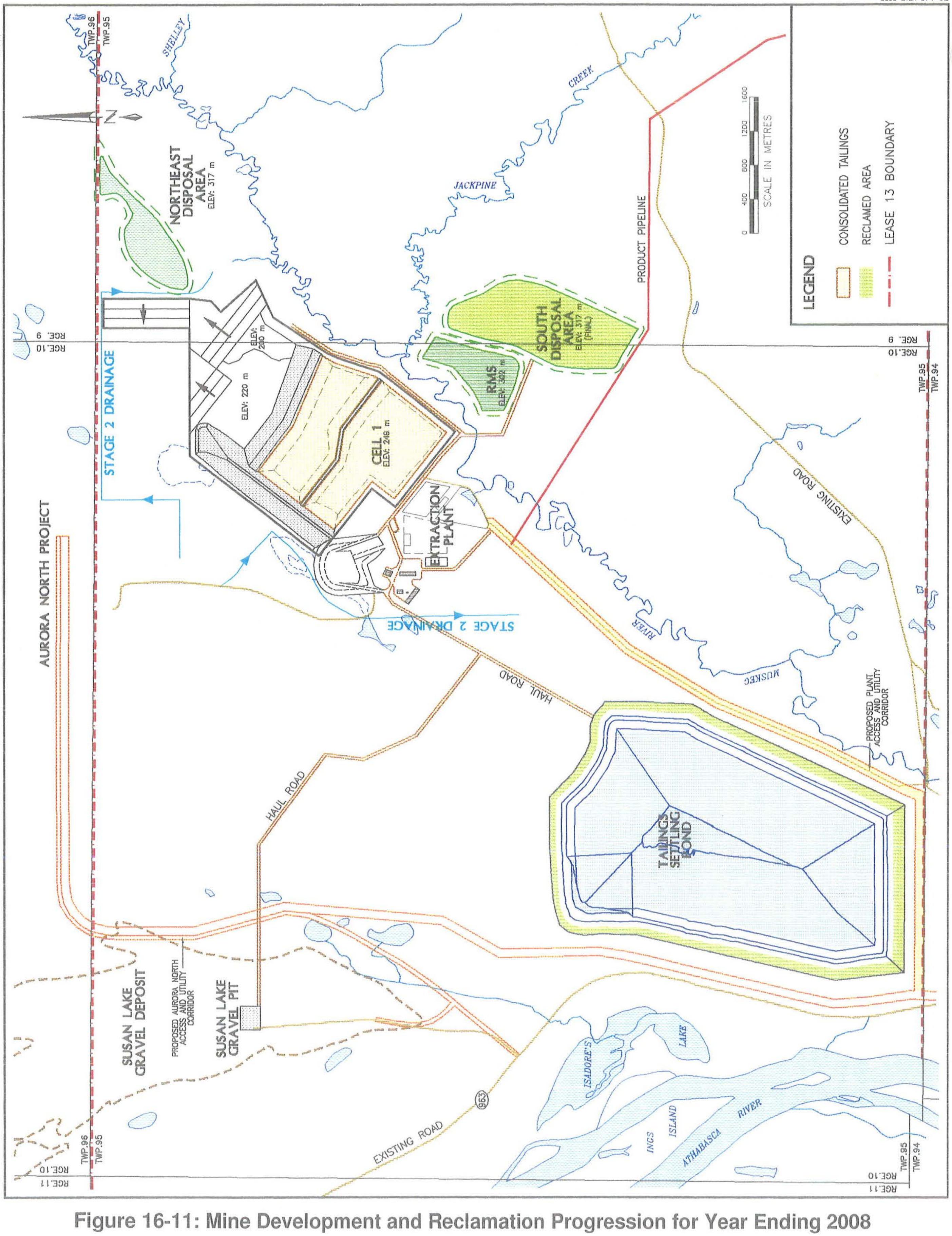


Figure 16-11: Mine Development and Reclamation Progression for Year Ending 2008

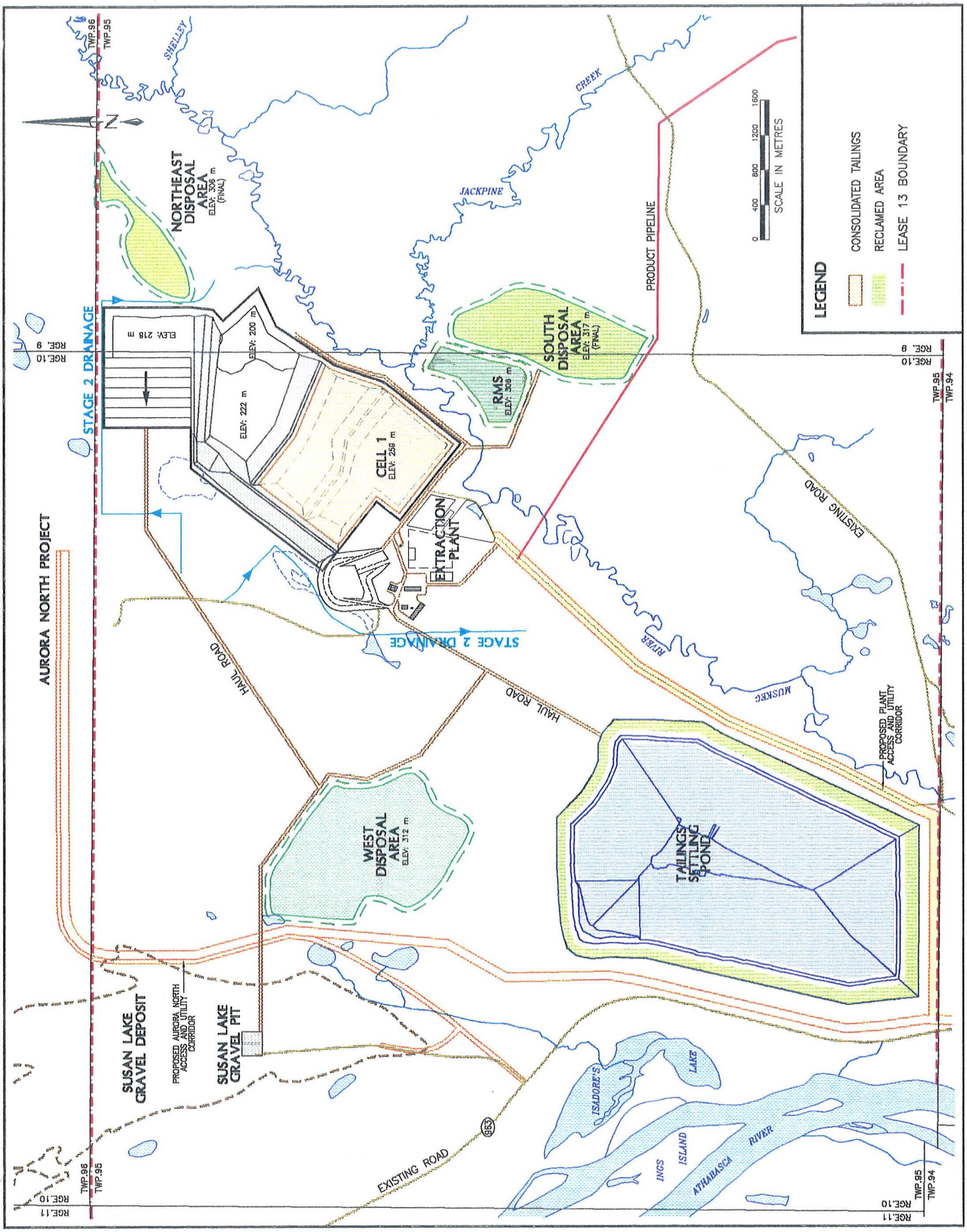


Figure 16-12: Mine Development and Reclamation Progression for Year Ending 2009

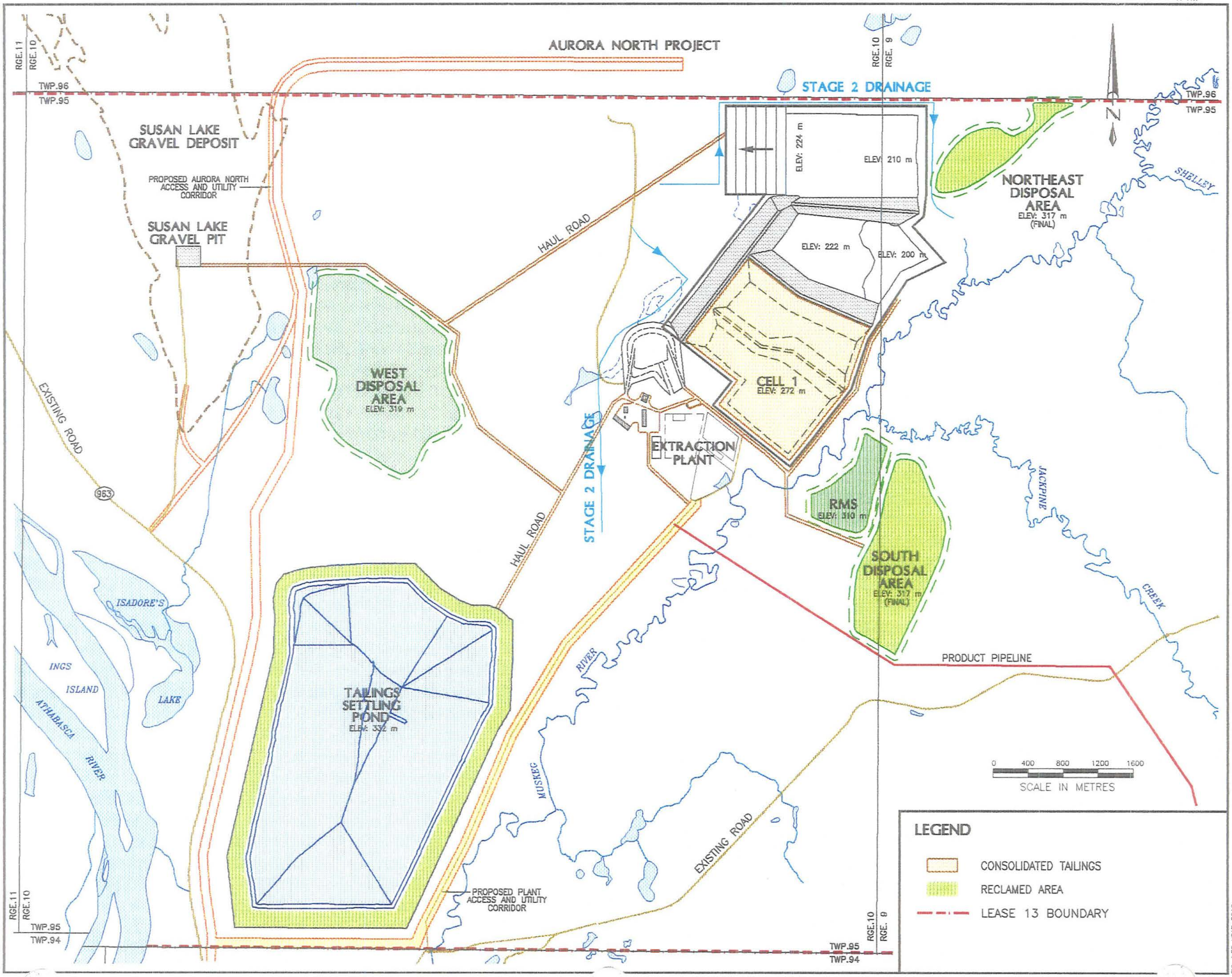


Figure 16-13: Mine Development and Reclamation Progression for Year Ending 2010

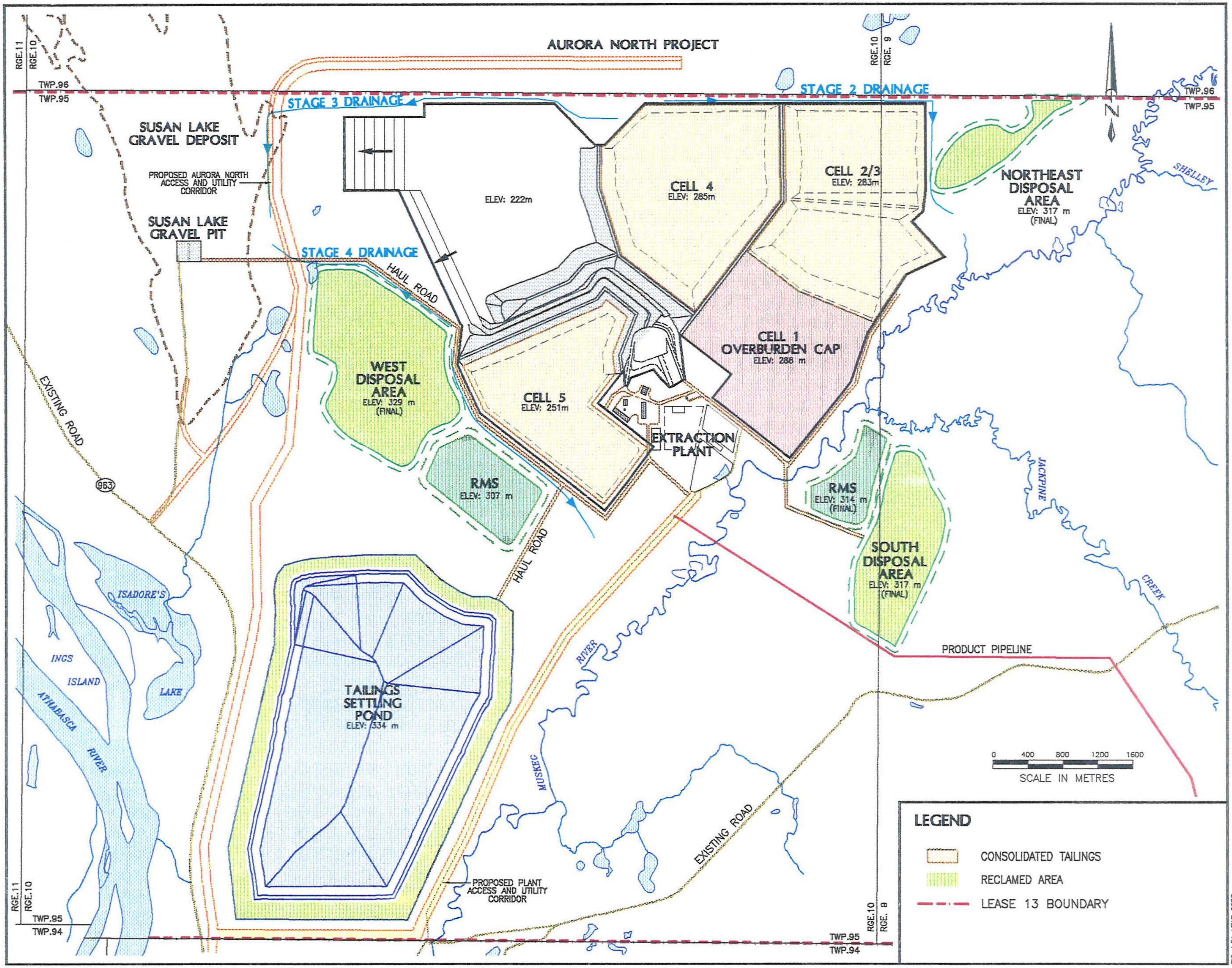


Figure 16-14: Mine Development and Reclamation Progression for Year Ending 2020

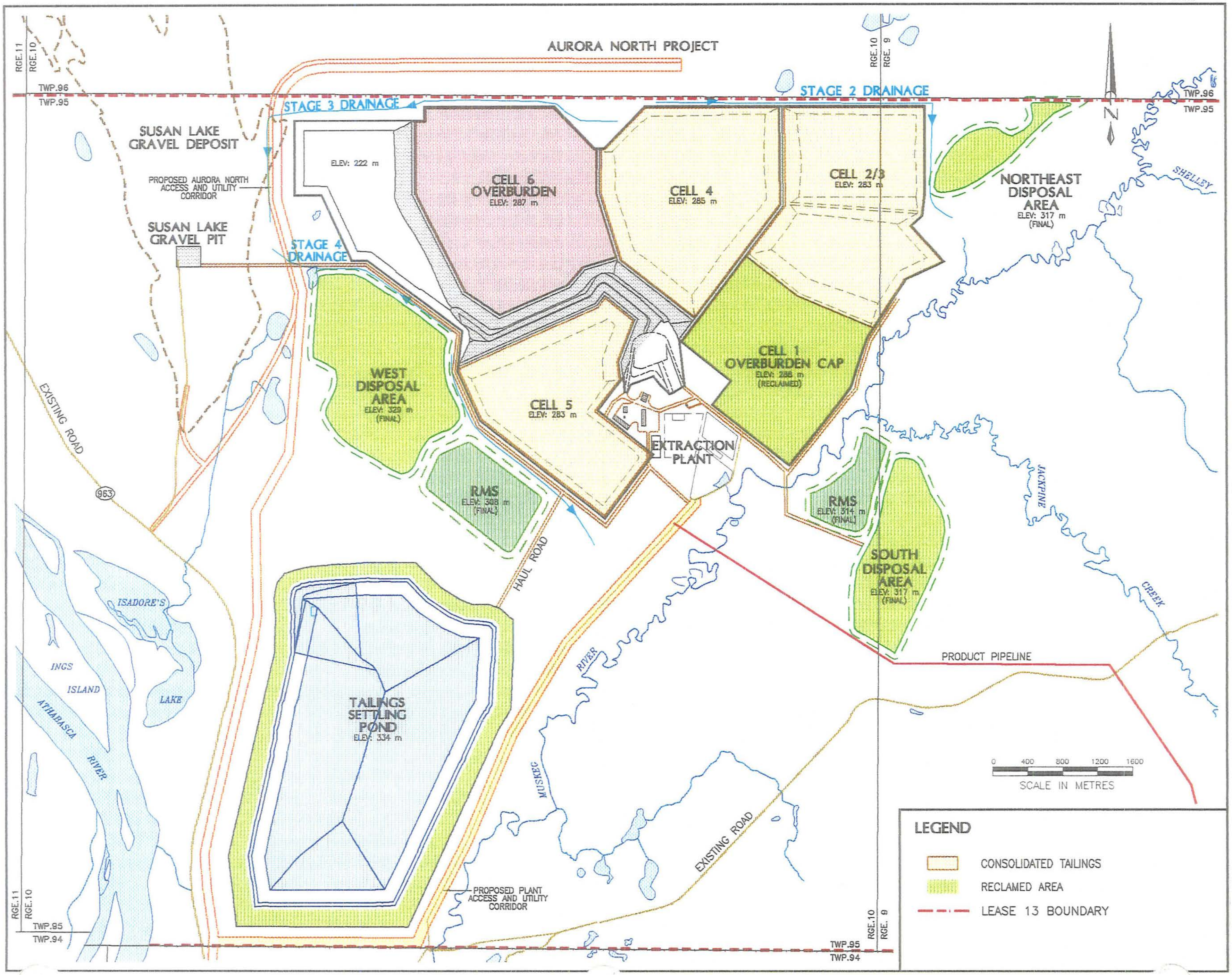


Figure 16-15: Mine Development and Reclamation Progression for Year Ending 2022

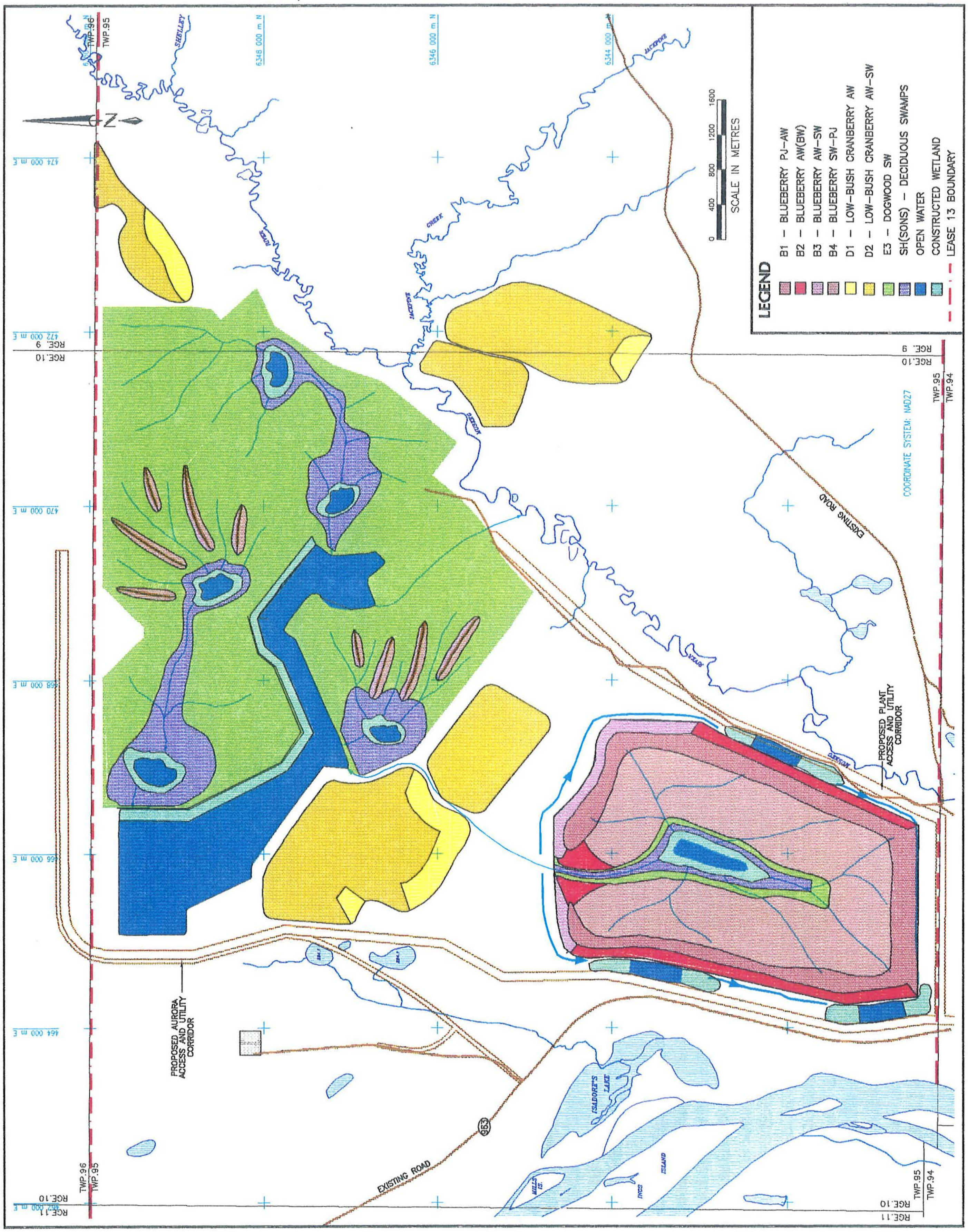


Figure 16-16: Final Ecological Land Classification Following Reclamation

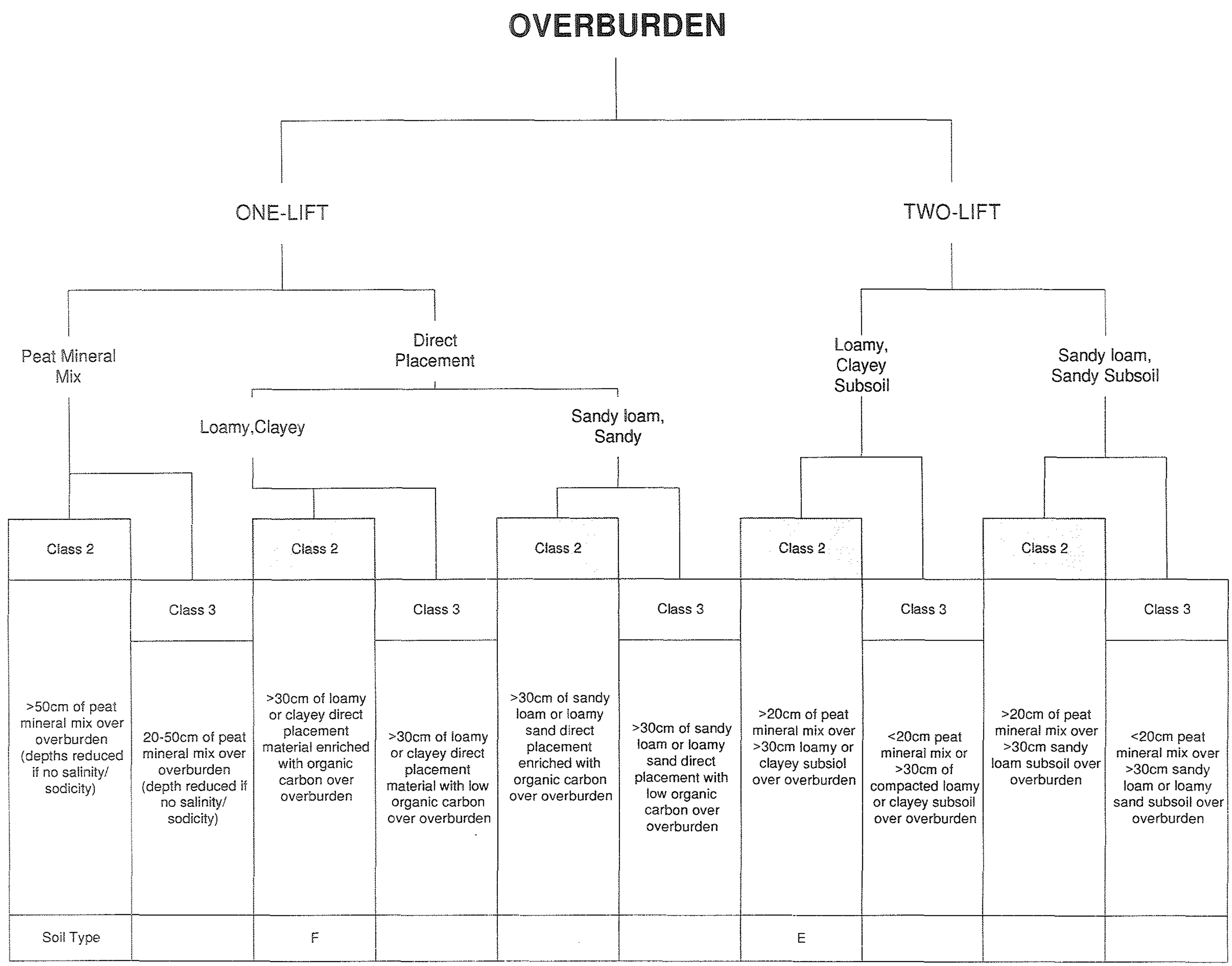


Figure 16-17: Overburden Decision Tree

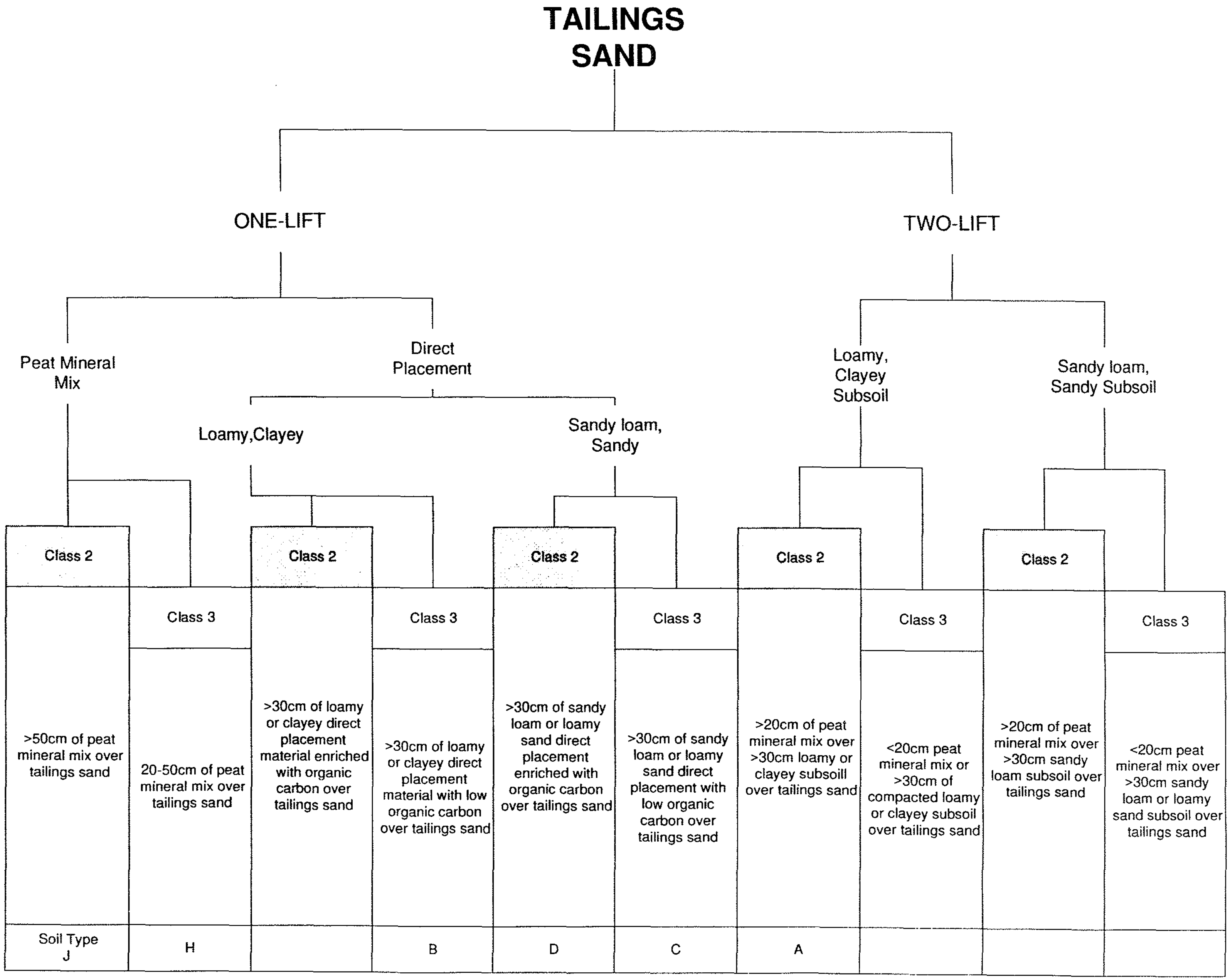


Figure 16-18: Tailings Sands Decision Tree

SCOPE

Approvals under EPEA are required for the use of:

- pesticides
- potable water
- a wastewater and stormwater drainage system

Approval under the Water Resources Act is required to:

- divert and use water
- construct water containment structures
- construct the Muskeg River road crossing

PESTICIDES

Approval

Approval is required under the Pesticide Sales, Handling, Use and Application Regulation 126/93 for the use of pesticides.

The routine use of controlled pesticides at the Muskeg River Mine Project is not expected, but there will be occasions to use certain controlled pesticides. These will be used for weed and shrub control on facility sites, pipeline rights-of-way and other developed areas. Another possible application is controlling on-site camp pests.

In response to the requirements outlined in Regulation 126/93, Shell has developed a corporate standard for using and managing pesticides. All activities associated with the handling, storage, use, and application of controlled pesticides will be carried out in a manner that recognizes and is in compliance with this regulation.

If it is necessary to use a controlled pesticide, a licensed contractor who has appropriately certified applicators will complete this task. The selection and performance monitoring of the contractor will be carried out according to the internal standard for contractor use and performance.

POTABLE WATER

Approval

Approval is required under the Potable Water Regulation 123/93 for the potable water treatment and distribution system for the Muskeg River Mine Project. The potable water systems are separately described for the construction camp and operations phases of this project

Construction Camp

The water supply for the construction camp will consist of a water well. A single well about 50 m deep is expected to provide the flows required. The well will be developed following Alberta Regulations and Guidelines to prevent aquifer contamination. Similarly, the well will be decommissioned in an environmentally acceptable manner as part of the camp demobilization at the end of the construction phase. The treatment and distribution system for potable water during the construction phase is discussed in Water Supply in Section 8.3.

The camp will house a population that will grow from a low of less than 300 to about 900 at the peak of activity. The water supply flows are expected to vary from about 100 m^3 per day up to 450 m^3 per day when the camp population peaks. These flows include living quarters and all services, such as cafeteria, kitchen, laundry and others. This expectation is based on maximum daily consumption of 500 L per person in the camp.

Iron and manganese might be present in well water at concentrations greater than the acceptable guidelines. Water from the well will be directed to an iron and manganese filtration system and received in a water supply tank from where it will be pumped to the camp distribution system. The iron and manganese filters will consist of a granular bed of a catalytic green sand or other similar material in flow-through pressure vessels with distribution and under drain systems. The well water will be aerated and chlorinated before entering the filter. Dissolved oxygen is required for iron and manganese oxidation. Chlorine will regenerate the catalyst and provide predisinfection. The filter backwash water will be discharged to a 700,000 m^3 storage pond that will later become the process recycle water pond. Filter backwash will represent about 5% of the total flow, or a maximum of about 23 m^3/d. The instantaneous backwash flow will be about 400 L per minute, for about an hour each day, assuming three or four filters in parallel.

The water distribution pumping system will be controlled to maintain constant pressure in the distribution piping, and accounting for the rather large instantaneous flow variabilities that are typical in these facilities. The peaking factor is estimated at five times the daily average. The well pump will be controlled to maintain a range of levels in the water supply tank, and an acceptable range of flows through the filters. The well pump will also maintain the level in an independent fire water storage tank.

Construction Camp (cont'd)

The well water will have chlorine added in the form of sodium hypochlorite to the water supply tank. The rate of addition will be controlled by the rate of water inflow to maintain a constant dosage and residual. This treatment will enable the water to meet the *Alberta Drinking Water Quality Guidelines* and the *Guidelines for Canadian Drinking Water Quality.*

The groundwater studies necessary to confirm or revise the assumptions made about water availability and quality will be conducted when the project is approved.

Operations Phase

Potable water for the operating facilities will be supplied from the Athabasca River. The permanent population, once the production facilities are in operation, is estimated at about 650. The consumption of water per person is expected to be significantly lower than during construction, because there will not be any living quarters. Assuming a consumption of 150 L per person per day, the total flow rate of potable water is estimated at about 100 m^3 per day. The instantaneous peaking factor is estimated to be about three times the average. These flows include hygiene facilities as well as other uses, such as kitchen and cafeteria.

Because the river water is laden with sediment and the quality is different from the groundwater quality, a separate treatment system (see Water Supply in Section 8.3) is proposed to provide:

- potable water for the operations
- softened water feed to the separate boiler feed water treatment

Filtered water from the water treatment plant will be pumped from the storage tank. A fraction of this water will be directed to the potable water supply. A constant pressure will be maintained in this drinking water distribution system. Chlorine in the form of sodium hypochlorite will be added to the drinking water supply to provide adequate residuals to meet Alberta Drinking Water Guidelines. A pressure vessel downstream of the point of chlorine injection will provide an adequate contact time.

Potable Water Monitoring

The potable water supply will be monitored during the construction and operation phases of the project. Monitoring will include sampling the raw water and treated water via collection of samples according to the program outlined in Table 16-16.

Monitoring protocols will be in place and any required corrective action will be taken to maintain potable water quality within the Alberta Drinking Water Quality Guidelines and Guidelines for Canadian Drinking Water Quality.

Table 16-16: Monitoring Program for Potable Water

Parameters		Frequency	Sample Type	Location
Raw water	Turbidity and pH	Daily	Grab	Before chemical addition
Treated water	Volume	Daily and continuously	Continuous	Entering distribution system
Treated water	Turbidity	Continuously	In-line turbidity meter	Entering the treated water reservoir
Treated water	pH	Daily	Grab	Before entering the distribution system
Treated water	Turbidity	Once a week	Grab	Random within the distribution system
Treated water	Free chlorine residual	Daily	Grab	Random within the distribution system
Treated water	Bacteriological quality	Four times a month at intervals greater than five days between samples	Grab	Random within the distribution system

OTHER WATER

Waste Water and Stormwater Drainage

Approval

Approval is required under the Wastewater and Stormwater Drainage Regulation 119/93 for the wastewater and stormwater drainage system to be constructed for the Muskeg River Mine Project. The approach to managing waste water and stormwater are provided in:

- Waste Water Treatment in Section 8.3
- Surface Water Management in Section 8.4
- Waste Minimization and Handling Procedures in Section 16.2

Process water will not be discharged offsite. The design, construction, operation and maintenance of the wastewater and stormwater drainage systems will be consistent with Alberta regulations and requirements.

WATER RESOURCES ACT

Approval under Section 11 of the Water Resources Act is sought to:

- divert and use water
- construct water containment structures
- construct the Muskeg River road crossing

WATER RESOURCES ACT (cont'd)

The location of information for diverting, using and containment is shown in Table P-4 in the Preface to this volume.

The information for approval of the road crossing will be provided by May 31, 1998.

GLOSSARY

a	The metric symbol for year.
acidification	The addition of acid to a solution until the pH falls below 7.
additive	A substance added to another substance in small amounts.
adsorption	The surface retention of solid, liquid or gas particles by a solid or liquid.
adverse effect	An undesirable effect to an organism (human, animal or plant).
AEC	The abbreviation for Alberta Energy Company Ltd.
AEP	The abbreviation for Alberta Environmental Protection.
AEPEA	The abbreviation for the Alberta Environmental Protection and Enhancement Act.
AFE	The abbreviation for Authorization for Expenditure.
Ag	The chemical formula for silver.
agglomeration	A technique that combines small particles to form larger particles.
agitation tank	A vessel in which slurry material is maintained in suspension by using an impeller or by recirculating the material with pumps.
AGRA	The abbreviation for AGRA Earth & Environmental.
Al	The chemical formula for aluminum.
ALS	The abbreviation for advanced life support.
alum	Any of a group of double sulphates of trivalent metals, such as aluminum, chromium or iron, and a univalent metal, such as potassium or sodium (e.g., aluminum sulphate).
ambient air	The air in the surrounding atmosphere.
antiscalant	An additive which prevents the buildup of scale, such as from calcium or iron.

AOSTRA	The abbreviation for Alberta Oil Sands Technology Research Authority.
API	The abbreviation for American Petroleum Institute.
APL	The abbreviation for Alberta Power Limited.
aqueous mixture	A combination of substances, one of which is water.
aquifer	A water-saturated, permeable body of rock capable of transmitting significant or usable quantities of groundwater to wells and springs under ordinary hydraulic gradients.
aquifer depressurization	The process of reducing the natural hydrostatic pressure in an aquifer.
archaeology	The scientific study of the unwritten portion of human historic and prehistoric past.
aromatic	Organic compounds with physical and chemical properties resembling those of benzene.
artifact	Any portable object modified or manufactured by humans.
asl	The abbreviation for above sea level.
asphaltene	Any of the dark, solid constituents of crude oils or other bitumens which are soluble in carbon disulphide but insoluble in paraffin naphthas. They hold most of the organic constituents of bitumens.
Assay	A qualitative or quantitative determination of the components of a material such as ore.
ATC	The abbreviation for Athabasca Tribal Council.
auxiliary utilities	Supplementary utilities, such as diesel fuel, nitrogen, plant air and steam.
B	The chemical symbol for boron.
B	The abbreviation for Beach facies.
Ba	The chemical symbol for barium.
bail	A loop of heavy wire snap-fitted around two or more parts of a connector or other device to hold the parts together.
bailer	A long, cylindrical vessel fitted with a bail at the upper end and a flap or tongue valve at the lower extremity.
bank cubic metre	A cubic metre of material in place.

baseline	A surveyed condition that serves as a reference point to which later surveys are coordinated or correlated.
BAW	The abbreviation for beach above water.
bbl	The abbreviation for barrel.
bbl/d	The abbreviation for barrels per day.
bbl/yr	The abbreviation for barrels per year.
BBW	The abbreviation for beach below water.
bcm	The abbreviation for bank cubic metres.
Be	The chemical symbol for beryllium.
bedrock	The body of rock that underlies gravel, soil or other superficial material.
benthic invertebrates	Organisms that live at the bottom of lakes, ponds or streams.
berm	A mound or wall of earth.
BHP	The abbreviation for The Broken Hill Proprietary Company Limited.
BIP	The abbreviation for bitumen in place.
bioaccumulation	The process of an organism storing in its body a higher concentration of a substance than is found in the environment.
bioavailability	The amount of a substance that enters the body following administration of or exposure to the substance.
biocide	A chemical agent that destroys pests. Also known as *pesticide*.
biodiversity	The variety of organisms and ecosystems within particular habitats.
biophysics	The application of physical principles and methods to study and explain the structures of living organisms.
bioremediation	The process of applying corrective action to unbalanced biological systems.
bitumen	A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that might contain sulphur compounds and that, in its naturally occurring state, will not flow to a well.
bitumen froth	Air-entrained bitumen with a froth-like appearance that is the product of the primary extraction step in the warm or hot water extraction process.

bitumen grade	The amount of bitumen in oil sands, usually expressed as a percentage.
blowdown	The act of emptying or depressurizing material in a vessel.
BOD	The abbreviation for biochemical oxygen demand.
boiler feed water	Water that meets required purity specifications and is used in the heat recovery steam generator to produce steam.
borehole	The hole made by drilling or boring.
broadcast seeding	A method of sowing seed using a machine with a rotating fan-like distributor.
BS&W	The abbreviation for basic sediment and water.
bucketwheel	A large mining excavator that uses multiple buckets on a digging wheel.
°C	The symbol for degrees Celsius.
Ca	The chemical symbol for calcium.
$CaCl_2$	The chemical formula for calcium chloride.
CaO	The chemical symbol for calcium oxide.
$CaCO_3$	The chemical symbol for calcium carbonate.
calcium hydroxide	A chemical compound ($CaOH_2$) used in manufacturing cement, mortar and calcium salts. Also known as *hydrated lime*.
calcium oxide	A caustic chemical compound (CaO). Also known as *quick lime* or *caustic lime*.
$CaOH_2$	The chemical formula for calcium oxide.
$CaSO_4\ 2H_2O$	The chemical symbol for gypsum.
catalytic green sand	Sand that is used to change the rate of a chemical reaction and which can be recovered in essentially unaltered form at the end of the reaction.
caustic lime	A caustic chemical compound (CaO). Also known as *calcium oxide* or *quick lime*.
caustic soda	Sodium hydroxide (NaOH), used to maintain an alkaline pH in petroleum fractions.
C&R	The abbreviation for conservation and reclamation.
CANMET	The acronym for the Canadian Centre for Mineral and Energy Technology.

CASA	The abbreviation for Clean Air Strategic Alliance.
CBLPS	The abbreviation for Cree Burn Lake Preservation Society.
CCME	Canadian Council of the Ministers of the Environment.
Cd	The chemical symbol for cadmium.
CEA	The abbreviation for cumulative effects assessment.
CEAA	The abbreviation for Canadian Environmental Assessment Agency.
centre reject material	Sand and clay material that is interbedded with the bitumen ore.
centrifuge	A rotating device for separating, by centrifugal force, suspended particles in solution, according to particle-size fractions.
CEPA	The abbreviation for Canadian Environmental Protection Act.
CHWE	The abbreviation for Clark hot-water extraction.
CH_4	The chemical formula for methane.
chlorination	The introduction of chlorine into a chemical compound or solution.
Cl	The chemical symbol for chlorine.
CML	The abbreviation for Consolidated Metis Locals.
Co	The chemical symbol for cobalt.
CO_2	The chemical formula for carbon dioxide.
cogeneration	The simultaneous on-site generation of electrical power and process steam or heat from the same plant.
coke	A solid residue that contains mainly carbon produced from the (dry) distillation of petroleum or carbonaceous materials.
coker	The processing unit in which coking occurs.
commissioning	The act of setting up equipment and facilities for service.
community	Plant or animal species living in close association or interacting as a unit.
compaction	The process of pore space reduction in soil or sediments from heavier overlying material weighing the soil down.
conceptual model	A model developed during early risk assessment that describes several working hypotheses.

condensate	A light hydrocarbon liquid obtained by condensing hydrocarbon vapours. Condensate typically contains mostly propane, butane and pentane.
conditioning tank	A vessel in which product is treated with additives to give it certain properties
connate water	Water, usually highly mineralized, entrapped in the interstices of igneous rocks when the rocks were formed.
CONRAD	The acronym for Canadian Oilsands Network for Research and Development.
consolidation	The process by which a loose, soft or liquid substance becomes coherent and firm.
consolidated tailings	A non-segregating mixture of plant tailings that consolidates quickly in tailings deposits.
construction phase	The project stage involving building the plant and facilities and preparing for start-up.
contaminant	A substance added to a receiving environment in excess of natural concentrations.
contamination	The process of making unfit for use by introducing unwholesome or undesirable elements.
contouring	The process of shaping the land surface to fit the form of the surrounding land.
Cr	The chemical symbol for chromium.
crude oil	Unrefined liquid petroleum.
crusher	A machine for crushing rock or other materials.
CS	The abbreviation for Coal Swamp facies.
CT	The abbreviation for consolidated tailings.
Cu	The chemical symbol for copper.
cut-off grade	The grade value below which an ore cannot be extracted economically.
CWZ	The abbreviation for clear water zone.
debottlenecking	The act of increasing the capacity of specific pieces of equipment, or parts of a process, to increase the capacity of the whole process.
decommissioning	The act of removing equipment and facilities from service.

deionization	An ion-exchange process in which all charged species or ionizable organic and inorganic salts are removed from solution.
density	The mass or weight of a substance per unit volume.
detritus feeder	A fish that feeds on the bottom substrate of a river or lake.
DFO	The abbreviation for Department of Fisheries and Oceans.
dilbit	A blend of diluent and bitumen.
diluent	The diluting agent added to bitumen to lower viscosity.
disposal well	A well into which salt water or spent chemical is pumped, most commonly part of a saltwater-disposal system.
distillation	The process of producing a gas or vapour from a liquid by heating the liquid in a vessel and collecting and condensing the vapours into liquids.
ditch	A long, narrow excavation dug in the earth for drainage.
dry year	A year in which the total precipitation is below the normal amount and statistically likely to occur once in 10 years.
dyke	A bank of earth constructed to confine water.
ecoregion	Ecological regions that have broad similarities in soil, relief and dominant vegetation.
ecosection	A recognizable landform, such as a river valley or wetlands area.
ecosite	A subdivision of an ecosection, described and analyzed in detail.
ecosystem	An integrated and stable association of living and nonliving resources functioning within a defined physical location.
EH&S	The abbreviation for Environment, Health and Safety.
EIA	The abbreviation for Environmental Impact Assessment.
emergency response	The action taken after an event to minimize the consequences of an emergency.
emissions	Substances discharged into the atmosphere through a stack. See also *stack emissions* and *fugitive emissions.*
emulsion	A stable dispersion of one liquid in a second liquid that will not mix with the first liquid.
ENGOs	The abbreviation for environmental non-government organizations.

end-pit lake — An artificial lake, used to fill the void at one end of a mine, into which the remaining fine tailings at the end of mine life are discharged and stored under a water cap.

Env Can — The abbreviation for Environment Canada.

environmental impact assessment — A review of the effects that a proposed development will have on the local and regional environment.

EPA — The abbreviation for Environmental Protection Agency.

EPC — The abbreviation for engineering, procurement and construction.

EPCM — The abbreviation for engineering, procurement and construction management.

EPEA — The abbreviation for Environmental Protection and Enhancement Act.

ERCB — The abbreviation for Energy Resources Conservation Board (now the EUB).

erosion — The process by which material, such as rock or soil, is worn away or removed by wind or water.

EUB — The abbreviation for Alberta Energy and Utilities Board.

exceedance — An emission whose measured value is more than that allowed by government regulations.

extraction — The process of separating bitumen from the oil sands.

fallback position — An alternative course of action.

facies — Part of a bed of sedimentary rock that differs significantly from the rest of the bed.

facilities — The surface equipment and pipelines required for mining and extraction operations.

FC — The abbreviation for Fluvial Channel Sand facies.

FCPB — The abbreviation for Fluvial Channel Point Bar facies.

Fe — The chemical symbol for iron.

FEED — The abbreviation for front-end engineering and design.

feed ore — Bitumen ore that is processed in the extraction plant.

feedstock — Raw material supplied to a processing or refining facility.

fenceline approval Approval for development activities within the boundaries of a lease area.

fibrous Capable of being separated into fibres.

fine tailings A suspension of fine silts, clays residual bitumen and water produced during bitumen extraction from oil sands.

fines Silt and clay particles.

flare stack A chimney used to dispose of surplus hydrocarbon gases by igniting them in the atmosphere.

floating roof tank A tank with a roof made of steel, plastic, sheet or microballoons, which floats upon the surface of the stored liquid. Floating roofs are used to decrease the vapour space and reduce the potential for evaporation.

flocculant A reagent added to a dispersion of solids in a liquid to bring together the fine particles to form flocs.

flocs Small masses formed in a fluid through coagulation, agglomeration or biochemical reaction of fine suspended particles.

fluvial channel A channel formed by stream or river action.

fluvial deposits All sediments, past and present, deposited by flowing water.

forecast An estimate or prediction of future conditions.

formation A geologic unit of distinct rock types that is large enough in scale to be mappable over a region.

FPOB The abbreviation for Flood Plain and Overbank facies.

froth A type of foam in which solid particles are also dispersed in the liquid, in addition to gas bubbles. The solid particles may be the stabilizing agent.

fresh water Water that is not salty, especially when considered as a natural resource.

fugitive emissions Trace amounts of uncombusted substances that are released into the atmosphere during normal facility and plant operations.

GDP The abbreviation for gross domestic product.

GJ The metric symbol for gigajoules.

glacial till Unsorted sedimentary material deposited directly by and underneath a glacier, consisting of a mixture of clay, silt, sand, gravel and boulders. Also known as *glacial deposits*.

glaciofluvial deposits Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice.

gland A device used to form a seal around a pump to prevent fluid leakage.

glycol A group of compounds, such as ethylene glycol and diethylene glycol, used to dehydrate gaseous or liquid hydrocarbons or to cool fluids (liquids or gas) by acting as a heat transfer medium.

glycol heater A vessel containing glycol that is used to transfer heat.

grade A measure of the quality of raw ore, usually expressed as a percentage of the content of a particular component. See also *bitumen grade*.

grading The process of levelling off to a smooth horizontal or sloping surface.

groundwater Subsurface water that occurs beneath the water table in soils and geological formations that are fully saturated. It is the water within the earth that supplies water wells and springs.

grubbing The process of clearing stumps and roots from land.

gypsum A mineral ($CaSO_4\ 2H_2O$).

H_2O The chemical formula for water.

H_2S The chemical formula for hydrogen sulphide.

ha The abbreviation for hectare.

habitat The part of the physical environment in which a plant or animal lives.

hazardous waste Any waste material that presents a potential for unwanted consequences to people, property and the environment.

Hc The abbreviation for Holocene Colluvium facies.

HCO_3 The chemical formula for bicarbonate.

He The abbreviation for Holocene Aeolian facies.

heat exchanger A piece of equipment used to transfer heat from one fluid (liquid or gas) to another.

heavy oil Crude oil that has a low API gravity.

herbaceous vegetation Plants that have little or no woody tissue.

Hf The abbreviation for Holocene Fluvial facies.

Hg The chemical symbol for mercury.

historical resources Works of nature or by humans valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.

Hl The abbreviation for Holocene Lacustrine facies.

Ho The abbreviation for Holocene Organics facies

HS&E The abbreviation for health, safety and environmental protection.

HV The abbreviation for heating value.

hydrated lime A chemical compound ($CaOH_2$) used in manufacturing cement, mortar and calcium salts. Also known as *calcium hydroxide.*

hydraulic gradient In an aquifer, the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.

hydroconversion The process of adding hydrogen to medium and heavy oils to produce light oil products.

hydrotransport A method of transporting granular material, such as oil sands or extraction tailings, in a water-based slurry in a pipeline.

hypochlorite A chemical (ClO_3^-) found in bleaching agents.

IB The abbreviation for interburden.

impeller The rotating member of a turbine, blower, fan, axial, or centrifugal pump or mixing apparatus. Also known as a *rotor.*

impervious Not allowing water or other fluid to pass through.

infrastructure Basic facilities, such as transportation, communications, power supplies and buildings, which enable an organization, project or community to function.

interburden Waste material located between economically recoverable oil sands.

inversion The process by which one type of emulsion is converted to another.

invertebrate An animal without a backbone and internal skeleton.

isopach map A geological map of subsurface strata showing the various thicknesses of a given formation underlying an area.

isopotential level	An imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise. Also known as *piezometric surface, potentiometric surface* and *pressure surface.*
JV	The abbreviation for joint venture.
K	The chemical symbol for potassium.
KCS	The abbreviation for Clearwater Shale facies.
KCW	The abbreviation for Clearwater Wabiskaw facies.
keq	The metric symbol for killiequivalent.
keq/ha/a	The metric symbol for killiequivalent per hectare per year.
kg	The metric symbol for kilogram.
kg/h	The metric symbol for kilograms per hour.
kg/m	The metric symbol for kilograms per metre.
kg/s	The metric symbol for kilograms per second.
km	The metric symbol for kilometre.
KM	The abbreviation for Cretaceous McMurray Formation (undifferentiated).
km/h	The metric symbol for kilometres per hour.
kPa	The metric symbol for kilopascal.
kPa(g)	The metric symbol for kilopascal gauge.
kV	The metric symbol for kilovolt.
kW	The metric symbol for kilowatt.
L	The metric symbol for litre.
lagoonal mud	Fine-grained deposits originally accumulating in a lagoon environment.
L/s	The metric abbreviation for litres per second.
lean oil sands	Oil sands that have less than 7% bitumen by weight.
leachate	A solution formed by leaching.
leaching	The process of dissolving soluble minerals or metals out of an ore.

Li	The chemical symbol for lithium.
lift	The horizontal surface, adjacent to the mine face, upon which mining equipment operates.
lime	Calcium carbonate ($CaCO_3$).
lime sludge	Discharge from the hot lime softener that contains reacted chemicals in water.
limestone	A sedimentary rock rich in calcium carbonate.
littoral zone	The biogeographic zone between the high and low-water marks.
LOC	The abbreviation for license of occupation.
LSA	The abbreviation for local study area.
LST	The abbreviation for Limestone facies.
M	The metric symbol for mega.
m	The metric symbol for metre.
m^3	The metric symbol for cubic metre.
m^3/a	The metric symbol for cubic metres per annum.
m^3/d	The metric symbol for cubic metres per day.
macronutrient	A large substance that provides nutrition.
makeup water	The process water required to replace that lost by evaporation or leakage in a closed-circuit, recycle operation.
masl	The abbreviation for metres above sea level.
material balance	A calculation to inventory material inputs versus outputs in a control system.
mature fine tailings	Fine tailings that have dewatered to about 30% solids during the three years following deposition.
Mbbl	The abbreviation for millions of barrels.
merchantable timber	The coniferous and deciduous trees that are cut down during site clearing and that can be sold.
meteorological measurements	Values for atmospheric or weather-related conditions, particularly wind, temperature and air density.

meteorology	The science of the atmosphere and its phenomena.
MFT	The abbreviation for mature fine tailings.
Mg	The chemical formula for magnesium.
mg/L	The metric symbol for milligrams per litre.
MIBC	The abbreviation for methyl isobutyl carbinol.
Microtox	A toxicity test that includes assaying light produced by a strain of luminescent bacteria.
mitigate	To cause to become less harsh or hostile.
MLD	The abbreviation for McLelland (soil type).
MLL	The abbreviation for miscellaneous lease.
MLP	The abbreviation for miscellaneous permit.
mm	The metric symbol for millimetre.
Mm^3	The metric symbol for millions of cubic metres.
MMSCFD	The abbreviation for million standard cubic feet per day.
Mn	The chemical symbol for manganese.
Mo	The chemical symbol for molybdenum.
monitoring	The process of measuring continuously, or at intervals, a condition that must be kept within set limits.
MSL	The abbreviation for mineral surface lease.
MUS	The abbreviation for Muskeg (soil type).
muskeg	A thick deposit of partially decayed vegetable matter of wet boreal regions.
MW	The metric symbol for megawatt.
N	The chemical symbol for nitrogen.
N_2	The chemical formula for nitrogen.
N_2O	The chemical formula for oxides of nitrogen. Also known as *nitrous oxide*.
Na	The chemical formula for sodium.

NAABA	The abbreviation for Northeastern Alberta Aboriginal Business Association.
NaOH	The chemical symbol for sodium hydroxide.
naphtha	A petroleum fraction with volatility between gasoline and kerosene.
net social benefit	The total economic benefit minus the economic cost of a project.
neutralization	The process of making a solution neutral (neither acidic nor basic, and with a pH of 7), by adding a base to an acidic solution or an acid to a basic solution.
NGO	The abbreviation for non-government organizations.
NGTL	The abbreviation for NOVA Gas Transmission Ltd.
Ni	The chemical symbol for nickel.
nitrogen blanket	A layer of nitrogen placed over volatile hydrocarbons to prevent fugitive emissions
NO_2	The chemical formula for nitrogen oxide.
NO_x	The chemical formula for oxides of nitrogen.
nonpotable water	Water unfit for human consumption.
non-toxic	Not poisonous.
NQ	The abbreviation for not quantified.
NRB	The abbreviation for net recoverable bitumen.
NRCan	The abbreviation for Natural Resources Canada.
nutrients	Environmental substances, such as nitrogen or phosphorous, that are necessary for the growth and development of plants and animals.
OB	The abbreviation for overburden.
OBIP	The abbreviation for original bitumen in place.
OD	The abbreviation for outside diameter.
OH&S	The abbreviation for Occupational Health and Safety.
oil sands	An unconsolidated, porous sand formation or sandstone containing or impregnated with petroleum or hydrocarbons.

operating costs	The dollar amount required to run a facility or organization.
operations phase	The project stage involving oil sands mining and bitumen extraction.
orebody	A solid and fairly continuous mass of ore, which may include low-grade ore and waste as well as pay ore, but is individualized by form or character from adjoining country rock.
ore grade	A measure of the quality of raw ore, usually expressed as a percentage of bitumen content.
ore deposit	Rocks containing minerals of economic value in an amount that can be profitably exploited.
ore reserve	The total tonnage and average value of proved ore, plus the total tonnage and assumed value of the probable ore.
organic matter	The fraction of a soil that contains plant and animal residues in various stages of decomposition.
OSEC	The abbreviation for Oil Sands Environmental Coalition.
OSM	The abbreviation for Offshore Mud facies.
osmosis	The transport of a solvent through a semipermeable membrane into a solution of higher concentration, equalizing the concentrations of solute on both sides of the membrane.
outlier	A group of rocks separated from the main mass and surrounded by outcrops of older rocks.
overburden	All material, including soil, sand, silt or clay, that has to be removed to expose the ore before it can be mined.
P	The chemical symbol for phosphorous.
P&IDs	The abbreviation for process and instrumentation diagrams.
PAH	The abbreviation for polycyclic aromatic hydrocarbon.
Paleosol	An ancient soil horizon.
paraffinic solvent	A solvent made up of a mixture of pentane and hexane.
particulate emissions	Emissions of fine particles of liquid or solid.
paste technology	A method of thickening fine clay particles by adding chemical polymers.
Pb	The chemical symbol for lead.

permeability The capacity of a porous rock, soil, or sediment for transmitting a fluid without damaging the structure of the medium.

pervious A rock, soil or sediment that can transmit a fluid without structural alteration.

pesticide A chemical agent that destroys pests. Also known as *biocide*.

Pfg The abbreviation for Pleistocene Fluvial Gravel facies.

Pfs The abbreviation for Pleistocene Fluvial Sand facies.

Pg The abbreviation for Pleistocene Till facies.

pH value The measurement of a substance's acidity or alkalinity.

phosphate A compound that contains the phosphate group (PO_4^{3-}). Also, the generic term for a phosphate-containing fertilizer material.

phreatic surface The planar surface between the zone of saturation and the zone of aeration. Also known as *water table*.

piezometer An instrument for measuring fluid pressure.

piezometric surface An imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise. Also known as *isopotential level, potentiometric surface* and *pressure surface*.

Pl The abbreviation for Pleistocene Lacustrine facies.

plant propagule A plant's shoot, which can be planted and grows into another plant.

PM The abbreviation for particulate matter.

Pog The abbreviation for Pleistocene Outwash Gravel facies.

porewater The fluid filling the small spaces between particles of rock.

Pos The abbreviation for Pleistocoene Outwash Sand facies.

potable water Water that is suitable for drinking.

potentiometric surface An imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise. Also known as *isopotential level, piezometric surface* and *pressure surface.*

ppm The abbreviation for parts per million.

precipitation The rain or snow that falls on the earth's surface.

prestripping	The process of removing overburden from the surface of the land in preparation for mining.
procurement	The process of obtaining materials, equipment and services, including purchasing, contracting and negotiating directly with the source of supply.
production forecast	The amount of oil expected to be recovered within a particular time frame.
PRD	The abbreviation for paraffin recovery unit.
PSD	The abbreviation for paraffinic solvent demulsification.
PSOL	The abbreviation for Paleosol facies.
Quaternary	The most recent geologic time period, encompassing the last two million years.
quick lime	A caustic chemical compound (CaO). Also known as *calcium oxide*.
quick lime slaker	A vessel in which quick lime (*calcium oxide*) is converted to slaked lime (*calcium hydroxide*).
radiotelemetry	The process of obtaining data at a location remote from the source of the data, using radio waves for transmitting the data.
RAMP	The abbreviation for Regional Aquatics Monitoring Program.
RAQCC	The abbreviation for the Regional Air Quality Coordinating Committee.
RCMP	The abbreviation for Royal Canadian Mounted Police.
reclamation	The process of stabilizing and returning disturbed land to a natural state of equivalent or better capability.
reclaimed landscape	An area that has undergone reclamation.
recycled water	Water that is stripped from the oil sands during the extraction process and treated for reuse in the process.
regenerant	A solution that restores the activity of an ion-exchange bed.
rejects	Material, such as clay or lean oil sands, that do not pass through the extraction sizing screens and are, therefore, excluded from the process.
reserves	The unproduced but recoverable bitumen in a formation that has been proven by production.
resin	A solid or semisolid organic product of natural or synthetic origin that has no definite melting point. Most resins are polymers.

resource	A natural source of revenue, such as oil or gas.
reticulation system	A system of overhead power lines which supplies mining equipment with electrical power.
revegetation	The process of providing denuded land with a new cover of plants.
reverse osmosis	A technique used in waste water treatment where pressure is applied to the surface of a waste solution, forcing pure water to pass from the solution through a membrane that will not allow sodium or chloride ions to pass.
rheology	The study of the deformation and flow of matter, especially the non-Newtonian flow of liquids and plastic flow of solids.
right-of-way	The right of passage or of crossing over someone else's land. An easement in lands belonging to others that is obtained by agreement or lawful appropriation for public or private use.
riparian corridors	Corridors that are located on a riverbank.
RIWG	The abbreviation for Regional Infrastructure Working Group.
risk assessment	The process of evaluating the probability of adverse effects occurring as a result of exposure to one or more stressors.
RMWB	The abbreviation for Regional Municipality of Wood Buffalo.
royalties	The share of profits reserved by the body granting an oil or mining lease.
RSA	The abbreviation for regional study area.
runoff	The portion of precipitation (rain and snow) that ultimately reaches streams via surface systems.
S	The chemical symbol for sulphur.
sandstone	A sedimentary rock composed of individual grains of sand cemented together.
SCO	The abbreviation for synthetic crude oil.
SCOSD	The abbreviation for Standing Committee on Oil Sands Development.
sedimentary rock	A rock composed of materials that were transported to their present position by water or wind.
sedimentary sequence	The particular order in which rock layers occur.
sedimentary zone	A sedimentary rock stratum that is different from or distinguished from another stratum.

sedimentation pond	A small waterbody where suspended solid particles settle out and are deposited at the bottom of the pond.
seepage	The slow movement of water or other fluids through a porous medium, or through small openings in the surface of unsaturated soil.
SEIA	The abbreviation for socio-economic impact assessment.
sensible heat	The heat absorbed or evolved by a substance during a change of temperature that is not accompanied by a change of state.
separator	A vessel designed to separate the oil phase in a petroleum fluid from some or all of the other three constituent phases (gas, solids and water).
separation	The process of isolating components in streams of mixed fluids.
SF	The abbreviation for Shoreface facies.
SFR	The abbreviation for sand to fines ratio.
shutdown	The process of stopping equipment or machinery or a process, partly or completely.
Si	The chemical symbol for silicon.
slaked lime	See *calcium hydroxide.*
slash burning	The process of clearing vegetation from the land and setting fire to the remaining undergrowth.
sluicing	The process of moving rock or mineral materials in a flowing stream of water.
slurry	A free-flowing, pumpable suspension of fine solid material in liquid.
Sm^3/d	The abbreviation for standard cubic metres per day.
Sm^3/h	The abbreviation for standard cubic metres per hour.
SMART	The abbreviation for Shell McKay Application Review Team.
SO_2	The chemical formula for sulphur dioxide.
SO_4	The chemical formula for sulphate.
socio-economics	The study of social and economic factors.
soil capability	The measure of a soil's capacity to sustain vegetation.
solvent	The part of a solution that is present in the largest amount.

Sr	The chemical symbol for strontium.
SRU	The abbreviation for solvent recovery process.
stack	The portion of a chimney rising above the roof.
stack emissions	Substances discharged into the atmosphere through a plant stack.
stakeholder	People or organizations with an interest or share in an undertaking, such as a commercial venture.
start-up	The act of restarting work or energizing machinery or equipment after a temporary shutdown or commissioning.
start-up water	The additional volume of water required temporarily to start up a new development.
sterilization of ore	The process of making ore recovery uneconomical.
stockpile	A gradually accumulated reserve of material.
stratigraphy	A branch of geology that deals with the arrangement of rock layers.
sulphuric acid	A toxic, corrosive strongly acidic colourless liquid (H_2SO_4).
supernatant	The liquid overlying settled solids.
surfactant	Any substance that lowers the surface or interfacial tension of the medium in which it is dissolved. Surfactants may be naturally occurring or a soluble chemical compound.
surge	The accumulation of liquid above a normal or average level, or a sudden increase in its flow rate above a normal flow rate.
surge tank	A vessel through which liquids or gases are passed to ensure steady flow and eliminate pressure surges.
sustainability	The process of managing biological resources (e.g., timber, fish) to ensure replacement by regrowth or reproduction of the part harvested before another harvest occurs.
sustainable landscape	Landscape that can survive extreme events and natural cycles of change without being subjected to accelerated erosion or environmental impacts more severe than those of the natural environment.
synthetic crude oil	Oil obtained by refining heavier hydrocarbons.
t	The metric symbol for tonnes.
t/d	The metric symbol for tonnes per day.

t/h	The metric symbol for tonnes per hour.
tailings	A by-product of oil sands extraction comprising water, coarse sand, fine minerals and minor amounts of rejected bitumen waste.
tailings settling pond	An artificial impoundment structure to contain tailings. Tailings settling ponds are enclosed by dykes made with tailings and overburden materials to stringent geotechnical standards.
TC	The abbreviation for Tidal Channel Sand facies.
TCB	The abbreviation for Tidal Channel Breccia facies.
TCM	The abbreviation for Tidal Channel Mud facies.
TCFC	The abbreviation for Tidal Channel and Fluvial Channel Sand facies.
TCTF	The abbreviation for Tidal Channel and Tidal Flat facies.
TDS	The abbreviation for total dissolved solids.
TEH	The abbreviation for total extractable hydrocarbons.
TFM	The abbreviation for Tidal Flat Muddy facies.
TFS	The abbreviation for Tidal Flat Sandy facies.
TFT	The abbreviation for thin fine tailings.
third-party services	Services contracted by one organization to another.
Ti	The chemical symbol for titanium.
timber salvage	The process of clearing the land of trees and retaining the trees to be sold for various uses.
TLM	The abbreviation for Tidal Lagoonal Mud facies.
tonnage	The total weight in tonnes.
topography	The configuration of a surface including its relief and natural and artificial features.
TOR	The abbreviation for Terms of Reference.
toxicity	The kind and amount of poison possessed by a chemical substance not of biological origin.
TRS	The abbreviation for total reduced sulphur.

truck-and-shovel mining The process of using large trucks and shovels to obtain ore from the ground.

TSRU The abbreviation for tailings solvent recovery unit.

TSS The abbreviation for total suspended solids.

turbine A rotary engine, usually made with a series of curved vanes on a central spindle, that is actuated by a current of fluid, such as water, steam or air.

TV The abbreviation for total volume.

TV/BIP The abbreviation for the ratio of total volume to bitumen in place.

TV/NRB The abbreviation for the ratio of total volume to net recoverable bitumen.

U The chemical symbol for uranium.

UMATAC The abbreviation for UMA Industrial Processes.

upgrader A system of process units that uses either hydrogen addition or carbon rejection to convert bitumen or heavy oil to light oil products or light oil components.

UTF The abbreviation for underground test facility.

utilities The supply of electricity, natural gas, water and sewer drains.

utility corridor A right-of-way containing pipelines, power lines and road access.

V The chemical symbol for vanadium.

vapour recovery The process of capturing and recycling process water vapour in a closed-circuit system.

VGO The abbreviation for vacuum gas oil.

viscosity The fluid property that characterizes the amount of functional energy loss during flow.

VOCs The abbreviation for volatile organic compounds.

vol% The abbreviation for volume percent.

waste All solids, liquids and sludge produced in the course of constructing, operating and abandoning the facilities.

waste management plan The system developed to track and control emissions and waste and evaluate pollution-prevention steps.

water management plan	The system developed to optimize the use of available water supplies.
waterbody	A natural geographical feature containing water, such as a lake or stream.
watershed	An area bounded peripherally by a divide and draining ultimately to a particular watercourse or waterbody.
water table	The upper surface of groundwater or the level below which the soil is saturated with water. Also known as *phreatic surface.*
wellbore	The hole drilled by the bit in a well.
wetlands	A broad group of wet habitats where the water table is usually at or near the surface or the land is covered by shallow water.
wet year	A year in which the total precipitation is above the normal amount and statistically likely to occur once in 10 years.
work-year	A unit of measurement for employment that is equivalent to one year's work by one person.
wt%	The abbreviation for weight percent.
Zn	The chemical symbol for zinc.