SUNCOR ENERGY

Project Millennium Application 2B

Submitted to **Alberta Energy and Utilities Board** and **Alberta Environmental Protection**

Volume 2B
Environmental Impact Assessment
Terrestrial Resources, Closure Assessment

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Project Millennium
Taking Suncor into the 21st Century

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LIST OF ABBREVIATIONS

"	Inch
$k	Thousand dollars
%	Percent
<	Less than
>	More than
°C	Temperature in degrees Celsius
°F	Temperature in degrees Fahrenheit
7Q10	Lowest 7-day consecutive flow that occurs, on average, once every 10 years
AAC	Annual Allowable Cut
AEOSRD	Alberta Energy Oil Sands and Research Division
AEP	Alberta Environmental Protection
AEP-LFS	Alberta Environmental Protection - Lands and Forest Service
AEPEA	Alberta Environmental Protection and Enhancement Act
AEUB	Alberta Energy and Utilities Board (also EUB)
Al-Pac	Alberta Pacific Forest Industries Inc.
AMD	Air Monitoring Directive
ANC	Acid Neutralizing Capacity
AOSERP	Alberta Oil Sands Environmental Research Program
API	American Petroleum Institute
ARC	Alberta Research Council
asl or ASL	Above sea level
ATP	AOSTRA Taciuk Process
avg.	Average
AVI	Alberta Vegetation Inventory
bbl	Barrel, petroleum (42 U.S. gallons)
bbl/cd	Barrels per calendar day
BCM	Bank cubic metres
BCY	Bank cubic yards
BOD	Biological oxygen demand
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
C	Carbon
C&R	Conservation and Reclamation
Ca^{2+}	Calcium base cation (particle)
$CaCO_3$	Calcium carbonate
CANMET	Canada Centre for Mineral and Energy Technology
CASA	Clean Air Strategic Alliance
$CaSO_4$	Calcium sulphate
CCME	Canadian Council of Ministers of the Environment
cd	Calendar day
CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Association
CEC	Cation exchange capacity
CEPA	Canadian Environmental Protection Act
ch	Calendar hour
CHWE	Clark Hot Water Extraction
CLI	Canadian Land Inventory

cm	Centimetre
cm/s	Centimetres per second
cm^2	Square centimetre
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical oxygen demand
COH	Co-efficient of haze
CONRAD	Canadian Oil Sands Network for Research and Development
Consortium	Fine Tailings Fundamentals Consortium
CPUE	Cateh per unit of effort
CSEM	Continuous Stack Emissions Monitor
CT	Consolidated Tailings
CWQG	Canadian Water Quality Guidelines
d	Day
DBH	Diameter at breast height
DCU	Delayed Coking Unit
DEA	Diethanolamine
DEM	Digital Elevation Model
DIAND	Department of Indian Affairs and Northern Development
DL	Detection Limit
DO	Dissolved oxygen
DRU	Diluent Recovery Unit
e.g.	For example
EA	Effective Acidity
EC	Effective Concentration
EIA	Environmental Impact Assessment
ELC	Ecological Land Classification
elev	Elevation
EPL	End Pit Lake
ER	Exposure Ratio
ESPs	Electrostatic Precipitators
FEM	Finite Element Modelling
FGD	Flue Gas Desulphurization
FMA	Forest Management Agreement
ft	Feet
ft^3	Cubic feet
FTPH	Final Tailings Pump House
g	Grams
g/cc	Grams per cubic centimetre
g/s	Grams per second
GC/FID	Gas Chromatography/Flare Ionization Detection
GC/MS	Gas Chromatography/Mass Spectrometry
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GJ	Giga-joules (10^9 joules)
GLC	Ground Level Concentration
Golder	Golder Associates Ltd.
GTG	Gas Turbine Generator
h	Hour

H_2S	Hydrogen sulphide
ha	Hectares
HNO_3	Nitric Acid (gas)
HQ	Hazard Quotient
HRSG	Heat Recovery Steam Generator
HSI	Habitat Suitability Indicies
HU	Habitat Unit
i.e.	That is
ibid.	In the same place
IC	Inhibiting Concentration
ICP	Inductively Coupled Argon Plasma Atomic Emission Spectrometric Analysis
IR	Infrared Spectrophotometric Analysis
IRIS	Integrated Risk Information System
IRP	Integrated Resource Plan
k	Thousand
K^+	Potassium Base Cation (particle)
kg	Kilogram
kg/d	Kilograms per day
kg/ha	Kilograms per hectare
kg/hr	Kilograms per hour
KIRs	Key Indicator Resources
km	Kilometre
km^2	Square kilometre
kmol.	kilo mole
kV	Kilovolt
kW	Kilowatt
L or l	Litre
lb/hr	Pounds per hour
LC	Lethal Concentration
LC/MS	Liquid Chromatography/Mass Spectrometry
LGHR	Low-Grade Heat Recovery
LHV	Lower Heating Value
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observed Effect Level
m	Metre
M	Mega (SI prefix)
m/s	Metres per second
m^2	Square metres
m^3	Cubic metres
m^3/cd	Cubic metres per calendar day
m^3/d	Cubic metres per day
m^3/ha	Cubic metres per hectare
m^3/hr	Cubic metres per hour
m^3/s	Cubic metres per second
masl	metres above sea level
MDEA	Methyl-diethanolamine
meq	Milli-equivalents
MFT	Mature Fine Tails

mg	Milligrams
MOU	Memorandum of Understanding
MSL	Mineral Surface Lease
μg	Microgram
μg/g	Micrograms per gram
μg/kg/d	Micrograms per kilogram body weight per day
mg/kg/d	Milligrams per kilograms body weight per day
μg/L	Micrograms per litre
mg/L	Milligrams per litre
$\mu g/m^3$	Micrograms per cubic metre
Mg^{2+}	Magnesium base cation (particle)
MJ	Megajoule (10^6 joules)
MM	Million
mm	Millimetre
MM.BTU	Million British Thermal Units
Mm^3	Mega metres (Million cubic metres)
Mobil	Mobil Oil Canada
mS/cm	milli-siemens per centimetre
MVA	Mega volt-amperes
MW	Megawatt
N	Nitrogen
ND	Not detected
N.D.	No data
N/A and n/a	Not applicable
NAP	Net Acidifying Potential
NAQUADAT	Alberta Environmental Historical Water Database
NH_4	Ammonia (particle)
NO	Nitric Oxide (gas)
No.	Number
NO_2	Nitrogen Dioxide (gas)
NO_3	Nitrate (particle)
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
NO_x	Oxides of nitrogen (NO, NO_2) (gas)
NO_y	All nitrogen species, $NO_x + N_2O + N_3O +$ ......(gas)
NPRI	National Pollutant Release Inventory
NRBS	Northern River Basin Study
NRU	Naphtha Recovery Unit
O & G	Oil and Grease
OB	Overburden
OSEC	Oil Sands Environmental Coalition
OSLO	Other Six Lease Owners
OSRPAP	Oil Sands Reclamation Performance Assessment Protocol
OSWRTWG	Oil Sands Water Release Technical Working Group
P	Phosphorus
PAH	Polycyclic aromatic hydrocarbons
PAI	Potential Acid Input
PANH	Polycyclic aromatic nitrogen heterocycles

PASH	Polycyclic aromatic sulphur heterocycles
PM_{10}	Particulate matter with mean aerodynamic diameter $\leq$ 10 microns
$PM_{2.5}$	Particulate matter with mean aerodynamic diameter $\leq$ 2.5 microns
PMF	Probable maximum flood
ppb	Parts per billion
ppm	Parts per million
psi	Pounds per square inch
Q	Quarter (i.e., three months of a year)
QA/QC	Quality Assurance/Quality Control
RA	Reclamation Area
RAMP	Regional Aquatic Monitoring Program
RAQCC	Regional Air Quality Coordinating Committee
RfD	Reference Dose
RIWG	Regional Infrastructure Working Group
RMWB	Regional Municipality of Wood Buffalo
RRTAC	Reclamation Research Technical Advisory Committee
RSA	Regional Study Area
RsD	Risk Specific Dose
s	Second
S	Sulphur
SAR	Sodium absorption ratio
scf/d	Standard cubic feet per day
SCO	Synthetic crude oil
sd	Stream day
sep cell	Separation cell
SFR	Sand to fines ratio
Shell	Shell Canada Limited
SLC	Screening Level Criteria
SO_2	Sulphur dioxide
SO_4^{2-}	Sulphate (particle)
SO_x	Sulphur oxides
spp	Species
Suncor	Suncor Energy Inc., Oil Sands
Syncrude	Syncrude Canada Ltd.
t	Tonne
t/cd	Tonnes per calendar day
t/d	Tonnes per day
t/h	Tonnes per hour
t/hr	Tonnes per hour
t/sd	tonnes per stream day
TDS	Total dissolved solids
TEH	Total extractable hydrocarbons
THC	Total hydrocarbons
TID	Tar Island Dyke
TIE	Toxicity Identification Evaluation
TKN	Total Kjeldahl Nitrogen
TOC	Total organic carbon
Ton	2 000 pounds
Tonne	2 205 pounds (1000 kg)
TRV	Toxicity Reference Value

TSS	Total suspended solids
TV/BIP	Ratio of total volume removed to total volume of bitumen in place
TV/NRB	Ratio of total volume removed to net recovered bitumen (in barrels)
Twp.	Township
U.S. EPA	United States Environmental Protection Agency
USgpm	U.S. gallons per minutes
VOC	Volatile organic compound
Vol.	Volume
VRU	Vapour Recovery Unit
vs.	Versus
WA	Waste Area

D1 TERRESTRIAL RESOURCES SCOPE OF ASSESSMENT

D1.1 COMPONENT DESCRIPTION

The assessment of terrestrial resources has been subdivided into four components:

- soils and terrain;
- terrestrial vegetation and wetlands;
- ecological land classification; and
- wildlife.

Terrestrial vegetation also includes an assessment of the existing and potential post-closure forest resources.

There is considerable interdependency among these components on both a local and regional scale. Field work specific to Project Millennium was conducted for soils and terrain, terrestrial vegetation and wetlands, and wildlife. The majority of this work was within the local study area (LSA) although vegetation was ground-truthed within the larger regional study area (RSA). The terrestrial models and descriptions used in this EIA build upon previous environmental studies conducted in the area, including EIAs for oil sands developments and other environmental studies as listed in Section A1 of this EIA.

D1.2 TERMS OF REFERENCE

The terrestrial resources section of the Project Millennium (the Project) EIA provides information on soils and terrain, terrestrial vegetation and wetlands, ecological land classification and wildlife, as required by the Project Terms of Reference issued on March 4, 1998 (AEP 1998). The final Terms of Reference were defined based on recommended modifications made to a draft submitted by Suncor. Provincial and federal government agencies, regional stakeholders and other interested parties provided Alberta Environmental Protection with suggested modifications to the Project EIA Terms of Reference. This section of the EIA addresses the following:

D1.2.1 Soils and Terrain

- Provide an assessment of the anticipated changes (type and extent) to the pre-disturbed topography, elevation and drainage patterns resulting from disturbance during pre-construction, construction, operations and reclamation. Identify these changes sequentially on maps.

- Describe and map the soil types and their distribution in the Project Area.
- Assess and map the pre- and post- disturbance land capability of the Project Area and describe the impacts to land capability due to the Project.
- Describe the availability and suitability of soils within the Project Area for reclamation.
- Outline the criteria to be used in salvaging soils for reclamation within the Project Area.
- Identify areas where soil will be salvaged and stockpiles located. Provide an estimate of the volume of soil salvaged and required to reclaim the Project Area.
- Identify any soil related constraints or limitations which would affect reclamation. Identify constraints or limitations on revegetation based on anticipated soil conditions. Discuss the potential for soil erosion and identify measures to minimize the effects of such erosion. Identify activities which may cause soil contamination.
- Discuss the results of any studies on regional soil sensitivity to acid deposition and reference any work planned by the Southern Wood Buffalo Zone or the Clean Air Strategic Alliance (CASA).
- Collect all baseline biophysical information in a manner which enables a detailed ecological land classification (ELC) of the Project Area to be completed.
- Describe the impact on each ELC unit from disturbance based upon key soil characteristics.

D1.2.2 Vegetation

- Map and describe plant communities affected by the Project using the Alberta Vegetation Inventory Standards Manual (AVI) Version 2.2.
- Describe the plant communities for each ecosite phase in the Project Area. Identify species which are important to wildlife as food or shelter, or which act as indicator species for environmental effects. Where ecosite phases are rare, or where a significant percentage of specific type may be removed by the Project, describe their regional significance.
- Provide ecological land classification (ELC) maps that show the pre- and post-disturbed landscapes. Comment on the importance of the size, distribution, and variety of these ELC units for wildlife habitat, timber harvesting and other land uses from both a local and regional perspective.

- Identify rare, vulnerable, threatened or endangered species outlined in the Alberta Rare Plant Classification and the Canadian Organization of the Status of Endangered Wildlife in Canada (COSEWIC). Identify opportunities to avoid and mitigate impacts to these species, if present.
- Determine the amount of commercial and non-commercial forest land base that will be disturbed within the Project Area. Classify the commercial forest land base according to the conifer, deciduous and mixedwood land base. Compare the pre- and post-disturbance percentages and distribution of all forested communities in the Project Area. Comment on how the disturbance of this renewable resource impacts present and future needs.
- Identify the amount of vegetation to be disturbed during each stage of the Project. Discuss temporary and permanent changes to plant communities. Comment on the significance of the effects and their implications on other environmental resources (wildlife habitat diversity and quantity, water quality, erosion potential, soil conservation, recreation and other uses).
- Provide a strategy to minimize the impact of the Project on vegetation. Outline expectations and roles for representatives of Alberta Environmental Protection (AEP) staff and other stakeholders as part of this strategy and consider future options for revegetation and reclamation of the land base.
- Develop a plan for mitigating the adverse effects of site clearing, with emphasis on the timing of vegetation clearing and the effects of site clearing on runoff and water quality.
- Provide an inventory of peatlands and wetlands affected by the Project using the Alberta Wetland Inventory Standards Manual (AWI) Version 1.0. Consider their importance for local and regional habitat, sustained forest growth and the hydrologic regime. Determine the rarity or abundance of peatlands and wetlands.
- Predict the anticipated effect of the Project on peatlands and wetlands in conjunction with other project-induced variations in hydrology, habitat quality and wildlife populations. Discuss how Suncor will minimize the impact.

D1.2.3 Wildlife

- Describe the use and potential use of the Study Area by wildlife.
- Identify rare, vulnerable, threatened or endangered species as outlined in the Status of Alberta Wildlife and the Canadian Organization of the Status of Endangered Wildlife in Canada (COSEWIC), as well as, species of international significance. Describe their habitat requirements.

- Discuss potential for adverse impacts on wildlife, wildlife utilization, habitat quality and food supply during the pre-construction, construction, operation and reclamation phases of the Project. Consider abandonment, loss, fragmentation or alteration of habitat, vehicle and wildlife collisions, obstructions to daily or seasonal movements, noise, hunting, mortality due to improved or altered access and potential impact to wildlife as a result of changes to air, water and soil quality.
- Discuss significant local habitat for indicator wildlife species, seasonal habitat use patterns (calving, rearing and nesting areas, escape terrain), extent of range in both summer and winter and seasonal movement corridors.
- Discuss the regional and temporal effects and the potential to return the area to pre-disturbed wildlife habitat conditions.
- Provide a strategy to minimize impacts on habitat and wildlife populations through the life of the Project. Provide a mitigation plan and schedule for wildlife and significant wildlife habitat areas impacted by the Project. Indicate how the plan will address applicable provincial and federal wildlife habitat policies. Identify the need for access controls or other management strategies to protect wildlife.
- Identify and discuss any monitoring programs that will be implemented to assess wildlife impacts from the Project and the effectiveness of mitigation strategies to ensure the protection of the wildlife resources in the area.
- Discuss how the current bird deterrent system will be expanded to incorporate the Project. Discuss any limitations to the current system, anticipated effectiveness and potential improvements for the Steepbank and Millennium pond areas. Explain any impact on adjacent reclaimed and undisturbed land from the use of such deterrents.

D1.3 KEY ISSUES/KEY QUESTIONS

The key terrestrial resources issues relate to the components of soils and terrain, terrestrial vegetation and wetlands, and wildlife. Ecological land classification (ELC) is included as a component for the purposes of an integrated analysis of the soils, terrain, terrestrial vegetation, and wetlands information.

Key issues have been identified based on a screening process that incorporated previous EIA experience, specific issues related to Project Millennium and public consultation. These key issues have been synthesized in terms of key questions to provide project focus. The complete list of key questions is presented in Table A2-3 of Section A2 of this EIA. The list of key questions related to the terrestrial resources components is duplicated in Table D1-1 of this section.

Table D1-1 Summary of Key Terrestrial Resources Questions for Project Millennium

Soils and Terrain	
ST-1	What impacts will development and closure of Project Millennium have on the quantity and quality of soils and terrain units?
ST-2	What impacts will acidifying emissions from Project Millennium have on regional soils?
Terrestrial Vegetation and Wetlands	
VW-1	What impacts will development and closure of Project Millennium have on ecological land classification (ELC) units, vegetation communities and wetlands?
VW-2	What impacts will air emissions and water releases from Project Millennium have on vegetation health?
VW-3	What impacts will development and closure of Project Millennium have on vegetation and wetlands diversity?
Wildlife	
W-1	What impacts will development and closure of Project Millennium have on wildlife habitat, movement, abundance and diversity?
W-2	What impacts will chemicals in operational air and water releases from Project Millennium have on wildlife health?
W-3	What impacts will chemicals in soils, plants and waters from the Project Millennium reclaimed landscapes have on wildlife health?
Cumulative Effects	
CTER-1	What impacts will result from changes to ecological land units (soils, terrain, vegetation and wetlands) associated with Project Millennium and the combined developments?
CTER-2	What impacts will result from changes to wildlife habitat, abundance or diversity associated with Project Millennium and the combined developments?

The key issues related to soils and terrain include:

- the quantity and quality of soils that will be available for reclamation;
- the loss of terrain units due to Project Millennium development and the replacement of these terrain units during closure; and
- the impact of potential acid input from air emissions on regional soils.

The key issues related to terrestrial vegetation and wetlands include:

- the loss of vegetation communities and wetlands due to Project Millennium and the replacement of these communities on closure;
- the loss of ecological land units due to Project Millennium and the replacement of these communities on closure;
- air emissions and water releases from Project Millennium as related to vegetation health; and
- impacts of disturbance and closure on terrestrial resource diversity.

The key issues related to wildlife include:

- impacts of land disturbance from Project Millennium activities on wildlife habitat, movement, abundance and diversity;
- constituents in air emissions and water releases during the operational phase of Project Millennium as related to wildlife health; and
- constituents in air emissions, water releases, and soils and plants from the reclaimed landscapes of Project Millennium as related to wildlife health.

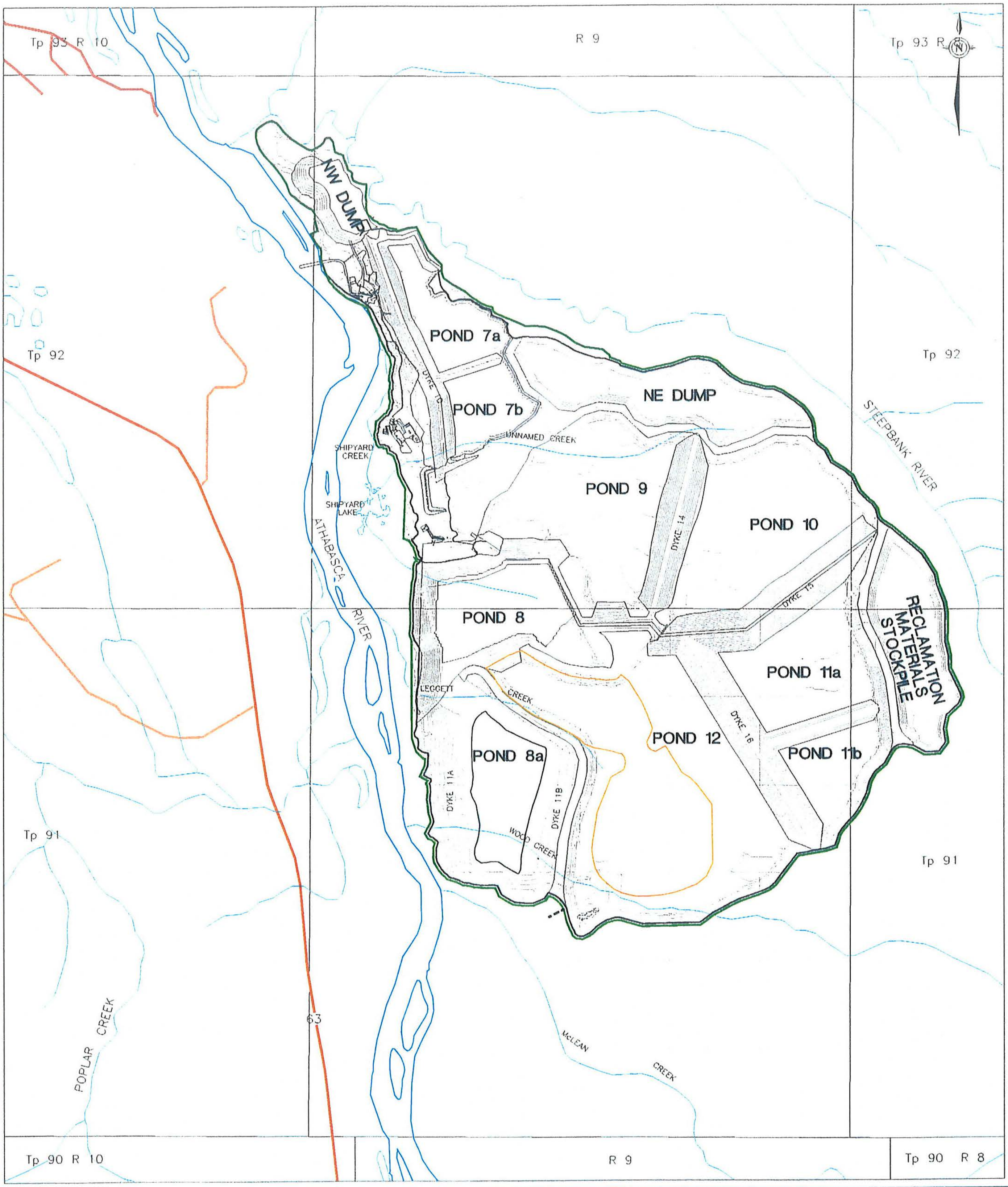
From a cumulative effects viewpoint, the key issues include:

- changes to ecological land units (soils, terrain, terrestrial vegetation and wetlands) associated with Project Millennium and the combined developments; and
- changes to wildlife habitat, abundance and diversity associated with Project Millennium and the combined developments.

In addition to the key issues described above, a number of other terrestrial issues are addressed in this EIA. Examples of these issues include rare plants (Section D3) and the impacts on terrestrial vegetation adjacent to mining areas due to aquifer drawdown (Sections D2 and D3). Additional issues that relate to terrestrial resources are also addressed in other components such as traditional land use and resource use (Section F3).

D1.4 RELATIONSHIP WITH THE APPROVED STEEPBANK MINE

Project Millennium represents an extension of the approved Steepbank Mine on the east side of the Athabasca River. Pit 1 of Steepbank will be developed as per the application submitted in April 1996 and approved by the AEUB on January 22, 1997. However, under Project Millennium, development of Pit 2 of Steepbank, will be accelerated in time and extended to the east and south. The locations of these pits along with the waste dumps, tailings pond, and infrastructure and mining/extraction facilities are shown on Figure D1-1. The combined Steepbank/Millennium area on the east bank of the Athabasca River is referred to as the east bank mining area. The assessment of terrestrial resources related to Project Millennium is made by considering the entire east bank mining area with the recognition that a portion of this area has already been approved for development. This approach allows direct comparison of pre-development resources with those



LEGEND

EAST BANK MINING AREA

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 1 2 3km
SCALE 1:100,000

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EAST BANK MINING AREA

11 Apr. 1998	Figure D1-1	DRAWN BY: CG

for the integrated closure plan for the Steepbank Mine and Project Millennium.

For the purposes of this application, the development zone of the east bank mining area is considered to be the limits of either the mine or the toe of waste dumps, with a 50 m buffer zone around the entire perimeter of this footprint. This 50 m buffer zone accounts for potential disturbance around the perimeter due to facilities such as drainage ditches and roads. In the northwest part of the site, the development zone also includes some infrastructure facilities such as the bridge approach, pipelines, roads and other facilities.

The size of the east bank mining area is 9,281 hectares. The size of the approved Steepbank Mine is 3,776 hectares. The approved Steepbank footprint is as per drawing number A1E-Y219-103-0-557 in the Supplemental Information Response report submitted to AEUB by Suncor on July 29, 1996 (Suncor 1996c).

The relationship of the approved Steepbank footprint and the east bank mining area is shown on Figure D1-2. The majority of the approved Steepbank Mine is within the development zone for the east bank mining area. There is, however, a 137 ha portion of a waste dump for the approved Steepbank Mine to the south of Shipyard Lake which has been eliminated in the Project Millenium design. This change results in less impact on the Athabasca River Valley and less potential impacts to Shipyard Lake.

Impact assessment calculations described in the different components show the pre-development status, the changes due to the approved Steepbank development, and the changes for the entire east bank mining area. Soil and terrain, terrestrial vegetation and wetlands, and ELC data within the approved Steepbank area have been updated as part of this EIA to be consistent with the newer techniques used for Project Millennium. As such, definition of soil and terrain, terrestrial vegetation and wetlands, and ELC units within the Steepbank area show some variation from the Steepbank Mine EIA.

D1.5 SPATIAL CONSIDERATIONS

As with the other EIA components, the assessment of the impact of Project Millennium on terrestrial resources is made for a local study area (LSA) and for a regional study area (RSA).

D1.5.1 Local Study Area

The terrestrial local study area is defined to include the spatial extent of terrestrial resources that may be directly affected by Project Millennium.

The terrestrial LSA is shown in Figure D1-2. The area is defined by the northeastern bank of the Steepbank River to the northeast, the eastern bank of the Athabasca River to the west, and south and east such that a minimum distance of 500 m is maintained from the development footprint.

The Athabasca and Steepbank rivers are considered to be natural divides with respect to soils and vegetation. The Steepbank River itself has been included to allow for assessment of animals in the river (e.g., beaver) and to allow consideration of the river valley as a movement corridor.

The south and southeast edges of the LSA are based on a minimum "buffer" distance of 500 m. The south boundary is typically 4 km south of the east bank mining area to include a large portion of the wetlands area that is drained by McLean Creek. Water table depression has been estimated to be less than 300 m and thus is predicted to occur within the "buffer zone".

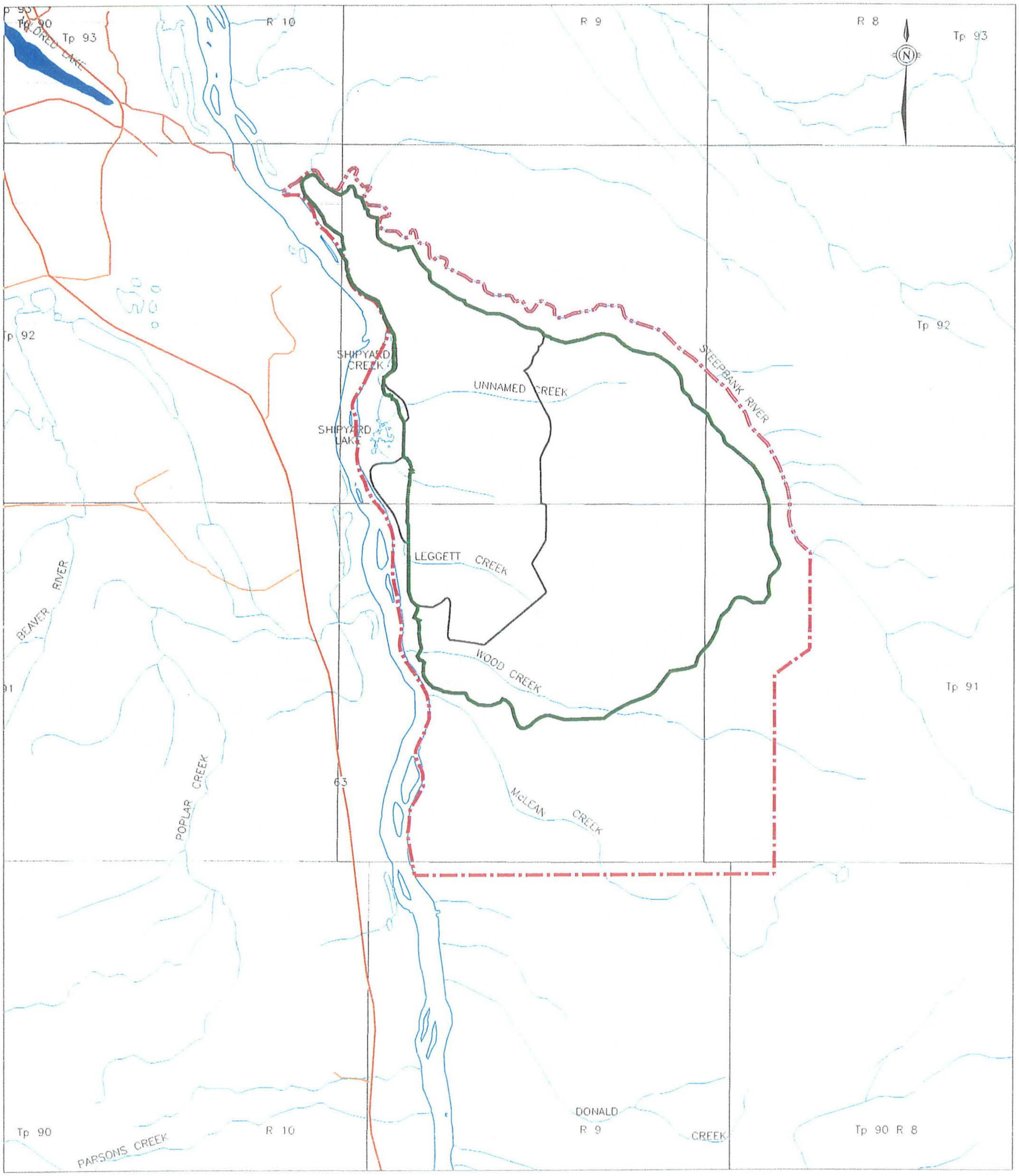
The area of the LSA is 16,181 hectares. The east bank mining area or overall development footprint comprises 57% of the LSA.

D1.5.2 Regional Study Area

The regional study area (RSA) for terrestrial resources has been expanded from that used for the Suncor Steepbank Mine EIA (Suncor 1996b). This expansion accommodates requests from regulatory representatives and stakeholders for inclusion of additional areas that may be affected by air emissions from oil sands developments. The RSA is used to study potential regional impacts due to Project Millennium and for the assessment of cumulative effects due to regional development.

The RSA is used to evaluate the impact of the change in terrestrial resources in a regional context. As an example, elimination of a specific wetlands unit within the LSA may not be regionally significant if these units are prevalent within the RSA. Potential environmental effects that extend beyond the LSA, such as acidifying emissions, are also assessed in the context of the RSA. Finally, cumulative effects assessment, which includes the impact of developments outside the LSA, are assessed in the RSA.

The location of the RSA is shown in Figure D1-3. The area of the RSA is 2,428,645 hectares.



LEGEND

- TERRESTRIAL LOCAL STUDY AREA
- EAST BANK MINING AREA
- SUNCOR STEEPBANK MINE

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 1 2 3 4 5km

SCALE 1:150,000

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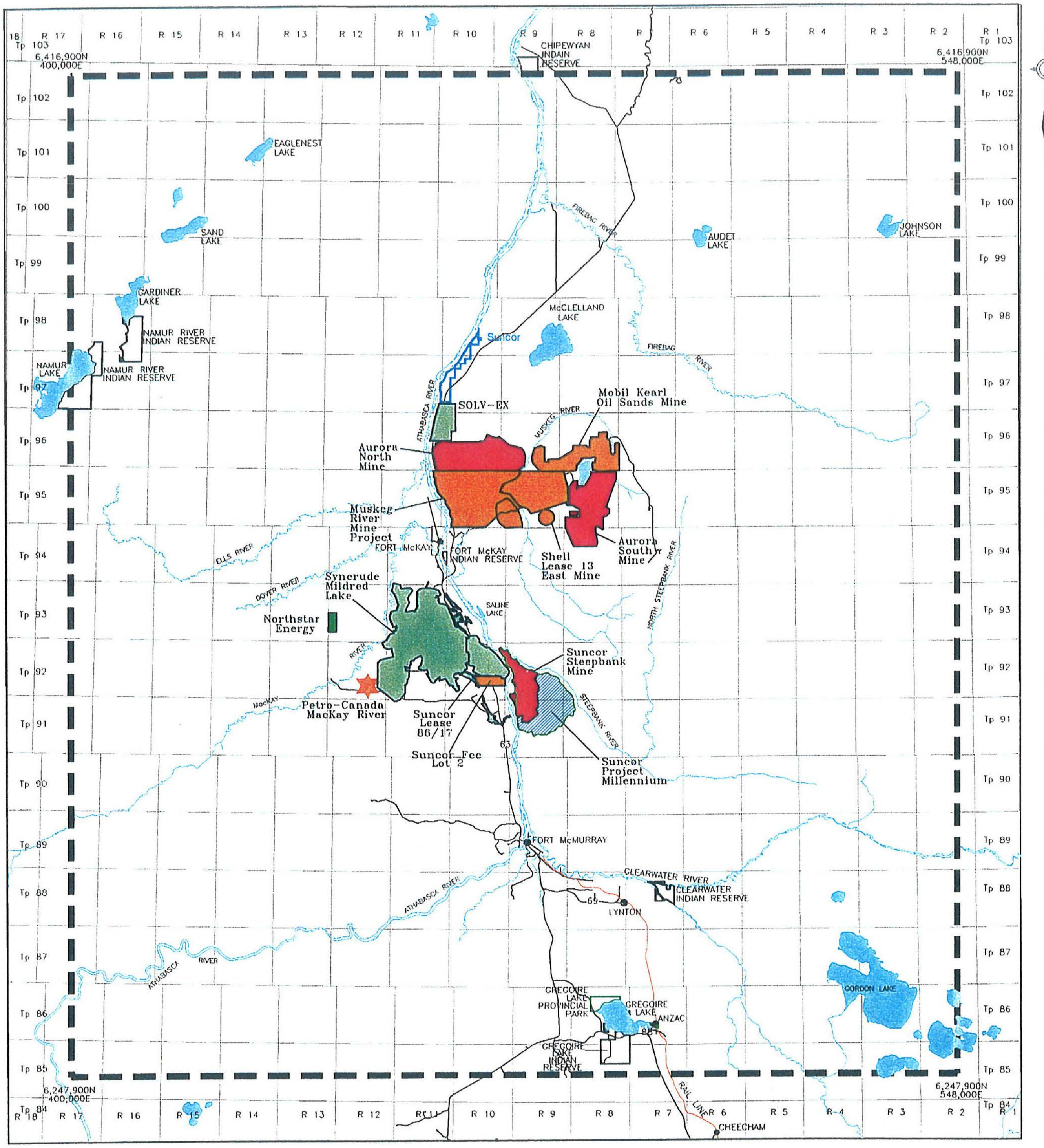
LOCAL STUDY AREA
FOR TERRESTRIAL RESOURCES

11 Apr 1998	Figure D1-2	DRAWN BY: RFM



LEGEND

- EXISTING DEVELOPMENTS
- APPROVED DEVELOPMENTS
- PLANNED DEVELOPMENTS
- PROJECT MILLENNIUM
- REGIONAL STUDY AREA FOR TERRESTRIAL RESOURCES
- ROADWAYS

0 10 20 30 40 50km

SCALE 1:1,000,000

REFERENCE

DIGITAL DATA SETS 74D, 74E, 74I
84A AND 84H FROM RESOURCE DATA DIVISION
ALBERTA ENVIRONMENTAL PROTECTION, 1997.
DATUM IS IN NAD83 UTM PROJECTION

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REGIONAL STUDY AREA FOR TERRESTRIAL RESOURCES

11 Apr. 1998	Figure D1-3	DRAWN BY: RFM/CG

D1.6 TEMPORAL CONSIDERATIONS

Due to the integration of the approved Steepbank Mine area within the assessment for Project Millennium, the pre-development conditions for the local study area terrestrial assessment have been set as the pre-clearing state which dates back to mid-1996. Development of the site is anticipated to continue until 2033.

For the purposes of impact analysis, the entire east bank mining area is used. The impact analyses conservatively do not take ongoing reclamation into account.

The closure assessment is based on a far-future time frame when ecosystems have become fully established.

D1.7 CONSULTATION AND ASSESSMENT FOCUS

Consultation with stakeholders and regulatory agencies involved with oil sands developments led to identification of specific terrestrial key indicator resources (KIRs) that are used to focus the assessment. KIRs are used because environmental systems include a very large number of complex interconnected elements with each element contributing to the functioning of an ecosystem as a whole. KIRs are used as surrogates for the entire system and are chosen to represent the range of ecological activity that is being studied.

Selection of KIRs is based on a process defined in Section A2 of this EIA. KIRs for the terrestrial resources component of the Project Millennium EIA include both wildlife species as well as vegetation communities. These KIRs were chosen based on plants and animals appropriate for the area with emphasis on those which are considered most valuable to the nearby communities or those which have been identified in previous documents such as the integrated resource plan for the area (AEP 1996a). Part of the selection process includes consideration of ecological importance and vulnerability, resource use value and monitoring value.

Extensive consultation has been conducted as part of this and previous EIAs to document traditional environmental knowledge, particularly within the aboriginal community. This traditional knowledge is incorporated within the environmental studies and impact assessments to enhance the scientific data. Specific knowledge was also used in the design of studies such as the plant tissue sampling and analysis program (see Section F1.2).

D1.8 ASSESSMENT METHODOLOGY

The assessment process for the terrestrial components varies somewhat between the LSA and the RSA due to the different nature of the data on which the assessment is based.

D1.8.1 Local Study Area Methodology

A schematic depiction of the data analysis and assessment processes for the terrestrial resources sub-components is shown in Figure D1-4. This diagram outlines major processes in analyzing data and preparing impacts. Other processes are also used to evaluate specific impacts such as the potential acid input from the air component to the soil impact and the use of consultation to identify plant KIRs that have spiritual or medicinal purposes.

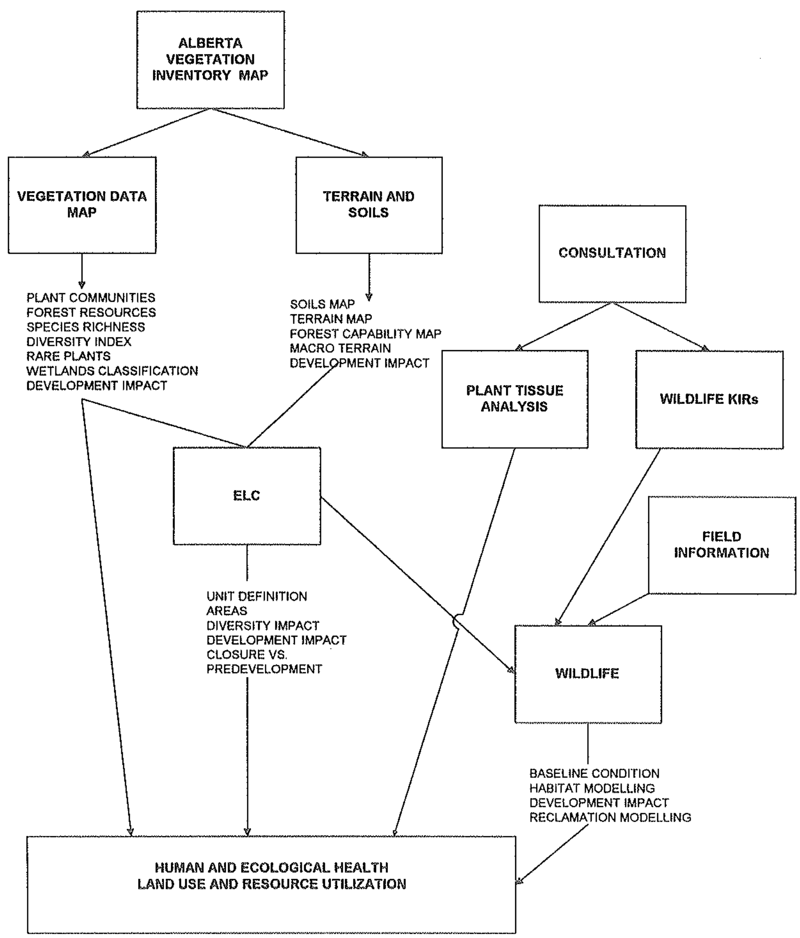
The data obtained during field work and literature surveys is compiled in GIS databases which are cross-linked between the different components. Changes are assessed based on the Project Millennium activities including direct disturbance, air and water quality changes, and other factors such as aquifer drawdown. These changes in terrestrial resources have direct and indirect impacts on human and ecological health, and land use and resource utilization. These impacts are described in section F1 (human health), D3 (plant tissue analysis), D5 (wildlife health) and F3 (traditional land use and resource use).

D1.8.1.1 Field Observations and Data

Data for the terrestrial LSA is primarily based on field observations and sampling conducted during the Steepbank and Project Millennium EIAs. The Project Millennium field observations and sampling included:

- soil sampling and vegetation description at 870 locations;
- detailed vegetation plot analyses at 9 plot sites at each of 35 locations;
- rare plant investigation at 51 plot sites;
- sampling and chemical analysis of plant tissue;
- site observations to verify forestry and Alberta Vegetation Inventory (AVI) maps; and
- winter and summer wildlife surveys.

Figure D1-4 Local Study Area Terrestrial Process Diagram



This data is described in detail in the EIA key reference reports which accompany this EIA, a listing of which is provided in Appendix IX. Specifically, the key reference reports for the terrestrial resources component include:

- Soils and Terrain Baseline for Project Millennium (Golder 1998k);
- Terrestrial Vegetation Baseline for Project Millennium (Golder 1998l);
- Wetlands Baseline for Project Millennium (Golder 1998m);
- Forestry Resources (AVI) Baseline for Project Millennium (Golder 1998e);
- Ecological Land Classification Baseline for Project Millennium (Golder 1998c);
- Wildlife Baseline Conditions for Project Millennium (Golder 1998n); and
- Winter Wildlife Surveys - Steepbank River Valley, Shipyard Lake, and Lease 25 and 29 Uplands (Golder 1997s).

D1.8.1.2 Terrestrial Resources Databases and Mapping

These field observations were compiled into databases which formed the basis for detailed maps and statistical analyses within the LSA. The basis for mapping is the AVI interpretation that was prepared based on air photo interpretation with field truthing. The databases are linked using an ArcInfo GIS system and the AVI map base to produce a compatible set of baseline maps for soils, terrain, vegetation, wetlands and timber productivity rating.

The soils data is presented in terms of soil series names as described by the Alberta Soils Advisory Committee. A distinction is made between organic and mineral soils and the composition and typical thickness of each soil series are noted. Terrain units are classified based on the texture (e.g., sand, silt, clay) and depositional mode (e.g., fluvial, glacial till) of the surficial materials. Where appropriate, areas of naturally reworked materials are also noted.

The soils baseline data and the associated map is used to compile a map delineating land capability for forest ecosystems. Land capability for forest ecosystems is described in terms of five classes which delineate the potential for commercial forestry ranging from no limitations (Class 1) to non-productive (Class 5).

In addition, the terrain map and other information was used to create a macroterrain map which amalgamates similar terrain units that are geographically distinct (e.g., Athabasca escarpment, Steepbank escarpment). Macroterrain is used to define the landscape level for an ecological land classification (ELC) unit.

The vegetation data is presented in terms of ecosite phases as described in "Ecosites of Northern Alberta" (Beckingham and Archibald 1996). An ecosite phase is a vegetation classification based on dominant tree species that includes a number of vegetation communities. Examples of ecosite phase are low-bush cranberry and trembling aspen.

Wetlands are classified according to the Alberta Wetlands Inventory (AWI) system (Halsey and Vitt 1996). The five primary wetlands types include bogs, fens, marshes, swamps and shallow open water. Vegetation and landform modifiers subdivide these primary wetlands types. The wetlands data was incorporated into the overall vegetation map.

Timber productivity rating provides an estimate of relative forest production according to standards described in the Alberta Vegetation Inventory (AVI). These ratings are described in terms of good, moderate, fair and unproductive and are based on the current forest resources in the LSA.

The soils, macroterrain and vegetation data are combined to provide an ecological land classification database and map. The ELC system provides information linking landforms and soils to terrestrial vegetation and wetlands. This information is valuable in reclamation and closure planning.

Data collected during the wildlife surveys is cross-referenced with the vegetation and soils units to provide a locally correlatable basis between habitat and animal usage. This correlation was used in the habitat suitability index (HSI) modelling which is used to assess both habitat loss during operation and quality of habitat regained during reclamation. The HSI modelling results are described in detail in the report Wildlife Habitat Suitability Index (HSI) Modelling for Project Millennium (Golder 1998o).

D1.8.1.3 Impact Analyses

The LSA terrestrial impact analyses describe the temporal loss of terrestrial resources (vegetation, habitat) due to development and the planned return of resources after closure. The primary impact is due to direct disturbance (mine excavation or placement of waste materials) to terrestrial resources within the east bank mining area footprint. Other impacts include:

- the effects of aquifer drawdown during dewatering of the muskeg and overburden, and depressurization of the basal aquifer;
- air quality impacts from the mining, extraction and upgrading operations; and

- potential for acidifying emissions from these operations.

In addition to the temporal loss of terrestrial resources, the effects from Project Millennium on terrestrial resources outside the disturbance area can also effect human and ecological health, and land use. The potential human health impacts relate primarily to air and water releases and consumption of plants and animals that may be affected by these releases. The ecological health assessments evaluate the potential impacts air and water releases may have on terrestrial and wetlands plants and animals within the LSA.

The impact of the change in terrestrial resources on land use includes:

- traditional plants used for medicine and spiritual functions;
- food plants;
- forestry;
- trapping; and
- hunting.

These impacts are discussed in detail in Section F3 of this EIA.

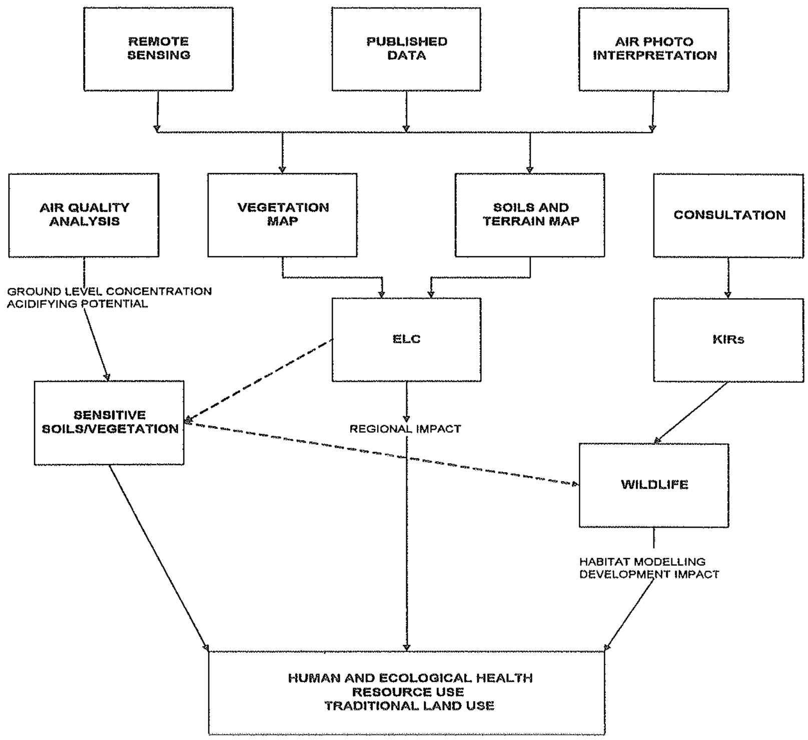
The impact analyses in the LSA are referenced to the pre-development conditions. As an additional reference, the impact caused by the approved Steepbank Mine are also shown in most cases. The reference to the predevelopment conditions is considered necessary to complete the predevelopment-operations-closure impact and mitigation cycle. The final closure plan for the site is then referenced to the predevelopment conditions for the assessment of changes in vegetation communities, habitat and diversity.

D1.8.2 Regional Study Area Methodology

A schematic depiction of the data analysis and assessment processes used for evaluating impacts in the RSA is presented in Figure D1-5. Since the RSA area is of considerable size, a different data gathering approach is used to assess impacts of Project Millennium on the regional terrestrial resources. The data sources used for the regional study area include:

- remote sensing LANDSAT TM satellite imagery;
- air photo interpretation;
- published AOSERP soil maps and data;
- ground truthing of vegetation and soils data; and
- existing data from previous studies in the region.

Figure D1-5 Regional Study Area Terrestrial Process Diagram



The remote sensing imagery is used to generate a RSA vegetation map that is described using sixteen distinct vegetation classes, which include descriptions of both overstory and understory units. The remote sensing data was field truthed using existing data and by actual field reconnaissance within the RSA. These vegetation units can typically contain a number of ecosite phases. Example of vegetation units include mixed coniferous pine dominant and shrubby fen.

Soils and terrain were mapped based on the existing AOSERP information. Extensions in areas where the AOSERP maps were incomplete were made based on remote sensing and air photo interpretation. As in the case of vegetation data, the soils data was ground truthed primarily using the existing database for the sites which have been documented within the RSA. The issue of soil acidification within the RSA is analyzed through the identification of potentially sensitive soils with an overlay of where the anticipated zones of potential acid input (PAI) will occur.

The soils, macroterrain and vegetation data are combined to develop landscape level detail on soils and macroterrain linkages to vegetation. This information is used in assessment of air emission effects on ecosystems and in diversity analysis for the RSA.

Baseline wildlife conditions within the RSA are analyzed based on existing studies and habitat modelling using the vegetation and terrain mapping described above. Wildlife impacts are based on a worst case scenario in which the area of the existing, approved and planned developments (see Table A2-11 and Figure A2-8 in Section A2 of this EIA) are considered to be completely developed.

The impact analyses in the RSA are referenced to baseline conditions which assume full development of the approved Steepbank and Aurora projects. It is recognized that a method of defining impacts within the RSA in terms of the percentage of certain vegetative, ELC, or wildlife habitat units is influenced by the size of the RSA. As such, quantitative values of impacts must be tempered with an overall qualitative approach that considers the impacts of disturbance on overall viability and diversity of ecological units. This approach is described in detail in each of the component impact analyses.

The assessment of cumulative effects for the terrestrial components is conducted through consideration of an additional RSA development scenario. The additional developments are included by considering new/increasing disturbance areas for planned oil sands projects, forestry, linear developments (roads, pipelines), urbanization and other planned activities as described in Section A2.

D1.9 LINKAGE TO RECLAMATION AND CLOSURE PLANNING

Closure is the ultimate mitigation for the terrestrial resource impacts of disturbance caused by resource extraction on the site. A description of the closure plan is provided in Section E of Volume 1 of this application. An assessment of this plan is provided in Section E of this EIA (Volume 2 of the application).

The documentation of baseline terrestrial resources in the LSA is essential for the purposes of reclamation and closure planning. The quantity, distribution and capability of different soil units for reclamation is documented as part of the soils and terrain baseline. The LSA vegetation data forms the basis in the determination of the most appropriate vegetation units on the various reclamation landforms. Vegetation data is linked to the existing soils, aspect, slope and drainage conditions which can be transposed to the equivalent attributes of the closure landscape. In this manner, there is an enhanced degree of confidence that the closure goals for forest capability, wildlife habitat, diversity and other land uses can be attained.

The assessment of wildlife habitat is based on a comparison of pre-development and closure conditions. It is recognized in any closure scenario that the final ecosystem will be in a state of constant evolution as the ecosystems change and mature. Assumptions made in terms of final habitat are described in the closure plan assessment.

D2 SOILS AND TERRAIN

D2.1 BASELINE ENVIRONMENTAL SETTING

D2.1.1 Natural Region and Climate

The Project Millennium local study area (LSA) is located in the Central Mixedwood subregion of the Boreal Forest Natural Region of Alberta (AEP 1994a). This subregion is the largest in spatial extent in the province and characterized by a cool, moist (i.e., boreal) climate regime conducive to the growth of mixed aspen-spruce forests with a significant component of bogs and fens in poorly drained areas. Strong (1992) classified this as the Mid-Boreal Mixedwood Ecoregion of the Boreal Ecoprovince. Pettapiece (1989) notes the climate as having moderate to severe temperature limitations to plant growth while both Dzikowski and Heywood (1990) and Strong (1992) provide extensive long-term statistical summaries on parameters such as growing-degree days and length of the frost-free season.

D2.1.2 Physiography and Surficial Geology

The LSA is characterized as having subdued relief and nearly level topography (Strong 1992). Elevations rise gradually, west to east, from approximately 320 masl (metres above sea level) along the Athabasca River escarpment to roughly 400 masl along the Steepbank River escarpment. A few minor uplands occur on the east side of the LSA rising to nearly 440 masl. From the northwest, the elevation rises gently from 320 masl at the confluence of the Athabasca and Steepbank river valleys to 380 masl in the extreme southeast. Overall, the slopes in the LSA are less than 0.5%.

Pettapiece (1986) places the western half of the LSA, townships 91 and 92, range 9, west of the fourth meridian, in the Northern Alberta Lowlands physiographic region. The eastern half of the LSA, townships 91 and 92, range 8, west of the fourth meridian, falls within the Saskatchewan Plains physiographic region. Table D2.1-1 provides a more detailed evaluation of the surface characteristics of the LSA.

Table D2.1-1 Physiographic Setting of the Project Millennium LSA

Region	Section	District	Surface Expression	Surficial Materials	Elevation, masl
Saskatchewan Plains	Methy Portage Plains	Steepbank Plain	Undulating	Glaciolacustrine, Morainal/Till	425 - 500
Northern Alberta Lowlands	Wabasca Lowland	Athabasca Valley	Steep	Undifferentiated	275 - 600
Northern Alberta Lowlands	McMurray Lowland	Kearl Lake Plain	Undulating	Glaciolacustrine	300 - 450

(after Pettapiece 1986)

Bayrock and Reimchen (1973) mapped the surficial geology of the LSA as primarily thin ground moraine composed of loamy Kinosis till in the north and thick, bedded glaciolacustrine sands and silts to the south. The valleys of the Athabasca and Steepbank Rivers are classed as erosional or slumping on the slopes (i.e., colluvium) with alluvial deposits along the floodplains. Small, isolated inclusions of glaciofluvial outwash sands and gravels are found in old channel bottoms and are often associated with medium to fine textured aeolian sands that occur in sheets and dunes. In the extreme south of the LSA are located small areas of: thick, bedded glaciolacustrine clays and silts; thin glaciolacustrine clays and silts with numerous pebbles; and thick, coarse textured glaciofluvial kame/kame moraine deposits consisting of mixed sands and gravel to pure gravel. In general the topography is level to undulating except along the river and stream channels

D2.1.3 Bedrock Geology

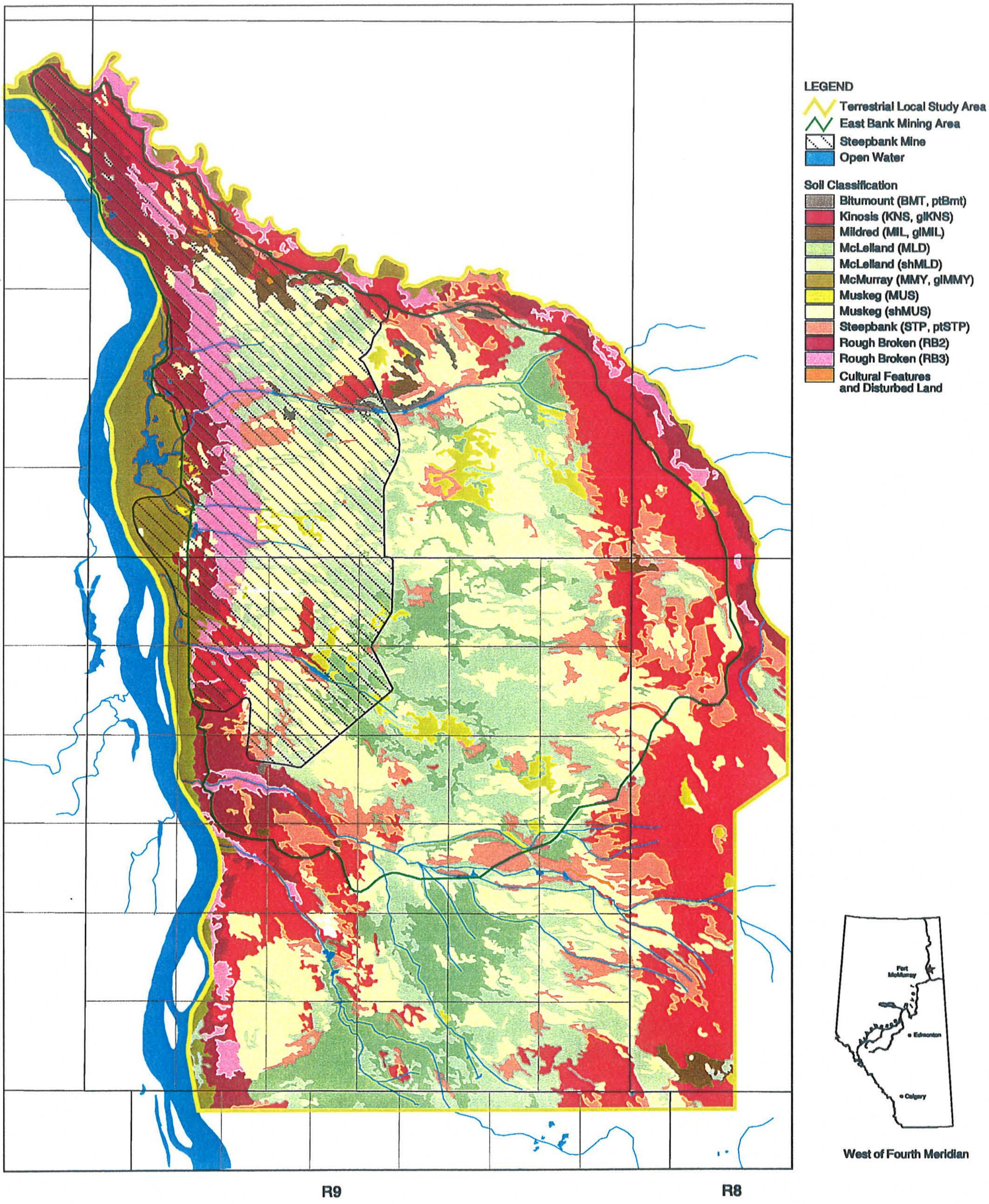
The bedrock geology in Townships 91 and 92, Range 9, W4M is principally marine origin Lower Cretaceous silty shale, siltstone and fine sandstone of the Clearwater Formation. McMurray Formation sandstone, siltstone and silty shales, of deltaic origin, are exposed along the Athabasca River valley and limited amounts of Waterways Formation (marine shales and argillaceous limestone) may be found in the Athabasca floodplain. In Townships 91 and 92, Range 8, West of the fourth meridian, the Grand Rapids formation, consisting of fine-grained, deltaic-marine sandstone, siltstone and shale dominate the bedrock geology (Green 1972, Ozoray 1974, RCA 1970). More detailed discussions of various aspects of the geology of the LSA may be found in Carrigy and Kramers (1973).

D2.1.4 Soil Classification

Two classes of soils are found in the LSA: those which have developed on organic deposits which have accumulated over poorly drained mineral materials; and those formed from directly from mineral parent materials. Organic soil orders include the McLelland and Muskeg series of the Mesisolic great group. Mineral soils include: Bitumount and Steepbank series of the Gleysolic order; Kinosis series of the Luvisolic order, Mildred series of the Brunisolic order and McMurray series of the Regosolic order. Additional units are mapped as Rough Broken 2, 3 as they are soil-like in nature but do not meet the criteria for classification as an order in the Canadian system. The soil series/map units and their areas are listed in Table D2.1-2 while their distribution within the LSA is shown in Figure D2.1-1 (Project Millennium LSA Soil Classification).

D2.1.4.1 Organic-Based Parent Materials and Soil Series

Organic soils, commonly referred to as peat, have formed accumulations of varying depths in poorly drained, depressional locations. Two main types are distinguished within the LSA; fen soils and bog soils.



SOURCES: Suncor
Golder
CAN-AG
The Forestry Corp

Map Projection: UTM 12
Datum: NAD 83

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LOCAL STUDY AREA
SOIL CLASSIFICATION

16 Apr. 1998 | Figure D2.1-1 | PRODUCED BY: JS REVIEWED BY:

Table D2.1-2 Extent of Soil Series in the Project Millennium LSA

Series	Area (ha)	% of LSA
Bitumount	65	<1
Kinosis	3,086	19
Mildred	188	1
McLelland	4,567	28
McMurray	784	5
Muskeg	3,988	25
Steepbank	1,462	9
Rough Broken	1,898	12
Total, Soil Units	16,040	99
Disturbed Lands	22	<1
Water	120	1
Total, Non-soil Features	142	1
Total LSA	**16,181**	**100%**

Fen Soils

McLelland series mesisols are found in upland areas where slopes are less than 0.5% or depressional and very poorly drained. Terric variants (shallow fens) were mapped where mineral contact occurred between 40 and 120 cm below the surface while Typic variants (fens) had organics of greater than 120 cm in depth.

Bog Soils

Mesisols of the Muskeg series are also found within the LSA. These tend to be less well drained areas than fens and hence are more acidic in nature. Bogs (Typic variants), where the organic materials exceeded 120 cm above mineral contact, and shallow bogs (Terric variants) where peat depth ranged between 40 and 120 cm were mapped.

D2.1.4.2 Mineral-Based Parent Materials and Soil Series

Four distinct mineral parent materials were identified within the Project Millennium LSA which have given rise to the five soil series and one unclassified category discussed below.

Soil Series Developed on Morainal/Till Parent Materials

Kinosis series Orthic Gray and Gleyed Gray Luvisols have developed on clay loam to sandy loam textured glacial till deposits. These soils occupy roughly 18% of the LSA, primarily along the eastern and southeastern boundaries.

Soil Series Developed on Glaciofluvial Parent Materials

Three series have evolved on the glaciofluvial deposits in the LSA.

Bitumount series Orthic Humic and peaty Orthic Gleysols are found in poor to imperfectly drained, level to depressional lower slope locations. Occupying less than 1% of the LSA, these soils are generally located in upland - fen transition areas.

Orthic Eutric and Eluviated Eutric Brunisols of the Mildred series may be found on coarse textured, sandy loam to sand, deposits making up slightly over 1% of the LSA. The well drained nature of these soils is shown by the jack pine - white spruce vegetation cover.

Steepbank series Orthic, peaty Orthic and Orthic Luvic Gleysols cover nearly 9% of the LSA. Composed of finer textured materials, clay to clay loam to sandy loam, these soils exhibit widely ranging drainage properties and vegetation associations (i.e., variable from upland to fen/swamp).

Soil Series Developed on Fluvial Parent Materials

Cumulic and gleyed Cumulic Regosols of the McMurray series have formed in the medium to coarse textured, silt loam to sandy loam, recently deposited materials of the Athabasca and Steepbank River floodplains. These soils comprise approximately 5% of the LSA and are populated by dogwood and shrubby fen species.

Unclassified Soils

The Rough Broken (RB)2 soils are most correctly described as colluvial deposits that, while they resemble soils, do not meet the criteria for classification as true soils in the Canadian system. These complexes occupy almost 7% of the LSA and are found along the steepest slopes of the Athabasca and Steepbank River valley escarpments. RB3 soils are Orthic Eluviated and Eutric Eluviated Brunisols which make up 4% of the LSA and are located in the less steeply sloping crest areas along the escarpments in close proximity to the RB2 units.

Non-Soil Features

This category, which includes existing disturbances and open water, accounts for 1% of the LSA.

D2.1.5 Capability Classification for Forest Ecosystems

The Land Capability Classification For Forest Ecosystems In The Oil Sands Region, revised edition (Leskiw 1998b) was devised to evaluate the potential of pre- and post-disturbance soils (i.e., naturally occurring and "reconstructed" respectively) for forest production. It's purpose was to aid in the evaluation of land capabilities and planning of soil-handling procedures. The rating system has five classes which are approximately equivalent to the Canada Land Inventory Forestry Capability Classes 3 to 7, respectively (CLI 1974). Defined capability classes and their characteristics are outlined in Table D2.1-3.

Table D2.1-3 Land Capability Classification for Forest Ecosystems in the Oil Sands Region, Revised (Leskiw 1998b)

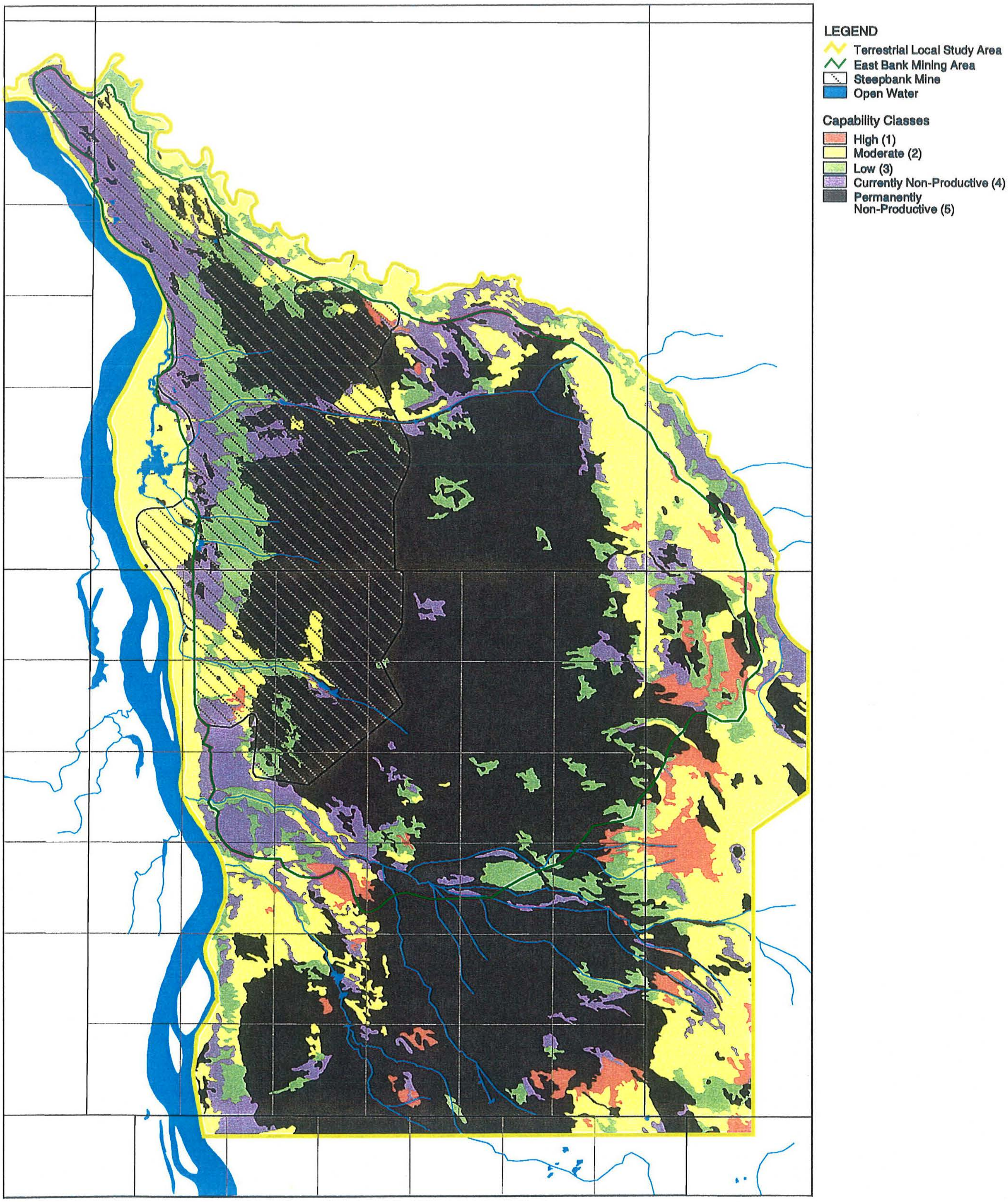
Capability Class	Index Points	Forest Capability - Productivity and Limitations
1	81 - 100	**High Capability** - Land having no significant limitations to sustained forest production, or only minor limitations that will be overcome with normal management practices.
2	61 - 80	**Moderate Capability** - Land having limitations which, taken together, are moderately limiting for sustained forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall cost-benefit will remain attractive but appreciably inferior to that expected on Class 1 land.
3	41 - 60	**Low Capability** - Land having limitations which, taken together, are severe for sustained forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained from the use will be low.
4	21 - 40	**Conditionally Productive** - Land having severe limitations; some of which may be surmountable through management, but which cannot be corrected with existing knowledge.
5	0 - 20	**Non-Productive** - Land having limitations which appear so severe as to preclude any possibility of successful forest production.

This classification system was developed for and applies directly to oil sands region forest ecosystems. It does not apply directly to other ecosystem types such as grasslands or wetlands. For example, lands rated in capability Class 4 (Conditionally Productive) and Class 5 (Non-Productive) for forest production may, in fact, be highly productive wetland areas. It should be noted that all the fen and bog soils in the Project Millennium LSA are rated as Class 5 for forest ecosystems

Forest capability ratings for the pre-disturbance soils of the LSA are listed in Table D2.1-4 while total areas for each capability class are summarized in Table D2.1-5. The spatial distribution of these classes is shown in Figure D2.1-2: Project Millennium LSA Land Capability for Forest Ecosystems.

D2.1.6 Evaluation of Soils in the Project Millennium LSA for Salvage and Suggested Placement

The soil series found in the LSA fall into two genetic classes; those derived from organic materials and those which have evolved on mineral deposits. Both have potential application for placement as reclamation materials in the closure landscape but a brief discussion of their relative merits is warranted.



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SOURCES: Suncor,
Golder,
CAN-AG Enterprises Ltd.,
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The Forestry Corp.

Map Projection: UTM 12
Datum: NAD 83

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LOCAL STUDY AREA
LAND CAPABILITY
FOR FOREST ECOSYSTEMS

29 Mar. 1998	Figure D2.1-2	PRODUCED BY: JS REVIEWED BY:

Table D2.1-4 Land Capability for Forest Ecosystems in the Project Millennium LSA

Soil Series	Area (ha)	Capability Rating[a] X(Y)[b]
Bitumount	65	4(2)
Kinosis	3,086	2(1)
McLelland	4,567	5
McMurray	784	2
Mildred	188	3(1)
Muskeg	3,988	5
Steepbank	1,462	4(3)
Rough Broken	1,898	3(4)
Disturbed Lands[c]	22	5
Water[c]	120	5
Total	**16,181**	**n/a**

[a] All variants within a soil series were grouped, e.g. - Bitumount includes Bitumount and peaty Bitumount.
[b] X(Y) dominant class (significant component of subdominant class)
[c] All disturbed lands and water were assumed to be non-productive for forestry.

Table D2.1-5 Summary of Areas for Each Land Capability Class for Forest Ecosystems in the Project Millennium LSA

Capability Class	Area (ha)	% of LSA
Class 1	465	3
Class 2	3,437	21
Class 3	2,096	13
Class 4	1,486	9
Class 5 [a]	8,697	54
Total	**16,181**	**100**

[a] All disturbed lands and water were assumed to be non-productive for forestry.

D2.1.6.1 Organic Soils

The soils of the McLelland and Muskeg series make excellent materials for incorporation in the reclamation soil mix. Organic matter has a high capacity for holding nutrient cations and moisture while reducing bulk density. The latter enhances root penetration and moisture percolation into the profile (Brady 1990). Table D2.1-6 presents an inventory of the approximate amounts of organic material estimated to be present in the Project Millennium LSA - note that these volumes do not take into account potential shrinkage due to dewatering of the materials or the inclusion of underlying mineral overburden. Some of the latter is excavated during soil salvage for incorporation in the reclamation soil mixture, details on the properties of the mineral substrate may be found in the Soil and Terrain Baseline for Project Millennium (Golder 1998k).

Table D2.1-6 Approximate Volumes of Salvageable Organic Materials in the Project Millennium LSA

Soil Series	Area (ha)	Average Depth (m)	Volume [(a)] 1000 m^3
McLelland	1,531	1.5	23,000
shMcLelland	3,038	0.8	24,300
Muskeg	316	1.5	4,700
shMuskeg	3,671	0.6	22,000
TOTAL	**8,556**	**1.1**	**74,000**

[(a)] Figures do not include potential shrink or swell of material.

D2.1.6.2 Mineral Soils

Very little of the mineral soil cover in the LSA is suitable for direct use as reclamation material. Rather, the most viable application is incorporation of the underlying substrate when salvaging organic soils (i.e. overstripping the peat to include some mineral material). The coarse textured Mildred and medium to coarse textured McMurray soils lack an A horizon, but the upper 0.5 m is suitable for combining with organic material to form the reclamation soil mix. This should be considered only if additional mineral material above and beyond that obtained during stripping of the peat is required. The utility of these soils is limited, due to their coarse textures, to mixing with finer materials (i.e., clays and clay loams) to enhance root penetration and moisture infiltration. Table D2.1-7 presents data on the approximate amounts of suitable mineral materials in the Project Millennium LSA, while a more detailed evaluation of their properties and suggested placement is set out in the Soil and Terrain Baseline for Project Millennium (Golder 1998k).

Table D2.1-7 Approximate Volumes of Mineral Soils Suitable for Salvage in the Project Millennium LSA

Soil Series	Area (ha)	Average Depth (m)	Volume [(a)] 1000 m^3
McMurray	784	0.5	3,920
Mildred	188	0.5	940
TOTAL	**972**	**n/a**	**4,860**

[(a)] Figures do not include potential shrink or swell of material.

D2.1.7 Terrain Classification Units

D2.1.7.1 Generation of the Terrain Units

The terrain units were developed by combining soil map units derived from similar genetic materials. This process of polygon amalgamation is set out in detail in Table D2.1-8. However, a brief explanation of one facet must be included at this point. The wetlands classification map (Golder 1998k) was used for reference when mapping LSA soils. Systemic differences between the soil and wetlands classification systems mean there are discrepancies between some of the bogs and fens. As a result, there is not a direct 100%

correlation between the organic soil and terrain units and their wetlands counterparts, either with respect to location or areas.

Table D2.1-8 Correlation of Soil Units to Terrain Units

Soil Unit - Name/Map Units		Terrain Unit - Name/Map Units	
Bitumount	BMT	Glaciofluvial	Fg
peaty Bitumount	ptBMT	Glaciofluvial	Fg1
Kinosis	KNS	Morainal/Till	Mor/T
gleyed Kinosis	glKNS	Morainal/Till	Mor/T
Mildred	MIL	Glaciofluvial	Fg1
gleyed Mildred	glMIL	Glaciofluvial	Fg1
McLelland	MLD	Fen	N
terric McLelland	shMLD	Shallow Fen	Ns
McMurray	MMY	Fluvial	F
gleyed McMurray	glMMY	Fluvial	F
Muskeg	MUS	Bog	B
terric Muskeg	shMUS	Shallow Bog	Bs
Steepbank	STP	Glaciofluvial	Fg2
peaty Steepbank	ptSTP	Glaciofluvial	Fg2
Rough Broken 2,3	RB2, RB3	Rough Broken	RB

(a) Fg1 = mainly Sands, Loamy Sands with some Sandy Loams
Fg2 = mainly Loams or finer, some Sandy Loams

D2.1.7.2 Description of Terrain Classification Units

Bogs (B Units)

Bogs are wet, poorly-drained peatlands occupying level or depressional areas in the landscape. They contain accumulations of poor to moderately decomposed organic material, mainly Sphagnum mosses. These deposits tend to be acidic in nature due to the stagnant water regime and are generally nutrient-poor (Beckingham and Archibald 1996).

Two categories of bogs were mapped in the LSA: bogs (B Units) where the depth of organics above mineral contact was greater than 120 cm and shallow bogs (Bs Units) where mineral substrate was encountered between 40 and 120 cm of the surface. The presence of permafrost was verified at six inspection sites.

Fens (N Units)

Fens are a form of peatland characterized by a water table at or near the surface for part of the year. As opposed to the stagnant conditions of the bog units, fens have varying degrees of surface or subsurface lateral flow which produces a relatively nutrient-rich, oxygenated environment (Beckingham and Archibald 1996). Fens develop on accumulations of poor to moderately decomposed organics, primarily mosses and sedges.

Two categories of fens were mapped in the LSA: fens (N Units), where the organic depth over mineral was greater than 120 cm and shallow fens (Ns

Units), where mineral contact was made between 40 and 120 cm of the surface.

Fluvial (F Units)

Fluvial deposits are of relatively recent origin, medium to coarse textured , well drained and restricted to the present floodplains of the Athabasca and Steepbank Rivers.

Glaciofluvial (Fg Units)

The composition varies from fine to coarse, clay loams through sandy loams to sands and, as a result, drainage conditions are also quite varied. These units are not extensive in any particular location in the LSA.

Morainal/Till (Mor/T Units)

Kinosis till is found primarily around the periphery of the LSA with the main areas in the east and southeast sectors. There is evidence of fluvial sorting with textures ranging from clay loam through sandy loam.

Rough Broken (RB2 & 3 Units)

A small percentage of the LSA along the escarpments of the Athabasca and Steepbank Rivers is mapped as Rough Broken. RB2 and RB3 are distinct units, with major differences due to variations in slope angle and slope position. The units are characterized by significant internal variability with parent materials described as undifferentiated, typical of colluvial deposits.

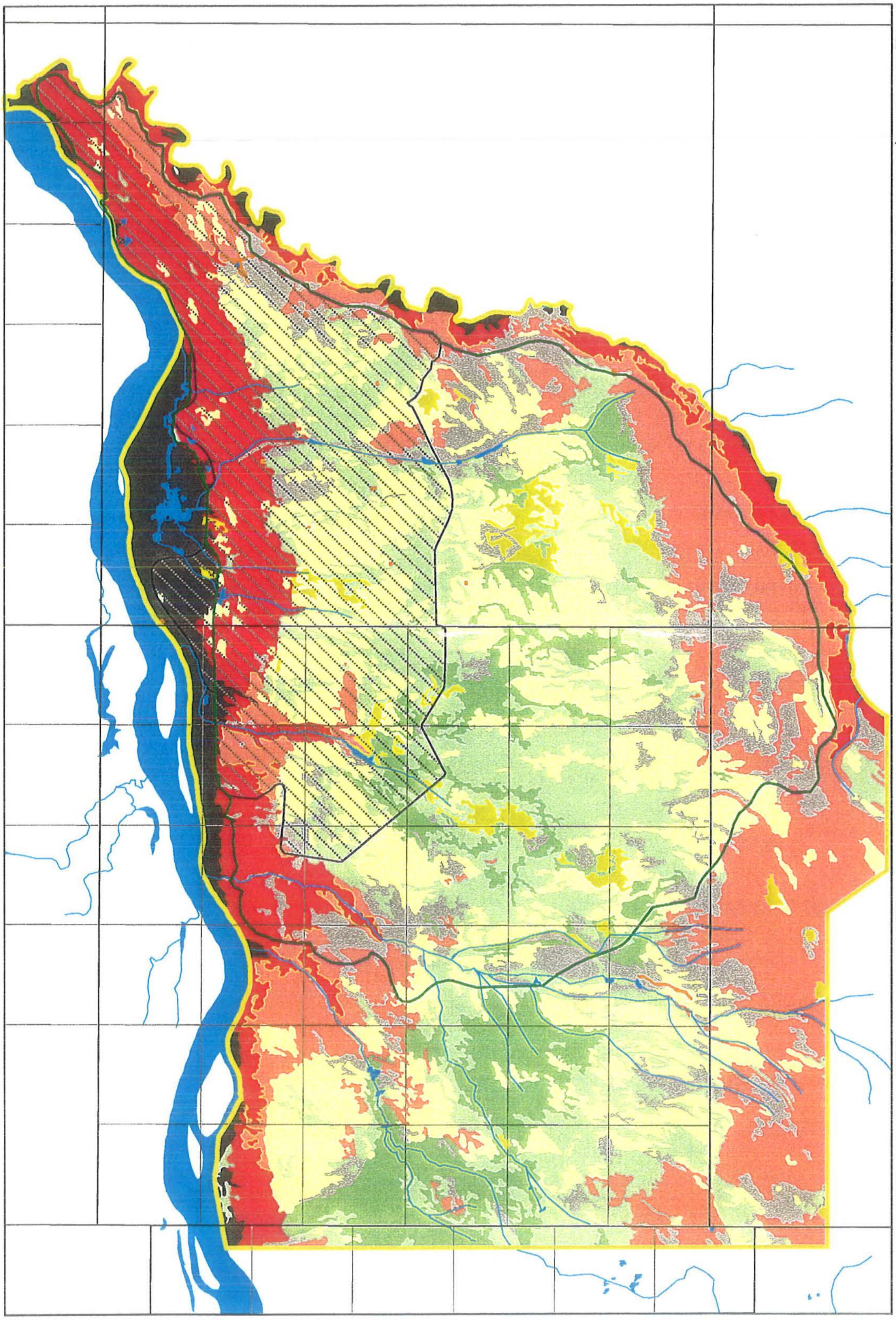
D2.1.7.3 Other Features

There are other features which make up part of the LSA in addition to the terrain units previously described. They are noted as disturbed lands and water.

The extent of terrain units in the LSA is outlined in Table D2.1-9, with their distribution illustrated in Figure D2.1-3.

D2.1.8 Summary

Organic deposits, split about equally between bogs and fens, are the dominant surficial materials occupying approximately 53% of the LSA. These are characterized by peat thicknesses ranging from 0.5 to >2 m. The soils are poorly drained with water tables near the surface (<1 m) for much of the growing season. Most of the soils are Mesisols and while minor amounts of Humisols and Fibrisols do occur, they are not large enough to warrant classifying as separate map units. Similarly, a small number of organic cryosols were encountered but were not extensive enough to be mapped.



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SOURCES: CAN-AG Enterprises Ltd.
The Forestry Corp.
Suncor
Golder

Map Projection: UTM 12
Datum: NAD 83

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Project Millennium

LOCAL STUDY AREA
TERRAIN CLASSIFICATION

29 Mar. 1998 | Figure D2.1-3 | PRODUCED BY: JS REVIEWED BY:

Table D2.1-9 Extent of Terrain Units in the Project Millennium LSA

Terrain Unit	Area (ha)	% of LSA
Bog (B)	316	2
Shallow Bog (Bs)	3,672	23
Bogs, total	**3,988**	**25**
Fen (N)	1,530	9
Shallow Fen (Ns)	3,037	19
Fens, total	**4,567**	**28**
Fluvial (F)	784	5
Glaciofluvial (Fg)	1,715	10
Morainal/Till (Mor/T)	3,086	19
Rough Broken (RB)	1,898	12
Total Area of Terrain Units	**16,039**	**99**
Disturbed Lands	22	<1
Water	120	1
Total Area, Other Features	**142**	**1**
Total Area in LSA	**16,181**	**100**

Deposits of Kinosis till make up 19% of the LSA and are found mostly along the eastern and southeastern sections with a few scattered pockets in the southwest.

Medium to coarse textured glaciofluvial materials account for slightly more than 10% of the LSA and are found in the peripheral upland areas, generally in association with the morainal/till units.

Small expanses of coarse textured fluvial materials of recent origin are found along the floodplains of the Athabasca and Steepbank Rivers. These make up slightly less than 5% of the LSA.

The final unit is referred to as Rough Broken. It includes mainly colluvial parent materials and is found along the steep escarpments of the Athabasca and Steepbank River valleys and proximal upland areas. It accounts for about 12% of the surficial materials.

Disturbed areas and water comprise the remainder of the LSA, about 1%.

D2.2 SOILS AND TERRAIN PROJECT IMPACT ASSESSMENT

D2.2.1 Introduction

Evaluation of the impacts of the Project on soil and terrain included:

- the generation of impact Key Questions;
- developing linkages for each Key Question;
- delineating the Local and Regional Study Areas (LSA and RSA Figures D1-2 and D1-3);
- developing impact assessment criteria;
- assessing the validity of the Key Question linkages;
- developing mitigation strategies for each valid linkage; and
- evaluating the impact assessment criteria for each valid linkage.

No key indicator resources (KIRs) were selected for the soils and terrain component of the Project.

D2.2.2 Key Questions and Linkages

The first phase of the evaluation of soils and terrain involved identifying Key Questions and developing linkage diagrams to illustrate possible impacts the development might have on the soils and terrain. These linkages are considered under two scenarios: construction and operation (Figure D2.2-1) and closure (Figure D2.2-2). Two Key Questions were formulated to encompass the most significant impacts associated with the Project.

ST-1: What impacts will development and closure of Project Millennium have on the quantity and quality of soils and terrain units?

The areas and spatial distribution for each soil series and terrain unit were determined for the pre-development LSA. Next, the disposition of areas to be disturbed by Project development were mapped and their extent calculated. Comparison of these figures allowed a quantification of Project impacts with respect to areas of soil and terrain units affected. Determination of the residual impacts of the Project required a further assessment of the soil and terrain status at closure, i.e., to incorporate reclamation and mitigation into the analysis.

Quality was assessed by assigning a forest capability rating (Leskiw 1998) to each soil series in the LSA then, as above, mapping and calculating their pre-development, development impact and closure areas and distributions. Comparison of these data allowed an assessment of Project related impacts and residual impacts on this property.

Figure D2.2-1 Linkage Diagram for Soil and Terrain for Construction and Operation Phase of Project Millennium

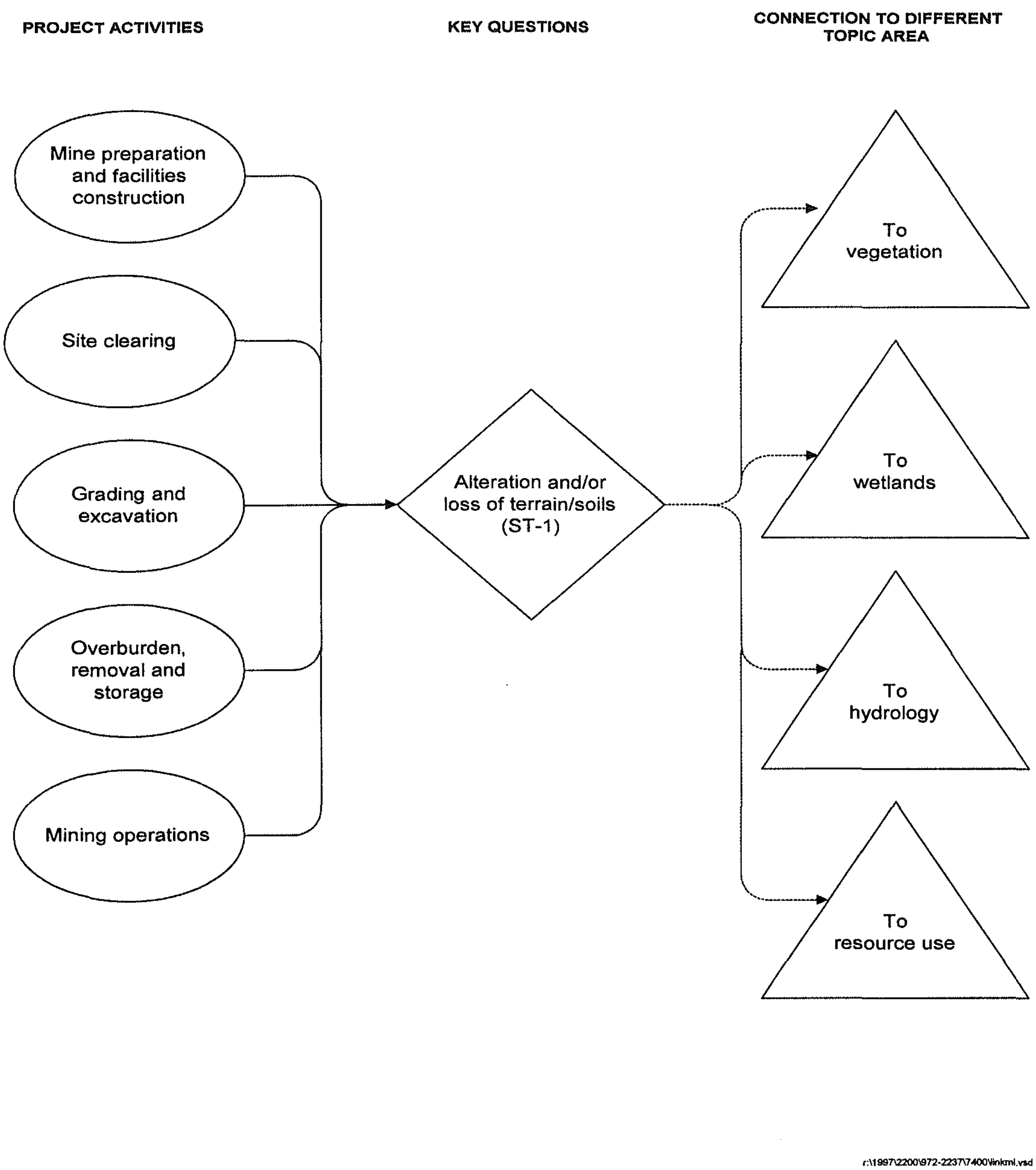
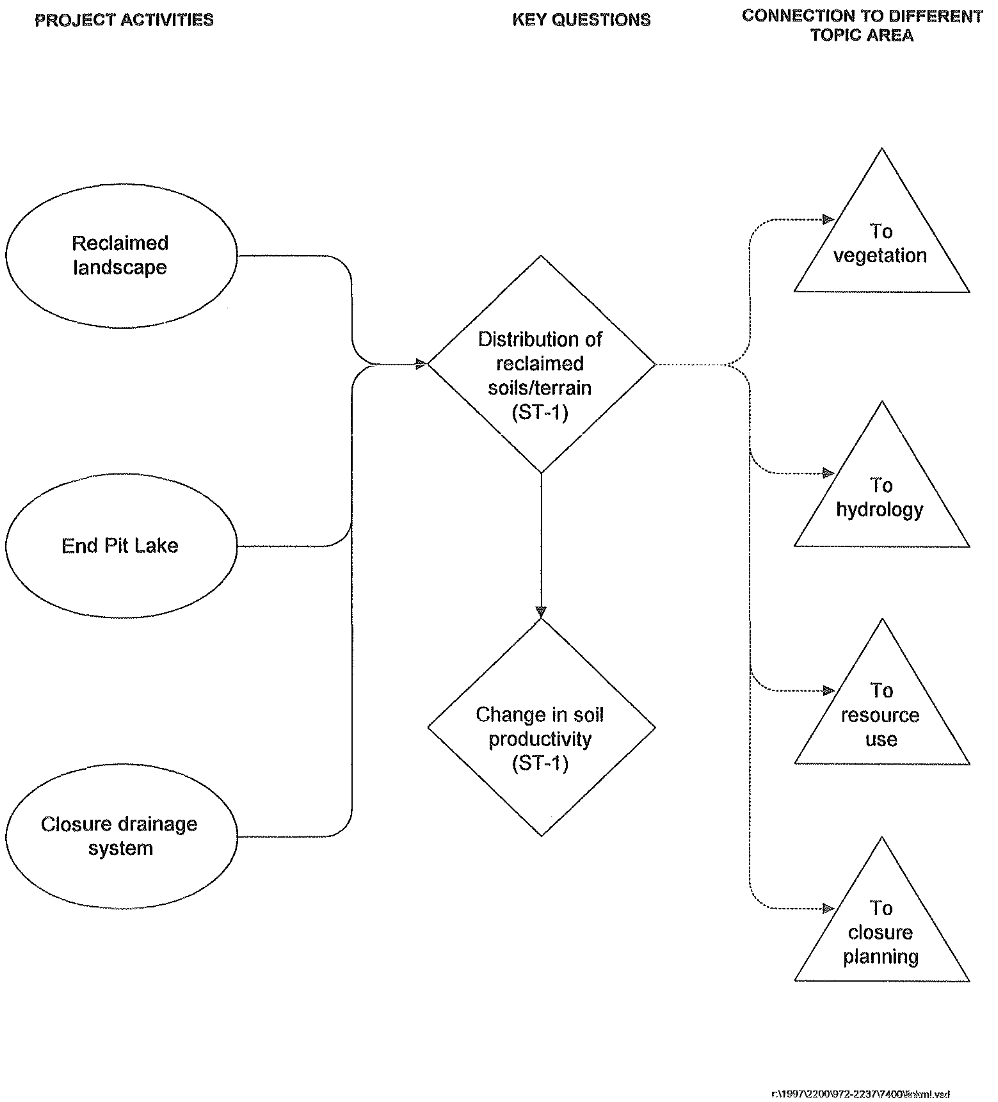


Figure D2.2-2 Linkage Diagram for Soil and Terrain for Closure Phase Project Millennium



ST-2: What impacts will acidifying emissions From Project Millennium have on regional soils?

A conceptual system for assigning relative sensitivity to Potential Acidifying Inputs (PAI) ratings for each soil series in the RSA (and LSA) was devised. The area of each series within defined critical load isopleths was then determined.

D2.2.3 Methods

D2.2.3.1 Linkage Validation

Linkages between Project activities and potential environmental changes that apply to each of the Key Questions were assessed for their validity based upon field data collected within and proximal to the LSA, review of the relevant literature, consultation with other disciplines involved in this EIA and professional judgment.

D2.2.3.2 Mapping Techniques

The primary tool used in this assessment was mapping of the spatial distribution of the various soil series and terrain units. Alberta Vegetation Inventory (AVI) mapping of the LSA was carried out in the pre-field phase of this investigation. Soil inspection sites were placed in as many AVI polygons as practicable, then soil series-AVI polygon associations were statistically evaluated. Where no strong relationships emerged (i.e., less than a 90% confidence level) reference was made to: vegetation and wetlands maps of the LSA, topographic maps, surficial geology reports and stereo airphoto coverage. These additional resources plus professional judgement were used to establish best-probable soil-AVI linkages. The soil units, or polygons, were given specific attributes based upon the analysis of field samples collected for this evaluation and mapped accordingly. The terrain units were derived by amalgamating all soil polygons having similar genetic material (e.g., glaciofluvial deposits) and mapped. Forest capability ratings were assigned to each soil series permitting another variable to be mapped for the pre-development and closure scenarios. There is, as a result, a common basis among the AVI, soil and terrain maps of the LSA.

D2.2.3.3 Development of Mitigation Measures

Mitigation, within the context of an EIA, may be defined as follows: "the application of design, construction or scheduling principles to minimize or eliminate potential adverse impacts and, where possible, enhance environmental quality" (Sadar 1994). Many of the impacts associated with this Project may be amenable to mitigation if appropriate environmental strategies are applied during the planning, construction and operations, and closure phases of the development. These strategies may include:

a) techniques for and timing of initial soil salvage;

b) sequencing of the stripping and replacement operations to minimize or eliminate stockpiling of the reclamation resources; and

c) appropriate design of the reconstructed landforms to optimize the potential for returning the Project development area to a capability equivalent to the pre-development state and/or to address the specified end land use objectives outlined in Section E (Closure).

Mitigation suggestions were devised for each valid linkage pathway.

D2.2.3.4 Impact Assessment Classification and Environmental Consequence

The criteria for the impact assessment classification and environmental consequence are described in Section A2 of the EIA.

D2.2.4 Monitoring

An effects monitoring program is generally deemed essential to assess whether:

- the predicted impacts occur or not; and
- the mitigation measures will achieve the objectives.

Compliance monitoring will also be completed by Suncor, as per the conditions of the project approval.

D2.2.5 Key Question ST-1: What Impacts Will Development and Closure of Project Millennium Have on the Quantity and Quality of Soil and Terrain Units?

D2.2.5.1 Analysis of Potential Linkages

This Key Question deals with the direct impacts of Project construction, development and closure on the loss or alteration of soil and terrain units in the LSA. Direct changes occur with the removal of soil and alteration of terrain features during site clearing, grading and excavation, overburden removal and storage, construction of the mine and its associated infrastructure over the life of the development (Figures D2.2-1 and D.2.2-2, respectively). These changes may be calculated and the areas of each affected component catalogued. To accurately determine the residual impacts of the Project on these components, one must also assess the mitigation achieved at closure - to what extent have any losses or alterations been remediated. This is achieved by evaluating the distribution of reclaimed soil and terrain features, new waterbodies and the closure drainage network. All of these factors interact and contribute to the degree of suitability of the closure landscape for the reclaimed vegetation communities discussed in Section E (Closure) of this EIA.

Impacts to quality were assessed by assigning a land capability for forest ecosystems classification (Leskiw 1998) to each soil series, mapping the pre-development, maximum impact and closure distributions of each and calculating changes/alterations due to the Project. As noted above, assessment at closure is required to accurately portray the residual impacts on the environment. The areas and distributions of the various land capability classes at closure provide a basis for evaluating the future potential of forest resources in the LSA.

Modelling of the hydrogeology for Project Millennium (Section C2 of this EIA) indicates surficial aquifer drawdown is likely to extend between approximately 50 m (maximum impact zone, included in 50 m buffer around mine pits) and 300 m (reduced impacts) around the development footprint. The primary impact of this will be a lowering of the water table which will affect soil drainage. This presents two potential scenarios. First, many of the LSA soils are rated as being non-productive for forest ecosystems due mainly to saturated conditions (e.g., the extensive fen and bog areas and some gleysols). Lowering the water table may well enhance the capability of some of the mineral soils and much of the organic soil in the LSA to support productive forest cover. A second aspect, as discussed in Section D3 (Terrestrial Vegetation and Wetlands) is the potentially negative impact on fen systems due to reductions in through-flow resulting from the drawdown. The direction and magnitude of these impacts are discussed in Section D3.2.

D2.2.5.2 Analysis of Soil and Terrain Unit Losses/Alterations

Activities that will result in the loss or alteration of soil and terrain units in the LSA include:

- clearing and grading of the soils to permit facility construction, followed by relocation and storage of the soil materials;
- excavation of overburden, followed by storage;
- sequential expansion of the mining operations over time; and
- emissions of potential acidifying inputs (PAI) into the atmosphere (this is discussed at length under Key Question ST-2).

Preparation of the areas for mining and facilities construction will involve complete removal of the soil cover. Reclamation will begin soon after construction, proceed incrementally throughout the operations phase and finish with closure. The preference is for direct placement of the salvaged material on newly reclaimed surfaces. If this is not feasible, the salvaged soils will be stored in designated stockpile areas for future reclamation applications. Neither organic materials or mineral topsoil will be stripped from the locations specified for the tailings settling pond, in overburden disposal areas or where reclamation materials are stored (RMS). Similarly, excavation and storage of overburden, a process required to expose the ore body for mining, will completely remove any existing terrain features in the affected areas.

The impact of these activities can be quantified by calculating the extent of each soil and terrain unit type in the pre-development landscape, then computing the areas of each that will be removed during Project construction and operations. The difference between the two will be the direct impact on these two resources.

Removal and alteration of soil and terrain units will occur as a result of Project activities. The Project will be developed progressively across the landscape followed by phased reclamation; however, the impact on soils and terrain will be that of the maximum extent of the development footprint. The second facet to be considered is the impact on the distribution of soil and terrain features resulting from reclamation measures instituted during operations and completed during the closure phase. Direct assessments of the areas of both the soil and terrain units that remain undisturbed and those which are reconstructed during closure can be calculated and comparisons made with pre-development conditions. These data permit residual impact assessments to be made. Figure D2.2-2 indicates this pathway.

While a portion of the LSA will remain undeveloped during construction and operations, a significant area of the LSA will consist of reconfigured landscape features covered by a reclamation soil mix. Neither the soil or terrain units will be analogous to their pre-development counterparts.

The objectives of the conservation and reclamation plan for this Project are to restore the area to "equivalent capability" with respect to pre-development conditions; this does not mean, nor is it meant to imply an exact replication of the pre-existing state. The result of this will be a landscape that incorporates the remaining undisturbed features with new features engineered to conform with the end land use objectives set out in the Project closure goals and objectives (Section E of Volume 1). Overall, the distribution of soil and terrain features will be substantially changed.

Soil Units

Approximately 60% of the soil units in the LSA will be affected by Project activities. The majority of these soils fall into the organic (39%) and morainal/glacial till (7%) classes, the former of which is relatively unproductive with respect to forestry. In the closure scenario, some of these resources will have been salvaged and used as reclamation soil material in the new landscape. In concert with the greater variety in topographic relief, these soils will enhance the overall productive capability of the ecosystem - in terms of commercial forest species. For the LSA as a whole this may be viewed as a positive impact of significant proportions.

Table D2.2-1 describes the loss/alteration of soil units due to Project activities. The naturally occurring soils will not be restored at closure, but will be replaced by a uniform reclamation soil mix that is approximately 60% peat (organic) and 40% mineral in composition. This will be applied to a uniform depth over all the non-wetlands areas in the reclaimed landscape. Its capacity to support vegetation regrowth will vary directly with the depth of the water table below the surface. The water table depth is controlled by the geotechnical specification of the recontoured structures. Note that the main soils affected by development will be currently non-productive organics of the McLelland and Muskeg series and the medium textured, moderate and low productivity mineral soils of the Kinosis and Steepbank series.

Table D2.2-1 Losses/Alterations of Soil Units in the Local Study Area

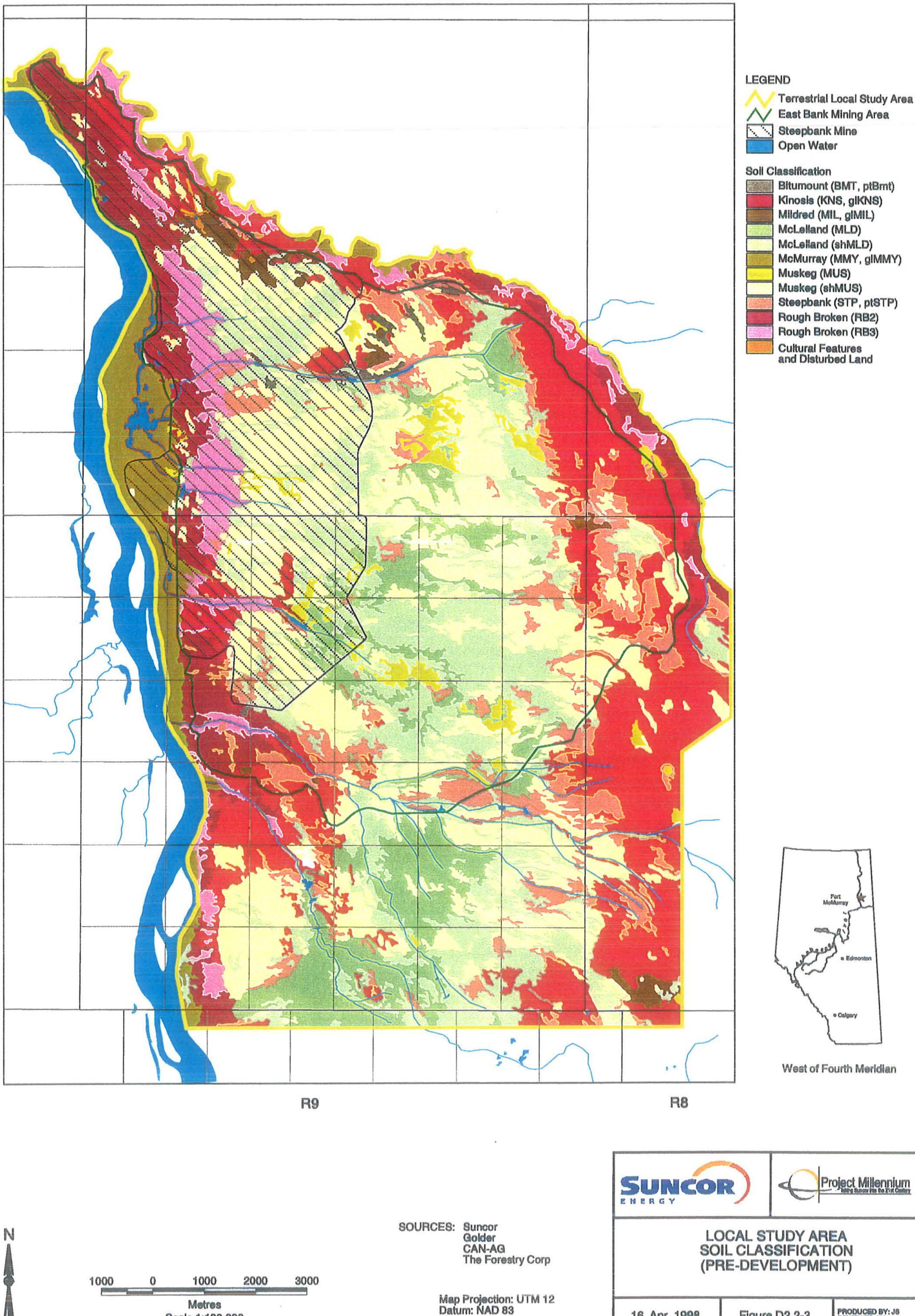
Soil Unit	Pre-Development ha/% LSA	Steepbank Impact ha/% LSA	East Bank Mining Area Impact ha/% LSA	Closure Landscape ha/% LSA	Change ha/% LSA
Bitumount	65/<1	0/0	62<1	5/<1	-60<1
Kinosis	3,086/19	321/2	1,143/7	2,010/12	-1,076/7
McLelland	4,567/28	917/6	2,802/17	1,944/11	-2,619/17
McMurray	784/5	156/<1	45/<1	758/5	-26/<1
Mildred	188/1	97/1	132/1	71/<1	-117/<1
Muskeg	3,988/25	1,094/7	2,880/18	1,137/7	-2,851/18
Rough Broken 2	1,158/7	563/3	767/5	448/3	-710/4
Rough Broken 3	740/5	443/3	475/3	270/2	-470/3
Steepbank	1,462/9	127/1	946/6	550/3	-912/6
Disturbed Lands	22/<1	14/<1	15/<1	8/<1	-14/<1
Water	120/1	8/<1	14/<1	110/<1	-10/<1
Sub-Total	***16,181/100***	***3,776/23***	***9,281/57***	***7,311/45***	***-8,865/-55***
Reclaimed Wetlands	n/a	n/a	n/a	191/1	+191/1
Reclaimed Soil	n/a	n/a	n/a	7,985/49	+7,985/49
Sub-Total	***n/a***	***n/a***	***n/a***	***8,176/51***	***+8,176/+51***
Water	n/a	n/a	n/a	694/4	+694/+4
TOTAL	**16,181/100**	**3,402/21**	**9,281/57**	**16,181/100**	**0/0**

n/a = not applicable.

A full description of each soil unit and the techniques by which the terrain units were derived may be found in the report, Soil and Terrain Baseline for Project Millennium (Golder 1998k). It should be noted that the soils surveyed for Suncor's Steepbank Mine were reclassified for this EIA (and its associated soil and terrain baseline report) to be consistent with the approaches used for Syncrude's Aurora Mine and Shell's Muskeg River Mine Project. This resulted in the Algar, Firebag, Horse River, Rough Broken 1 and Ruth Lake series being deleted and the Bitumount, Mildred and Steepbank series appearing. Direct comparisons between the 1996 Steepbank Mine document and the Project Millennium baseline are, therefore, difficult so deference should be made to the latter as being the more current and authoritative classification.

Table D2.2-1 also describes the types and distribution of soil units in the closure landscape. Figure D2.2-3 shows the pre-development soil distribution, while Figure D2.2-4 shows the closure soil distribution. It can be seen that the reclaimed soils provide the potential for enhanced productivity via an overall increase in potential forest ecosystem capability (this is discussed in more detail in subsection D2.2-8). This is due primarily to their placement in the new landscape which results in a greater range of aspects, drainage regimes and slopes.

Reclamation of Project Millennium will not restore either the soils or terrain to pre-development conditions. Much of the closure landscape will be recontoured and capped with a non-naturally occurring reclamation soil mixture. Therefore reclamation will change the distribution of soils in the LSA.



SOURCES: Suncor
Golder
CAN-AG
The Forestry Corp

Map Projection: UTM 12
Datum: NAD 83

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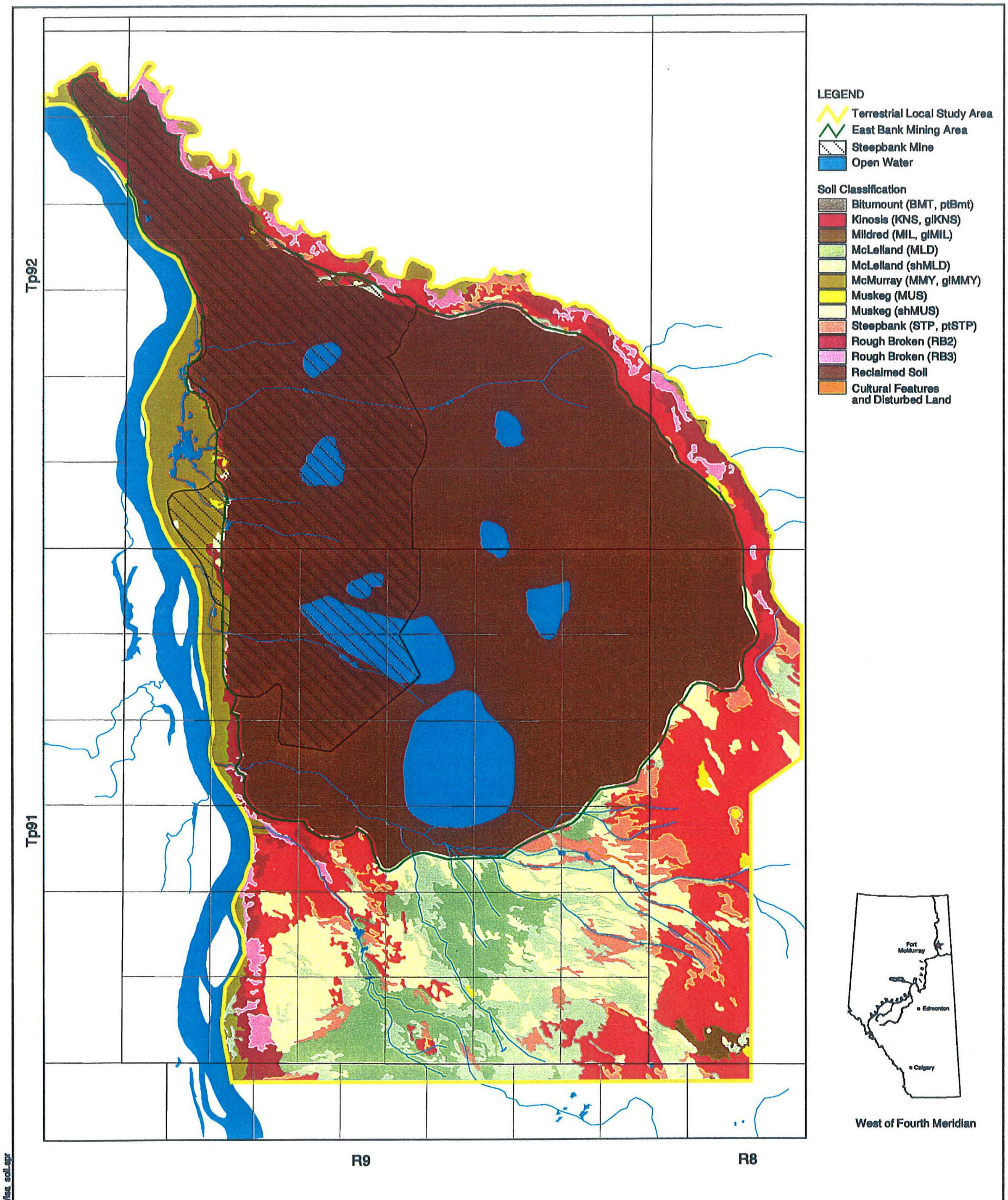
LOCAL STUDY AREA
SOIL CLASSIFICATION
(PRE-DEVELOPMENT)

16 Apr. 1998	Figure D2.2-3	PRODUCED BY: JS REVIEWED BY:



SOURCES: Suncor
The Forestry Corp
CAN-AG
Golder

Map Projection: UTM 12
Datum: NAD 83

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LOCAL STUDY AREA
CLOSURE SOIL CLASSIFICATION

16 Apr. 1998	Figure D2.2-4	PRODUCED BY: JS REVIEWED BY:

Table D2.2-2 Losses/Alterations of Terrain Units in the Local Study Area

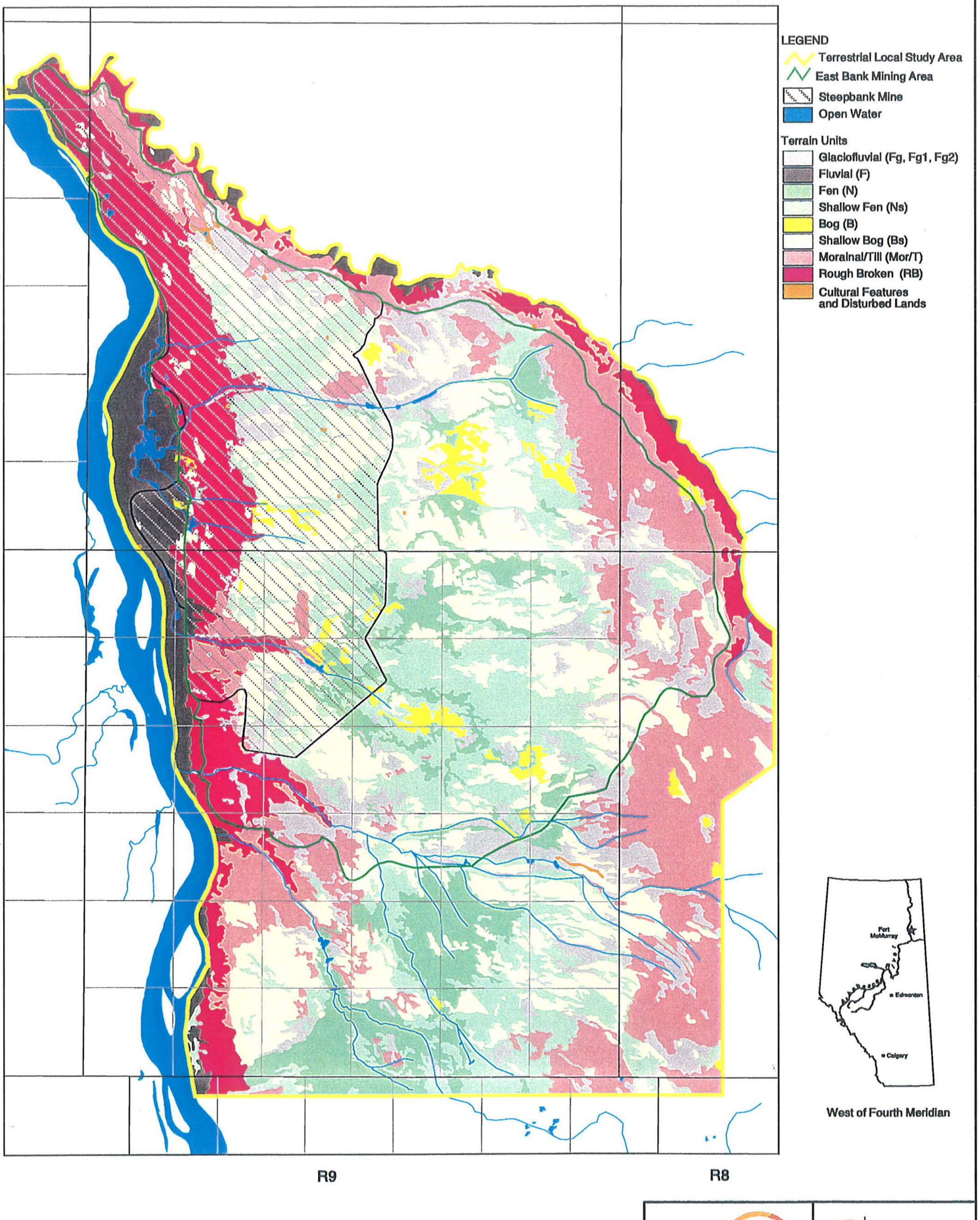
Soil Unit	Pre-Development ha/% LSA	Steepbank Impact ha/% LSA	East Bank Mining Area Impact ha/% LSA	Closure Landscape ha/% LSA	Change ha/% LSA
Bog	316/2	64/<1	284/2	52/<1	-264/2
Shallow Bog	3,671/23	1,030/6	2,596/16	1,315/8	-2,356/15
Fen	1,531/9	810/1	691/4	887/5	-644/4
Shallow Fen	3,037/19	110/5	2,111/13	1,122/7	-1,915/12
Fluvial	784/5	157/<1	45/<1	774/5	-10/<1
Glaciofluvial	1,715/10	239/1	1,139/7	871/5	-844/5
Morainal/Till	3,086/19	341/2	1,144/7	2,239/14	-1,942/12
Rough Broken	1,898/12	1,004/5	1,242/8	1,155/7	-743/5
Disturbed Lands	22/<1	14/<1	15/<1	8/<1	-14/<1
Water	120/1	8/<1	14/<1	110/<1	-10/<1
Sub-Total	***16,181/100***	***3,776/23***	***9,281/57***	***8,533/53***	***-7,648/47***
Consolidated Tailings	n/a	n/a	n/a	3,278/20	+3,278/20
Littoral Zone				190/<1	+190/<1
Overburden	n/a	n/a	n/a	2,609/16	+2,609/16
Overburden-Sand Mix	n/a	n/a	n/a	274/2	+274/2
Tailings Sand	n/a	n/a	n/a	603/4	+603/4
End Pit Lake	n/a	n/a	n/a	694/4	+694/4
Total New Landforms	n/a	n/a	n/a	7,648/47	+7,648/47
TOTAL	**16,181/100**	**3,776/23**	**9,281/57**	**16,181/100**	**0/0**

n/a = not applicable

Terrain Units

As shown in Table D2.2-2 the major units that will be affected by Project development will be the fens and shallow fens (organics) and morainal/till units. The pre-development terrain units are shown in Figure D2.2-5. While these terrain units will be removed from the landscape, most of the material will be used to recontour the surface and construct new landforms (mineral materials) while the organics will be salvaged for use in the reclamation soil cover. While the pre-existing terrain units will not be restored to their original form, a suite of new, more varied landforms will take their place.

Table D2.2-2 also outlines the distribution of terrain units in the closure landscape, as illustrated in Figure D2.2-6. Two main points are worthy of elaboration to place these scenarios in context. On the order of 40% of the pre-development terrain units will remain intact at closure thus preserving a substantial area relatively undeveloped. The remaining 60% of the LSA will consist of newly reconstructed features that conform with the Project closure goals and objectives and are described in greater detail in the C&R Plan for the Project (Section E of Volume 1). Table D2.2-2 shows that a greater variety of terrain types will be present at closure, thereby enhancing the overall diversity of features within the LSA. In addition, the majority of the terrain at present is poorly drained, a function of the topography and surficial materials, while by comparison the closure landforms will present greater relief, varied drainage regimes and, potentially, a wider variety of environmental types for vegetation recolonization and wildlife habitat.



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SOURCES: Suncor
Golder
CAN-AG
The Forestry Corp

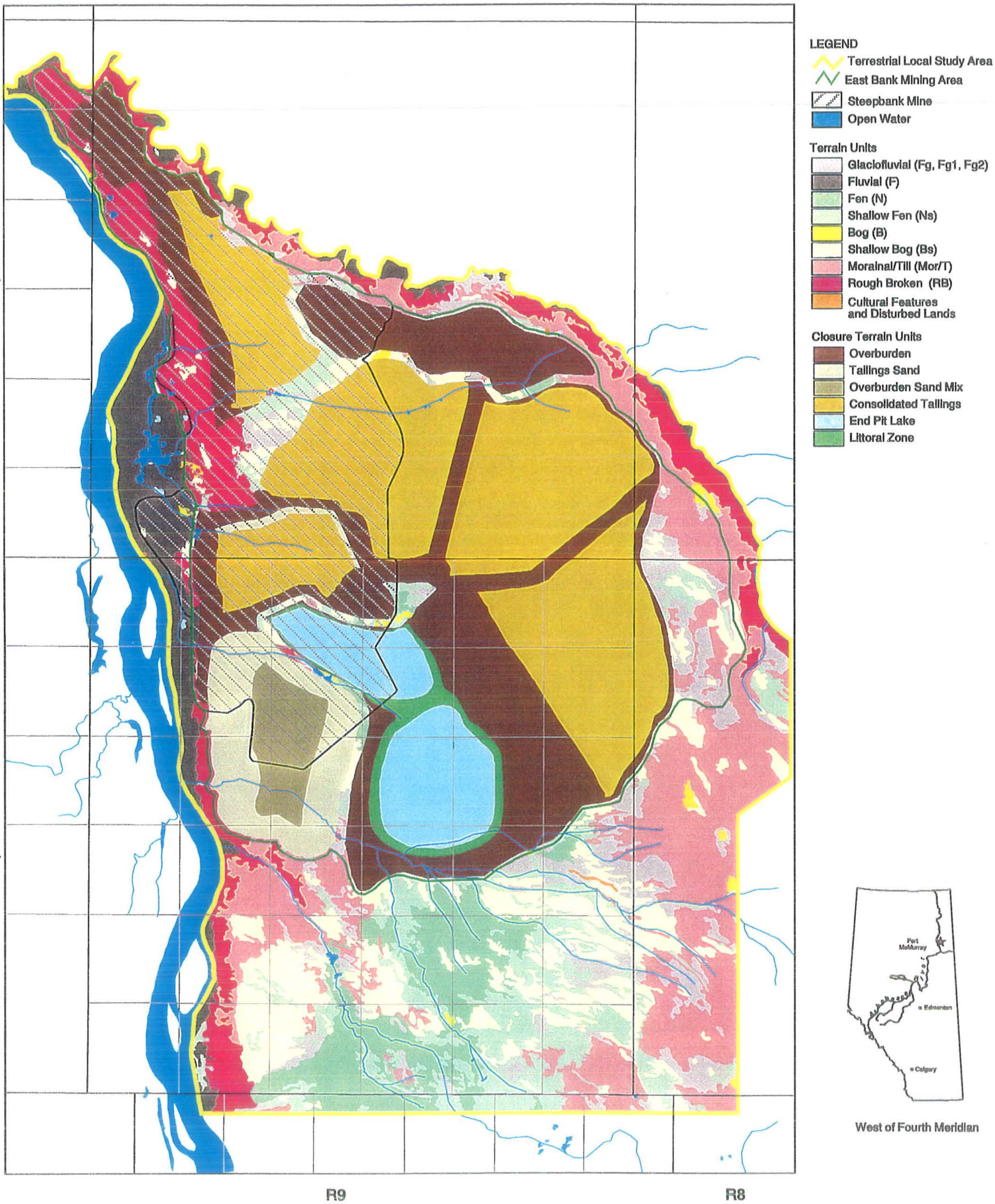
Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
TERRAIN CLASSIFICATION
(PRE-DEVELOPMENT)

16 Apr. 1998 | Figure D2.2-5 | PRODUCED BY: JS REVIEWED BY:



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SOURCES: Suncor
Golder
The Forestry Corp
CAN-AG

Map Projection: UTM 12
Datum: NAD 83

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Project Millennium

LOCAL STUDY AREA
CLOSURE TERRAIN CLASSIFICATION

16 Apr. 1998	Figure D2.2-6	PRODUCED BY: JS REVIEWED BY:

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D2.2.5.3 Impact Assessment, Residual Impacts and Environmental Consequences

Soils

Table D2.2-3 describes the development impacts, residual impacts and environmental consequences associated with soil unit changes in the LSA. These evaluations apply only to the areas disturbed by Project development. The soils within the development footprint will be significantly affected, in a negative manner, in that they will be for the greater part removed. However, since much of the organic and some of the mineral materials will be used in the reclaiming of the mine areas, this is more correctly viewed as alteration not loss of the resource. Environmental Consequence ratings provide a qualitative evaluation of the impacts which, in this case, are of a transitory nature. Land capability ratings are a more quantitative tool for assessing the effects of change in the soils of the LSA. This is discussed in greater detail in Subsection D2.2.8 but in summary, a substantial area of currently non-productive soils (both organic and mineral) will be reconstructed to more productive status, i.e., class 3 versus class 5 for forest ecosystems. While the immediate impact must be seen as negative, at closure the potential exists for a positive, extensive enhancement of the ecosystem - with respect to forest ecosystem potential. The Environmental Consequence ratings for both of these actions is rated as being high; however, in the longer-term they may well be nearly off-setting in a spatial sense as the impacted area will be remediated, albeit to a different end land use.

Table D2.2-3 Impacts, Residual Impacts and Environmental Consequences Due to Soil Unit Changes in the LSA

	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Disturbed Soils • poorly-drained, organic dominated soils	Negative	High	Local	Life of Project	Irreversible	Low	High
• moderately well-drained, mineral dominated soils	Negative	High	Local	Life of Project	Irreversible	Low	High
Reclaimed Soils • soil capability class 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
• soil capability class 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
• soil capability class 3	Positive	High	Local	Long-Term	Irreversible	Low	High
• soil capability class 4	n/a	n/a	n/a	n/a	n/a	n/a	n/a
• soil capability class 5	Negative	High	Local	Long-Term	Irreversible	Low	High

n/a = not applicable

Terrain

Similar to the soils, approximately 60% of naturally occurring terrain units will be affected, although to varying degrees. The principal areas of impact will be in the fen and bog, and morainal/glacial till units. While these losses may appear to be negative, Table D2.2-6 indicates that the closure landscape will in fact be composed of a greater variety of landform types. From a terrain variability perspective the alterations brought about by the Project will be substantial in nature, increase the variety and therefore be positive in direction.

The residual impacts of reclamation on the soil and terrain are positive in direction. The landforms are reconstructed and significantly different from the pre-existing state in that there is much more relief (i.e., changes in elevation) incorporated in their design. This provides a wider range of micro- and macro-environments by comparison and, thereby, introduces the potential for greater diversity in ecological niches for the closure landscape.

Table D2.2-4 shows development impacts, residual impacts and associated Environmental Consequences for terrain unit alterations in the LSA, these assessments pertain only to the areas which will be disturbed by Project development. (Note - Some parts of the footprint are designated as "unmined development area" which it is assumed will not be graded and excavated, therefore the soils and terrain features will remain in the pre-development state.) The units sustaining the greatest degree of impact are the organics, which are the primary component of the reclamation soil. While the environmental consequences related to these units is classed as high, based on the area affected, it fails to account for the "recycling" of the materials. In fact, it would be more accurate to view this as a redistribution of the resource versus a complete loss. The morainal/till units are somewhat less affected and again some of the resources will be used to recontour the landscape so loss is not completely accurate. The reclaimed terrain units present a positive alteration in that the variety of genetic materials upon closure will be greater than pre-disturbance, leading to an overall increase in potential ecosystem variability. The high Environmental Consequence ratings associated with the bog, fen, morainal/till and glaciofluvial units are a function of their removal during site preparation - there can be no doubt that these are permanent losses to the ecosystem. However, the high positive Consequence given to the reclaimed overburden unit partially accounts for the "recycling" of some of the disturbed mineral materials back into the landscape at closure. Overburden is simply pre-disturbance terrain unit material that has been used in reconfiguring the site after the operational life of the Project. A second, similar pattern that is present but is not explicit in the terrain unit ratings - although it does appear in the soil ratings - is the re-use of removed organic materials in the reclamation soil mix. The fen and bog units themselves do not reappear at closure but much of the material that composes them does. A final point of note relates to the CT (consolidated tailings) deposits which also receive a positive, high Environmental Consequence rating. This material is predominantly sandy in nature and the reclaimed terrain units which it forms the basis of will be fairly well drained, unlike much of the pre-development Project area which has developed on finer parent materials. With regard to the defined end land use objectives for the Project, this an enhancement to the landscape which is reflected in the land capability for forest ecosystems ratings discussed at a later point in this section.

Table D2.2-4 Impacts, Residual Impacts and Environmental Consequences Due to Terrain Unit Changes in the LSA

	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Pre-Development Terrain Units							
• bogs, shallow bogs, fens, shallow fens	Negative	High	Local	Long-term	Irreversible	Low	High
• morainal-till/glaciofluvial	Negative	Moderate	Local	Long-term	Irreversible	Low	High
• fluvial/rough broken	Negative	Low	Local	Long-term	Irreversible	Low	Low
Reclaimed Terrain Units							
• CT deposits	Positive	High	Local	Long-term	Irreversible	Low	High
• overburden	Positive	High	Local	Long-term	Irreversible	Low	High
• tailings sand	Positive	Low	Local	Long-term	Irreversible	Low	Low
• overburden/sand mix	Positive	Low	Local	Long-term	Irreversible	Low	Low
• end pit lake	Positive	Low	Local	Long-term	Irreversible	Low	Low
• littoral zone	Positive	Low	Local	Long-term	Irreversible	Low	Low

D2.2.5.4 Mitigation

A significant aspect of the construction and operational phase of the Project is progressive reclamation, which accompanies mine development. As a result, new terrain features (reclaimed landscapes) covered with a reclamation soil mixture will mitigate the losses/alterations to pre-development soil and terrain conditions. Reclamation is viewed as mitigating Project activities by replacing rather than restoring pre-development conditions. Furthermore, as outlined in Section E of Volume 1, the diversity of the landscape will be increased by the greater range of relief and slope conditions associated with the variety of the reconstructed surface features.

D2.2.5.5 Monitoring

During stripping of the organic soil materials, monitoring will be conducted to ensure correct soil salvage and handling procedures. As set out in the Conservation and Reclamation plan (Section E of Volume 1), a degree of over-stripping to incorporate specified amounts of mineral substrate is required for building the reclamation soil. Monitoring will ascertain that stripping is carried out as required in the correct soil and terrain units. Once stockpiled, the salvaged materials will be allowed to naturally revegetate to minimize potential losses to wind and water erosion. This process should be relatively rapid while retaining the viability of the natural species seed bank and root stocks - use of domestic cover species would be detrimental to the latter.

Once the landscape has been recontoured, capped with the reclamation soil mix and revegetated, a comprehensive, on-going monitoring program will be instituted. This program is discussed in detail in Section D2.2.7.2 of the EIA.

D2.2.6 Project Millennium Impacts in the Context of the Regional Study Area

While the direct impacts of construction and development will have their greatest effects on the soil and terrain components within the LSA, they must also be placed in the context of the RSA as they form a part of the extended resource base. Table D2.2-5 presents inventories of the pre-development and impact distributions of soils in the RSA. It is apparent from examining the table that the LSA in total makes up only 0.4% of the RSA; therefore, the disturbances associated with Project Millennium even at its maximum extent will be negligible in the spatial context of the RSA. Furthermore, none of the soils in the LSA (or RSA) are particularly unique so in both quantitative and qualitative aspects the environmental consequences associated with the Project will be negligible.

Table D2.2-5 Soils of the Project Millennium RSA, Baseline and Impact Conditions

Soil Series/Map Unit	RSA Baseline Area, ha/%RSA	Project Millennium Area, ha/%RSA	Project Millennium Impact Area, ha/%RSA	Change Area, ha/%RSA
Algar	47,879/2	0/0	0/0	0/0
Bitumount	11,110/<1	65/<0.1	62/<0.1	62/<0.1
Buckton	32,571/1	0/0	0/0	0/0
Dover	79,418/3	0/0	0/0	0/0
Eaglesham (McLelland)[a]	148,060/6	4,568/0.18	2,802/0.12	2,802/0.12
Firebag	128,251/5	0/0	0/0	0/0
Fort	3,861/<1	0/0	0/0	0/0
Horse River	26,076/1	0/0	0/0	0/0
Heart	87,154/4	0/0	0/0	0/0
Joslyn	86,797/4	0/0	0/0	0/0
Kearl	1,167/<1	0/0	0/0	0/0
Kinosis	72,705/3	3,086/0.13	1,143/<0.1	1,143/<0.1
Kenzie (Muskeg)[b]	804,394/33	3,988/0.16	2,880/0.12	2,880/0.12
Legend	105,507/4	0/0	0/0	0/0
Livock	47,198/2	0/0	0/0	0/0
Mildred	205,269/8	188/<0.1	132/<0.1	132/<0.1
Mikkwa	112,834/5	0/0	0/0	0/0
McMurray	71,246/3	783/<0.1	45/<0.1	45/<0.1
Namur	55,302/2	0/0	0/0	0/0
Rough Broken	66,577/3	1,898/0.08	1,242/0.05	1,242/0.05
Ruth Lake	22,417/1	0/0	0/0	0/0
Rock	19,329/1	0/0	0/0	0/0
Steepbank	40,871/12	1,462/0.06	946/<0.1	946/<0.1
Surmont	18,088/1	0/0	0/0	0/0
Total, Soil Units	***2,299,727/95***	***16,038/0.66***	***9,252/0.4***	***9,252/0.4***
Disturbed Lands	49,955/2	22/<0.1	15/<0.1	15/<0.1
Water	72,764/3	120/<0.1	14/<0.1	14/<0.1
IR [c]	7,199/<1	0/0	0/0	0/0
Total, Non-soil Units	***128,918/5***	***142/<0.1***	***29/<0.1***	***29/<0.1***
TOTAL	**2,428,645/100**	**16,181/0.67**	**9,281/0.4**	**9,281/0.4**

[a] Eaglesham (McLelland) - this soil series was named McLelland in the LSA to conform with the Alberta Soil Names File.
[b] Kenzie (Muskeg) - this soil series was named Muskeg in the LSA to conform with the Alberta Soil Names File.
[c] IR - Indian Reserves, no soil survey data available.

Table D2.2-6 Soil Series - Terrain Unit Correlation for the Project Millennium RSA

Terrain Unit	Soil Series[a]	Area, ha	Area, % of RSA
Bog (B)	Kenzie 1	807,781	33
Shallow Bog (Bs)	Kenzie 2; Mikkwa 1 and 2	112,576	5
Eolian (E)	Heart 4, 5 and 6	87,154	4
Fen (N)	Eaglesham 1	148,060	6
Fluvial (F)	Chipewyan 1; Mamawi 1 and 2; McMurray 1 and 2; Namur 1 and 2	126,087	5
Glacio-fluvial (Fg)	Bitumount 1; Firebag 1, 2 and 3; Mildred 1 and 2; Ruth Lake 1	355,287	15
Glacio-fluvial & Glacio-lacustrine, medium, over Morainal/Till (LFg)	Livock 1	59,752	2
Glacio-lacustrine over Morainal/Till (Lg1/M)	Algar 1, Dover 1, Joslyn 1, Steepbank 1	257,585	11
Glacio-lacustrine (Lg2)	Kearl 1	1,167	<1
Morainal/Till, fine (M1)	Buckton 1, Horse River 1, Legend 1, Surmont 1	184,588	8
Morainal/Till, coarse (M2)	Kinosis 1	73,757	3
Rough Broken (RB)	Rough Broken	66,603	3
Rock	Rock	19,329	1
Total, Terrain Units		***2,299,727***	***96***
Disturbed Lands	Disturbed Lands	48,955	2
Water	Water	72,764	3
IR[b]	Indian Reserves	7199	<1
Total, Non-Terrain		**128,918**	***5***
TOTAL		**2,428,645**	**100**

(a) Soil Series - names are as used in Turchenek and Lindsay (1982).
(b) Indian Reserves, no terrain classification done for these areas.

Table D2.2-7 Terrain Units of the Project Millennium RSA, Baseline and Impact Conditions

Terrain Unit	RSA Baseline ha/%RSA	Project Millennium ha/%RSA	Project Millennium Impact ha/%RSA	Change ha/%RSA
Bog (B)	807,781/33	316/<0.1	284/<0.1	284/<0.1
Shallow Bog (Bs)	112,576/5	3,671/<0.15	2,596/<0.1	2,596/<0.1
Eolian (E)	87,154/4	0/0	0/0	0/0
Fen (N)	148,606/6	4,567/0.2	2,802/0.1	2,802/0.1
Fluvial (F)	126,087/5	784/<0.1	45/<0.1	45/<0.1
Glacio-fluvial (Fg)	355,287/15	1,715/0.1	1,139/0.05	1,139/0.05
Glacio-fluvial & Glacio-lacustrine, medium, over Morainal/Till (LFg)	59,752/2	0/0	0/0	0/0
Glacio-lacustrine over Morainal/Till (Lg1/M)	257,585/11	0/0	0/0	0/0
Glacio-lacustrine (Lg2)	1,167/<1	0/0	0/0	0/0
Morainal/Till, fine (M1)	184,588/8	3,086/0.1	1,144/0.05	1,144/0.05
Morainal/Till, coarse (M2)	73,757/3	0/0	0/0	0/0
Rough Broken (RB)	66,603/3	1,898/0.1	1,242/0.05	1,242/0.05
Rock	19,329/1	0/0	0/0	0/0
Total, Terrain Units	***2,299,727/96***	***16,039/0.66***	***9,252/0.4***	***9,252/0.4***
Disturbed Lands	48,955/2	22/<0.1	15/<0.1	15/<0.1
Water	72,764/3	120/<0.1	14/<0.1	14/<0.1
IR[a]	7,199/<1	0/0	0/0	0/0
Total, Non-terrain	***128,918/5***	***142/<0.1***	***29/<0.1***	***29/<0.1***
TOTAL	**2,428,645/100**	**16,181/0.67**	**9,281/0.4**	**9,281/0.4**

(a) IR = Indian Reserves, no terrain classification done for these areas.

A description of the technique by which the soil series were combined to generate terrain units and the extent of these units in the RSA is provided in Table D2.2-6, while Table D2.2-7 shows the distribution of the units at baseline and maximum impact.

D2.2.7 Will Construction, Development and Reclamation of the Landscape for Project Millennium Alter Soil Quality?

D2.2.7.1 Analysis of Potential Linkages

This facet of the Key Question focuses on the changes in land capability within the LSA brought about by the construction, development and reclamation activities briefly described in Section A2 of the EIA. These changes can be quantified by assessing the productive capabilities of the naturally occurring soils in the pre-development setting and computing overall areas per class. Comparable processes may be used for the closure setting except the soils will be a combination of those that occur naturally (i.e., undisturbed by the Project activities) and reconstructed soils used for the reclaimed landscape. Capability ratings and areas for the reclaimed soils may also be calculated to permit before and after comparisons of overall soil productivity.

Rating Soil Quality/Capability

Soils in the pre-development and closure landscapes were rated for their potential capability to support productive forest ecosystems using the classification system devised by Leskiw (1998), see Table D2.2-8. The pre-development LSA will consist of naturally occurring soils whereas the closure landscape will consist of two distinct components, undeveloped areas and those which have been significantly altered by Project activities. Table D2.2-9 and Figure D2.2-7 show the pre-disturbance distributions of the land capabilities in the LSA while Table D2.2-10 provides a comparison of the pre-disturbance and closure distributions, the latter is illustrated in Figure D2.2-8. Both components have been evaluated with respect to their extent and spatial distribution in Section D2.2.6.2.

This classification system was developed for and applies directly to oil sands region forest ecosystems; it does not apply directly to other ecosystem types such as grasslands or wetlands. For example, lands rated in capability Class 4 (Conditionally Productive) and Class 5 (Non-Productive) for forest production may, in fact, be highly productive wetlands areas. It may be observed that all of the fen and bog soils in the Project Millennium LSA are rated as Class 5 for forest ecosystems. In general, Classes 1, 2 and 3 are judged to be productive forest soils, while Classes 4 and 5 are non-productive.

Table D2.2-8 Land Capability Classification for Forest Ecosystems in the Oil Sands Region, Revised (Leskiw 1998)

Capability Class	Index Points	Forest Capability - Productivity and Limitations
1	81 - 100	**High Capability** - Land having no significant limitations to sustained forest production, or only minor limitations that will be overcome with normal management practices.
2	61 - 80	**Moderate Capability** - Land having limitations which, taken together, are moderately limiting for sustained forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall cost-benefit will remain attractive but appreciably inferior to that expected on Class 1 land.
3	41 - 60	**Low Capability** - Land having limitations which, taken together, are severe for sustained forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained from the use will be low.
4	21 - 40	**Conditionally Productive** - Land having severe limitations; some of which may be surmountable through management, but which cannot be corrected with existing knowledge.
5	0 - 20	**Non-Productive** - Land having limitations which appear so severe as to preclude any possibility of successful forest production.

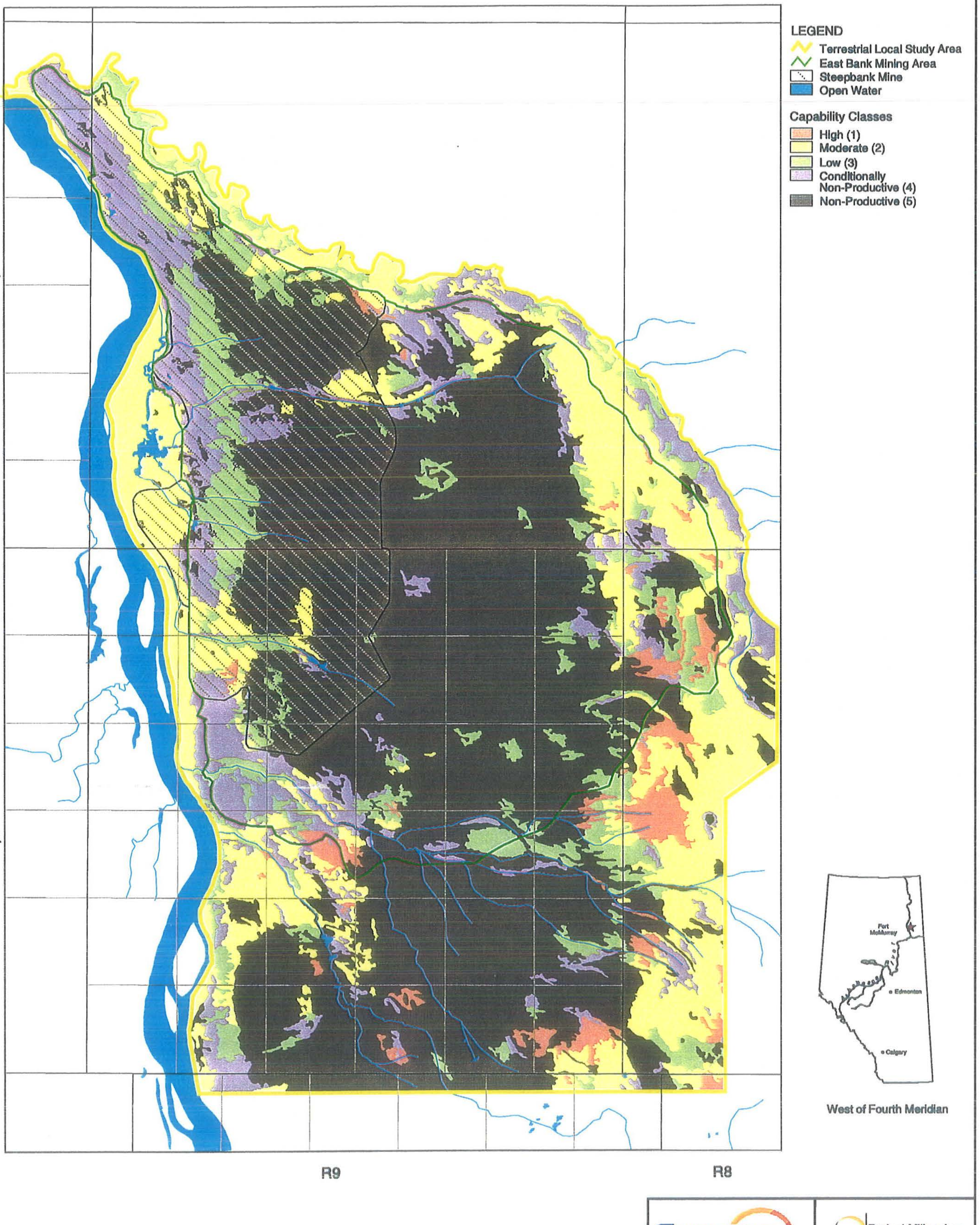
Table D2.2-9 Pre-Development and Closure Forest Capability Classes for Soils in the Project Millennium LSA

Soil Unit	Pre-Development Area, ha/%LSA	ebma Impact Area, ha/% LSA	Closure Area, ha/% LSA	Change Area, ha/% LSA	Capability Class[a]
Bitumount	65/<1	62/<1	62/<1	-3/<1	4 (2)
Kinosis	3,086/19	1,143/7	2,010/7	-1,076/7	2 (1)
McLelland	4,568/28	2,802/17	1,789/11	-2,779/17	5
McMurray	784/5	45/<1	761/5	-23/0.1	2
Mildred	188/1	132/1	71/<1	-117/0.7	3 (1)
Muskeg	3,987/25	2,880/18	1,137/7	-2,851/18	5
Rough Broken 2	1,158/7	767/5	448/3	-710/4	4
Rough Broken 3	740/5	475/3	270/2	-470/3	3
Steepbank	1,462/9	946/6	550/3	-912/6	4 (3)
Reclamation Soil	n/a	n/a	7,985/49	+7,985/49	3
Reclamation Soil	n/a	n/a	191/1	+191/1	4
Disturbed Lands[b]	22/<1	15/<1	8/<1	-14/<1	5
Water[b]	120/1	14/<1	899/<1	+779/5	5
TOTAL	**16,181/100**	**9,281/57**	**16,181/100**	**0/0**	**n/a**

(a) X (Y): Where two classes are given, the first number is the dominant class, while the number in parentheses indicates a minor component of a second class.

(b) All disturbed lands and water were assumed to be permanently non-productive for forestry.

n/a = not applicable.



SOURCES: Suncor
Golder
CAN-AG
Klohn-Crippen
The Forestry Corp

Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

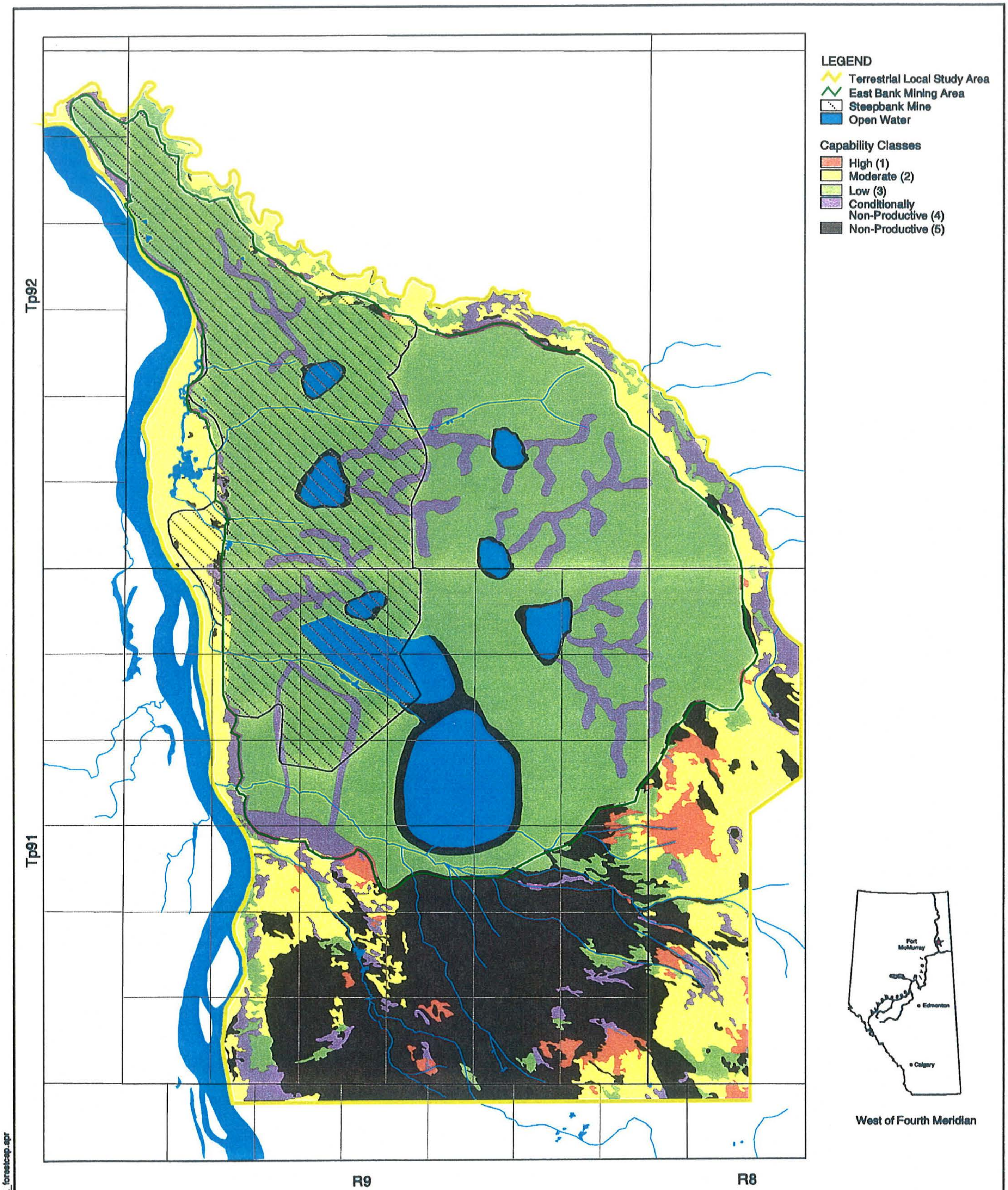
LOCAL STUDY AREA
LAND CAPABILITY
FOR FOREST ECOSYSTEMS
(PRE-DEVELOPMENT)

16 Apr. 1998

Figure D2.2-7

PRODUCED BY: JS
REVIEWED BY:

/data14/suncor/local/9700/9740/arcview/lsa_forestcap.apr



SOURCES: Suncor
Golder
CAN-AG
Klohn-Crippen
The Forestry Corp

N

1000 0 1000 2000 3000
Metres
Scale 1:100,000

Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
CLOSURE LAND CAPABILITY
FOR FOREST ECOSYSTEMS

16 Apr. 1998	Figure D2.2-8	PRODUCED BY: JS REVIEWED BY:

/data14/suncor/local/8700/8740/arcview/lsa_forestcap.apr

D2.2.7.2 Monitoring

Once the landscape has been recontoured, capped with the reclamation soil mix and revegetated, a comprehensive, on-going monitoring regime will be instituted. As outlined in the Soil Quality Criteria (Alberta Agriculture 1987) this will include assessments of the following soil characteristics: organic matter content (% OM); pH; cation exchange capacity (CEC); extractable cations (sodium, calcium, magnesium and potassium) and salinity; electrical conductivity (EC); sodium absorption ratio (SAR); total nitrogen, phosphorus and potassium; plant available nitrogen, phosphorus, potassium and sulphur; bulk density and particle size distribution. A ratings guide is provided in the above-cited document to permit evaluation of these parameters and determination of soil suitability for various species. Sampling will be done for the reclamation topsoil mix and the underlying subsoil, this will allow detection of any trends that may require attention.

Typically, a strategy of this kind would be conducted in concert with a vegetation monitoring program to detect any interactions that may indicate further remediation is in order. No time limit is specified for the monitoring plan. Suncor completes annual surveys of its reclamation program which include assessments of soils. The monitoring program is detailed in Section E of Volume 1.

The data presented in Table D2.2-10 indicate significant variations between the pre-development and closure distributions of the various capability classes. Most prominent is the conversion of 5,681 ha of conditionally and non-productive class 4 and 5 lands to the moderately productive class 3. Soil productivity, as evaluated using the land capability classification system for forest ecosystems, will change as a result of reclamation in the LSA.

Table D2.2-10 Total Areas for Each Forest Capability Class in the Pre-Development and Closure Landscapes of the Project Millennium LSA

Capability Class	Pre-Development Area, ha/% LSA	ebma Impact Area, ha/% LSA	Closure Area, ha/% LSA	Change Area, ha/% LSA
Class 1	465/3	130/1	343/2	-122/1
Class 2	3,437/21	1,089/7	2,427/15	-1,010/6
Class 3	1,675/10	1,091/7	7,570/47	+5,895/36
Class 4	1,907/12	1,260/8	1,605/10	-302/2
Class 5[a]	8,698/54	5,710/35	3,319/21	-5,379/33
Water	n/a	n/a	918/6	+918/6
TOTAL	**16,181/100**	**9,281/57**	**16,181/100**	**0/0**

[a] All disturbed lands and water were assumed to be permanently non-productive for forestry. However, at closure the significant area of new open water was partitioned out of the class 5 figures to provide a more accurate assessment of the reclaimed terrestrial capability classes.

D2.2.7.3 Impact Assessment, Residual Impacts and Environmental Consequences

Table D2.2-11 outlines the impacts, residual impacts and environmental consequences associated with closure forest capabilities in the LSA.

The closure landscape, as described in Section E of Volume 1, will see a significant alteration in the areas of potentially productive forest soils. Approximately 4,500 ha of soils, primarily but not exclusively the organic series, presently rated as class 5 (non-productive) will be replaced by a soil mixture rated as class 3, low productivity for forestry, which will have a positive impact on about 28% of the area of the LSA and more than 45% of the area within the development footprint. This change should be viewed as positive in direction and high in magnitude. In addition, on the order of 1000 ha of class 2 soils will be reclaimed as class 3 - a negative change but low in magnitude.

Table D2.2-11 Impacts, Residual Impacts and Environmental Consequences of Changes to Land Capability Classes in the Project Millennium LSA

Capability Class	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Class 1	Negative	High	Local	Long-term	Irreversible	Low	High[a]
Class 2	Negative	Low	Local	Long-term	Irreversible	Low	Low
Class 3	Positive	High	Local	Long-term	Irreversible	Low	High[a]
Class 4	Negative	Negligible	Local	Long-term	Irreversible	Low	Negligible
Class 5	Negative	High	Local	Long-term	Irreversible	Low	High[a]

[a] see explanation in text

Examination of the residual impacts, (i.e., considering both development impacts and the changes in land capability distributions resulting from reclamation) provides the most accurate assessment of the longer-term affects of the Project. Three items noted in Table D2.2-11 require elaboration in this respect. Class 1, as discussed previously, is extremely limited in the pre-development landscape and any losses cannot be restored. Hence, while as a percent of the total soils in the LSA the loss of class 1 is small, the environment consequence is high as this particular component is very limited in extent and on the order of 25% of it is permanently lost. With regard to capability class 3 the direction is positive in that approximately 5,900 additional ha appear in the closure scenario as the result of reclamation activities. This is given an environmental consequence rating of high because it affects over 35% of the LSA in a positive manner. The final aspect is the permanent removal of more than 5,000 ha of non-productive class 5 lands from the inventory at closure. This is seen as negative in direction as it is a loss and high in magnitude due to the area involved - the associated environmental consequence is thus rated high as well. What requires some interpretation is that in the context of the end land use objectives of the Project Closure Plan (Section E), the conversion of lands currently viewed as non-productive for forest species to areas of higher potential is a significantly positive alteration to the LSA.

To place the impacts of Project Millennium on land capabilities for the extended resource base in context, a comparison with the capability class distributions in the RSA is necessary. Table D2.2-12 describes the distributions of land capabilities for the pre-development, Project impact and closure scenarios with respect to the resources in the RSA.

Table D2.2-12 Areas for Each Forest Capability Class in the Pre-Development and Closure Landscapes of the Project Millennium RSA

Capability Class	Pre-Development RSA Area, ha/%RSA	Project Millennium Impact Area, ha/%RSA	Closure Area, ha/%RSA	Change ha/%RSA
Class 1[(a)]	465/<0.1	130/<0.1	*343/2*	*-122/1*
Class 2	439,060/18	189/<0.1	*2,427/15*	*-1,010/6*
Class 3	332,722/14	1,091/<0.1	*7,570/47*	*+5,895/36*
Class 4	438,304/18	1,260/0.05	*1,605/10*	*-302/2*
Class 5 [(b)]	1,210,895/50	5,710/0.02	*3,319/21*	*-5,379/33*
Water[(b)]	0/0	0/0	*918/6*	*+918/6*
IR [(c)]	7,199/0.3	0/0	*0/0*	0/0
TOTAL	**2,428,645/100**	**9,281/0.4**	**16,181/0.67**	**0/0**

(a) Class 1 - Forest capability classes require site-specific data to compute, as a result some areas within the LSA met the Class 1 criteria; however, when extrapolating to the RSA scale it was determined that no Class 1 soils outside the LSA could be confidently assigned. The area designated Class 1 in Table D2.2-12 was subtracted from the RSA Class 2 area for this reason.

(b) All disturbed lands and water were assumed to be permanently non-productive for forestry. However, at closure the significant area of new open water was partitioned out of the class 5 figures to provide a more accurate assessment of the reclaimed terrestrial capability classes in the LSA.

(c) IR - Indian Reserves, no capability ratings were assigned to these areas.

Examination of Table D2.2-13 reveals a high degree of similarity to Table D2.2-11 except for the environmental consequence ratings for each capability class. This is a reflection of the relatively small proportion of the RSA that the LSA makes up 0.67%. The ultimate result of placing the impacts of Project Millennium into a regional perspective is that alterations which may be significant at the smaller scale become minute at the larger scale. The somewhat anomalous situation with the class 1 category has been reviewed previously but overall there is nothing particularly unique or environmentally significant about the soil or terrain units which comprise any of the classes. Therefore, the consequences to the environment at the regional level are deemed to be negligible.

Table D2.2-13 Impacts, Residual Impacts and Environmental Consequences of Changes to Land Capability Classes in the Project Millennium RSA

Capability Class	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Class 1	Negative	High	Local	Long-Term	Irreversible	Low	Negligible
Class 2	Negative	Low	Local	Long-Term	Irreversible	Low	Negligible
Class 3	Positive	High	Local	Long-Term	Irreversible	Low	Negligible
Class 4	Negative	Negligible	Local	Long-Term	Irreversible	Low	Negligible
Class 5	Negative	High	Local	Long-Term	Irreversible	Low	Negligible

D2.2.8 Key Question ST-2: What Impacts Will Acidifying Emissions From Project Millennium Have on Regional Soils?

D2.2.8.1 Soil Sensitivity

Soil sensitivity was evaluated in the context of the capacity of the soils in the RSA to resist the acidifying effects of anthropogenic inputs (i.e., emissions from industrial sources). Generally the potentially acidifying emissions in studies of this nature are oxides of sulfur (SO_x) and oxides of nitrogen (NO_x). These are quantified and discussed using the concept of PAI (Potential Acidifying Inputs, measured in keq/ha/a).

Holowaychuk and Fessenden (1987) have classified and mapped potential susceptibility of soils in the province to acid deposition as well as providing assessments of the capacities of both the surface soils and substrates to buffer acid inputs. Their evaluation was based upon a synthesis of three chemical processes: sensitivity to base loss (mobilization of exchangeable cations mainly Ca, Mg and K), sensitivity to acidification and sensitivity to solubilization of toxic elements such as aluminum. Since the mapping and evaluations were done at a scale of 1:2,000,000, the degree of generalization involved is necessarily broad and the authors caution that the interpretations represent their assessment for only the dominant soil type in each map unit. Nevertheless, this 1987 document remains the principal reference cited in discussions of soil acidification in Alberta. Each of these parameters will be discussed briefly to establish the context for the rating scheme used in this report, first with respect to mineral soils then concerning organic soils.

Mineral Soils

Sensitivity to base loss may be examined in two ways, which produce dramatically varying interpretations, thus it is vital to emphasize which approach one uses. The first equates high absolute base loss with high sensitivity and low absolute base loss with low sensitivity. In applying this method, soils with high pH levels, above 5.5 to 6.0, would exhibit high sensitivities since there is an abundance of base reserves (high base saturation) which increases the efficiency of hydrogen ions as a displacing agent. Conversely, at pHs below 5.5, base saturation is low and therefore the efficiency of hydrogen ion replacement decreases markedly.

The second technique examines relative base loss, (i.e., absolute base loss as a proportion of total base reserves). Approached this way, soils with high base saturation levels, and high pHs, would have low sensitivities - absolute losses may be high, but are relatively small compared to total base reserves. Soils with low base saturation, and low pHs, would have high sensitivities - low absolute losses, but relatively high losses relative to the total base content of the soil. Holowaychuk and Fessenden (1987) followed the relative base loss approach when evaluating the impacts of acidic deposition as they judged it to be a more valid indicator of the effects on soil fertility and potential plant productivity.

Sensitivity to acidification is an assessment of the amount of change in pH (decrease) that the addition of a specified quantity of acidifying inputs are likely to have on the buffering capacity of a soil. Bache (1980 cited in Holowaychuk and Fessenden 1987) proposed that since sensitivity is inversely related to buffering capacity, soils with high capacities would have low sensitivities to acid inputs and vice versa. Cation exchange capacity (CEC), the potential for a soil to absorb, retain and release basic ions, is the principal factor controlling buffering capacity. Further, CEC is a direct function of the clay and/or organic matter content of a soil as both of these constituents have high negative surface charge characteristics. Soils with high clay and/or organic matter levels tend to exhibit high CEC, high buffering capacities and low sensitivity to acidification (Birkeland 1974, Brady 1990). Thomas and Hargrove (1984 cited in Holowaychuk and Fessenden 1987) state, "Generally, soils that have a pH of 6.5 or greater tend to be well buffered by a carbonate-bicarbonate buffering system. Acid soils, with a pH of 3.5-5.5, also tend to be well buffered because of hydrolysis reactions of aluminum ... Thus, soils that are most sensitive to acidification are those with low CEC and a pH of 5.5 - 6.5." Halsey et al. (1996), Myrold (1990), Pauls et al. (1996) and Turchenek et al. (1987) report similar findings although in some instances the window of sensitivity is limited to a pH range between 5.5 and 6.0.

Toxic elements (e.g., aluminum and manganese are usually the most significant with respect to impacts on plant growth) tend to become more soluble as pH values drop. The degree is negligible in neutral (pH 7.0) and slightly acidic soils, but increases gradually between 6.0 and 5.5 to the point where sensitive species may show toxicity symptoms (Gorham et al. 1984, Jenny 1980, Myrold 1990). The rate of solubilization accelerates below a pH of 5.5 and more tolerant vegetation species begin to show adverse affects.

Various systems have been developed in attempts to quantify acidifying impacts on terrestrial soils and will be reviewed briefly at this point. Most divide soils on a regional scale into high, moderate and low sensitivity categories each of which is defined by some combination of measurable criteria. Lucas and Cowell (1984) used soil chemistry (exchangeable bases or surrogates of particle size, pH and CEC), soil depth and drainage, present vegetation cover and type, topographic relief and geology. Turchenek and Lindsay (1982) selected buffering capacity (based on CEC), drainage class, perviousness and moisture holding capacity as the primary controlling factors and rated the LFH, A, B and C soil horizons individually. Holowaychuk and Fessenden (1987) refined the latter technique to incorporate considerations of soil depth, exchangeable base content, parent material type, bedrock composition and soil drainage class.

With respect to the buffering capabilities of the mineral substrates underlying organic deposits in the RSA, some further comments are in order. Since many of the organic deposits are on the order of 1 m in depth, or greater, the contribution of the subsoil with respect to offsetting acidic inputs is questionable. What is more certain is that the removal or buffering of these inputs is highly dependent on the rate of flow and chemical composition of the surface and near surface water. Mesotrophic fens are characterized by significant rates of recharge due to horizontal flow. These waters may influence potential acidification by: flushing out concentrations of acidic ions and/or, replacing mobilized bases with dissolved cations (Halsey and Vitt 1996). Substrate materials are unlikely to have much direct impact on surface acidic inputs until, and unless, they are incorporated in the reclamation soil mixture applied to reconfigured terrain features. Obviously, this will affect only the development areas and be highly contingent upon the characteristics of the materials at those particular locations.

Another complicating factor that probably has a direct yet difficult to quantify role is the influence of the surface litter layer on acidifying inputs. Litter on the forest floor (i.e., the LFH horizon) varies in its thickness and composition, but is important due to the recycling of cations absorbed at depth that are subsequently deposited upon the surface. This annual cycle of leaf drop, decomposition and cation release most probably has some neutralizing effect (Brady 1990, Johnson 1987) but the degree and effectiveness of this mechanism are notably ill-defined. What may result is some amount of reduction in the acidity levels of the inputs before they have an opportunity to be translocated downward into the mineral horizons of the profile. Dufour (1996) notes with respect to a major study on the particulate sulphur deposition effects on forests in the Ram River - Strachan area, "The dusting loadings are in the tonnes of sulfur per hectare range rather than in the kg per hectare deposition estimates found for gaseous deposition in Alberta. Leaf litter even at these extreme sulfur loadings did not decrease significantly at the sites over a 10 year period, and the underlying mineral soil at most sites was not impacted by the deposition. As the litter layer overlies the mineral soil it is obviously supplying some buffering power ameliorating the acidic inputs. This factor has not been taken into account in the models predicting the response of mineral soils to acidic inputs". In short, estimated PAI and effective PAI - from a pedological perspective at least - may not be the same. Myrold (1990) notes that since many soil systems are limited by low nitrogen levels, acidic input species (originating from NO_x emissions) may in fact have a fertilizing effect on some plant communities.

The majority of studies focus on two distinct facets, the susceptibility of the topsoil to acidification and the capacity of the subsoils and geology to offset these acidifying inputs. For the purposes of the rating system devised for this study, some assumptions and criteria must be explicitly stated at the outset. First, as noted in the brief preceding discussion of organic soils, the role of the substrate in ameliorating surface inputs is uncertain and likely to be minimal except in areas where either through-flow in the near-surface region may recharge cation levels (i.e., fens which are mesotrophic versus bogs which are oligotrophic), or where disturbances result in the subsurface materials being incorporated with or deposited upon the soil surface. The former condition is limited to peatlands while the latter is probable only in unstable areas, steep slopes and river valley escarpments, or where construction activities include overstripping of peat to include some of the underlying mineral materials - common practice for soil salvage in oil sands developments. Second, as most rooting occurs in the upper 40 - 50 cm of the profile, sensitivity ratings are of greatest utility if restricted to data available either directly or by surrogate methods for the near-surface horizons. Third, a combined rating arrived at by "averaging" those for the topsoil and subsoil would be not only artificial but of no scientific validity. Fourth, and last, given the scarcity of data from the geographical region in question and the inherently high level of variability among properties within any soil series one must bear in mind the following constraints. Turchenek and Lindsay (1982) stated: "Information on types and locations of reaction in soils resulting from acidic deposition is scarce ... Thus, it must be emphasized that the sensitivity classes are very broad categories and that they are relative.". Holowaychuk and Fessenden (1987) also noted that: "Because of the paucity of soil survey information, and because of some of the assumptions that had to be made, the map unit designations and subsequent interpretations should be considered as provisional."

Table D2.2-14 sets out the criteria employed by Holowaychuk and Fessenden in their evaluation of sensitivities for mineral soils. Table D2.2-15 presents a unified system matrix devised for this analysis by amalgamating the approaches from a range of other systems, again restricted to rating the surface mineral horizons. Also considered in developing this rating system were some more general relationships proposed by Turchenek et al. (1987), including: eluviated and dystric brunisols developed on sandy deposits = highly sensitive, organic soils = highly sensitive except organic cryosols = low sensitivity, gleysols = low sensitivities, regosols = low sensitivities. The ratings presented are general and relative in nature only.

Table D2.2-14 Criteria for Rating the Sensitivity of Mineral Soils to Acidic Inputs (Holowaychuk and Fessenden 1987)

CEC [(a)]	pH [(b)]	Sensitivity to: Base Loss	Sensitivity to: Acidification	Sensitivity to: Al Solubilization	Overall Sensitivity
<6	<4.6	High	Low	High	High
	4.6-5.0	High	Low	High	High
	5.1-5.5	High	Medium	High	High
	5.6-6.0	High	High	Medium	High
	6.1-6.5	High	High	Low	High
	>6.5	Low	Low	Low	Low
6 - 15	<4.6	High	Low	High	High
	4.6-5.0	Medium	Low	High	Medium
	5.1-5.5	Medium	Low-Medium	Medium	Medium
	5.6-6.0	Medium	Low-Medium	Low-Medium	Medium
	>6.0	Low	Low	Low	Low
>15	<4.6	High	Low	High	High
	4.6-5.0	Medium	Low	High	Medium
	5.1-5.5	Medium	Low	Medium	Medium
	5.6-6.0	Low	Low-Medium	Low-Medium	Low
	>6.0	Low	Low	Low	Low

(a) CEC = Cation Exchange Capacity in cmol(+) kg^{-1}.
(b) pH = pH in $CaCl_2$, or adjusted to $CaCl_2$ equivalent.

Table D2.2-15 A Conceptual Unified System Matrix for Assessing Mineral Soil Sensitivity to Acidifying Inputs[(a)]

Criteria	Low	Moderate	High
CEC (BFC [(b)])	>15	6 - 15	<6
Texture [(c)]	>35%	10 - 35%	<10%
pH	>5.5	4.5 - 5.5	<4.5
Drainage	poor	imperfect - well	rapid
Depth [(d)]	>100	25 - 100	<25
Parent Material	calcareous	neutral	acidic

(a) synthesized from Holowaychuk and Fessenden (1987), Lucas and Cowell (1984), Turchenek and Lindsay (1982).
(b) Cation Exchange Capacity in cmol $^{(+)}$ kg^{-1} = relative index of Buffering Capacity.
(c) texture = % clay.
(d) soil depth in cm.

Applying both of these systems to the rather sparse data available for mineral soils in the RSA outside of the Project Millennium LSA produced the results displayed in Tables D2.2-16 and D2.2-17 for the A and B horizons, respectively.

Table D2.2-16 Sensitivity to Acidifying Inputs Ratings for A Horizons of Mineral Soil Series in the Project Millennium RSA

Soil Series/Map Unit	Sensitivity to Acidifying Inputs	Sensitivity to Base Loss	Sensitivity to Aluminum Solubilization	Overall Sensitivity Rating [(a)]
Algar	M	L	H	M/M
Bitumount	L	L-M	L	L/L
Buckton	M	L-M	M	M/M
Dover	M	L-M	L-M	M/M
Eaglesham	n/a	n/a	n/a	n/a
Firebag	H	L	H	H/H
Fort	H	L	H	H/H
Horse River	M	L-M	M	M/M
Heart	H	L	H	H/H
Joslyn	H	L	H	H/M-H
Kearl	H	M	H	H/H
Kinosis	M	L-M	L-M	M/M
Kenzie	n/a	n/a	n/a	n/a
Legend	H	L	H	H/M-H
Livock	H	L	H	H/H
Mildred	M	L	H	M/M-H
Mikkwa	n/a	n/a	n/a	n/a
McMurray	M	L	H	M/M-H
Namur	M	L	H	M/M
Rough Broken[(b)]	M	M	M	M/M
Ruth Lake	H	L	H	H/H
Rock[(c)]	n/a	n/a	n/a	n/a
Steepbank	H	L	H	H/M
Surmont	H	L	H	H/M

(a) X/Y = Holowaychuk and Fessenden (1987) rating/Unified System Rating.
(b) Rough Broken - these soils are extremely heterogeneous in composition, therefore a single index value is somewhat artificial.
(c) Rock - varies significantly in composition and sensitivity throughout the RSA, generally becoming more sensitive toward the northeast.
n/a = not applicable.

Table D2.2-17 Sensitivity to Acidifying Inputs Ratings for B Horizons of Mineral Soil Series in the Project Millennium RSA

Soil Series/Map Unit	Sensitivity to Acidifying Inputs	Sensitivity to Base Loss	Sensitivity to Aluminum Solubilization	Overall Sensitivity Rating[a]
Algar	M	L	H	L/M
Bitumount	M	L-M	L-M	M/M
Buckton	L	L-M	L-M	L-M
Dover	L	L-M	L-M	L/L
Eaglesham	n/a	n/a	n/a	n/a
Firebag	H	L	H	H/H
Fort	L	L	L	L/M
Horse River	M	L	M	M/L-M
Heart	H	M	H	H/H
Joslyn	L	L	L	L/L
Kearl	H	M	H	H/H
Kinosis	L	L	L	L/L-M
Kenzie	n/a	n/a	n/a	n/a
Legend	H	L	H	H/M-H
Livock	M	L	H	M/M
Mildred	M	L	H	M/M-H
Mikkwa	n/a	n/a	n/a	n/a
McMurray	L	L	L	L/M
Namur	H	L	H	H/M-H
Rough Broken[b]	M	M	M	M
Ruth Lake	M	L	H	M/M
Rock [c]	n/a	n/a	n/a	n/a
Steepbank	M	L	H	M/M
Surmont	H	L	H	H/L-M

(a) X/Y = Holowaychuk and Fessenden (1987) rating/Unified System Rating.
(b) Rough Broken - these soils are extremely heterogeneous in composition therefore a single index value is somewhat artificial.
(c) Rock - varies significantly in composition and sensitivity throughout the RSA, generally becoming more sensitive toward the northeast.
n/a = not applicable.

Organic Soils

Organic soils have been less intensively examined until relatively recently, with the work of Halsey et al. (1995) in northeastern Alberta being the most relevant to this analysis. Therefore, the response of organic soils to acidifying inputs are much less well defined than for mineral soils (Gorham et al. 1984). Field work by Rochefort and Vitt (1988) verified experimental work indicating that acidic deposition had a fertilizing effect on certain species in a rich fen (i.e., mesotrophic environment). What is ill-defined at present is the length of time such a phenomenon may last, i.e., is the effect only present until another limiting factor is reached and what temporal frame is involved. Very little definitive information is available for these systems so developing a sensitivity rating scheme that may be applied with any degree of confidence is tenuous at best (Holowaychuk and Fessenden 1987, Pauls et al. 1996). The approach followed in this paper was to use the rating system shown in Table D2.2-18 as a basis, noting that "this scheme is based on meager data and several assumptions; it should therefore, be considered to be provisional" (Holowaychuk and Fessenden 1987). Modifications were made where reliable data indicated the need. Halsey and Vitt (1996) indicated the following peatland relationships: oligotrophic = bog, mesotrophic = fen, eutrophic = marsh. Applying these general classes to the AOSERP (1982) soil inventory data for organic soil series one would arrive at the following: bog = Kenzie, bog = Mikkwa, fen = Eaglesham. However, Holowaychuk and Fessenden also note that most of the oligotrophic peatlands in the oil sands region consisted of Organic Cryosols (i.e., the Mikkwa series). Pulling all these interpretations together yields the ratings set out in Table D2.2-19.

Combining all of the preceding data for both the organic and mineral soils produced a table of <u>relative sensitivities</u>, these ratings form the basis for the sensitivity mapping of the RSA, see Table D2.2-20.

Table D2.2-18 Sensitivity Rating of Alberta Peatland Systems to Acidic Inputs (Holowaychuk and Fessenden 1987)

Peatland System	Sensitivity to Base Loss	Sensitivity to Acidification	Sensitivity to Al Solubilization	Overall Sensitivity
Eutrophic	low	low	low	low
Mesotrophic	high	high	medium	high
Oligotrophic	low	low	high	low

Table D2.2-19 Composite Sensitivity Ratings for Organic Soil Series in the Project Millennium RSA

Soil Series	Peatland System	Overall Sensitivity	Extent ha/%RSA
Eaglesham[(a)]	mesotrophic	high[(b)]	146,547/6
Kenzie[(c)]	oligotrophic	low	822,010/34
Mikkwa	oligotrophic	low	113,249/5

(a) Eaglesham was renamed McLelland in the LSA.
(b) Rochefort and Vitt (1988) and Halsey et al. (1996) note that the chemical properties of rich fens indicate that they are relatively insensitive to acidifying inputs. Therefore a significant proportion of the Eaglesham series may in fact have low sensitivities; however, as the fens were not broken down into poor-moderately rich-rich classes attempting to quantify the extent and distribution of each potential subdivision is untenable.
(c) Kenzie was renamed Muskeg in the LSA.

Table D2.2-20. Soils of the Project Millennium RSA and LSA, Relative Sensitivities to Acidifying Inputs

Soil Series/Map Unit	Sensitivity Rating
Algar	Moderate
Bitumount	Moderate
Buckton	Moderate
Dover	Low
Eaglesham (McLelland)[(a)]	High
Firebag	High
Fort	Low
Horse River	Moderate
Heart	High
Joslyn	Low
Kearl	High
Kinosis	Low
Kenzie (Muskeg)[(b)]	Low
Legend	High
Livock	Moderate
Mildred	Moderate
Mikkwa	Low
McMurray	Low
Namur	High
Rough Broken	Moderate[(a)]
Ruth Lake	Moderate
Rock	Moderate[(a)]
Steepbank	Moderate
Surmont	Moderate

(a) Eaglesham was renamed McLelland in the LSA.
(b) Kenzie was renamed Muskeg in the LSA.
Moderate* = both Rough Broken and Rock are extremely variable in composition; actual sensitivity is probably highly site-specific

Analysis of the Key Question

The assessment of soil sensitivities, buffering capabilities and potential acidification is not straightforward. "The impacts of acidic deposition on aquatic and terrestrial ecosystems are difficult to predict, because the effects are exceedingly complex, subtle and long-term. Furthermore, every ecosystem has a different inherent capacity to resist acidification." (Cheng and Angle 1993, p. 1). A variety of parameters must be taken into account when endeavoring to evaluate the potential effects of anthropogenic emissions on soil properties, including:

- the composition and volumes of the emissions;
- the distribution of the sources, assuming more than one point source;
- the capacity of the atmosphere to neutralize acidic ions (Cheng and Angle (1993) and White (1983) have noted, "Alberta's atmosphere has a high concentration of ammonia which reacts with sulfurous ions to neutralize them - an atmospheric buffering effect.");
- Long Range Transport of Atmospheric Pollutants (LRTAP) - it is estimated that up to 50% of locally produced emissions are advected out of the immediate vicinity, therefore a direct emission to deposition correlation is not possible;
- seasonal variations in wind direction and velocity, atmospheric stability and precipitation scavenging (wet versus dry);
- deposition-percolation efficiency - Gorham et al. (1984) observed that much of the acidifying input load may be deposited when the soil is frozen and snow covered, as a result upon spring thaw a significant proportion of the acidifying agents may be removed in runoff and never enter the soil system; and
- the time scale under consideration, Bloom and Grigal (1985) use initial, plus 100, 200 and 500 year scenarios in modelling of soil responses to acidic deposition.

All of these variables introduce their own degrees of uncertainty when attempting to determine the impacts of acidic emissions on potentially sensitive soils. Substantial background discussions on emission impacts may be found in Section B (Air Quality) of this EIA.

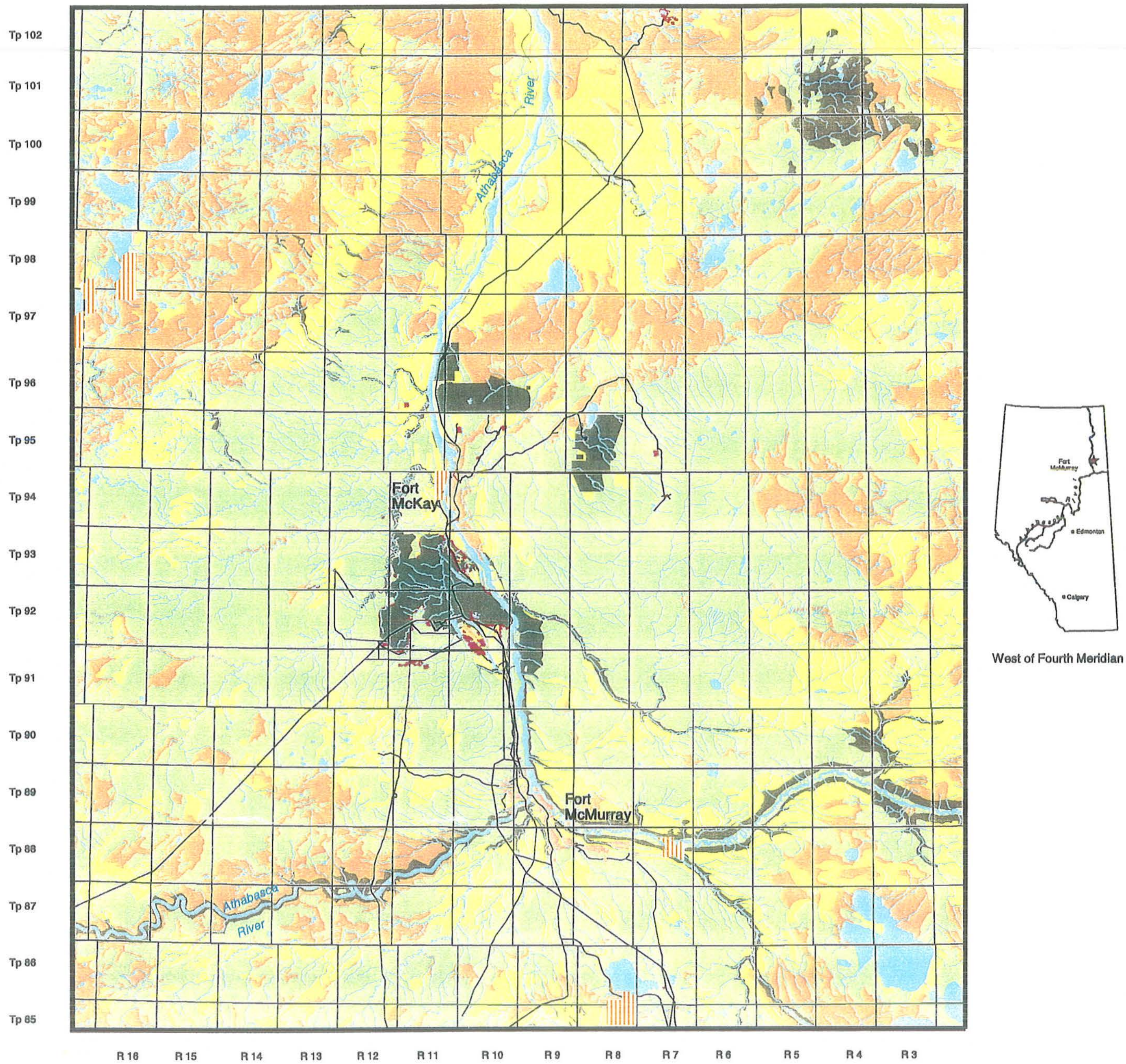
One of the key unknown relationships in this sort of assessment is the length of time required for sustained acidic inputs to have measurable impacts on soil properties - as noted above, Bloom and Grigal (1985) looked at intervals in the hundreds of years in this context. The second, and equally critical, unknown variable is that the level of correlation between PAI and soil acidification is not well defined at present. Continuing research into this linkage in the international forum may well help reduce the uncertainties in this relationship and permit more accurate evaluations. This, however, is contingent on future developments beyond the scope of this document. Roberts and Reiger 1989 (cited in BOVAR 1996a, Aurora

Mine EIA) indicate that despite high predicted effective acidity levels (EA has been replaced by PAI as a measurement parameter) no trends suggesting soil acidification which might be attributed to development-related activities have been found in northeastern Alberta. Similar conclusions may be found in Dufour (1996) in her review of acid deposition research in Alberta through the mid 1990s. Pauls et al. (1996) observe, "Significant acidification at current levels of deposition is likely to take decades or even centuries ... Models of soil acidification, while useful in identifying areas and processes where research might be most usefully concentrated, cannot be used to confidently predict the time course of soil acidification.". Johnson (1987) sums up the situation most admirably, "In the final analysis, the degree to which acid disposition has caused or will cause soil acidification depends on site-specific conditions (i.e., soil properties and amount of input). Thus, broad generalizations as to the amount of soil acidification caused by acid deposition have little meaning.".

Table D2.2-21 presents the soil series found in the Project Millennium RSA, their areas and relative sensitivity ratings - this information is illustrated in Figure D2.2-9. Table D2.2-22 provides the total areas in each of the 3 sensitivity classes.

D2.2.9 Impact Assessment, Residual Impacts and Environmental Consequences

The World Health Organization has proposed critical loading factors for potential acid input (PAI) for sensitive ecosystems of 0.25 keq/ha/a and 0.50 keq/ha/a for moderately sensitive ecosystems based on European, mainly Scandinavian experience (WHO 1994). In 1996 the Target Loading Subgroup (CASA 1996) recommended that Alberta adopt the European approach to determining critical loads and target levels for a 3 to 5 year period. During this interval a critical loading value of 0.25 keq/ha/a for sensitive areas was suggested as being practical until further analysis could result in the selection of appropriate Target Load figures. Using the WHO and CASA parameters in conjunction with PAI isopleth maps of the RSA for baseline, Project Millennium impact and full CEA scenarios (Figures D2.2-10, and D2.2-11 respectively) one may quantify potential impacts as shown in Table D2.2-23. A more detailed breakdown of the areas within each sensitivity class that fall within the specified target critical loading zones is shown in Table D2.2-24.



SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

SOIL SENSITIVITY
- Low
- Moderate
- High
- Variable

N

SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA
RELATIVE SOIL SENSITIVITIES
TO ACIDIFYING EMISSIONS

16 Apr. 1998

Figure D2.2-9

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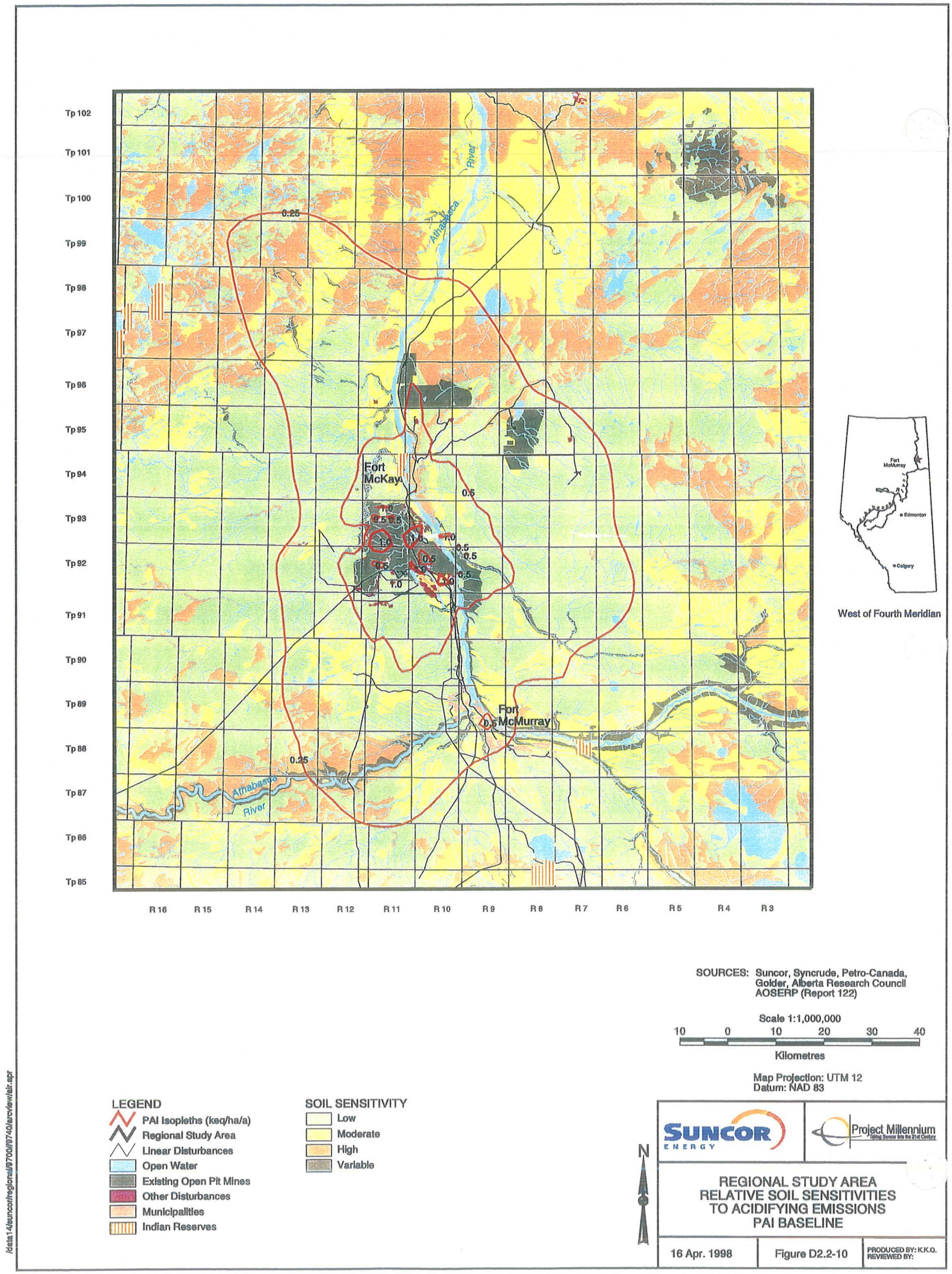
Table D2.2-21 Distribution of Soils in the Project Millennium RSA and LSA, Relative Sensitivities to Acidifying Inputs

Soil Series/Map Unit	Sensitivity Rating	RSA Area, ha/% RSA	Project Millennium LSA Area, ha/% of RSA
Algar	Moderate	47,879/2	0/0
Bitumount	Moderate	11,110/0.5	65/<0.1
Buckton	Moderate	32,571/1	0/0
Dover	Low	83,279/3	0/0
Eaglesham (McLelland)[a]	High	148,060/6	4,568/0.18
Firebag	High	128,251/5	0/0
Fort	Moderate	3,861/<1	0/0
Horse River	Moderate	26,076/1	0/0
Heart	High	87,154/4	0/0
Joslyn	Low	86,797/4	0/0
Kearl	High	1,167<0.1	0/0
Kinosis	Low	72,705/3	3,086/0.13
Kenzie (Muskeg)[b]	Low	804,394/33	3,987/0.16
Legend	High	105,507/4	0/0
Livock	Moderate	47,198/2	0/0
Mildred	Moderate	205,269/8	188/<0.1
Mikkwa	Low	112,834/5	0/0
McMurray	Low	71,246/3	783/<0.1
Namur	High	55,302/2	0/0
Rough Broken	Moderate*	66,577/3	1,898/0.08
Ruth Lake	Moderate	22,417/1	0/0
Rock	Moderate*	19,329/1	0/0
Steepbank	Moderate	40,871/2	1,462/0.06
Surmont	Moderate	18,088/1	0/0
Total, Soil Units	***n/a***	***2,299,727/95***	***16,038/0.66***
Disturbed Lands	n/a	48,955/2	22/<0.1
Water	n/a	72,764/3	120/<0.1
IR[c]	n/a	7,199/0.3	0/0
Total, Non-soil Units	***n/a***	***128,918/5***	***142/<0.1***
Total	**n/a**	**2,428,645/100**	**16,181/0.67**

[a] Eaglesham (McLelland) - fen soils classified as McLelland in the LSA
[b] Kenzie (Muskeg) - bog soils classified as Muskeg in the LSA
[c] IR - Indian Reserves, not classified due to lack of soil data
Moderate* = both Rough Broken and Rock are extremely variable in composition, actual sensitivity is probably highly site-specific

Table D2.2-22 Total Areas in the RSA Within Each of the Sensitivity Classes

Sensitivity Class	Area, ha [a]	Area, %RSA
Low	1,491,124	61
Moderate	586,044	24
High	525,441	22



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R 4
R 3
Athabasca River
Fort McKay
Fort McMurray
0.25
0.5
1.0
West of Fourth Meridian
Fort McMurray
Edmonton
Calgary
SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)
Scale 1:1,000,000
10 0 10 20 30 40
Kilometres
Map Projection: UTM 12
Datum: NAD 83
LEGEND
PAI Isopleths (keq/ha/a)
Regional Study Area
Linear Disturbances
Open Water
Existing Open Pit Mines
Other Disturbances
Municipalities
Indian Reserves
SOIL SENSITIVITY
Low
Moderate
High
Variable
N
SUNCOR ENERGY
Project Millennium
REGIONAL STUDY AREA
RELATIVE SOIL SENSITIVITIES
TO ACIDIFYING EMISSIONS
PAI BASELINE
16 Apr. 1998
Figure D2.2-10
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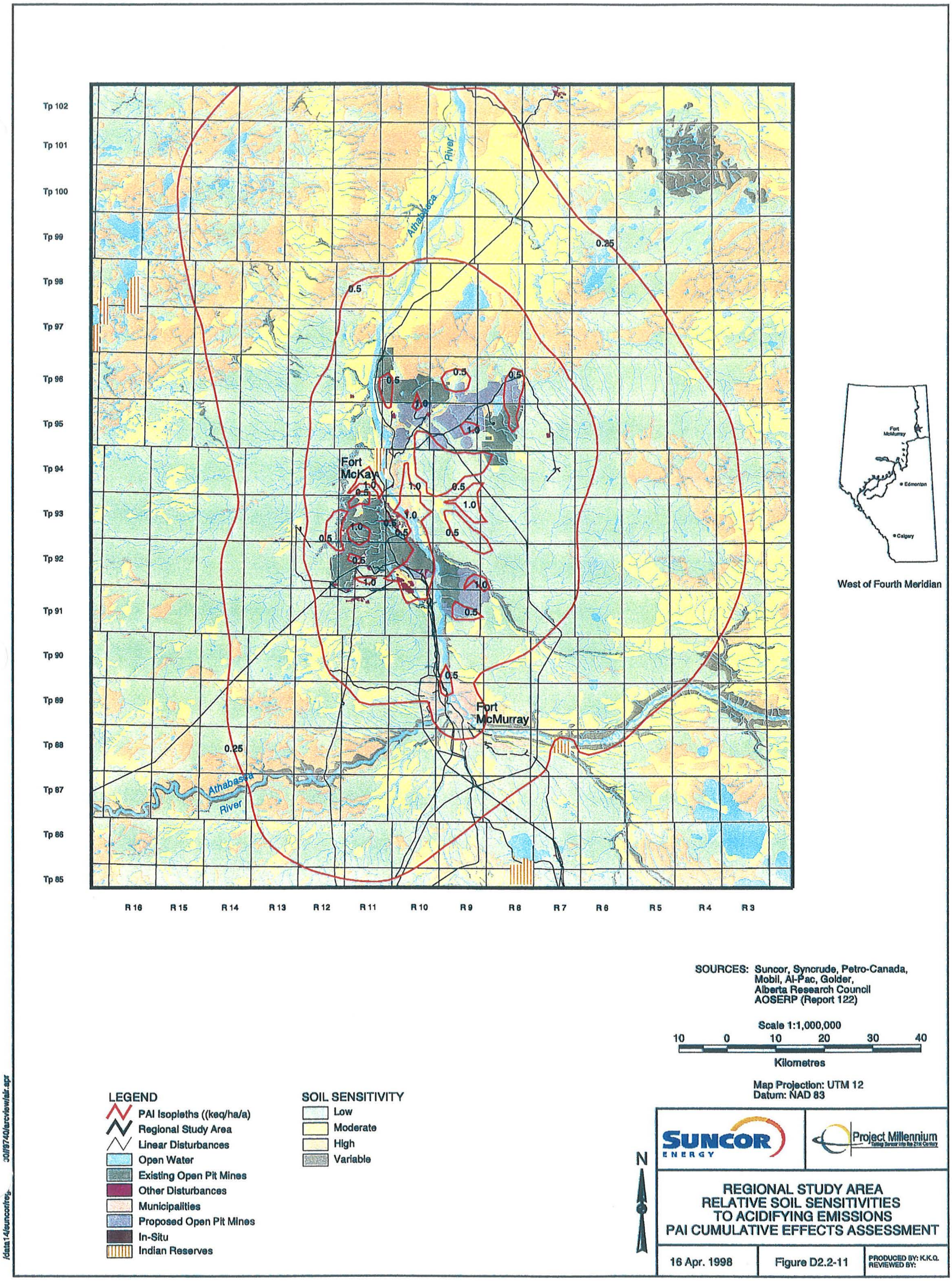


REGIONAL STUDY AREA
RELATIVE SOIL SENSITIVITIES
TO ACIDIFYING EMISSIONS
PAI CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998 | Figure D2.2-11 | PRODUCED BY: K.K.Q. REVIEWED BY:

Table D2.2-23 Total Areas in the RSA Within Each of the Sensitivity Classes, Baseline and CEA Scenarios

Sensitivity Class	Baseline Area, ha / %RSA	Project Millennium Impact Area, ha / %RSA	CEA Area, %RSA
Low	1,235,928/51	1,230,791/51	1,218,009/50
Moderate	451,454/19	451,161/19	445,940/18
High	525,367/22	525,337/22	521,270/21
Variable[(a)]	86,122/4	85,907/4	84,967/3
Not Applicable[(b)]	129,777/5	135,421/6	158,459/7
Total	2,428,645/100	2,428,645/100	2,428,645/100

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis.
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings.

Table D2.2-24 Areas Within Specified Critical Load Isopleths for Baseline, Impact and CEA Scenarios in the RSA

PAI Critical Load Value	Sensitivity Rating	Baseline ha / %RSA	Project Millennium Impact ha / %RSA	CEA Scenario ha / %RSA
>0.25 keq/ha/a	Low	391,660/16	507,373/21	734,983/30
	Moderate	102,706/4	131,461/5	266,279/11
	High	88,778/4	121,802/5	266,833/11
	Variable[(a)]	26,104/1	28,846/1	39,852/2
	Not Applicable[(b)]	61,261/3	71,677/3	107,885/4
>0.50 keq/ha/a	Low	62,763/3	126,324/5	229,889/9
	Moderate	12,105/<1	18,494/<1	57,923/2
	High	4,443/<1	5,007/<1	40,163/2
	Variable[(a)]	5,230/<1	8,454/<1	12,781/<1
	Not Applicable[(b)]	31,157/1	37,359/2	79,332/3

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis.
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings.

As indicated in Figures D2.2-10 and D2.2-11, and described in Section B (Air Quality), PAI values in the immediate vicinity of the existing and approved developments either do at present, or will, once the facilities are in operation, exceed the critical loading benchmarks. It follows, therefore, that potential soil acidification would have the greatest likelihood of occurring in these same areas. However, it must be emphasized is that the PAI values are for operational maxima whereas in reality they will be phased in as the various projects come on-stream, then cease completely at the end of the development time frame.

The data from Table D2.2-24 have been further analyzed in Table D2.2-25 to permit assessment of the incremental contributions of Project Millennium to the increased PAI levels in the RSA. Applying the 0.25 keq/ha/a critical load for sensitive ecosystems the following observations may be made:

a) For the high sensitivity soils the Project will potentially affect 33,024 ha over and above baseline emissions - this equates to approximately 19% of the estimated impact area due to the full CEA emission scenario.

b) For the moderately sensitive soils the Project will potentially affect an additional 28,755 ha above baseline or roughly 18% of the predicted CEA impact area.

c) For low sensitivity soils the Project will potentially affect 115,713 ha more than baseline emissions, this is approximately 34% of the estimated CEA impact area.

Table D2.2-25 Contribution of Project Millennium to Areas Affected by Acidifying Emissions in the RSA

PAI Critical Load Value	Soil Sensitivity Rating	CEA - Baseline ha / %RSA	Project Millennium Baseline ha / %RSA	Incremental Impact of Project Millennium
>0.25 keq/ha/a	Low	343,323/14	115,713/5	34
	Moderate	163,573/7	28,755/1	18
	High	178,055/7	33,024/1	19
	Variable[a]	13,748/<1	2,742/<1	20
	Not Applicable[b]	46,624/2	10,416/<1	22
>0.50 keq/ha/a	Low	167,126/7	63,561/3	38
	Moderate	45,818/2	6,389/<1	14
	High	35,720/1	564/<1	2
	Variable[a]	7,551/<1	3,224/<1	43
	Not Applicable[b]	48,175/2	6,202/<1	13

[a] Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis.
[b] Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings.

For moderately sensitive ecosystems the critical load is 0.50 keq/ha/a, the following results obtain:

a) For highly sensitive soils the Project will potentially affect an additional 564 ha with respect to baseline or <1% of the CEA impact area.

b) For moderately sensitive soils the Project will potentially affect 6,389 ha above baseline or <1% of the CEA impact area.

c) For low sensitivity soils the Project will potentially impact 63,561 additional ha or 38% of the CEA impact area.

It must be emphasized at this point that two significant qualifications must be recalled when evaluating the acidifying emissions relationships. First, the PAI values are generated by model simulations and thus subject to whatever inherent limitations may be associated with the specific model being used - these are future projections not verified field measurements. Second, the soil sensitivity rating system is conceptual in nature and the rankings are relative, they are in no way intended to be interpreted or represented as being quantitative values.

Given that there is a moderate level of scientific uncertainty associated with the whole area of emissions-deposition-soil reaction-acidification, it would be unrealistic to apply the impact, residual impact, environmental consequence analysis to this component of the impact assessment. The most definitive statement that may be made with any degree of confidence is that the soils classified as highly sensitive which fall within the area defined by the 0.25 keq/ha/a isopleth are the most logical candidates to experience any adverse impacts associated with the Project. It is further suggested that these would be the primary recipients of future monitoring activities to verify whether or not the predicted impacts may be taking place and to what extent.

D2.2.10 Mitigation

The primary course of mitigation would be to reduce the output of PAI at the source via continuing refinement of processing techniques which may, over time, succeed in lowering emission levels to below those used in the present model simulations. This is a field that has seen significant developments over the course of oil sands operations and while further enhancements may not be as dramatic, incremental improvements may well be possible.

D2.2.11 Monitoring

The actual impacts of acid deposition in the oil sands region can best be determined by the establishment and long-term maintenance of extensive field monitoring networks. As Johnson (1987) notes, most studies centre on the processes which tend to acidify soils but very few consider natural compensating mechanisms such as: deep rooting and recycling by vegetation, atmospheric cation inputs and soil weathering. It is very important, therefore, to try and determine which of the observed changes may be due to natural phenomena and which might be attributable to anthropogenic influences. Dufour (1996) and Pauls et al (1996) observe that significant acidification from current input loadings will probably require a temporal frame of decades, if not centuries, to occur. Modelling may be a useful tool for identifying potential areas of concern which should be closely watched but all models have their limitations - generally, predictions made in the 1970s have not been substantiated by subsequent field studies.

Soil properties naturally exhibit high ranges of variability over short distances; therefore, large numbers of sample locations are required to generate reliable data with a meaningful level of confidence (i.e., >90%). There are presently in place a number of disparate monitoring networks that could be integrated to produce a reasonable spatial, if not temporal, database from which to evaluate future trends. The Acid Rain National Early Warning System (ARNEWS) monitoring program has been in place since 1984 but has only a single site in northeastern Alberta (Maynard and Fairbarns 1994). Siltanen et al. (1997) compiled a database of existing soil information for Canadian forest soils from published sources, a reasonable number of the sites are in northeastern Alberta and might supply good background data. Of greater value in establishing a reliable, extensive baseline is the 56 site sampling network initially set out by Syncrude in 1976 for lichen monitoring to which a further 60 sites were added in 1983. Pauls et al. (1996) collected extensive amounts of soil data from 65 of these sites which would form a reliable starting point which could be augmented with additional sites in the future - strategically located based upon refined PAI deposition model outputs. These plots are probably the best base as it is most logical to combine vegetation and soil monitoring programs so that concurrent sites are used. Annual measurements of soil properties are probably superfluous but frequent vegetation surveys may indicate a need for same. It is unclear to this author whether or not, or how many, of the sites used by Pauls are coincidental with those discussed in Conor Pacific (1997) and Conor Pacific and Landcare (1997). If these are in fact two completely, or partially, discrete networks efforts to combine them and adopt common sampling and analytical procedures should go a long way toward setting in place a comprehensive spatial base for future data collection.

D2.3 SOILS AND TERRAIN CONCLUSION

D2.3.1 Introduction

The development of Project Millennium will involve complete removal of soils and overburden. Therefore, almost all of the soil resources and landforms (i.e., terrain units) within the development footprint will be altered. At closure, terrain and soil will be replaced by a reconfigured landscape covered with a reclamation soil mix. The closure soil and terrain units will not be identical to their pre-development counterparts, rather they will be reconstructed to provide a variety of macro- and micro-environments designed to enhance the potential success of the end land use objectives outlined in Section E of Volume 1 of the application. This will be achieved by incorporating more varied relief than in the initial landscape and including a greater variety of subsurface materials in the landforms. The results of these alterations include more diversity in slopes and aspects, and a wider range of drainage classes.

The soils and terrain impact assessment predicted the incremental effects of the Project on top of existing and approved oil sands operations. The assessment considered the issues, as addressed through the key question approach in Section D2.2 of the EIA. The issues and environmental consequences are summarized in Table D2.3-1.

Table D2.3-1 Soils and Terrain Issues and Environmental Consequences

Issue	Environmental Consequence
Quantity of soils and terrain units	Low
Quality of soils and terrain units (i.e., land capability)	Negligible
Acidification of soils	Undetermined

D2.3.2 Impact Assessment

Quantity of Soils and Terrain Units

Organic soils of the McLelland and Muskeg series comprise just over half the area of the local study area (LSA). For the remainder (i.e., the mineral soils), the largest unit is the Kinosis series at roughly 20%. Terrain units reflect a similar pattern, which is to be anticipated since they are based on the parent materials of the soils. Combined bog and fen units make up just over 50% of the LSA, with the morainal/till unit accounting for roughly another 20%.

The removal of soils and terrain and reconstruction of landforms and soils will result in a return of the area to a condition similar to, but altered from pre-development conditions. Because the existing soils and terrain units cannot be replaced, except by reclamation landforms and soils, the magnitude must be rated as moderate. However, because the potential diversity of the reclamation terrain is equal to or greater than that which existed pre-development, the environmental consequence was assessed as low. The same applies to the soil units removed and replaced with reconstructed soils. These impacts were assessed as being of low environmental consequence. Overall, the closure landscape will have no major areas of soil or terrain that will be unreclaimed and while the new units will differ from their pre-disturbance counterparts, they will be of sufficient quality and quantity to fulfill the end land use objectives for the Project. It must be reiterated that none of the soil types or terrain units in the LSA (or RSA) are particularly unique or distinctive as discussed in previous subsections of this analysis. While the disturbances will be significant for a specific soil or terrain unit in a specific location, in the broader context they are judged to be negligible in both impact and consequence.

Quality of Soils and Terrain Units (Land Capability)

Land capability ratings show a similar pattern to the soils and terrain as they are a product of the combined properties of the two. Over half the LSA is rated as non-productive (Class 5) for commercial forestry, while moderately productive lands account for another quarter of the area. Within the disturbance footprint, roughly 60% of the area is rated Class 5, while Classes 2, 3 and 4 range about 12% each.

The reclamation soils and terrain are predicted to result in a significant increase in land capability ratings for the development area. The net result is an increase of approximately 5,681 ha in Class 3 land. There will be an elimination of some 5,380 ha of Class 5, non-productive land capability areas.

The impacts of the Project on soils and terrain quality is rated as positive in direction. Therefore, the impacts to soil and terrain quality were rated as being of negligible environmental consequence.

Acidification of Soils

The Project operations, in conjunction with existing and approved operations that generate air emissions leading to acidification potentials have been modelled to identify areas where acidifying emissions may contribute potential acid input (PAI). The modelling results indicate that the existing and Project emissions have the potential to exceed the interim critical load of 0.25 keq/ha/y for highly sensitive environments in an approximately 90 x 150 km area.

The current soil sensitivity rating system is in development. Field verification of soil sensitivities is currently linked with the RAQCC environmental effects monitoring program.

The uncertainties associated with the soil sensitivity ratings, as well as the fact that the PAI results are generated by model simulations leads to a high level of scientific uncertainty about the predicted impact of acidifying emissions on regional soils. Therefore, the environmental consequences for the impact of acidifying emissions on soils has been rated as undetermined. However, this rating is qualified through recognition that if the modelling results are representative of actual field conditions, and if there are sensitive soils within the influence area, then these soils have the potential to be impacted.

D2.3.3 Monitoring

Monitoring programs will include:

- continuation of Suncor's routine program of monitoring: soil salvage and handling procedures, soil reconstruction activities and development of reclamation soils;
- evaluation of the development of soil capability, using the land capability guidelines; and
- monitoring of soil acidification through linkage with the environmental effects monitoring program under RAQCC.

D3 TERRESTRIAL VEGETATION AND WETLANDS

D3.1 BASELINE/ENVIRONMENTAL SETTING

D3.1.1 Introduction

Terrestrial vegetation, as defined here, corresponds to upland vegetation. Uplands are defined as areas where the soil is not saturated for extended periods, and in the study area are vegetated almost exclusively by forest stands.

The National Wetlands Working Group (NWWG 1988) has defined wetlands as "*land that is saturated with water long enough to promote wetlands or aquatic processes as indicated by hydric soil, hydrophytic vegetation and various kinds of biological activity which are adapted to the wet environment*". This has been adopted as a working definition for the purposes of the current study.

The main objective of the study is to describe the terrestrial vegetation of the Local and Regional Study Areas at different levels of generalization in terms of:

- species composition and coverage;
- physical structure;
- age structure;
- diversity;
- rare plants; and
- plants with traditional uses.

The objective of the wetlands component of the ecological landscape classification study was to describe the lowland or wetlands ecosite types in the Local Study Area (LSA) and Regional Study Area (RSA) and determine their rarity or abundance.

The terrestrial vegetation descriptions provided input to the ecological land classification (Section D4) and were used in that impact assessment. Study area wetlands are described and classified using the wetlands classifications in the Field Guide to Ecosites of Northern Alberta (Beckingham and Archibald 1996) and the Alberta Wetlands Inventory (AWI) (Halsey and Vitt 1996). Beckingham and Archibald's system is used as the basis for the floristic analysis and initial classification of wetlands types, but the AWI is used for the final wetlands classification presented in the ELC (Section D4).

D3.1.2 Methods

D3.1.2.1 Terrestrial Vegetation Classification

The terrestrial vegetation classification process is based on the following sources of information:

- Alberta Vegetation Inventory (AVI) mapping, which uses a forestry-based vegetation classification system;
- the *Field Guide to Ecosites of Northern Alberta* (Beckingham and Archibald 1996), which uses a vegetation classification system based on the principles of ecological land classification (ELC);
- field data reported in the Terrestrial Baseline Report for the Steepbank Mine (Golder 1996t); and
- field data collected for the current study.

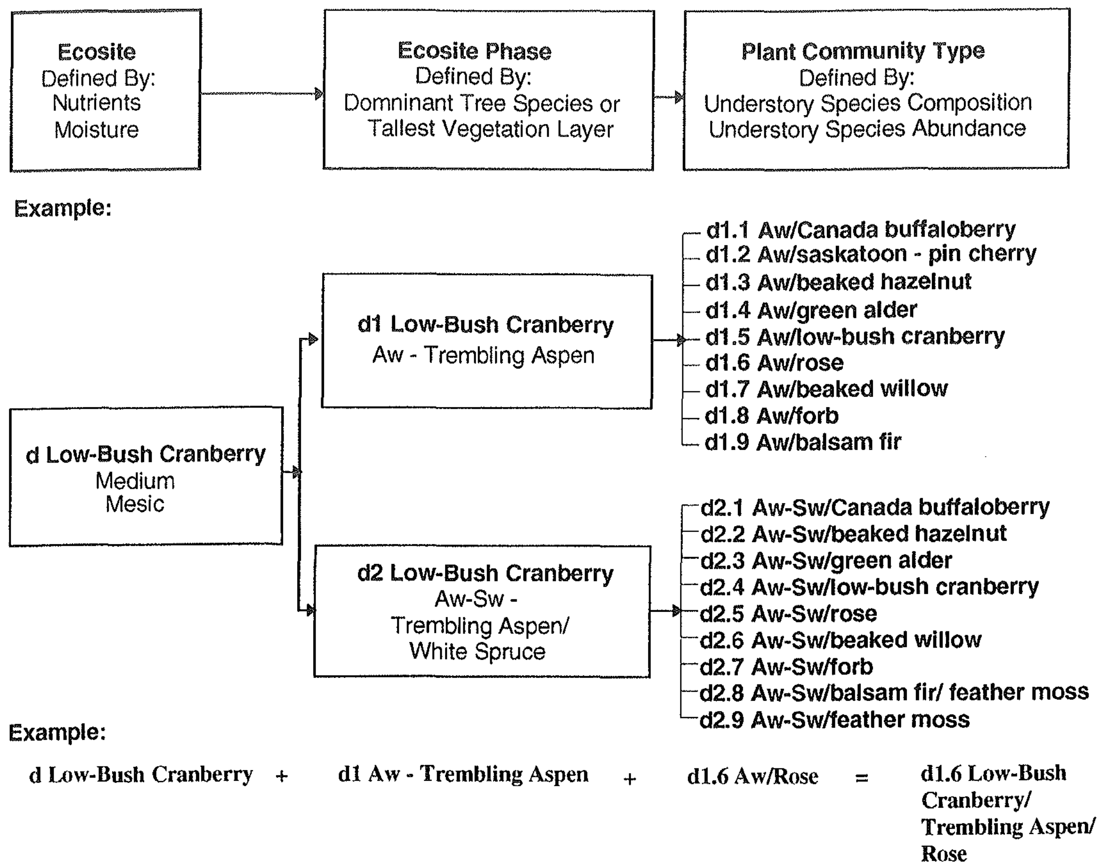
There are four steps in the terrestrial vegetation classification process:

1. AVI polygons were selected as mapping units.
2. AVI polygons were classified using Beckingham and Archibald's system to provide an initial delineation of ecosite phase.
3. Ground-truthing data were collected from plots located on the basis of the preliminary delineation.
4. The preliminary delineation was finalized as necessary using field data. Polygons and plots that did not fit Beckingham and Archibald's system were defined either as complexes of Beckingham units or as new vegetation units.

Beckingham and Archibald's Classification System

Beckingham and Archibald's system, as expressed in their *Field Guide to Ecosites of Northern Alberta* (1996), uses a mixture of biotic and abiotic variables to create a hierarchical, or nested, ecological classification structure. At the coarsest level of classification, ecological areas and subregions are defined on the basis of broad ecoclimatic factors. At this level of generalization the entire study area is within the boreal mixedwood forest. Differences in soil nutrient and moisture regimes are then used to differentiate ecosites. Beckingham and Archibald recognized 8 upland ecosites in the boreal mixedwood forest. Ecosites are subdivided into ecosite phases according to the dominant species in the forest canopy or tallest vegetation layer. At the finest level of classification, ecosite phases are in turn subdivided into plant community types on the basis of differences in species composition within the understorey vegetation (typically the shrub layer). Figure D3.1-1 summarizes the classification process, starting at the ecosite level, and works through an example for one ecosite.

Figure D3.1-1 Ecosite Classification Steps for Upland Areas

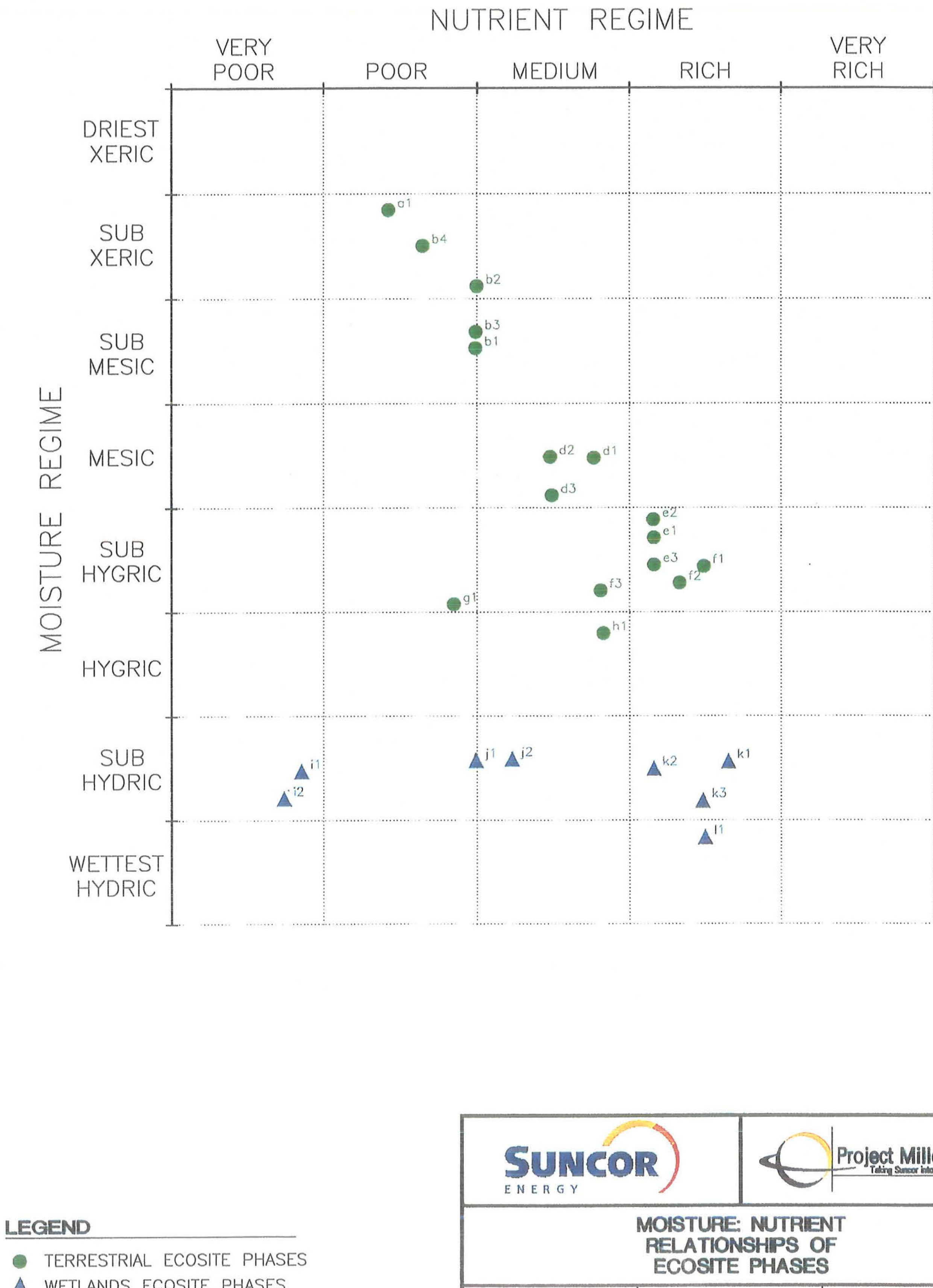


Only polygons that were field visited so understories could be identified can be classified to the plant community level. Therefore, the vegetation classification for the LSA was completed only to the ecosite phase level.

Figure D3.1-2 is an edatropic grid showing the ecological relationships, as defined by gradients of moisture and nutrient supply, of the 17 upland ecosite phases described by Beckingham and Archibald (1996). The eight wetlands ecosite phases are included for comparison. Moisture conditions, on the vertical (y) axis, range from hydric (wettest) to xeric (driest). Nutrient conditions, on the horizontal (x) axis, range from very poor to very rich. The positions of the ecosite phases shown in Figure D3.1-2 represent the mid-points of the ranges of moisture and nutrient regime reported by Beckingham and Archibald.

Plant Community Assessment Field Methods

Plot locations for the upland plant community assessment were determined using the initial delineation of plant communities. Plots of 20 x 20 m were randomly located in map polygons representative of each ELC unit. Species composition and structural data were collected within each plot as follows:



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MOISTURE: NUTRIENT RELATIONSHIPS OF ECOSITE PHASES

05 Apr. 1998	Figure D3.1-2	DRAWN BY: CG/TM

- tree layer (>5 m high) - entire 20 x 20 m plot
  - % coverage for each species
  - average tree height
  - dbh (diameter at breast height) for all living, dead and downed trees
  - age of 3 largest trees

- shrub layer (0.5-5 m high) - 10 x 10 m subplot in one corner of 20 x 20 m plot
  - % coverage for each species
  - height of shrubs

- herb layer (<0.5 m high) - 7, 1 x 1 m plots within 10 x 10 m subplot
  - % cover for each herb, moss and lichen species.

Standard field techniques were used throughout. Field taxonomy followed *Flora of Alberta* Moss (1983) and Packer and Bradley (1984). Specimens of plants that could not be identified in the field were collected for herbarium identification.

Rare Plants

A list of rare plant species potentially present in the study area was prepared from existing literature sources. The known habitat associations of these species were considered in selecting the field plot locations. During the field studies, each rare plant occurrence was documented using the rare native plant survey form provided by the AHNIC. Rare plants were photographed and specimens were collected.

Plants With Traditional Uses

Plants traditionally used by local aboriginal people for food, medicine or spiritual purposes were identified using published literature and past interviews with community members (Fort McKay 1996d).

Species Richness and Diversity

Species richness and diversity indices were not calculated for the field data because only a few of the ecosite phases were represented by a sufficient number of plots to allow meaningful statistical comparisons. Instead, the mean and range of numbers of species for the ecosite phases with plots are been presented, both for the unit as a whole and for each of the tree, shrub and herb layers.

D3.1.2.2 Wetlands Classification

There were five steps in the wetlands vegetation classification process:

1. Alberta Vegetation Inventory (AVI) polygons were selected as mapping units.

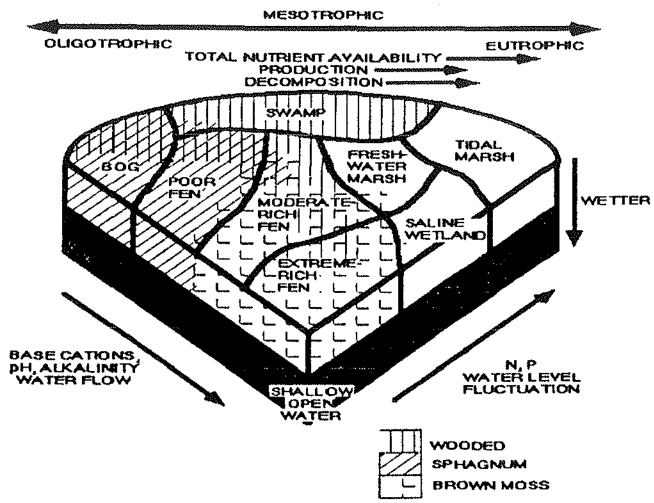
2. AVI polygons were classified using Beckingham and Archibald's system to provide an initial delineation of vegetation communities.
3. Ground truthing data were collected from plots located on the basis of the preliminary delineation.
4. The preliminary delineation was finalized as necessary using field data.
5. Wetlands were reclassified and mapped using the AWI classification system.

Beckingham and Archibald recognize four wetland ecosites-bog, poor fen, rich fen and marsh-in the boreal mixedwood forest. The four wetlands ecosites are subdivided into eight ecosite phases according to the gross physiognomy of the vegetation (i.e., tree, shrub or graminoid). At the finest level of classification, ecosite phases are in turn subdivided into plant community types on the basis of differences in plant species composition. A summary of the classification process and an example are presented in Figure D3.1-1.

In the AWI system, five primary wetland types-bog, fen, marsh, swamp and shallow open-water-are defined in terms of interrelationships among the hydrologic, chemical and biotic processes that control wetlands development (Figure D3.1-3). Vegetation and landform modifiers are then applied to subdivide the primary wetlands types (Figure D3.1-4). The modifiers have been defined in such a way that the subdivided wetland classes can readily be discriminated on air photos.

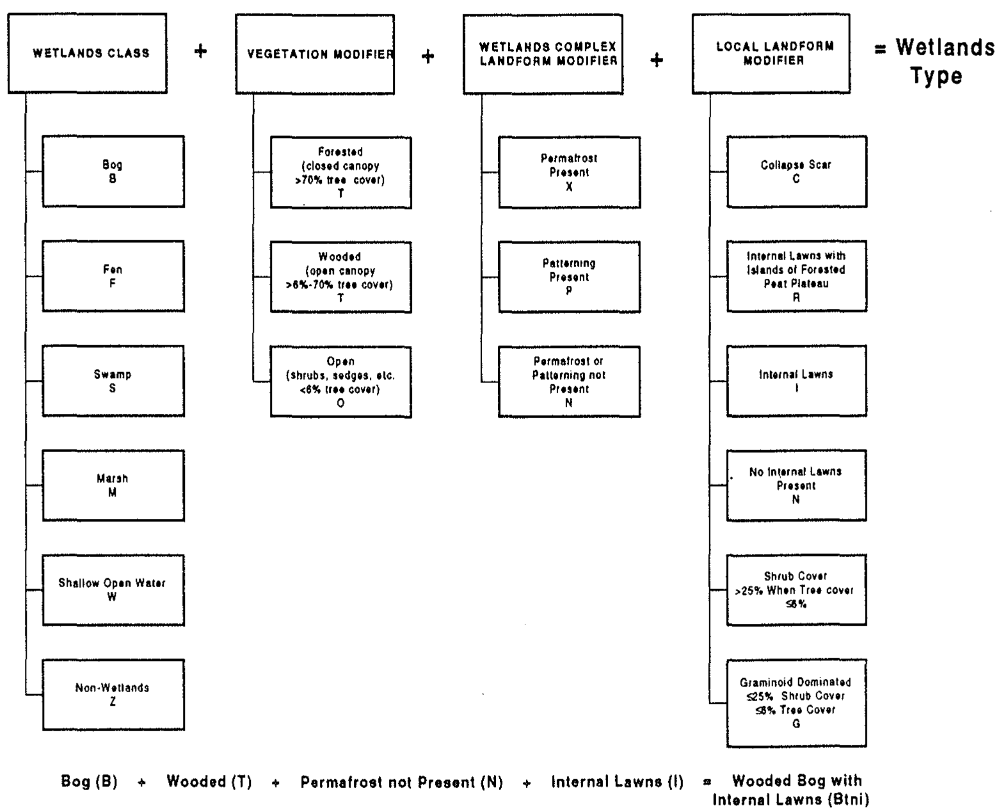
An important consequence of the different ways in which wetlands units are defined in the Beckingham and Archibald (1996) and AWI systems is that AWI wetlands units are often easier to identify on air photos. At the same time, the AWI system provides a finer subdivision of units. Table D3.1-1 compares the two systems.

Figure D3.1-3 Primary Wetlands Classification Based on Hydrologic, Chemical and Biotic Gradients



Source: Halsey and Vitt 1996

Figure D3.1-4 AWI Wetlands Classification Process



Source Nesby 1977

Table D3.1-1 Comparison of AWI and Field Guide to Ecosites of Northern Alberta Wetlands Classification Systems

Alberta Wetlands Inventory [a]			Field Guide to Ecosites[b]
Class	Subclasses		
Shallow open-water (W)	not applicable	Shallow Open Water (WONN)	not applicable
Marsh (M)	not applicable	Graminoid/shrub Marsh (MONG and MONS)	Marsh (l1)
Swamp (S)	Combination of black spruce and tamarack at > 70% cover	Forested Swamp (SFNN)	Wetter end of horsetail (f)
	Combination of black spruce and tamarack (>10 ≤ 70% tree cover)	Wooded Swamp (STNN)	Wetter end of horsetail (f)
	Shrub cover > 25%	Shrubby Swamp (SONS)	any upland ecosite phase
Fen (F)	Shrub cover > 25% when tree cover ≤ 6%	Non-patterned shrubby fen (FONS)	Shrubby poor fen (j2) and shrubby rich fen (k2)
	Graminoid dominated with shrub cover ≤ 25% and tree cover ≤ 6%	Non-patterned graminoid fen (FONG)	Graminoid rich fen (k3)
	Wooded fen (>10% - ≤70% tree cover)	Non-patterned wooded fen with no internal lawns (FTNN	Treed poor fen (j1) and treed rich fen (k1)
	Forested fen > 70% tree cover	Non-patterned forested fen with no internal lawns (FFNN)	Treed poor fen (j1) and treed rich fen (k1)
Bog (B)	Wooded bog (>10%, ≤70% tree cover)	No internal lawns (BTNN)	Treed bog (i) and shrubby bog (i)
	Forested bog (closed canopy >70% tree cover)	No internal lawns (BFNN)	Treed bog (i) and shrubby bog (i)

(a) Halsey and Vitt (1996)
(b) Beckingham and Archibald (1996)

D3.1.2.3 Results

D3.1.2.4 Vegetation Communities

Areas of Ecosite Phases

Beckingham and Archibald (1996) define eight upland ecosites and 17 associated ecosite phases within the boreal mixedwood forest. All of the ecosite phases except f1 (horsetail Pb-Aw), f2 (horsetail Pb-Sw) and f3 (horsetail Sw) are represented within the LSA. Table D3.1-2 gives the baseline areas of the upland ecosite phases and complexes of ecosite phases mapped within the LSA. Included are two upland vegetation types that do not fit into Beckingham and Archibald's classification, shrublands and black spruce-tamarack forest. In total, upland forest vegetation units comprise 36% of the LSA.

Table D3.1-2 Baseline Areas of Ecosite Phases Within the LSA

Ecosite Phase	Code	Area (ha)	Percent Cover
lichen jack pine	a1	1	< 1
blueberry Pj-Aw	b1	226	1
blueberry Aw(Bw)	b2	28	< 1
blueberry Aw-Sw	b3	60	< 1
blueberry Sw-Pj	b4	50	< 1
Labrador Tea-mesic Pj-Sb	c1	1	< 1
low-bush cranberry Aw	d1	3,348	21
low-bush cranberry Aw-Sw	d2	588	4
low-bush cranberry Sw	d3	941	6
dogwood Pb-Aw	e1	212	1
dogwood Pb-Sw	e2	63	< 1
dogwood Sw	e3	127	< 1
Labrador tea - subhygric Sb-Pj	g1	1	< 1
Labrador tea/horsetail Sw-Sb	h1	59	< 1
shrubland	-	131	1
black spruce-tamarack	-	20	< 1
Total, upland ecosite phases		**5,856**	**36**
Total, wetlands vegetation units		**9,994**	**62**
Existing disturbances and water		**331**	**2**
TOTAL LSA		**16,181**	**100**

The ecosites and ecosite phases are described below. The characteristic species of the ecosite phases are summarized in Table D3.1-3. No floristic data is available for the shrubland and black spruce-tamarack vegetation types.

Table D3.1-3 Mean Cover (%) of Charactersitic Species Which Show up in 50% or More of the Sites

Layer	Species	b1	b2	b3	b4	d1	d2	d3	e1	e2	e3
Tree	balsam fir										38
Tree	balsam poplar									10	
Tree	black spruce	4									
Tree	jack pine	21		7	49						
Tree	paper birch									27	
Tree	tamarack	4									
Tree	trembling aspen	11	70	42	4	49	33	3			
Tree	white spruce	12		21	9	10	27	58		26	
Shrub	alder-leaved buckthorn								10		
Shrub	balsam fir									5	10
Shrub	balsam poplar								5	13	
Shrub	black gooseberry									2	
Shrub	bog cranberry	13			10						
Shrub	buckbrush									3	
Shrub	buffaloberry	10		15	6	9	14				
Shrub	common bearberry	5	3	5							
Shrub	dwarf blueberry	15									
Shrub	green alder		10								
Shrub	jack pine				1						
Shrub	Labrador tea	15	5	10	18						
Shrub	low-bush cranberry					17	11	12		5	
Shrub	myrtle-leaved willow	1									

Layer	Species	b1	b2	b3	b4	d1	d2	d3	e1	e2	e3
Shrub	prickly rose	7	5	10	14	15	11	6		8	10
Shrub	pussy willow								20		
Shrub	red-osier dogwood								15	10	12
Shrub	river alder								80	8	28
Shrub	shrubby cinquefoil	1									
Shrub	tamarack	2									
Shrub	trembling aspen	2	25		4	4	3	1		3	
Shrub	twin-flower	5	10		9	6	9			3	
Shrub	velvet-leaved blueberry	15	30	30							
Shrub	white spruce	15		25	26	5	3	3	3	4	
Shrub	wild red currant								5	5	7
Shrub	wild red raspberry								10		12
Forb	American milk-vetch	1									
Forb	bishop's-cap						4	4			3
Forb	bunchberry	20	15	40	8	13	14	12		5	10
Forb	common horsetail	1			2				5	5	13
Forb	common pink wintergreen		2	5				2		2	
Forb	cow-wheat	2									
Forb	dewberry		3			7	7			20	9
Forb	dwarf scouring-rush	2									
Forb	fireweed	1	7								
Forb	fringed aster	1		10							
Forb	northern bedstraw					2				1	
Forb	northern water-horehound								5		
Forb	palmate-leaved coltsfoot	1								3	
Forb	red and white baneberry		25								
Forb	Siberian yarrow			2							
Forb	spinulose shield fern								10		
Forb	spotted touch-me-not								5		
Forb	tall lungwort			10							
Forb	three-leaved false Solomon's-seal		5								
Forb	three-toothed cinquefoil	1		3							
Forb	water-hemlock								15		
Forb	wild lily-of-the-valley					3					
Forb	wild sarsaparilla					11		6		3	
Forb	wild strawberry			5		4					
Graminoid	bluejoint	1	1	15					5		
Graminoid	mud sedge		1								
Graminoid	northern ricegrass	2									
Moss	big red stem			70	23		26	51		35	25
Moss	juniper moss	3			13						
Moss	moss species		15						5	3	
Moss	pigtail moss									5	
Moss	Sphagnum	15									
Lichen	Cladonia	40									
Lichen	hair lichens										85
Lichen	monk's hood lichen										63
	Total Number of Sites	**2**	**1**	**1**	**4**	**12**	**9**	**7**	**1**	**2**	**3**

Vegetation Commmunities Occuring in the LSA

Lichen Ecosite (a)

The soils of the lichen ecosite are well-to rapidly-drained, with submesic to xeric moisture regimes. The nutrient regime is typically poor. This ecosite has only one phase, the lichen jack pine.

The canopy of the lichen jack pine (a1) ecosite phase is dominated by jack pine. The shrub understorey typically consists of blueberry, bearberry, green alder, bog cranberry, Labrador tea, twin-flower, jack pine and sand heather.

Wild lily-of-the-valley is the only common forb. On the forest floor, reindeer lichen is dominant, while Schreber's moss, awned hair-cap moss and brown-foot cladonia are also found. The lichen jack pine ecosite phase occupy 1 ha or less than 1% of the LSA.

Blueberry Ecosite (b)

The soils of the blueberry ecosite are moderately well-to rapidly-drained. The moisture regime is usually submesic to subxeric, and the nutrient regime is poor to medium. The four ecosite phases occur in the LSA and occupy 364 ha (Table D3.1-2).

Figure D3.1-5 Blueberry Ecosite with Jack Pine - Trembling Aspen Canopy

The canopy of the blueberry jack pine-trembling aspen (b1) ecosite phase is dominated by jack pine and aspen (Figure D3.1-5; picture taken from a jack pine-trembling aspen ecosite phase in Muskeg River Mine Project, Golder 1997o). White birch, white spruce and black spruce may also be found in the canopy. The shrub layer is diverse, typically consisting of bog cranberry, blueberry, green alder, bearberry, Labrador tea, twin-flower, Canada buffaloberry, aspen, white spruce and prickly rose. Herbs may include bunchberry, fireweed and cream-colored vetchling. Hairy wild rye is the characteristic graminoid. Schreber's moss, stair-step moss and reindeer lichen are the characteristic non-vascular species.

Figure D3.1-6 Blueberry Ecosite with Trembling Aspen (White Birch) Canopy

The blueberry trembling aspen (white birch) (b2) ecosite phase is dominated by aspen and white birch (Figure D3.1-6). White spruce may also be found in the canopy. The shrub layer is sparse when compared to that of b1. Species composition differs only in that black spruce is not common in b2. Bunchberry, wild lily-of-the-valley and cream-colored vetchling are characteristic of the herb layer. The most common grasses, mosses and lichens include marsh reed grass, hairy wild rye, Schreber's moss, stair-step moss and reindeer lichen.

Figure D3.1-7 Blueberry Ecosite with Trembling Aspen - White Spruce Canopy

Aspen and white spruce dominate the canopy of the blueberry aspen-white spruce (b3) ecosite phase (Figure D3.1-7). White birch and jack pine may also be present in the canopy. The shrub layer is denser than that of b2 but species composition differs only in that Canada buffaloberry is not common in b3. Bunchberry, fireweed, wild lily-of-the-valley, wild strawberry and cream-colored vetchling are characteristic of the herb layer. The dominant grasses, mosses and lichens are the same as in b2, with higher percent coverages.

Figure D3.1-8 Blueberry Ecosite with White Spruce - Jack Pine Canopy

The canopy of the blueberry white spruce-jack pine (b4) ecosite phase is dominated by white spruce and jack pine, although white birch and aspen are usually present as well (Figure D3.1-8). The shrub layer is similar to that of b3, with slightly lower average percent cover. The herb layer is characterized by bunchberry, wild lily-of-the-valley and bastard toad-flax. Hairy wild rye is the characteristic graminoid. The moss layer is better developed than in the other blueberry ecosite phases, with >30% coverage, but the species are the same. Reindeer lichen is also characteristic.

Labrador Tea-Mesic Ecosite (c)

The soils of the Labrador tea ecosite are usually moderately well-to well-drained. The moisture regime is subhygric to submesic, and the nutrient regime is typically poor. A picture of a Labrador tea-mesic jack pine-black spruce (c1) ecosite is shown in Figure D3.1-9. This picture was taken from a jack pine-black spruce ecosite phase in the Muskeg River Mine Project (Golder 1997o). This ecosite phase occupies 1 ha or less than 1% of the LSA.

Figure D3.1-9 Jack Pine-Black Spruce Forest With Labrador Tea Understorey

The canopy of the Labrador tea-mesic jack pine-black spruce ecosite phase is dominated by jack pine and black spruce. The shrub layer typically consists of Labrador tea, bog cranberry, black spruce, blueberry, green alder, and twin-flower. Bunchberry is the only characteristic species in the poorly developed herb layer. The forest floor is dominated by Schreber's moss, with average ground coverage exceeding 40%. Stair-step moss, knight's plume moss and reindeer lichen are also characteristic.

Low-Bush Cranberry Ecosite (d)

The central moisture-nutrient concept of this ecosite is mesic-medium, although moisture regimes may vary from submesic to subhygric and nutrient regimes from poor to rich. Three low-bush cranberry ecosite phases occur in the LSA and occupy 4,877 ha (Table D3.1-2).

Figure D3.1-10 Trembling Aspen Canopy With Low-Bush Cranberry Understorey

The tree layer of the low-bush cranberry aspen (d1) ecosite phase is usually dominated by a closed canopy of aspen (Figure D3.1-10), although white birch may be locally dominant.

Balsam poplar and white spruce are the other characteristic tree species. Balsam fir may also be present in the canopy. Prickly rose and low-bush cranberry are dominant in the shrub layer. Other typical shrubs are beaked hazelnut, green alder, Canada buffaloberry, Saskatoon, willow, twin-flower and aspen. The herb layer is well-developed and is characterized by wild sarsaparilla, fireweed, bunchberry, dewberry, cream-colored vetchling and northern bedstraw. Marsh reed grass and hairy wild rye are abundant and characteristic. Stair-step moss and knight's plume moss may also be present.

Figure D3.1-11 Low-Bush Cranberry Ecosite with Trembling Aspen - White Spruce Canopy

The canopy of the low-bush cranberry aspen-white spruce (d2) ecosite phase (Figure D3.1-11) is typically dominated by aspen and white spruce; however, balsam fir, black spruce, white birch and balsam poplar may all be locally dominant. The species composition of the shrub layer is the same as that of d1, except for the addition of pin cherry and choke cherry. The herb layer is less diverse than in d1, but grass coverage is essentially the same. Unlike d1, a moss layer is present. It is characterized by stair-step moss, Schreber's moss and knight's plume moss.

Figure D3.1-12 Low-Bush Cranberry Ecosite with White Spruce Canopy

The canopy of the low-bush cranberry white spruce (d3) ecosite phase is dominated by white spruce (Figure D3.1-12). Balsam fir, aspen, black spruce, white birch and balsam poplar are also characteristic. The shrub layer typically contains balsam fir, low-bush cranberry, twin-flower, prickly rose, green alder and Canada buffaloberry. Wild sarsaparilla, bunchberry, dewberry and tall lungwort characterize the herb layer, along with hairy wild rye as the common graminoid. Ground coverage by moss is usually >50%. The species are as in d2, with stair-step moss dominating.

Dogwood Ecosite (e)

Drainage conditions in the soils of the dogwood ecosite vary widely. Moisture regimes range from mesic to hygric and nutrient regimes from medium to rich, although the central concept of the ecosite is subhygric-rich. All three dogwood ecosite phases occur in the study area and occupy an area of 402 ha (Table D3.1-2).

Figure D3.1-13 Dogwood Ecosite with Balsam Poplar - Trembling Aspen Canopy

The tree canopy of the dogwood balsam poplar-aspen (e1) ecosite phase is usually dominated by aspen and balsam poplar, although white spruce may be locally dominant (Figure D3.1-13). In addition, white birch may be present. Dogwood, prickly rose, and low-bush cranberry are the most abundant shrub species. Other characteristic shrubs are bracted honeysuckle, green and river alder, willow and currant. In the herb layer, wild sarsaparilla, dewberry and fireweed are the most abundant of the characteristic species. Marsh reed grass is the characteristic graminoid. Ferns are also characteristic but typically have cover values <1%.

Figure D3.1-14 Dogwood Ecosite with Balsam Poplar - White Spruce Canopy

White spruce, aspen and balsam poplar dominate the tree canopy of the dogwood balsam poplar-white spruce (e2) ecosite phase (Figure D3.1-14). White birch are generally present in the canopy as well. The dominant shrub species are the same as in e1 and the other characteristic shrub species differ only slightly. The herb layer is also the same except that bunchberry and bishop's-cap replace fireweed. There is a moss layer with approximately 20% ground coverage. It is dominated by stair-step moss.

Figure D3.1-15 Dogwood Ecosite with White Spruce Canopy

The dogwood white spruce (e3) ecosite phase (Figure D3.1-15) usually occurs on wetter sites than e1 and e2. The dominant tree species is white spruce, with canopy coverage averaging about 40%. Balsam fir is typically present, with balsam poplar, white birch and aspen being occasionally present. Low-bush cranberry, prickly rose, green and river alder, twin-flower, dogwood, bracted honeysuckle, wild red raspberry, balsam fir and currant are the characteristic shrub species. Less common are Labrador tea and bog cranberry. Woodland horsetail, wild sarsaparilla, bishop's-cap, dewberry, bunchberry and tall lungwort are the most characteristic forbs. Marsh reed grass is abundant. The well-developed moss layer consists of stair-step moss, Schreber's moss and knight's plume moss.

Labrador Tea-Subhygric Ecosite (g)

The soils of the Labrador tea-subhygric ecosite are imperfectly to very poorly drained, with subhygric to hydric moisture regimes. The nutrient regime is typically poor. There is only one ecosite phase, the Labrador tea black spruce-jack pine (g1) in this ecosite. A picture taken from a black spruce-jack pine ecosite phase in the Muskeg River Mine Project (Golder 1997o) is shown in Figure D3.1-16. This ecosite occupies an area of 1 ha or less than 1% of the LSA.

Figure D3.1-16 Jack Pine-Black Spruce Forest With Labrador Tea Understorey

The canopy of the Labrador tea black spruce-jack pine ecosite phase is usually dominated by black spruce. Jack pine, the other characteristic tree species, may be locally dominant. Labrador tea is the dominant shrub. The other characteristic species in the shrub layer are bog cranberry, black spruce, blueberry, prickly rose and twin-flower. Only one species, bunchberry, is characteristic of the poorly expressed herb layer. Moss cover is quite high, usually >50%. Stair-step moss and Schreber's moss dominate, but knight's plume moss, peat moss and tufted moss are also typically present. Reindeer lichen is usually present as well.

Labrador Tea/Horsetail Ecosite (h)

The soils of the Labrador tea/horsetail ecosite are imperfectly to very poorly drained. Moisture regimes vary widely, from mesic to hydric, although most sites are in the subhygric-hygric range. Nutrient regimes range from rich to poor. There is one ecosite phase, the Labrador tea/horsetail white spruce-black spruce (h1). A picture taken from a white spruce-black spruce ecosite phase in the Muskeg River Mine Project (Golder 1997o) is shown in Figure D3.1-17. This ecosite occupies an area of 59 ha or less than 1% of the LSA.

Figure D3.1-17 White Spruce Canopy With Labrador Tea and Horsetail Understorey

The canopy of the Labrador tea/horsetail white spruce-black spruce ecosite phase is dominated by white spruce, with black spruce typically being subdominant. White birch is usually present. Labrador tea is the most abundant shrub. The other species characteristic of the shrub layer are bog cranberry, willow, prickly rose and twin-flower. Common horsetail, meadow horsetail, woodland horsetail, bunchberry and dwarf scouring rush are the only common forbs. Marsh reed grass and sedges are typically present at low cover values. The moss layer is very well-developed, with cover values averaging 70% or more. Stair-step moss and Schreber's moss dominate; tufted moss and knight's plume moss are also characteristic.

D3.1.3 Uplands Plant Communities Species Richness, Diversity, Cover and Tree Measurements

D3.1.3.1 Community Diversity

Community level biodiversity can be assessed by assessing the number of vegetation polygon (patches) within the LSA (Table D3.1-4). The most extensive ecosite phase, the low-bush cranberry Aw (d1), has a mean patch size of 32 ha. The blueberry Aw(Bw) ecosite phase has a mean patch size of 27 ha and the blueberry Aw-Sw (b3) ecosite phase, 20 ha. The dogwood Pb-

Aw (e1) ecosite has a mean patch size of 5 ha; for the e2 ecosite phase, 3 ha; and for the e3 ecosite phase, 4 ha. The lichen Pj (a1), Labrador tea-mesic Pj-Sb (c1) and Labrador tea-subhygric Sb-Pj (g1) ecosite phase have a mean patch of 1 ha. The black spruce-tamarack complex has a mean patch size of 10 ha and the shrubland has 8 ha. Low-bush cranberry Aw (d1) has the largest patch size at 678 ha.

Table D3.1-4 Mean, Minimum and Maximum Vegetation Polygon or Patch Size

Map Code	Eco Site Phase (Vegetation Types)	Number of Vegetation Polygons	Baseline		
			Min. Patch Size (ha)	Max. Patch Size (ha)	Mean Patch Size (ha)
a1	lichen Pj	1	1	1	1
b1	blueberry Pj-Aw	26	1	47	9
b2	blueberry Aw(Bw)	1	27	27	27
b3	blueberry Aw-Sw	3	3	36	20
b4	blueberry Sw-Pj	7	1	16	7
c1	Labrador tea-mesic Pj-Sb	1	1	1	1
d1	low-bush-cranberry Aw	104	<1	678	32
d2	low-bush-cranberry Aw-Sw	55	<1	150	10
d3	low-bush-cranberry Sw	123	<1	114	8
e1	dogwood Pb-Aw	45	<1	44	5
e2	dogwood Pb-Sw	23	<1	7	3
e3	dogwood Sw	28	<1	18	4
g1	Labrador tea-subhygric Sb-Pj	1	1	1	1
h1	Labrador tea/horsetail Sw-Sb	15	<1	10	4
-	black spruce-tamarack	2	9	11	10
-	shrubland	17	1	24	8

Species Richness

Total richness tells us the entire set of observed species for each vegetation type. However, since an exhaustive survey was not completed, these values are conservative estimates which cannot be compared. Thus, the average per plot richness is used to make comparisons. It is, however, affected by low sample sizes in some types but is the best unbiased estimate for comparison. In addtion, total richness tells species numbers likely to be encountered in a vegetation phase, whereas, plot average richness tells how many are expected at any one location.

Richness of species is determined by counting the number of different classified units or species within a given landscape or community unit. For species, the richness is determined from samples, so a mean is determined. Species richness may be split among taxonomic or functional groups such as trees, shrubs and herbs.

The mean and range of species richness values for individual plots within the ecosite phases are also shown in Table D3.1-5. These data provide an indication of the species richness that is characteristic of small areas within ecosite phases. The highest mean and maximum of total species richness are in the d1, d2 and d3 ecosite phases. The minimum number of total species richness for individual plots within the ecosite phases are in e2. The highest mean richness in the tree layer is in b1 and b3; in the shrub layer it is in d1 and d2; and in the herb layer it is in d1 and d3. The lowest mean richness in the tree layer is in e1. The lowest mean richness in the shrub layer is in b3. The lowest mean richness in the herb layer is in e2.

The minimum number of total species within the tree layer is one species (b2, d1, d2, e3) and the maximum number of tree species is 5 (b1). The minimum number of herb species is one (b4) and the maximum number is 17 (d3). Overall, shrub and herb species comprise the most species for individual plots within the ecosite phases surveyed.

Table D3.1-5 Species Richness For Ecosite Phase

	Total Vascular Species			Tree Layer			Shrub Layer			Herb Layer		
Phase	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
b1	17.5	17	18	3.5	2	5	8.5	8	9	6.0	5	7
b2	15.0	15	15	1.0	1	1	7.0	7	7	8.0	8	8
b3	16.0	16	16	3.0	3	3	6.0	6	6	8.0	8	8
b4	13.3	11	17	2.5	2	3	8.5	8	9	3.8	1	7
d1	20.7	16	26	2.5	1	4	10.2	7	13	9.1	5	13
d2	18.3	10	26	2.3	1	4	10.0	4	18	7.1	5	12
d3	18.7	12	27	2.7	2	4	7.6	3	11	9.4	6	17
e1	14.0	14	14	0.0	0	0	8.0	8	8	6.0	6	6
e2	12.0	7	17	2.5	2	3	7.5	4	11	3.5	2	5
e3	15.3	10	21	1.7	1	2	7.7	4	10	6.7	5	9

Species Diversity

Diversity refers to the numbers of species in given areas, the ecological roles that these species play, the way that the composition of species changes as we move across a region and the groups of species (ecosystems) that occur in particular areas, together with the processes and interactions that take place within and between these systems (UNEP 1995).

The Shannon Index is used to measure species diversity. This index combines the number of types (species) and the frequency distribution of the species or types. The more types and the more evenly distributed they are, the higher the index value. The index is generally used on random samples drawn from a large community, where there is less likely the chance to randomly select the same sample twice.

Table D3.1-6 gives the mean and range of species diversity values for individual plots within the ecosite phases surveyed. The b1 and b3 blueberry ecosite phases have the highest mean among ecosite phases sureyed. The highest mean for the shrub layer are in b1, b4, d1 and d2. For the tree layer, the highest mean are in b1 and b3. Mean diversity is lowest in b2, among ecosite phases surveyed. The lowest mean diversity in the tree layer is in e1 and e3. The lowest mean diversity in the shrub layer is in e1. The lowest mean diversity in the herb layer is in b4 and e2. There is little difference in mean diversity between the shrub and herb layers in many of the ecosite phases and there is no discernible overall trend to higher diversity in either layer. Mean diversity is lowest in the tree layer for all ecosite phases surveyed.

Table D3.1-6 Species Diversity for Ecosite Phases

	Total Vascular Species			Tree Layer			Shrub Layer			Herb Layer		
Phase	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
b1	1.08	1.04	1.12	0.40	0.14	0.65	0.80	0.76	0.84	0.52	0.47	0.57
b2	0.84	0.84	0.84	0.00	0.00	0.00	0.72	0.72	0.72	0.69	0.69	0.69
b3	1.05	1.05	1.05	0.39	0.39	0.39	0.71	0.71	0.71	0.72	0.72	0.72
b4	0.94	0.88	1.02	0.21	0.09	0.45	0.85	0.83	0.87	0.40	0.00	0.75
d1	1.11	0.95	1.20	0.25	0.00	0.53	0.89	0.77	1.02	0.78	0.54	0.97
d2	1.07	0.75	1.29	0.29	0.00	0.58	0.86	0.53	1.17	0.72	0.53	0.87
d3	0.96	0.64	1.14	0.16	0.03	0.31	0.73	0.37	0.93	0.83	0.60	1.13
e1	0.91	0.91	0.91	0.00	0.00	0.00	0.65	0.65	0.65	0.73	0.73	0.73
e2	0.89	0.73	1.05	0.30	0.22	0.39	0.76	0.55	0.96	0.43	0.22	0.64
e3	0.94	0.77	1.07	0.08	0.00	0.14	0.75	0.58	0.90	0.60	0.54	0.68

Structure

In terms of structure, species richness is highest in the shrub layer and lowest in the tree layer for all ecosite phases surveyed. Structurally, both mean and maximum richness are lowest in the tree layer in each ecosite phase surveyed. Generally, mean and maximum richness are higher in the shrub layer than in the herb layer. The differences in relative species richness among ecosite phases, may result from differences in internal compositional variability among ecosite phases.

The use of structure also aids in describing the appearance of the community. Structure relates to the vertical spacing and height of the plants making up the community. Table D3.1-7 shows the percentage of stands with multilayered structure (i.e., overstorey and understorey). Lichen Pj (a1) and Labrador tea-mesic Pj-Sb (c1) have only single layered structured stands. Blueberry Aw(Bw) (b2) also has a single layered structured stand. The dogwood ecosites have a higher percentage of single layered structured stands, whereas the low-bush cranberry ecosites have higher percentage of multilayered structured stands.

Table D3.1-7 Percentage of Stands in the LSA With Multilayered Structure: Overstorey and Understorey

Phase	Multilayered Stand Percentage	Single Layer Stand Percentage
a1	0.0	100.0
b1	44.0	56.0
b2	100.0	0.0
b3	61.2	38.8
b4	76.1	23.9
c1	0.0	100.0
d1	65.5	34.5
d2	61.6	38.4
d3	55.2	44.8
DL	0.0	100.0
e1	13.7	86.3
e2	24.2	75.8
e3	42.7	57.3
g1	0.0	100.0
h1	0.0	100.0
Sb/Lt	0.0	100.0

Total Richness and Diversity

Total richness is the total number of species found in each ecosite phase. Likewise, total diversity is the Shannon Index value calculated with total richness and average cover per plant species. Community diversity and richness was calculated for vascular plants only because these were the only plant types completely surveyed at any site. Total diversity and richness were determined from the combined set of sites which were classed within the same ecosite phase. However, each ecosite phase did not have the same number of sample sites. The number of species will likely increase with the number of sites sampled. Thus, total richness for undersampled ecosite phases is a conservative estimate of the total species richness.

The highest number of total species found in each site are the d1 and d2 ecosite phase (Table D3.1-8). The lowest number of total species found in each site are the e1, b2 and b3 ecosite phases. The highest number of species in the tree layer are in the d1 and d2 ecosite phase; in the shrub layer it is in d1 and d2; and in the herb layer it is in d1, d2 and d3. Total species are lowest in the e1 among all ecosite phases surveyed.

It should be noted that some tree species are also measured as shrubs, consequently the total richness is often less than the sum of trees, shrubs and herbs (i.e., some tree species are in two categories).

The highest diversity was found within the d1 and d2 ecosite phases particularly in the shrub layer (Table D3.1-8). The b2 and e1 ecosite phase have the lowest diversity among all ecosite phases surveyed. The highest diversity for the tree layer was found in the d2 ecosite phase. The lowest diversity for the tree layer was found in the b2 and e1 ecosite phases. The highest diversity for the herb layer was found in the d1 and d2 ecosite phases.

Table D3.1-8 Total Richness and Diversity For Ecosite Phases Sampled

Richness						Diversity					
Phase	Trees	Shrubs	Herbs	Total	Number of Ecosites Sampled	Phase	Trees	Shrubs	Herbs	Total	Number of Ecosites Sampled
b1	5	13	11	26	2	b1	0.61	0.99	0.63	1.19	2
b2	1	7	8	15	1	b2	0	0.72	0.69	0.84	1
b3	3	6	8	16	1	b3	0.39	0.71	0.72	1.05	1
b4	3	14	13	27	4	b4	0.28	0.99	0.84	1.07	4
d1	6	38	33	72	12	d1	0.34	1.31	1.22	1.43	12
d2	7	34	28	63	9	d2	0.56	1.29	1.21	1.45	9
d3	5	26	28	54	7	d3	0.2	1.11	1.18	1.23	7
e1	0	8	6	14	1	e1	0	0.65	0.73	0.91	1
e2	3	12	7	20	2	e2	0.44	1.01	0.63	1.1	2
e3	3	14	14	29	3	e3	0.23	0.96	0.91	1.2	3

Tree Measurements

Stand height is the average height in meters of the dominant and codominant trees of the leading species in a stand (Nesby 1997). The heights of standing trees are usually estimated indirectly by instruments called hypsometers, such as an Abney level or Suunto clinometer. Each type of hypsometer has advantages and disadvantages that depend on topography and density of trees. In general, the measurement is obtained from a position where both the top and base of the tree can be seen. The weighted mean heights by ecosite phase are shown in Table D3.1-9. The means and standard deviation were weighted by stand area.

The ecosite phase with the highest mean height was the dogwood Sw (e3). The Labrador tea/horsetail Sw-Sb (h1) ecosite phase has the minimum mean height. The maximum height of standing trees was found in four ecosite phases; the low-bush cranberry Sw (d3); the dogwood Pb-Aw (e1); the dogwood Pb-Sw (e2); and the blueberry Pj-Aw (b1).

Table D3.1-9 Weighted Mean Heights by Ecosite Phase from AVI Data

Ecophase	Number of Stands	Mean Height	Standard Deviation	Minimum Height	Maximum Height
a1	1	20.0	0.0	20	20
b1	32	16.0	14.5	11	31
b2	1	17.0	0.0	17	17
b3	4	15.1	0.4	14	16
b4	9	15.2	0.3	15	17
c1	1	12.0	0.0	12	12
d1	338	17.6	4.8	8	30
d2	72	18.7	23.3	8	27
d3	172	19.3	29.8	5	32
e1	54	22.5	37.8	13	31
e2	23	21.0	31.6	10	31
e3	29	24.3	28.0	11	30
g1	1	10.0	0.0	10	10
h1	15	10.1	7.6	7	20

The age of trees are measured by increment borers. A typical increment borer consists of a hollow auger that is bored into the tree until it intersects the growing center of the tree in a plane perpendicular to the longitudinal axis of the tree. The auger is carefully turned backwards a fraction of a turn to break the wood core and then the sample core is removed for counting growth rings and measuring the width of each ring. The age of the tree is estimated from the number of growth rings (Bonham 1989). The mean stand ages by ecosite phase are shown in Table D3.1-10 (raw age data was determined by subtracting vegetation sample year (1997) from year of origin classes, consequently all raw values end in the digit 7).

The ecosite phase with the highest mean age was the dogwood Sw (e3). The "oldest" trees were found in three ecosite phases; the low-bush cranberry Sw (d3); the dogwood Pb-Sw (e2); and the dogwood Sw (e3). The ecosite phases with the lowest mean age were the blueberry ecosites (b1, b2, b3 and b4) and Labrador tea/horsetail (h1).

Crown closure is the percentage of ground area covered by a vertical projection of tree crown areas onto the ground (Nesby 1997). Canopy closure can be used as a basis for comparison among tree species of different ecosite phases. Canopy closure can be measured directly in percentage, but more often it is estimated according to crown closure classes. The mean canopy closure by ecosite phase are shown in Table D3.1-11 (determined from the total stand area representing each class within each ecosite phase).

Table D3.1-10 Mean Stand Ages by Ecosite Phases

Phase	Number of stands	Mean Age	Standard Deviation	Minimum Age	Maximum Age
a1	1	87	0	87	87
b1	32	69	41	57	97
b2	1	67	0	67	67
b3	4	67	0	67	67
b4	9	67	0	67	67
c1	1	77	0	77	77
d1	338	70	109	17	117
d2	72	91	444	57	137
d3	172	104	1437	57	207
e1	54	84	121	67	137
e2	23	102	1083	67	207
e3	29	142	2144	67	207
g1	1	77	0	77	77
h1	15	69	76	67	117
Sb/Lt	2	130	234	117	147

Note: All ages end in 7 since they were determined by subtracting origin age from the year 1997.

When examining the crown closure classes, the ecosite phases are well distributed among the various crown closure classes accept for the lichen Pj (a1); Labrador tea-mesic Pj-Sb (c1); Labrador tea-subhygric Sb-Pj (g1) and the black spruce/tamarack complex. These ecosite phases occur in one crown closure class. The lichen Pj (a1), for example, occurs in the B (31-50%) crown closure class. The ecosite phase with the highest percentage (71-100%) of ground area covered was the Labrador tea-subhygric Sb-Pj (g1). This means that the g1 ecosite phase occurring within the LSA have closed canopies and are very dense. The ecosite phase with the lowest percentage (6-30%) of ground area covered was the blueberry Aw-Sw (b3). Sixty-one percent of blueberry Aw-Sw (b3) ecosite phases occurring within the LSA are in the A (6-30%) crown closure class. This means that the b3 ecosite phase is open and not very dense.

Table D3.1-11 Mean Canopy Closure by Ecosite Phase.

Phase	A (6 - 30 %)	B (31 - 50 %)	C (51 - 70 %)	D (71 - 100 %)	Open (0 - 5 %)
a1	0.0	100.0	0.0	0.0	0.0
b1	5.8	49.3	42.0	2.9	0.0
b2	0.0	0.0	100.0	0.0	0.0
b3	61.2	33.9	4.9	0.0	0.0
b4	20.3	55.8	23.9	0.0	0.0
c1	0.0	0.0	100.0	0.0	0.0
d1	17.2	11.6	61.9	9.3	0.0
d2	33.3	13.0	53.2	0.4	0.0
d3	20.5	32.3	43.2	3.9	0.0
e1	9.2	17.4	72.3	1.2	0.0
e2	29.3	35.2	34.1	1.5	0.0
e3	19.4	26.6	54.1	0.0	0.0
g1	0.0	0.0	0.0	100.0	0.0
h1	0.0	0.0	66.0	34.0	0.0
Sb/Lt	0.0	0.0	100.0	0.0	0.0

Composition of vegetation implies a list of plant species that occur in a particular vegetation type (Bonham 1989). All species, woody and herbaceous, can be measured for composition, although methods may differ for various lifeforms. For example, when measuring tree composition it is the individual species that contribute to the overall species composition of a patch or polygon that are measured (Nesby 1997).

The mean tree species composition by ecosite phase are shown in Table D3.1-12 (the AVI interpretation did not distinguish balsam fir or white birch). Tree species composition for each ecosite phase generally relates to what Beckingham and Archibald (1996) have classified in their Field Guide to Ecosites of Northern Alberta. For example, the dominant tree species in the lichen Pj (a1) ecosite phase is jack pine. For the low-bush cranberry Aw-Sw (d2) ecosite phase the dominant tree species are white spruce and aspen. The only vegetation type not described in Beckingham and Archibald (1996) are the black spruce/tamarack complex, where the tree species composition is 64% for black spruce and 36% for tamarack.

Table D3.1-12 Mean Tree Species Composition by ecological phase in the LSA from AVI

Phase	Jack Pine	White Spruce	Black Spruce	Tamarack	Aspen	Balsam Poplar	Total
a1	100	0	0	0	0	0	100
b1	46	11	0	0	34	10	100
b2	10	0	0	0	80	10	100
b3	15	28	0	0	53	3	100
b4	63	28	4	0	5	0	100
c1	80	0	20	0	0	0	100
d1	0	4	0	0	92	3	100
d2	0	54	1	0	42	3	100
d3	1	85	2	0	9	3	100
e1	0	5	0	0	20	75	100
e2	0	47	2	0	6	45	100
e3	0	90	0	0	0	10	100
g1	0	0	100	0	0	0	100
h1	0	53	34	0	7	6	100
Sb/Lt	0	0	64	36	0	0	100

Rare Plants

Previous studies (Golder 1996t) documented the existence of four species of vascular plants listed as rare within the LSA (Table D3.1-13).

Table D3.1-13 Rare Plants Observed Within the Steepbank Mine Study LSA During 1995 Field Surveys

Common Name	Botanical Name	Status	Habitat Type	Location
cyperus-like sedge	*Carex pseudocyperus*	S2G5	bogs and fens	sedge fen on west side of Athabasca River
stemless lady's-slipper	*Cypripedium acaule*	S2G5	jack pine forests	east-facing escarpment slope of Steepbank River
small-water lily	*Nymphaea tetragona*	S1G5T5	ponds and quiet water	floodplain marsh immediately north of Steepbank-Athabasca confluence
pitcher-plant	*Sarracenia purpurea*	S2G5	bogs and fen	sedge fen on west side of Athabasca River

Within the RSA, 25 species have previously been documented. During the 1997 field studies, four species of rare plants were found within the LSA (Table D3.1-14). None of the rare plants occurring within the LSA or RSA is considered to be rare nationally (COSEWIC 1997).

Table D3.1-14 Rare Plant Species Observed Within Project Millennium LSA During 1997 Field Surveys

Common Name	Botanical Name	Status	Habitat Type	Location
turned sedge	*Carex retrorsa*	S2S3G5	swampy woods and wet meadows	gravel bar on east side of Athabasca River
small-water lily	*Nymphaea tetragona*	S1G5T5	ponds and quite waters	lake at end of McLean Creek
wool-grass	*Scirpus cyperinus*	S2G5	marshy areas	2 locations; cutline in Steepbank Mine area and upland forest above Athabasca River
prairie cord grass	*Spartina pectinata*	S2G5	saline shores and marshes	2 locations; along edge of Athabasca River and north of Leggett Creek (southeast of Shipyard Lake)

Neither the 1995 nor the 1997 studies generated enough data to find statistically significant relationships between rare plants and vegetation units. During the 1997 field studies, three species of rare plants were observed in two different upland vegetation units, as shown below in Table D3.1-15.

Table D3.1-15 Rare Plant Species

Species	Community Type
Carex retrorsa	e1
Scirpus cyperinus	d1
Spartina pectinata	e1

Plants With Traditional Uses

The baseline report (Golder 1998l) lists plants documented as having traditional uses in the RSA. In all, 30 species or species groups are used either for food, medicine or spiritual purposes by First Nations people (Table D3.1-16). A majority of these occur in upland vegetation types.

Table D3.1-16 Plants Gathered for Food, Medicine, and Spiritual Purposes in the area of Project Millennium

Plant	Food	Medicine	Spiritual	Habitat
balsam fir		x		mixedwood boreal forest; moist woods [(a)]
bearberry	x		x	open woods, sandy soils and on gravel terraces; moist to dry woods [(a)]
black poplar (balsam poplar)		x		riparian; boreal forest, river banks and alluvial flats [(a)]
blueberry	x			primarily found in moist wood; dry woods and sandy ground [(a)]
cranberry (low-bush and bog)	x			found in a variety of forest habitats; mossy bogs; moist woods [(a)]
Labrador tea		x		found in acidic bogs, swamps and moist woods
mint	x	x		boreal forest species most commonly occur in wet places, including, bogs, marshes, lakeshores and fields
moss		x		a variety of habitats but abundant in bogs
rose hips (prickly rose)	x	x		found in open forest and on river banks
Senega snakeroot		x		limestone soils in the dry woods or rocky slopes of the boreal forest
spruce (white and black)	x	x		common throughout boreal forest; well-drained, moist soils; black spruce common in bogs and swamps [(a)]
Strawberry	x	x		open areas, meadows; woods [(a)]
sweet flag		x		found in swampy, marshy areas or where there is still water
sweet grass		x	x	open meadows and moist areas
tamarack		x		bogs and moist forest areas; fens and swamps [(a)]
birch (white and bog)	x	x		well drained but moist sites; bogs and seepage areas [(a)]
buffaloberry	x	x		sparsely wooded areas; shores [(a)]
common juniper	x	x		throughout the boreal forest; woods and open slopes [(a)]
red currant and black gooseberry	x	x		moist woods; streambanks and swamps [(a)]
twisted stalk	x			moist woods; thickets [(a)]
dogwood	x			common in wooded areas; moist woods, riverbanks [(a)]
frying pan plant		x		muskeg [(b)]
green frog plant (pitcher-plant)		x		muskeg [(b)]; bogs and fens [(a)]
hazelnuts	x			found in thickets and woods with well drained soils
nettles	x	x		disturbed areas; moist shady woodland; streambanks [(a)]
pin- and chokecherry	x	x		often found on dry and exposed sites with sandy soils; woods and clearings [(a)]
raspberry (dwarf and trailing)	x	x		shady woods; boggy woods and marshes; moist woods [(a)]
Saskatoon berry	x	x		found in dry to moist forests in thickets and on open hillsides with well drained soils; open woodlands [(a)]
fungi (puffball)		x		Found in variety of forest habitats
cattail	x			Found in marshes, ponds, lakes and along the edges of slow moving streams
willow		x	x	found in variety of forest habitats

Information from Fort McKay 1996d.
[(a)] Moss, E.H. 1983. Flora of Alberta.
[(b)] Fort McKay First Nations. 1983. There is Still Survival Out There.

D3.1.3.2 Wetlands

Alberta Wetlands Inventory Classification System

The Alberta Wetland Inventory (AWI) (Halsy and Vitt 1996) describe the wetlands that are common in Alberta. Of the fifteen wetland types found, eight are recognized in the LSA. Among the wetlands classified are four types of fens and two bogs. Included within the LSA was a wetland type that did not fit into the AWI classification, riparian shrub complex, which was dominated by willow and river alder. Table D3.1-17 gives the baseline areas of the wetlands identified within the LSA. In total, wetlands vegetation comprise 62% of the LSA.

The wetlands classes that occur in the LSA are described in Subsection D3.1.4.3. The floristic characteristics of the ecosite phases are summarized in Table D3.1-18.

Table D3.1-17 Areas of Wetlands Identified in the Local Study Area

Wetlands Type	LSA		
Level Code	AWI Class	Area (ha)	Percent
Shallow Open Water (W)	Shallow Open Water (WONN)	15	< 1
Marsh (M)	Marsh (MONG) Marsh (MONS)	107 211	1 1
Subtotal	***Marsh***	***333***	
Swamps (S)	Wooded swamp (STNN)	1,359	8
	Forested swamp (SFNN)	687	4
	Shrubby swamps (SONS)	161	1
Subtotal	***Swamps***	***2,207***	
Fens (F)	Open non-patterned shrubby fens (FONS)	426	3
	Open non-patterned graminoid fen (FONG)	4	< 1
	Non-patterned wooded fen with no internal lawns (FTNN)	6,012	37
	Non-patterned forested fen with no internal lawns (FFNN)	966	6
Subtotal	***Fens***	***7,407***	
Bogs (B)	Wooded bog (>10%, ≤ 70% tree cover) not internal lawns (BTNN)	20	< 1
	Forested bog, >70% tree cover (BFNN)	26	< 1
Subtotal	***Bogs***	***46***	
Total Wetlands		**9,994**	
Non-Wetlands		**5,856**	
Existing Disturbances and Water		**331**	
Total Area		**16,181**	

Table D3.1-18 Mean Cover (%) of Characteristic Species Which Show up in 50% or More of the Sites

Layer	Species	FFNN	FONG	FONS	FTNN	MONG	MONS	SONS	STNN
Tree	black spruce	73			24				
Tree	paper birch								45
Tree	tamarack	13		<1	10				
Tree	white spruce								5
Shrub	alder-leaved buckthorn	2						5	
Shrub	balsam poplar							10	
Shrub	black spruce	13			14				
Shrub	bog cranberry	7							5
Shrub	bracted honeysuckle							1	
Shrub	dwarf blueberry	5							2
Shrub	flat-leaved willow							30	
Shrub	fly honeysuckle	4							
Shrub	Labrador tea	33			39			5	45
Shrub	low-bush cranberry							30	
Shrub	prickly rose	4							
Shrub	pussy willow						12		
Shrub	red-osier dogwood							15	
Shrub	river alder						22	20	
Shrub	shrubby cinquefoil	6							
Shrub	small bog cranberry								5
Shrub	tamarack	2		2	9				
Shrub	twin flower							5	
Shrub	white spruce							15	10
Shrub	wild red currant							5	
Forb	bishop's-cap							2	
Forb	bunchberry							5	
Forb	common horsetail	2							
Forb	dewberry							5	
Forb	marsh cinquefoil						5		
Forb	marsh skullcap						1		
Forb	marsh violet							1	
Forb	meadow horsetail								40
Forb	palmate-leaved coltsfoot	3							
Forb	swamp horsetail							40	
Forb	tall lungwort								
Forb	three-leaved false Solomon's-seal				5				3
Forb	water-hemlock						3		
Forb	wild lily-of-the-valley							5	
Forb	wild sarsaparilla							10	
Forb	wild strawberry	1						1	
Forb	yellow marsh-marigold							1	
Graminoid	beaked sedge						23		
Graminoid	bluejoint					7	8	2	
Graminoid	drooping wood reed								2
Graminoid	mud sedge							5	
Graminoid	northern rough fescue								10
Graminoid	water sedge		18	26		43	25		
Moss	juniper moss								5
Moss	moss species		12			8			
Moss	Sphagnum	80		21	70			30	50
Lichen	Cladonia	13			11				
	Total Number of Sites	**3**	**3**	**8**	**20**	**5**	**3**	**1**	**1**

D3.1.3.3 Wetland Classes Occuring in the LSA

Bogs (BTNN/BFNN)

Bogs are peatlands that have low surface water flow. The only water available for bogs is from precipitation; consequently, bogs are generally acidic, with a pH of less than 4.5. Bogs are dominated by acid-loving plant species such as peat moss, feathermoss and lichens. They are subdivided into categories based on the percentage and type of forest cover, and on the presence of permafrost and internal lawns (Vitt et al. 1994). Examples of bog locations include drainage divides, stagnation zones of peatland areas and small isolated basins. A picture taken from a wooded bog within the Muskeg River Mine Project (Golder 1997q) is shown in Figure D3.1-18.

Figure D3.1-18 Wooded Bog With a Variety of Understorey Species

Wooded and forested bogs without internal lawns (BTNN/BFNN), the only bogs identifed in the study area, have a flat, uniformly wooded, homogeneous surface. Typically they occur as islands or peninsulas within large fens or are confined to small basins associated with hummocky terrain. Peat moss and lichens dominate the ground cover (Halsey and Vitt 1996). Wooded and forested bogs occupy an area of 46 ha or less than 1% of the LSA.

Fens (FTNN, FFNN, FONS, FONG)

Fens are peatlands or wetlands where peat accumulates because the rate of plant decomposition is slower than plant production. Fens are also characterized by water flow (i.e., they may have inflow and outflow). Fens can be open and dominated by sedges, rushes and cotton grasses; shrubby and dominated by willow or birch; forested or wooded and dominated by black spruce, tamarack or willow.

The water level of typical fens is at or near the surface. Fens are relatively rich in mineral elements and, thus, vegetation. The number of indicator vegetation species present can be used to subdivide fens based on acidity: poor fens are acidic (pH of 4.5 to 5.5) with few indicators; moderately rich fens are slightly acid to neutral (pH of 5.5 to 7.0) and have more indicator species; and extremely rich fens are basic (pH >7.0), with a high number of indicator species. As rich and poor nutrient levels cannot be differentiated by air photo interpretation, the AWI classification uses vegetation and patterning to distinguish between treed, patterned, shrubby and open fens (Halsey and Vitt 1996).

Figure D3.1-19 Shrubby Fen Dominated by Dwarf Birch and Willow

Non-patterned fens represent the highest proportion of wetlands types in the LSA, occupying an area of 7,407 ha (Table D3.1-17). They can be dominated by either shrubs (FONS) or grasses (FONG). In shrub-dominated fens (Figure D3.1-19), shorter birch and willow are common, with >25% cover. Conifers may have ≤6% cover. Shrub-dominated fens are located in small isolated basins and in areas sloping gently in the direction of drainage.

Figure D3.1-20 Graminoid Fen With Continuous Sedge Layer

Open, non-patterned, grass and grass-like dominated peatlands may be poor, moderately rich or extremely rich in nutrients (Vitt and Chee 1990; Nicholson and Gignac 1995). They are characterized by a continuous sedge layer (Figure D3.1-20). Tree cover in these fens is ≤6% and shrub cover is <25%. Open, grass and grass-like dominated poor fens occur as collapse scars (low, wet areas) in association with peat plateaus (Halsey and Vitt 1996). They also have ground cover characterized by drier species of peat moss that can withstand nutrient-poor conditions. Open, graminoid-dominated fens are also found in small isolated basins, and in areas that slope gently in the direction of drainage.

Figure D3.1-21 Wooded Fen With Tamarack and Black Spruce Canopy

Fens (FTNN, FFNN)

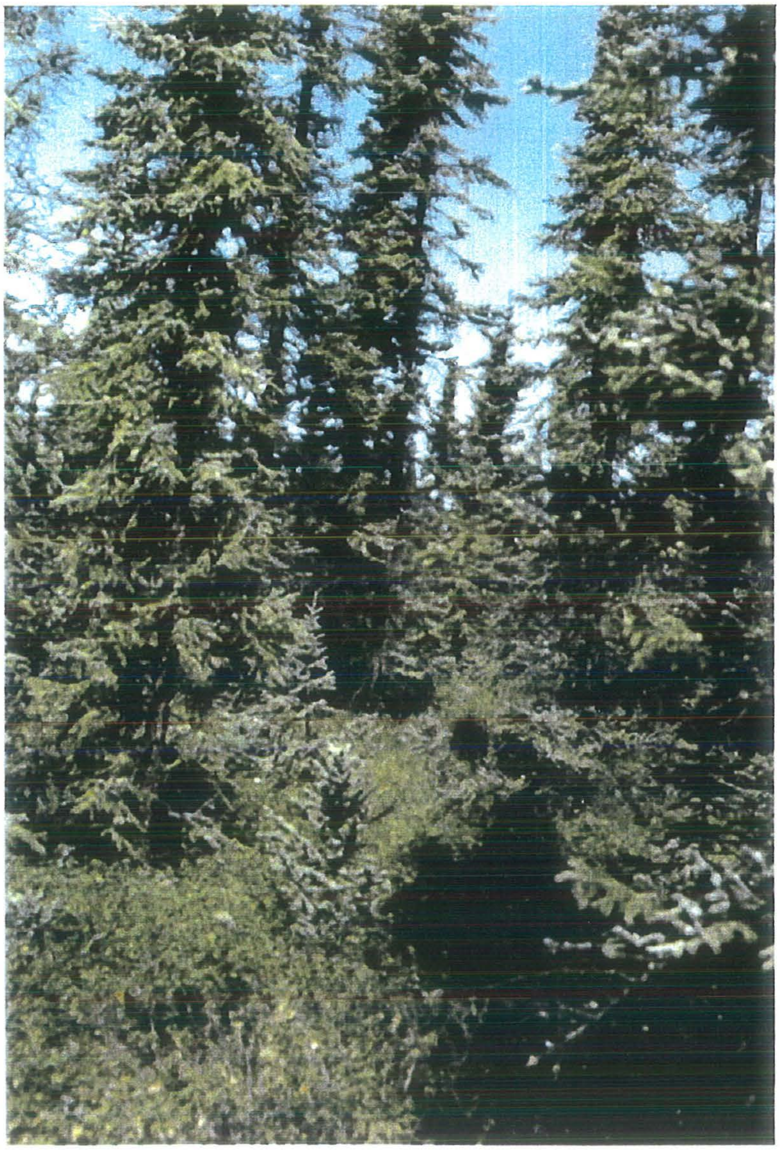
Wooded and forested fens have greater than 10% tree cover and are classified into two categories, based on the presence of permafrost. Non-patterned, wooded fens with no internal lawns, or lower wet areas, vary in nutrients from poor, to moderately rich, to extremely rich. For wooded fens, the overstory is composed of 6 to 70% black spruce and/or tamarack, and birch and willow may be found in the understory. For forested fens, the overstory is composed of greater than 70% black spruce and/or tamarack. The ground cover of wooded and forested fens can be dominated by peat moss or brown moss. Wooded and forested fens are found only in level areas of land, distinguishing them from upland wooded regions, which may be found in sloped areas. Only non-patterned fens without internal lawns were identified in the LSA (Figure D3.1-21).

Figure D3.1-22 Marsh Dominated by Sedges, Rushes and Cattails

Marshes (MONG, MONS)

Marshes have relatively high water flow and seasonally fluctuating water levels (Halsey and Vitt 1996). While elevated concentrations of nitrogen and phosphorus allow for high plant productivity in marshes, decomposition rates are also high. For this reason, little peat accumulates in these wetlands, and mosses and lichens are uncommon. They are dominated instead by sedges, rushes (*Juncus* sp., *Luzula* sp.) and cattails (Figure D3.1-22). Marshes are often associated with the margins of streams and lakes. Marshes occupy 318 ha or 2% of the LSA.

Figure D3.1-23 Forested Swamp With Black Spruce and Tamarack



Swamps (STNN, SFNN, SONS)

Swamps often occur where there are bodies of water that flood frequently or where water levels fluctuate (e.g., along peatland margins). They are non-peaty wetlands that can be forested, wooded or shrubby. Few mosses and lichens grow in swamps due to the fluctuating water levels and peat accumulation is low due to high decomposition rates. Common species within swamps include tamarack, birch, willow, alder and black spruce. Three types of swamps recognized by the AWI classification system are wooded, forested and shrubby. Swamps represent 2,207 ha or 14% of the LSA.

Wooded and forested swamps (Figure D3.1-23) exist near floodplains and streams associated with peatland areas. Forested swamps have a dense (>70%) tree cover of black spruce and tamarack. Wooded swamps have 6 to

70% tree cover of black spruce and tamarack. Shrubby swamps, which are dominated by willow, are associated with floodplains, stream terraces and peatland ridges. Shrub cover is >25%, with few bryophytes (e.g., liverworts, mosses) due to fluctuating water levels.

Shallow Open-Water (WONN)

Shallow open-waters are areas where water up to 2 m deep occurs during midsummer, but which do not function as typical aquatic (pond or lake) systems. Submergent and/or floating vegetation is present, representing the middle ground between terrestrial and aquatic systems. This wetlands class is often associated with other wetlands types such as marshes in the south, or thermokarst basins associated with peat plateaus in the north. Only a relatively small amount of open shallow water (15 ha or < 1%) is represented in the LSA.

Riparian Shrub Complex

Riparian areas are wetlands associated with running water systems found along rivers, streams and drainageways (Figure D3.1-24). Riparian areas are bounded on the landward side by upland, by the channel bank, or by wetlands. Water is usually, but not always, flowing in the Riparian area. They are dominated by willow and river alder in the shrub layer and swamp horsetail in the herb layer.

Figure D3.1-24 Riparian Shrub Complex Dominated by Willow and Alder

D3.1.3.4 Wetlands Species Richness, Diversity, Cover and Tree Measurements

Community Diversity

A measure of wetlands diversity is patch (or polygons) size (Table D3.1-19). The most extensive wetlands type, the wooded fens (FTNN), have a mean patch size of 35 ha. Bogs (BTNN/BFNN) have a mean patch size of 5 ha. Graminoid marshes (MONG) and shrubby marshes (MONS) have mean patch sizes of 6 ha and 8 ha. Wooded (STNN) and shrubby (SONS) swamps have mean patch sizes of 9 ha and 7 ha. Graminoid fens (FONG) and shrubby fens (FONS) have mean patch sizes of 2 ha and 10 ha, respectively.

Table D3.1-19 Mean, Minimum and Maximum Wetlands Patch Size

Map Code	AWI Class	Patch Count	Baseline Patch Size (ha)		
			Min	Max	Mean
FTNN	Wooded Fen	172	<1	4,667	35
FFNN	Forested Fen	46	1	116	21
FONG	Graminoid Fen	2	1	3	2
FONS	Shrubby Fen	41	1	64	10
BTNN	Wooded Bog	4	2	12	5
BFNN	Forested Bog	5	1	12	5
STNN	Wooded Swamp	153	<1	100	9
SFNN	Forested Swamp	51	<1	93	13
SONS	Shrubby Swamp	24	<1	33	7
MONG	Marsh	18	<1	67	6
MONS	Marsh	27	1	85	8
WONN	Shallow Open Water	16	<1	3	1

D3.1.3.5 Species Richness and Diversity

Table D3.1-20 provides an indication of relative species richness among wetlands classes, as indicated by the mean and range of numbers of species. The highest number of total species found in each wetland site are in the forested fen (FFNN) and the shrubby swamp (SONS) (Table D3.1-20). The lowest number of total species found in each wetland site are the wooded swamp (STNN) and graminoid fen (FONG). The highest number of species in the shrub layer are in the forested fen (FFNN) and the shrubby swamp (SONS); in the herb layer it is in the marsh (MONS) and shrubby swamp (SONS). Total shrub species are high among wetlands surveyed. Total tree species are low among wetlands surveyed, particularly among graminoid fens (FONG), marshes (MONG/MONS) and shrubby swamps (SONS).

Table D3.1-20 Species Richness by Wetlands

Class	Total Vascular Species			Tree Layer			Shrub Layer			Herb Layer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
FFNN	19.7	18	22	2.0	2	2	12.0	9	15	6.7	3	9
FONG	10.0	8	14	0.0	0	0	1.3	0	3	8.7	5	13
FONS	15.9	9	25	0.8	0	2	5.8	2	8	9.9	5	18
FTNN	14.6	6	23	1.5	1	2	7.6	3	14	6.5	1	12
MONG	10.8	3	16	0.0	0	0	0.6	0	2	10.2	3	14
MONS	15.0	11	21	0.0	0	0	3.0	2	4	12.0	7	19
SONS	22.0	22	22	0.0	0	0	11.0	11	11	11.0	11	11
STNN	10.0	10	10	2.0	2	2	5.0	5	5	4.0	4	4

Table D3.1-21 gives the mean and range of species diversity values for individual plots surveyed within the wetlands surveyed. The SONS (shrubby swamp) and MONS (marsh) wetlands classes have the highest mean among wetland classes surveyed. Mean diversity is lowest in the MONG (marsh) wetlands class. The highest mean diversity in the shrub layer is in the SONS (shrubby swamp) wetlands class, and the lowest mean diversity is in the FONG (graminoid fen) wetlands class. The highest mean diversity in the herb layer is in the MONS (marsh) and the lowest mean diversity is in the STNN (wooded swamp) wetlands class. Among all wetlands surveyed, mean diversity is highest in the herb layers and lowest in the tree layers.

Table D3.1-21 Species Diversity for Wetlands

Class	Total Vascular Species			Tree Layer			Shrub Layer			Herb Layer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
FFNN	0.91	0.85	0.99	0.14	0.02	0.27	0.88	0.81	0.99	0.72	0.48	0.90
FONG	0.84	0.64	1.15	0.00	0.00	0.00	0.13	0.00	0.40	0.77	0.45	1.11
FONS	0.93	0.69	1.21	0.03	0.00	0.28	0.53	0.22	0.72	0.75	0.53	1.14
FTNN	0.89	0.50	1.06	0.09	0.00	0.27	0.68	0.27	0.97	0.65	0.00	0.95
MONG	0.68	0.16	0.93	0.00	0.00	0.00	0.06	0.00	0.30	0.65	0.16	0.89
MONS	0.98	0.89	1.09	0.00	0.00	0.00	0.41	0.28	0.54	0.85	0.63	1.11
SONS	1.13	1.13	1.13	0.00	0.00	0.00	0.92	0.92	0.92	0.73	0.73	0.73
STNN	0.78	0.78	0.78	0.14	0.14	0.14	0.45	0.45	0.45	0.36	0.36	0.36

Structure

In terms of structure, species richness is highest in the shrub and herb layer and lowest in the tree layer for all wetlands classes. Structurally, both mean and maximum richness are lowest in the tree layer in each wetlands surveyed. Generally, mean and maximum richness are higher in the herb layer than in the shrub layer. The differences in relative species richness among wetlands classes, may result from differences in internal compositional variability among wetlands surveyed.

The use of structure also aids in describing the appearance of the community. Structure relates to the vertical spacing and height of the plants making up the community. Table D3.1-22 shows the percentage of stands with multilayered structure (i.e., overstorey and understorey). BTNN/BFNN (wooded and forested bogs), FONS (shrubby fens), FONG (graminoid fens), MONG (marshes) and SONS (shrubby swamps) have only single layered structured stands. The FTNN/FFNN (wooded and forested fens) and STNN/SFNN (wooded and forested swamps) have multilayered structured stands.

Table D3.1-22 Percentage of Stands in the LSA With Multilayered Structure: Overstorey and Understorey

Wetlands Class	Multilayered Stand Percentage	Single Layer Stand Percentage
BFNN	0.0	100.0
BTNN	0.0	100.0
FFNN	13.0	87.0
FONG	0.0	100.0
FONS	0.0	100.0
FTNN	39.0	61.0
MONG	0.0	100.0
MONS	1.8	98.2
NMC	0.0	100.0
NMS	0.0	100.0
NWF	0.0	100.0
NWL	0.0	100.0
NWR	0.0	100.0
SFNN	8.3	91.7
SONS	0.0	100.0
STNN	52.1	47.9
WONN	0.0	100.0
Mean	**40.9**	**59.1**

Total Richness and Diversity

The highest number of total species found in each wetlands site surveyed are in the wooded fen (FTNN) and the shrubby fen (FONS) (Table D3.1-23). The lowest number of total species found in each wetland site are the wooded swamp (STNN). The highest number of species in the shrub layer are in the wooded fen (FTNN); in the herb layer it is also the wooded (FTNN) and shrubby fen (FONS). Total shrub species are high among wetlands classes surveyed. Total tree species are low among wetlands sampled, particularly among graminoid fens (FONG), marshes (MONG/MONS) and shrubby swamps (SONS).

The highest diversity was found within the shrubby fen (FONS) and wooded fen (FTNN) among all wetlands surveyed (Table D3.1-23). The wooded swamp (STNN) has the lowest diversity among all wetlands surveyed. The highest diversity for the shrub layer was found in the shrubby fen (FONS) and wooded fen (FTNN) among all wetlands surveyed. The highest diversity for the herb layer was also found in the shrubby (FONS) and wooded fens (FTNN). The highest diversity among all wetlands surveyed was in the herb layer. The lowest diversity among all wetlands surveyed was in the tree layer.

Table D3.1-23 Total Richness and Diversity for Wetlands Sampled

Richness						Diversity					
Phase	Trees	Shrubs	Herbs	Total	Number of Ecosites Sampled	Phase	Trees	Shrubs	Herbs	Total	Number of Ecosites Sampled
FFNN	2	19	18	37	3	FFNN	0.18	1.02	1.18	1.03	3
FONG	0	3	26	29	3	FONG	0	0.4	0.99	1.07	3
FONS	2	25	52	77	8	FONS	0.18	1.18	1.34	1.56	8
FTNN	2	35	51	86	20	FTNN	0.26	1.14	1.31	1.34	20
MONG	0	4	35	39	5	MONG	0	0.55	1.05	1.09	5
MONS	0	6	26	32	3	MONS	0	0.64	1.11	1.22	3
SONS	0	11	11	22	1	SONS	0	0.92	0.73	1.13	1
STNN	2	5	4	10	1	STNN	0.14	0.45	0.36	0.78	1

Tree Measurements

The weighted mean heights by wetlands classes occurring in the LSA are shown in Table D3.1-24. The means and standard deviation were weighted by stand area. The wetlands class with the highest mean height was the wooded swamp (STNN). The shrubby fen (FONS) wetlands class has the lowest mean height. The maximum height of standing trees was found in the wooded fen (FTNN) wetlands class. The graminoid fen (FONG), marsh (MONG) and shallow open water (WONN) wetlands classes did not have a mean height recorded.

Table D3.1-24 Weighted Mean Heights by Wetlands Classes from AVI data

Ecophase	Number of Stands	Mean Height	Standard Deviation	Minimum Height	Maximum Height
BFNN	5	2.9	0.4	2	5
BTNN	4	4.1	2.0	2	5
FFNN	66	4.9	5.6	2	10
FONG	2	0.0	0.0	0	0
FONS	45	1.5	0.6	1	6
FTNN	620	6.0	11.5	1	22
MONG	21	0.0	0.0	0	0
MONS	43	2.9	9.3	0	16
SFNN	63	8.2	7.1	3	16
SONS	31	2.6	2.1	0	5
STNN	228	12.3	23.4	3	29
WONN	16	0.0	0.0	0	0

The mean stand ages by wetlands classes are shown in Table D3.1-25 (raw age data was determined by subtracting vegetation sample year (1997) from year of origin classes, consequently all raw values end in the digit 7). The wetlands class with the highest mean age was the wooded swamp (STNN). The wetlands class with the lowest mean age was the forested bog (BFNN). The "oldest" trees were found in the wooded and forested swamp (STNN/SFNN) and the wooded fen (FTNN) wetlands classes. There was no recorded mean stand age data the graminoid fen (FONG); the shrubby fen (FONS); the marsh (MONG); and shallow open water (WONN). This is because these wetlands classes usually do not have standing trees in their communities.

Table D3.1-25 Mean Stand Ages by Wetlands Classes

Phase	Number of stands	Mean Age	Standard Deviation	Minimum Age	Maximum Age
BFNN	5	65	15	57	67
BTNN	4	84	283	57	97
FFNN	66	74	376	17	117
FONG	0	0	0	0	0
FONS	0	0	0	0	0
FTNN	618	84	742	0	147
MONG	0	0	0	0	0
MONS	5	4	323	0	117
SFNN	63	89	496	57	147
SONS	0	0	0	0	0
STNN	228	109	821	67	207
WONN	0	0	0	0	0

Note: All ages end in 7 since they were determined by subtracting origin age from the year 1997.

The mean canopy closure by wetlands classes are shown in Table D3.1-26 (determined from the total stand area representing each class within each ecosite phase). The wetlands class with the highest percentage (71-100%) of ground area covered was the forested swamp (SFNN). This means that the SFNN wetlands class have closed stands and are very dense. The wetlands class with the lowest percentage (6-30%) of ground area covered was the wooded swamp (STNN) and the wooded fen (FTNN) This means that the FTNN and STNN wetlands classes are open and not very dense.

Table D3.1-26 Mean Canopy Closure by Wetlands Class

Phase	A (6 - 30 %)	B (31 - 50 %)	C (51 - 70 %)	D (71 - 100 %)	Open (0 - 5 %)
BFNN	0.0	0.0	16.9	83.1	0.0
BTNN	0.0	0.0	92.0	8.0	0.0
FFNN	13.0	0.0	3.8	83.2	0.0
FONG	0.0	0.0	0.0	0.0	100.0
FONS	0.0	0.0	0.0	0.0	100.0
FTNN	30.4	16.4	50.5	2.6	0.2
MONG	0.0	0.0	0.0	0.0	100.0
MONS	4.7	0.8	0.0	0.0	94.5
SFNN	3.4	4.9	0.0	91.7	0.0
SONS	0.0	0.0	0.0	0.0	100.0
STNN	33.8	19.7	41.3	5.1	0.0
WONN	0.0	0.0	0.0	0.0	100.0

D3.1.3.6 Rare Plants

Rare plants often require unique habitat types, a number of which were observed in the Steepbank Mine Project LSA by Golder (1996t) and Project Millennium Golder (1998m). Within the LSA, 6 rare plants have been identified in wetlands, which include bogs, fens, swamps and marshes (Table D3.1-27). Riparian areas, which were also surveyed, provide considerably more unique microhabitats for rare plants. Two rare plants, prairie cord grass and turned sedge were observed in the riparian area along the Athabasca River. None of the rare plants occurring within the LSA are considered to be rare nationally (COSEWIC 1997).

Table D3.1-27 Rare Plants Observed in Wetlands in the LSA During 1995 and 1997 Field Surveys

Common Name	Botanical Name	Status	Habitat Type	Location: 1995 Steepbank Mine Study	Location: 1997 Project Millennium LSA Study
cyperus-like sedge	Carex pseudocyperus	S2G5	bogs and fens	sedge fen on west side of Athabasca River	not observed
turned sedge	Carex retrorsa	S2S3	swampy woods and wet meadows	not observed	gravel bar on east side of Athabasca River
stemless lady's-slipper	Cypripedium acaule [(a)]	S2G5	jack pine forests	east-facing escarpment slope of Steepbank river	not observed
small water-lily	Nymphaea tetragona	S1G5T 5	ponds and quiet waters	floodplain marsh immediately north of Steepbank-Athabasca confluence	2 locations; lake at end of McLean Creek and Shipyard Lake
pitcher-plant	Sarracenia purpurea	S2G5	bogs and fens	sedge fen on west side of Athabasca River	not observed
wool-grass	Scirpus cyperinus	S2G5	marshy areas	not observed	2 locations; cutline in Steepbank Mine area and Upland forest above Athabasca River
prairie cord grass	Spartina pectinata	S2G5	saline shores and marshes	not observed	2 locations; along edge of Athabasca River and north of Leggett Creek (southeast of Shipyard Lake)

(a) Denotes rare plants found primarily in uplands (terrestrial) ecosite places, the remainder are primarily found in wetlands.

n/o = not observed

D3.2 TERRESTRIAL VEGETATION AND WETLANDS IMPACT ASSESSMENT

D3.2.1 Introduction

This section of the Project Millennium EIA provides information as required by the Project Terms of Reference issued on March 4, 1998 (AEP 1998). Specifically, the following are addressed in this section:

- identify the amount of vegetation to be disturbed during each stage of the Project and the types of vegetation communities affected in the Project area;
- assess how development and mitigation of the Project will affect peatlands/wetlands in the Project area;
- identify rare, vulnerable, threatened or endangered species outlined in the Alberta Rare Plant Classification and by the Canadian Organization of the Status of Endangered Wildlife in Canada (COSEWIC 1997) and identify opportunities to avoid and mitigate impacts to these species; and
- describe the mitigative measures to be implemented to offset the adverse effects of site clearing on vegetation communities.

The development of Project Millennium will have impacts on terrestrial vegetation and wetlands at the landscape, plant community and plant species levels. The objective of this section is to review the potential impacts associated with construction, operation and closure of The Project on plant communities and species (rare plants, traditional use plants, and key indicator resources) within the Local Study Area (LSA). The analysis presented in this section is based upon issues identified by the study team through consultation with regulators, aboriginal groups and other stakeholders.

D3.2.2 Approach

This section includes a description of the overall approach used to analyze impacts of Project Millennium on terrestrial vegetation and wetlands. The basis for the assessment is the east bank mining area which is the total development (approved Steepbank plus Project Millennium expansion) on the east side of the Athabasca River.

The assessment methodology includes the definition of key indicator resources (KIRs), the analysis of potential linkages between Project Millennium activities and terrestrial vegetation and wetlands resources, the analysis of key questions, a description of residual impacts associated with the key questions, and proposed monitoring in areas where there is uncertainty. A description of this approach is provided in the following sections.

The approach used to assess potential impacts to terrestrial vegetation and wetlands utilizes the ELC developed for the LSA. The basis for the assessment at the plant community level of analysis is the ecosite phase ELC unit (see Section D3.1). At this scale of mapping (1:20,000), vegetation is grouped within ecosite phases according to characteristic plant communities. Impacts in terms of loss/alteration of plant communities can therefore be quantified using the GIS database by overlaying the mine development plan. In addition, the sequential development and reclamation of the mine can be followed in both a spatial and temporal context.

The impact analysis involved the following:

- collection of baseline information relevant to the key questions and linkage diagrams;
- mapping and quantification of terrestrial vegetation and wetlands resources in the LSA;
- mapping and quantification of terrestrial vegetation and wetlands resources affected by Project Millennium development; and
- mapping and quantification of reclaimed terrestrial vegetation and wetland resources based on the Closure Plan.

Each residual impact is classified according to the environmental consequence which is determined by a combination of direction, magnitude, duration, and geographical extent of the impact.

D3.2.3 Key Indicator Resources

The identification of key indicator resources (KIRs) provides a focus for impact analysis and assessment of the Project. KIRs are representative of key plant communities or species within the LSA and RSA. An analysis of the potential impacts on KIRs can be applied to the construction, operation and closure phases.

The terrestrial vegetation KIRs at the plant community level include:

- old-growth forest communities, including:
  - white spruce communities,
  - jack pine - lichen communities
  - aspen communities,
  - balsam poplar communities.

- plant communities of economic importance
  - aspen - white spruce communities

The wetland KIRs at the plant community level include:

- riparian shrub complexes; and
- riparian poplars.

Vegetation KIRs at the plant species level include:

- rare plants; and
- traditional use plants, including:
  - medicinal plants,
  - spiritual use plants.

At the Landscape level of vegetation analysis, the potential impacts on environmentally significant areas are addressed in the Land Use & Resource Utilization (Section F3).

D3.2.4 Methods

D3.2.4.1 Terrestrial Vegetation Resource

The terrestrial vegetation impact assessment is completed through a comparison of the baseline conditions of the terrestrial LSA to conditions within the LSA that are expected to result from the Project development. The level of impact is determined based on an impact rating system which incorporates the following parameters: direction, magnitude, geographic extent, duration, reversibility and the frequency of the impact.

Terrestrial vegetation resources are mapped using a Geographical Information System (GIS) to allow the relative abundance of plant communities to be compared within the LSA and also to the RSA. By superimposing the Project Millennium development plan over the existing vegetation polygons, the area of each plant community (ecosite phase) affected is quantified and an assessment of significance made using the criteria previously described. Similarly, by superimposing the successive reclamation activities onto the Project Millennium development area, the progression of re-vegetation can be quantified and monitored.

D3.2.4.2 Wetlands Resource

The key questions were developed out of the identification of the issues raised by stakeholders and the EIA study team for the Project. To effectively address each of the questions and issues, it was necessary to acquire baseline information which described the current conditions of the LSA. These essentially reflect the landscape, community and species level concerns about wetland communities and their diversity. The impact assessment was done through a comparison of pre-development conditions within the LSA to conditions that are expected to result from development.

The wetland resources of the LSA were mapped according to the Alberta Wetlands Inventory (AWI). The area of wetlands was determined and a wetlands database, linking each map polygon to a geographic information system (GIS), was created to allow the relative abundance of wetlands to be compared within the LSA. By superimposing the development plan over the wetlands polygons, the area of each wetland affected was quantified and an assessment of significance made using the criteria previously described.

By projecting the successive reclamation activities onto the Project Millennium development area, the progression of reclamation wetland types is quantified.

D3.2.4.3 Diversity Measurements

Diversity is assessed for plant species by two main indices: species richness and species diversity (Shannon Index).

Compositional diversity is commonly described using measures of richness and patch size.(species number) and evenness (relative abundance). Species richness is the total number of species present in the area (Krebs 1989). Species richness was calculated for herb, shrub and tree layers in each plot surveyed (Section D3.1.4.5). Community richness was calculated by averaging the species richness recorded for each community type. Community diversity at the ecosite phase is assessed in the ELC Assessment (Section D4.2).

Species diversity is measured using the Shannon Index, which describes both species richness and evenness (Krebs 1989). Similar to species richness, diversity was measured for each stratum within the surveyed ecosite phases and wetlands (Section D3.1.4.5). Patch size assessment is discussed in the ELC Impact Assessment (Section D4.2)

D3.2.4.4 Modelling Methods

Modelling of reclaimed landscapes was completed by using data and observations regarding vegetation growth and establishment from over 25 years of reclamation research and operational experience in the Fort McMurray oil sands area. Based on landform and reclamation soil capability ratings, the re-vegetated areas of Project Millennium were modelled for a variety of different conditions.

D3.2.5 Potential Linkages and Key Question

D3.2.5.1 Linkage Diagrams

Linkage diagrams have been prepared for the construction and operation phases, as well as for the closure phase. The diagrams are intended to demonstrate the connections between the development and the environment in which it will be developed and reclaimed. In this section, the focus of the linkage diagrams are on the connections between Project Millennium and the vegetation and wetlands resources of the LSA and RSA. They are used to help understand and explain the often complex interactions which can take place between the development and the environment over the life of the project.

D3.2.5.2 Potential Linkages: Construction and Operation

Terrestrial Vegetation Resource

Analysis of impacts on vegetation as a result of Project Millennium have been split into two phases:

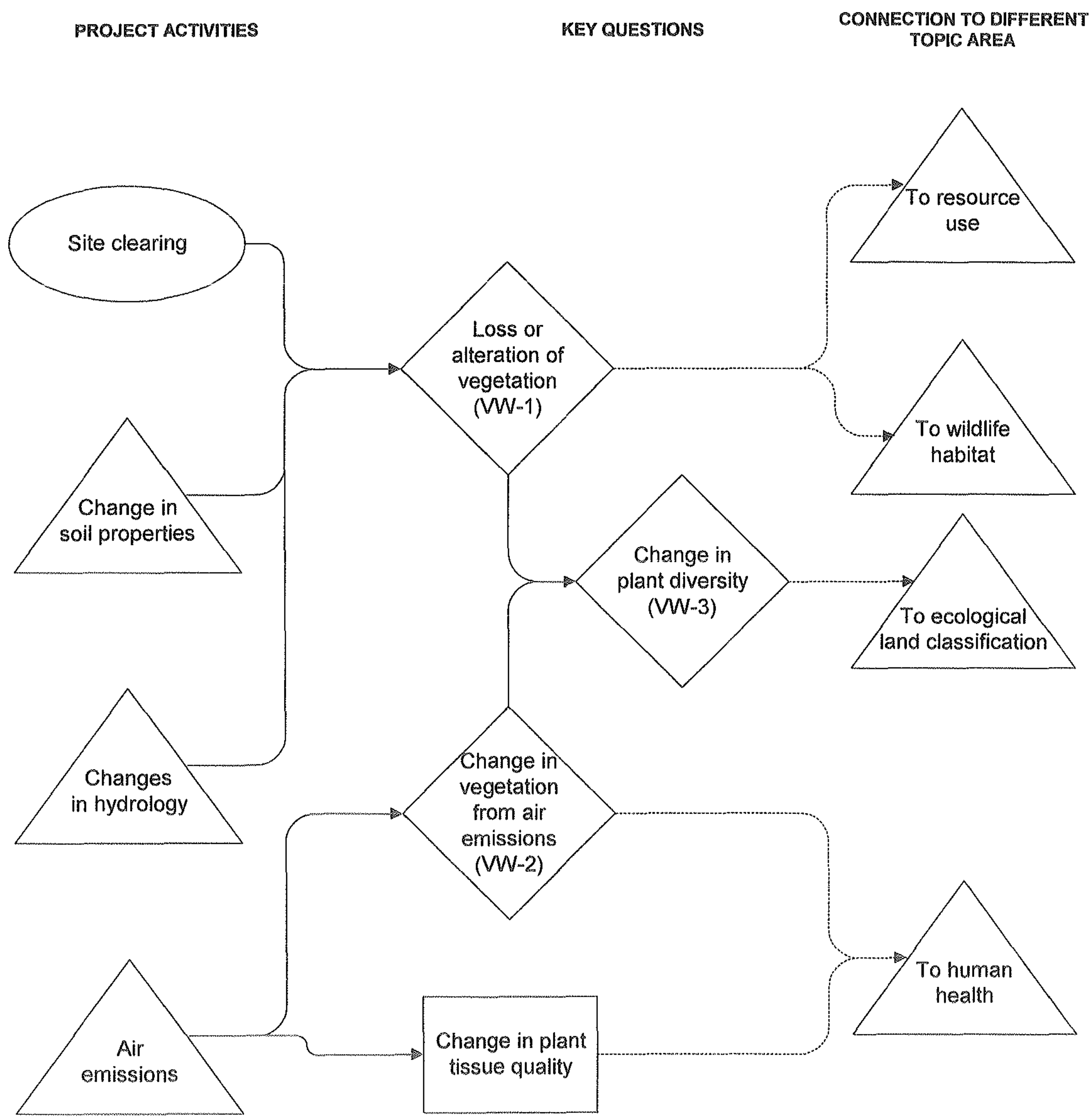
- construction and operation impacts, key questions 1 and 3; and
- impacts upon closure, key question 1.

Key question 2 examines the effects of air emissions and water releases on vegetation health.

The first vegetation resource linkage diagram (Figure D3.2-1) is used to demonstrate the potential impacts of the construction and operation phases on terrestrial vegetation and their associated plant communities of both the LSA and RSA. Project Millennium activities that may affect vegetation resources include, but are not limited to site clearing, soil and overburden stripping and storage, changes in soil properties, development of facilities and infrastructure, changes to hydrology and emissions and releases to the air, ground and water. The impacts from these activities are expected to include direct losses or alteration of vegetation as a result of site clearing and physical removal of vegetation, while the indirect losses may result from air emissions and/or water releases.

The impacts may also result in localized effects on vegetation, including changes in plant diversity and plant tissue quality. The linkage diagrams also detail the potential pathways of change in other related resources, as a result of potential impacts to vegetation, including changes in resource use, wildlife habitat and human health.

Figure D3.2-1 Terrestrial Vegetation Resources Linkage Diagram for Construction and Operation Phase of Project Millennium



Wetlands Resource

Analysis of impacts on wetlands as a result of Project Millennium have been split into two phases:

- construction and operation impacts, (key questions 1 and 3); and
- impacts upon closure, (key question 1).

The linkage diagrams illustrating both key questions and potential linkages associated with wetlands resources are presented in (Figures D3.2-2 and D3.2-3). The key questions identified for wetland resources are listed in Section D3.6.

D3.2.5.3 Potential Linkages: Closure

Another linkage diagram (Figure D3.2-4) was developed to identify the potential impacts on the vegetation resource at (and beyond) closure. Project Millennium activities that may affect which plant communities (ecosite phases) can be re-established at closure include, but are not limited to:

- reclamation activities, such as grading and replacement of overburden and topsoil materials,
- development of an end pit lake; and
- alterations to surface drainage patterns.

These activities will result in a variety of reclamation surfaces which will be re-vegetated to meet end land use objectives.

Re-vegetation efforts will eventually replace some plant communities displaced during construction and operation. However, the reclaimed vegetation will initially result in changes in vegetation successional stage within and among the reclaimed communities. The effects of reclamation on resource use and wildlife habitat within the Project area are depicted in Figure D3.2-4.

Figure D3.2-2 Wetlands Resources Linkage Diagram for Construction and Operation Phase of Project Millennium

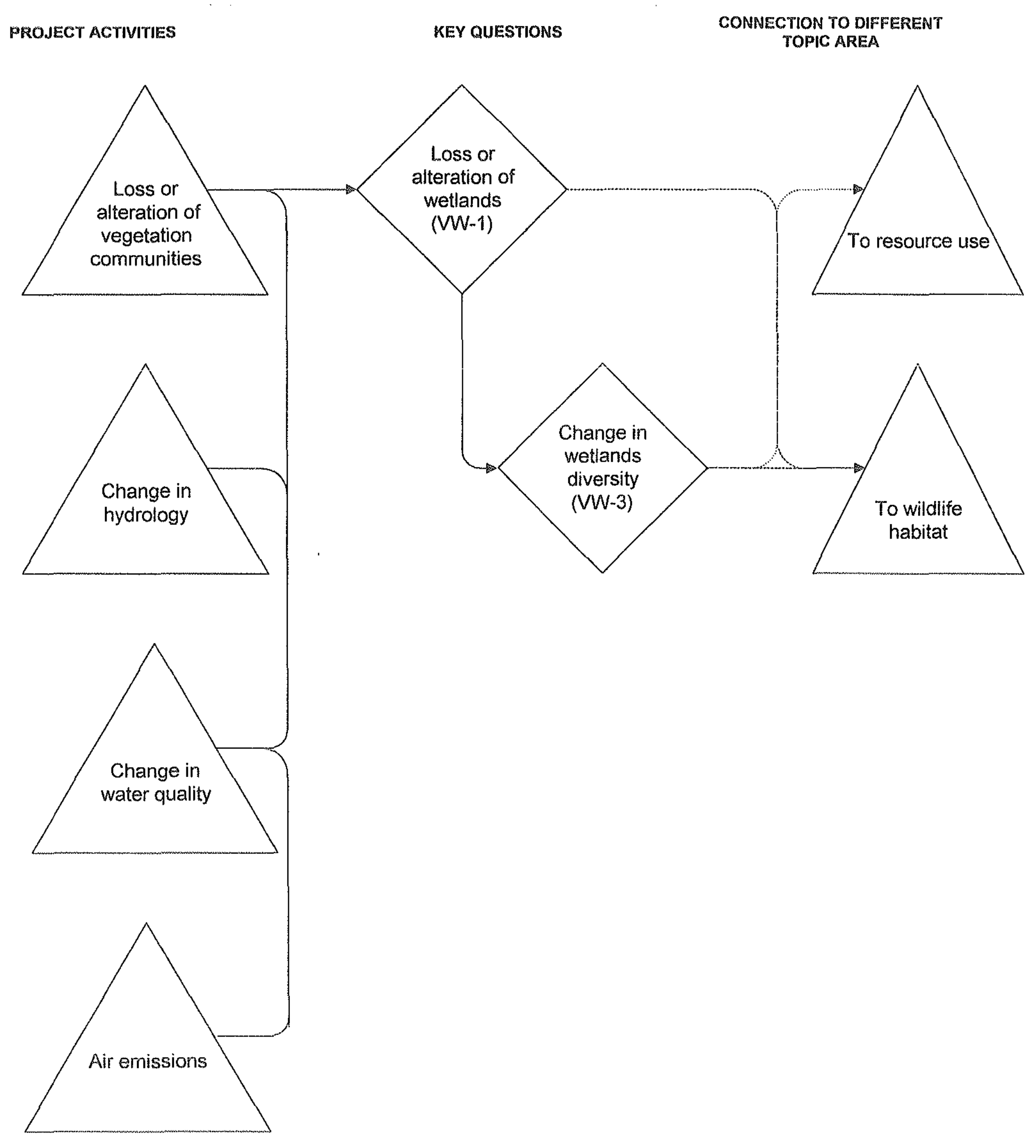


Figure D3.2-3 Wetlands Resources Linkage Diagrams for Closure Phase of the Project Millennium

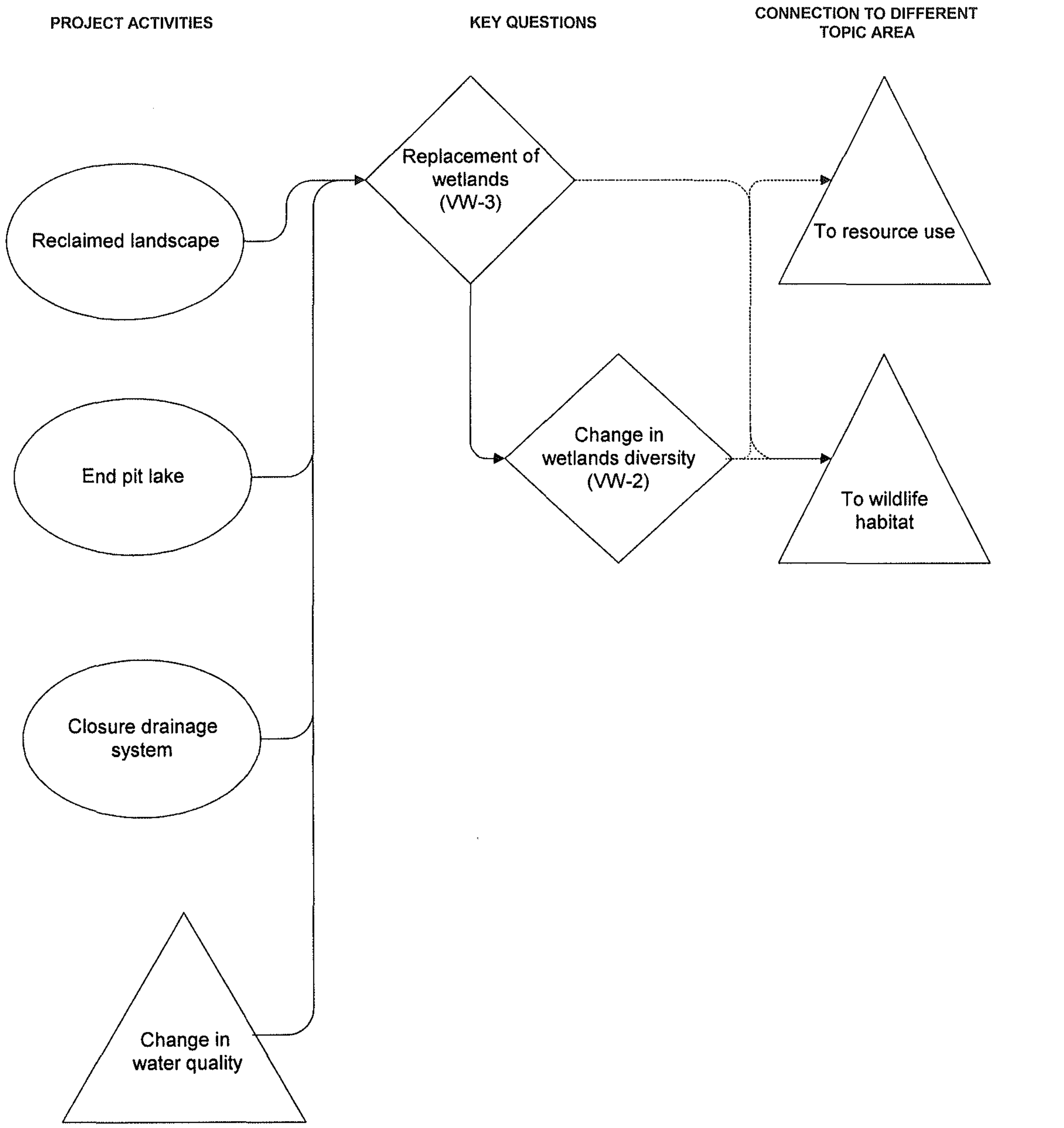
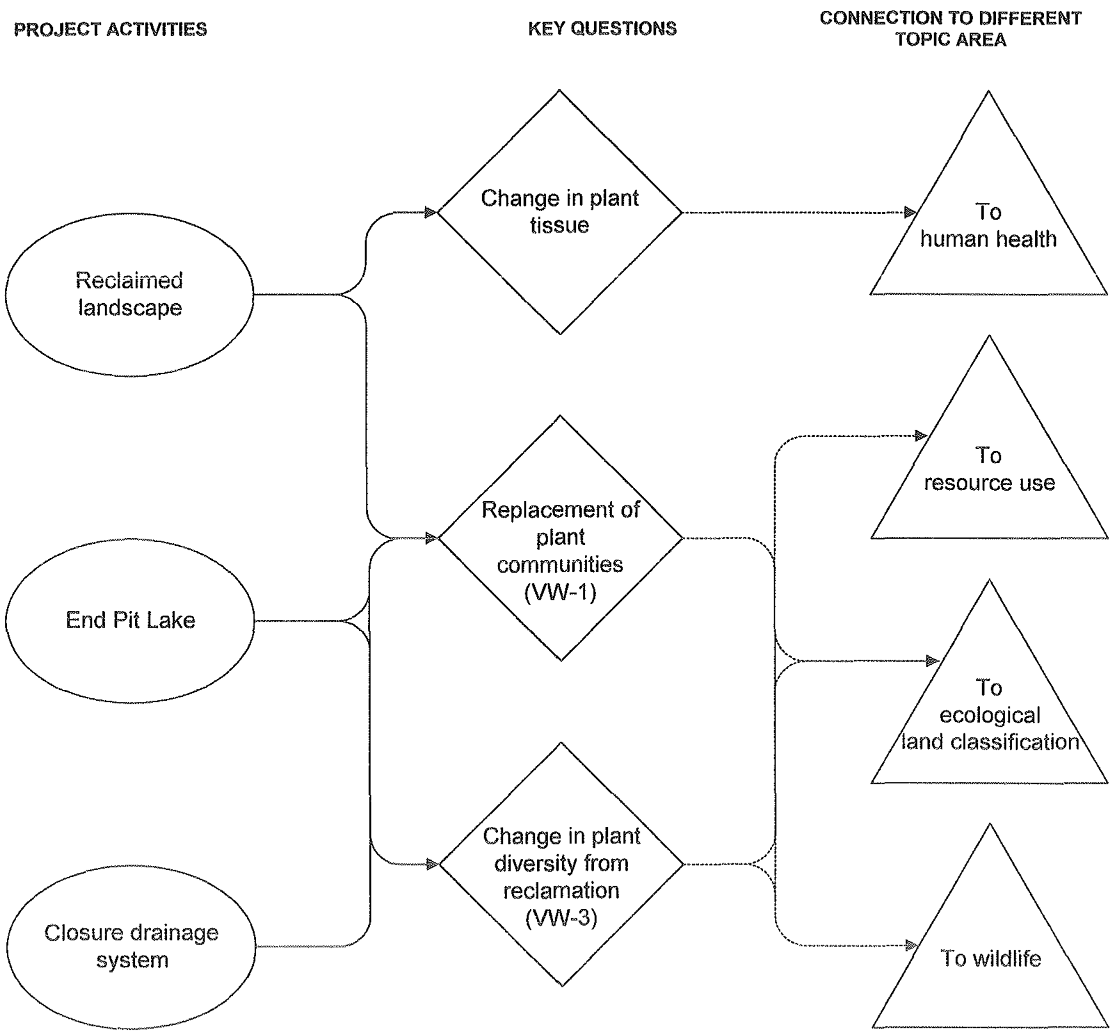


Figure D3.2-4 Terrestrial Vegetation Resources Linkage Diagram for Closure Phase of the Project



D3.2.6 Key Questions

Key vegetation and wetlands impact questions have been developed based on the issues previously identified. A key impact question is an explicit question raised during the EIA process which guides data collection and analysis to determine the magnitude and significance of the effects of the potential impact on the terrestrial vegetation. Three key questions have been developed for terrestrial vegetation and wetlands resources. Each one is briefly described as follows:

VW-1 What impacts will development and closure of Project Millennium have on vegetation communities and wetlands?

Terrestrial Vegetation Resources

During construction and operation of Project Millennium, landscapes and their associated vegetation may be substantially altered. The loss and/or alteration of vegetation communities is examined at the plant community and plant species level within this section, while this question is examined at a much broader level of generalization in the ELC section (Section D4.2).

The objective of reclamation is to return the developed landscape to a condition of "equivalent capability". Various stakeholders identified the replacement of plant communities as an issue with respect to reclamation. This question lends itself to an examination of the vegetation resources of the LSA at a series of scales so that broad landscape types, their component plant communities and plant species can be examined in the context of successive development and reclamation over time. In general, the diversity of reclaimed plant communities increases over time, eventually resulting in vegetation associations and plant communities more similar to the pre-development conditions than that found immediately following reclamation.

Wetlands Resources

During construction and operation, loss or alteration of wetlands will result from changes in hydrology and clearing of the development area. Loss or alteration of wetlands may also occur due to operational emissions (air and water).

Successful replacement of wetlands upon closure is dependent upon two main factors:

- effectiveness of closure drainage system; and
- whether changes in water quality will impact the capability of wetlands to support wetland communities.

VW-2 What impacts will air emissions and water releases from Project Millennium have on vegetation health?

Vegetation health may be affected through air and water releases as a result of the construction and operation of Project Millennium. Air emissions are primarily associated with the operational phase while water releases are a consequence of both operational and closure phases.

VW-3 What Impacts will development and closure of Project Millennium have on vegetation and wetlands diversity?

The LSA is characterized by a diversity of landscapes, vegetation, soils and drainage conditions. As a consequence of the construction and operation phase, as well as the subsequent closure phase, there is a concern that the vegetation of the LSA will not be as diverse as the pre-development conditions.

Changes in wetlands diversity may occur due to loss or alteration of wetlands. Changes in wetlands diversity can be measured by comparing the number and type of wetlands present before development with the number and type remaining after the project is operational.

Potential changes in vegetation and wetlands diversity may also result in changes in resources use, wildlife habitat and aquatic resources.

D3.2.7 Key Question VW-1: What Impacts Will Development and Closure of Project Millennium have on Vegetation Communities and Wetlands?

D3.2.7.1 Analysis of Potential Linkages

Development of Project Millennium will result in construction and operational activities that could affect vegetation and wetlands as summarized in the linkage diagrams shown in Figures D3.2-1 and D3.2-2.

Activities are identified as having either a direct or indirect effect on the types and distribution of vegetation and wetlands resources. Direct losses are a result of site clearing including overburden and muskeg stripping/storage, while indirect losses can be a result of changes in surface water hydrology affecting soil moisture conditions (e.g., changes to the hydrological regime of sites located near the mine pits, along access roads and near drainages or wetlands).

Reclamation of plant communities is dependent on the capability of the various reclamation landscapes to support vegetation establishment and growth. Plant communities typically vary in their sensitivity and capacity to re-establish on reclaimed sites. Re-establishment is also dependent upon the availability of plant seed and rhizomatous plant material from within the reclaimed organic storage materials. Linkage diagrams between closure and vegetation and wetlands impacts are presented in Figures D3.2-3 and D3.2-4.

Linkage between Site Clearings and Vegetation and Wetlands Resources

Development will result in the clearing of 9,281 ha or 57% (Table D3.2-1) of the LSA for the mine, tailings settling pond, overburden disposal sites, reclamation material storage areas, plant site, linear infrastructures such as roads and pipelines, and other associated facilities including ponds and drainage structures. Wetlands are the dominant vegetation types within the LSA (9,994 ha or 62%). Development will result in direct losses of 6,502 ha or 65% of the wetlands within the LSA.

Table D3.2-1 Direct Losses/Alteration of Existing Terrestrial Vegetation, Wetlands, Rivers and Lakes Within the Project Area and LSA

Ecosite Phase and AWI Class	Pre-development LSA		Impact Area: Steepbank		Impact Area: East Bank Mining Area		Closure: Reclamation Area		Closure: LSA		% Change in LSA
	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)	%	
Terrestrial Vegetation	5956	36	1,556	27	2,684	46	7,239	78	10,410	64	+28
Wetlands/ Riparian	9,994	62	2,202	22	6,502	65	1,115	12	4,608	28	-34
Lakes & Ponds	26	<1	0	0	3	12	918	10	941	6	+6
Rivers	79	<1	2	2	2	3	0	0	77	<1	-<1
Existing Disturbances	226	1	16	7	90	40	9	<1	145	1	-<1
TOTAL	**16,181**	**100**	**3,776**	**100**	**9,281**	**100**	**9,281**	**100**	**16,181**	**100**	**n/a**

Linkage Between Hydrogeology, Hydrology and Wetlands

In the natural setting, groundwater discharges to streams and wetlands and recharges to deeper groundwater systems. The lowering of groundwater levels in the surficial aquifer will affect groundwater flow patterns by directing groundwater from surficial aquifers into the mine dewatering system and not toward natural discharge areas. Dewatering will lower groundwater levels in the surficial aquifer within 300 m of the mine area. Wetlands in this area will therefore be affected by the dewatering of the surficial aquifer. However, Basal Aquifer depressurization will have negligible effect on wetlands and lake levels in the LSA. Therefore, this linkage is only considered valid for surficial aquifer effects.

Linkages Between Water Quality and Wetlands

The quality of surface water, during construction and operation of the Project, is not expected to affect wetlands resources (Water Quality Impact Assessment C3.2). As such, there will be no direct or indirect effects on wetlands as a result of water quality.

Linkages Between Air Quality and Terrestrial Vegetation and Wetlands

Peatlands, fens and bogs, may be particularly sensitive to acid forming emissions (SO_2 and NO_x). The WHO (1994) has proposed a potential acid input (PAI) critical loading factor of 0.25 keq/ha/a for sensitive ecosystems and a 0.50 keq/ha/a for moderate sensitive ecosystems. According to the Air Impact Section (B3) critical loads will exceed 0.25 keq/ha/a. Therefore, there is a valid linkage between air quality and terrestrial vegetation and wetlands.

D3.2.7.2 Impact Analysis

The analysis of potential linkages indicates that losses or alteration of terrestrial vegetation and wetlands are primarily due to site clearing during construction and operation phases and from mine dewatering. Changes in water and air quality and atmospheric deposition can also cause losses or alteration to terrestrial vegetation and wetlands resources. Site clearing and overburden removal involves the direct removal of landforms, associated soils and vegetation communities, including wetlands. Surficial aquifer drawdown may result in indirect changes to wetlands. Acid forming emissions and low level ozone could also affect terrestrial vegetation and wetlands.

Direct Losses/Alterations to Terrestrial Vegetation Resources

Construction will result in the clearing of 9,281 ha or 57% of the LSA for the mine, tailings settling pond, overburden disposal sites, reclamation material storage areas, plant site, linear infrastructures such as roads and pipelines, and other associated facilities including ponds and drainage structures.

Terrestrial ecosite phases occupy 5,956 ha or 36% of the LSA (Table D3.2.1). Impacts due to site clearing in the east bank mining area will result in a total loss of 2,684 ha or 46% of terrestrial ecosite phases. The Steepbank Mine accounts for 27% (1,556 ha) of this loss.

The ecosite phases occupying the LSA at present and those that will be cleared for the east bank mining area are outlined in Table D3.2-2. The greatest impact will occur within the wetlands, especially the wooded fen (FTNN) where 4,397 ha will be cleared (73 % of wooded fens within the LSA) and in the shrubby fen (FONS) where 325 ha will be cleared (76% of shrubby fens within LSA). Within the uplands (terrestrial ecosite phases), all of the lichen Pj (a1); Labrador tea-mesic Pj-Sb (c1); and Labrador tea-subhygric Sb-Pj (g1), which collectively occupy only 3 ha, will be lost due to development. In the blueberry ecosites (b1-b4) 279 ha will be cleared (76% of blueberry ecosites within the LSA). A total of 2,230 ha or 46% of low-bush cranberry ecosites (d1-d3) will be cleared within the LSA. In addition, development at the east bank mining area will clear 16% (63 ha) of dogwood ecosites (e1-e3) within the LSA (Table D3.2-2).

The direct losses/alterations to vegetation will be phased over the mine construction and operation schedule. Substantial increases in ecosite phases Blueberry Aw (Bw) (b2); Blueberry Aw-Sw (b3); Low-bush cranberry Aw-Sw (d2); and Dogwood Pb-Aw (e1) are foreseen following closure (307 ha; 873 ha; 2,724 ha; and 2,062 ha, respectively, Table D3.2-2).

As development proceeds, sequential reclamation and re-vegetation will take place to minimize the area of disturbance at any one time and to initiate re-vegetation in conjunction with mine construction and operation. Reclamation and re-vegetation will therefore result in a series of multi-aged re-vegetation communities at a variety of successional stages. This is important for wildlife habitat utilization and resource use. Further details are provided in the Closure Plan (Volume 1, Section E) and the Closure Plan Assessment (Volume 2, Section E).

Direct Losses/Alterations to Wetlands Resources

Wetlands occupy 62% (9,994 ha) of the LSA. Mine development will remove 6,502 ha or 65% of wetlands within the LSA (Table D3.2-1).

Each wetlands type and associated areas lost to mine development are listed in Table D3.2-2. Non-patterned, wooded fens (FTNN/FFNN) are the dominant wetlands types in the LSA that collectively occupy 43% (6,978 ha) of the LSA. Mine development will remove 71% (4,944 ha) of these fens. Similarly, 76% of all non-patterned shrubby fens in the LSA will be directly lost from mine development. Wooded (STNN/SFNN) and shrubby (SONS) swamps represent 14% (2,207 ha) of the LSA. Clearing of wooded and shrubby swamps will result in a loss of 54% (1,190 ha).

Table D3.2-2 Vegetation (Ecosite Phases and AWI Classes) Types Within the Local Study Area and Areas to be Cleared and Reclaimed for Project Millennium

Vegetation Type		Local Study Area		Impact Area: Steepbank		Impact Area: East Bank Mining Area		Closure: Reclamation Area	Closure: Local Area		% Change of LSA
Map Code	Ecosite Phase and AWI Class	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(ha)	(%)	
Terrestrial Vegetation											
a1	Lichen Pj	1	< 1	1	100	1	100	0	0	0	-<1
b1	Blueberry Pj-Aw	226	1	98	43	145	64	180	261	2	+1
b2	Blueberry Aw(Bw)	28	< 1	26	93	27	96	306	307	2	+2
b3	Blueberry Aw-Sw	60	< 1	57	95	57	95	870	873	5	+5
b4	Blueberry Sw-Pj	50	< 1	37	74	50	100	2	2	<1	-<1
c1	Labrador Tea-mesic Pj-Sb	1	< 1	1	100	1	100	0	0	0	-<1
d1	Low Bush Cranberry Aw	3,348	21	923	28	1,780	53	1,207	2,775	17	-4
d2	Low Bush Cranberry Aw-Sw	588	4	60	10	135	23	2,271	2,724	17	+13
d3	Low Bush Cranberry Sw	941	6	212	23	315	33	151	777	5	-1
e1	Dogwood Pb-Aw	212	1	28	13	35	17	1,885	2,062	13	+12
e2	Dogwood Pb-Sw	63	< 1	16	25	14	22	3	52	<1	-<1
e3	Dogwood Sw	127	1	25	20	14	11	277	390	2	+1
g1	Labrador Tea-subhygric Sb-Pj	1	< 1	0	0	1	100	0	0	0	-<1
h1	Labrador Tea/Horsetail Sw-Sb	59	< 1	21	36	32	54	4	31	<1	-<1
Sb/Lt	Black Spruce-Tamarack Complexes	20	< 1	0	0	20	100	0	0	0	-<1
Shrub	Shrubland	131	1	51	39	57	43	82	156	1	0
Wetlands											
BTNN	Wooded Bog	20	< 1	0	0	0	0	0	20	<1	0
BFNN	Forested Bog	26	< 1	0	0	0	0	0	26	<1	0
FTNN	Wooded Fen	6,012	37	1,530	25	4,397	73	43	1,659	10	-27
FFNN	Forested Fen	966	6	262	27	547	57	10	429	3	-3
FONS	Shrubby Fen	426	3	110	26	325	76	5	106	1	-2
FONG	Graminoid Fen	4	< 1	0	0	3	76	0	1	<1	-<1
MONG	Graminoid Marsh	107	1	12	11	14	13	1	94	1	-<1
MONS	Shrubby Marsh	211	1	22	10	18	9	1	194	1	-<1
STNN	Wooded Swamp	1,359	8	162	12	769	57	45	635	4	-4
SFNN	Forested Swamp	687	4	51	7	378	55	13	322	2	-2
SONS	Shrubby Swamp	161	1	47	29	43	27	6	124	1	-<1
WONN	Shallow Open Water	15	< 1	6	40	8	53	0	7	<1	-<1

Vegetation Type		Local Study Area		Impact Area: Steepbank		Impact Area: East Bank Mining Area		Closure: Reclamation Area	Closure: Local Area		% Change of LSA
Map Code	Ecosite Phase and AWI Class	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(ha)	(%)	
Existing Disturbances											
AIH, AIG, CIP, CIW	Cultural Disturbance	22	< 1	14	64	15	68	0	8	<1	-<1
HG/CC	Herbaceous Graminoid Cutblock	170	1	0	0	69	41	8	109	1	-<1
NMC	Cutbanks	33	< 1	2	6	6	18	0	27	<1	-<1
NMS	Sand	1	< 1	0	0	0	0	0	1	<1	0
Water											
NWL	Lakes and Ponds	20	< 1	0	0	3	15	0	17	<1	-<1
NWR	Rivers	79	< 1	2	2	2	3	0	77	<1	-<1
NWF	Flooded Area	6	< 1	0	0	0	0	0	6	<1	0
Reclaimed Units											
	Constructed wetlands							276	276	4	+4
	Deciduous Swamp (SONS)							715	715	6	+6
	Open Water							918	918		
TOTAL		**16,182**		**3,776**		**9,281**		**9,281**	**16,181**	**100**	

Wooded bogs without internal lawns (BTNN/BFNN) represent less than 1% (46 ha) of the LSA and will not be affected by mine development.

Graminoid (MONG) and shrubby (MONS) marshes together represent 2% (318 ha) of the LSA (Table D3.2-2). Losses due to mine development, will affect 13% (14 ha) of graminoid marshes (MONG) and 9% (18 ha) of shrubby marshes (MONS) within the LSA.

Shallow open water (WONN) represents less than 1% (15 ha) of the LSA. Mine development will affect 53% (8 ha) of the shallow open water areas in the LSA.

Indirect Losses/Alteration to Terrestrial Vegetation Resources

The indirect losses/alterations to the vegetation of the LSA include the area around the perimeter of the east bank mining area which may be affected by mine dewatering or local aquifer drawdown. The effects have been calculated for a buffer zone around the development area of 300 m in width (Section C2.2, Hydrology). The effects of mine dewatering or local aquifer drawdown, however, are largely restricted to the wetlands and lake margins and are not expected to affect the terrestrial or upland vegetation communities.

Clearing of vegetation may lead to wind throw or blowdown effects in the surrounding forest, resulting in further vegetation disturbances. This damage may extend many meters into the forest (Mavratil 1995) and will generally occur for a period of approximately 15 years following development (Busby 1966). Spruce, especially black spruce, is susceptible because it is shallow rooted. Blowdown of trees around the existing oil sands projects in the area has been infrequent, and thus this effect should be minor for the Project.

Indirect Losses/Alterations to Wetlands Resources

Groundwater drawdown will occur in areas adjacent to the mining pits due to dewatering of the muskeg (if present) and dewatering/depressurization of the overburden between the muskeg and the oil sands. Depressurization of the basal aquifer will likely not have a significant impact on the near surface water conditions except in very coarse grained areas.

Muskeg dewatering is conducted ahead of the mine face advance to remove the free water from the upper more permeable peat layers. The lower zones of the muskeg tend to exhibit relatively low permeability with values of 10^{-5} cm/sec being reported as typical for decomposed peat (MacFarlane 1969). Current oil sands practice is to dewater the muskeg with a series of trenches that are typically spaced at approximately 70 m. This implies that the zone of influence from muskeg dewatering is 35 m over the one to two year period that is typical for this operation.

The hydrogeological analysis described in Section 2.2 identifies a value of 300 m for the maximum width of groundwater drawdown that may occur due to overburden dewatering. This value is based on "worst case" hydrogeological conditions (i.e., coarse grained soils). Since this is likely to govern over the horizontal flow case of muskeg dewatering, the impact of overburden dewatering is anticipated to draw water downward from the surface soils. However, the impact of this downward drawdown may be mitigated to some extent by the relatively low permeability of the lower, decomposed peat layer.

In summary, the major impacts due to aquifer drawdown are anticipated to be within 50 m of the mine pit, with less impact occurring out to a limit of approximately 300 m. This area of major impact has been included in the 50 m buffer zone which has been included in the development area. The degree to which groundwater is drawn in the 50 to 300 m zone around the pit and the impact of this drawdown will depend on factors such as the parent soil and the occurrence of lower permeability horizontal layers, both of which are site specific.

Swamps in the LSA are located adjacent to floodplains or along the margins of peatland complexes. Swamps, associated with peatland margins, are the vegetation types primarily affected by surficial aquifer drawdown. The affects of drawdown may result in a change in species composition in swamps. For example, plant species that have adapted to moister soil conditions may decline in abundance and vigour. In time, swamps may change to upland communities as species associated with wetter conditions become replaced with those adapted to drier conditions. In addition, tree growth may increase and become more productive as a result of reduced soil moisture (Hillan et al. 1990). This drawdown is expected to affect 103 ha or approximately 5% of swamps within the Project area (Table D3.2-3).

Marshes may change to dry grassland or shrub communities. Aquatic plants, such as some sedges and rushes, may be reduced. These areas may over time become invaded with upland shrub communities. shrubby marshes (MONS) may be reduced by 1 ha or less than 1% in the LSA due to surficial aquifer drawdown (Table D3.2-3).

Fens will be affected from a change in surficial aquifer drawdown. All fen types may shift in species composition. Hydric adapted shrubs and herbs such as crowberry and bog cranberry usually decline in abundance following a decrease in soil moisture whereas, tall shrubs such as willows and alder generally increase (Hillan et al. 1990). Moreover, studies have found that drawdown on peaty soils resulted in a net increase in the abundance of shrub and deciduous trees such as aspen (Hillan et al. 1990, Leiffers and Rothwell 1987 and Leiffers 1984). Rare plant habitat associated with the fen system may also be reduced. The indirect loss to wooded fens from drawdown are expected to be 109 ha or less than 2% of fens within the LSA (Table D3.2-3).

Table D3.2-3 Wetlands Losses and Alteration During the Construction and Operation Phase of the Project

Wetlands Type		LSA (ha)	Loss due to Clearing (ha)	Loss due to Surficial Aquifer Drawdown (ha)	Total Loss (ha)	% Loss of Wetlands in LSA
Level Code	AWI Class					
Shallow Open Water (W)	Shallow Open Water (WONN)	15	8	0	8	53
Marsh (M)	Marsh (MONG)	107	14	0	14	13
	Marsh (MONS)	211	18	1	19	9
Subtotal	Marsh and Shallow Open Water	333	40	1	41	12
Swamps (S)	Coniferous swamp (STNN)	1,359	769	45	814	60
	Coniferous swamp (SFNN)	687	378	57	435	63
	Deciduous swamps (SONS)	161	43	1	44	27
Subtotal	Swamps	2,207	1,190	103	1,293	59
	Open, non-patterned shrubby fens (FONS)	426	325	4	329	77
	Open, non-patterned graminoid fen (FONG)	4	3	0	3	75
	Wooded fen, (open canopy >6% - 70% tree cover) no internal lawns (FTNN)	6,011	4,396	87	4,483	74
	Wooded fen, (closed canopy >70% tree cover) no internal lawns (FFNN)	966	547	18	565	58
Subtotal	Fens	7,406	5,271	109	5,380	73
Bogs (B)	Wooded bog, (>10%, ≤ 70% tree cover) no internal lawns (BTNN)	20	0	0	0	0
	Wooded bog, (closed canopy >70% tree cover), no internal lawns (BFNN)	26	0	0	0	0
Subtotal	Bogs	46	0	0	0	0
Total Wetlands		9,993	6,502	213	6,714	67
Terrestrial Vegetation		6,027	2,753	180	2,933	49
Lakes		20	3		3	15
Rivers		79	2		2	2
Existing Disturbances		62	21	1	22	35
Total		16,181	9,281	394	9,674	

Reclamation Landscapes

Reclamation refers to the construction of topographic, soil and plant conditions after disturbance, which may not be identical to the pre-disturbance site, but which permits the degraded land mass to function adequately in the ecosystem of which it was, and is a part (Munshower 1994). The Alberta Environmental Protection and Enhancement Act (1993) states that reclamation should achieve "equivalent land capability."

> "The ability of the land to support various land uses after reclamation is similar to the ability that existed prior to an activity being conducted on the land. The ability to support individual land uses will not necessarily be identical" (Gerling et al. 1996).

Growth requirements of each selected plant species must match the texture, pH, salinity, nutrient levels and all of the chemical and physical characteristics of the root zone materials. The plant species selected must also meet aspect, elevation, precipitation and temperature limitations of the area.

AEP requires that the plant species composition be compatible with the original plant community, a neighboring community, or other reasonable land management objectives (Gerling et al. 1996). The plant species selected should contribute to the attainment of the land use goal for the site. At almost all sites these will include soil stabilization, erosion control and soil development. Under the land use goal, the plant species selected should meet the needs of commercial forestry and wildlife habitat (moose habitat). Food and cover for the wildlife species (moose) anticipated on the site must be addressed in plant species selection.

Diverse plant communities will meet these goals better than simple mixtures of a few plant species. A diverse plant community will offer mixed diets and habitat for wildlife. Therefore, diversity is clearly desirable for new plant communities.

Reclamation and Closure

The Closure Plan (Section E of Volume 1 of the Application) identifies the vegetation communities that will be re-established to meet specific land use objectives. Generally, this process involves the following steps:

- identify vegetation communities that can be established on a variety of reclaimed landscapes;
- identify techniques to establish vegetation communities on reclaimed landscape;
- identify land use objectives for reclaimed landscapes;
- identify design criteria for selected land use;
- design of monitoring program; and
- design of research program.

Community types that naturally occur in the oil sands region (i.e., native species) were identified during baseline investigations. Of the communities present in the area, blueberry Pj-Aw; blueberry Aw(Bw); blueberry Aw-Sw; low-bush cranberry Aw; low-bush cranberry Aw-Sw; low-bush cranberry Sw; dogwood Pb-Aw; dogwood Pb-Sw; and dogwood Sw have been identified as possible replacement communities (Table D3.2-4). Establishment of vegetation communities on the reclaimed landscape is dependent upon the type of landform, slope, aspect, soil type/capability, and soil drainage conditions. Table D3.2-4 presents a summary of parameters corresponding to vegetation community types and predicted replacement areas upon closure of the Project.

Table D3.2-4 Replacement Plant Communities for the Developed Area

Landscape Features	Soil Capability and Moisture Regime[1]	Target Ecosite phase[2]	Tree Species (1800 - 2200 Stems/ha Total Density)	Shrub Species[3] (500 - 700 Stems/ha Total Density)	Predicted Replacement Area (Ha)	% LSA
Tailings Sand Slope, South Aspect	Soil Class 4-3, Subxeric, Submesic	Blueberry Pj-Aw (b1)	Jack Pine, Aspen White Spruce	Blueberry, Bearberry, Labrador Tea, Green Alder	180	1
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	Blueberry Aw(Bw) (b2)	Aspen White Birch White Spruce	Blueberry, Bearberry, Labrador Tea, Green Alder	306	2
Tailings Sand Slope, North Aspect	Soil Class 3-2 Subxeric, Submesic	Blueberry Aw-Sw (b3)	Aspen White Spruce White Birch	Blueberry, Bearberry, Labrador Tea, Green Alder	870	5
Tailings Sand Slope, North Aspect	Soil Class 3-2 Subxeric, Submesic	Blueberry Sw-Pj (b4)	White Spruce Jack Pine White Birch	Blueberry, Bearberry, Labrador Tea, Green Alder	2	<1
Overburden, South Aspect	Soil Class 3-2, Mesic	Low-bush Cranberry Aw (d1)	Aspen White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada Buffaloberry, Saskatoon, Green Alder, Rose, Raspberry	1,207	7
Overburden, North Aspect	Soil Class 3-2, Mesic	Low-bush Cranberry Aw-Sw (d2)	Aspen, White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry	2,271	14
Overburden, North Aspect	Soil Class 3-2, Mesic	Low-bush Cranberry Sw (d3)	White Spruce Aspen Balsam Poplar White Birch	Low-bush Cranberry, Canada buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry	151	1
Near Level Overburden or Tailings Sand, Lower Slope Position	Soil Class 3-2, Subhygric, Mesic	Dogwood Pb-Aw (e1)	Aspen Balsam Poplar White Spruce White Birch	Dogwood, Low-bush, Cranberry, Raspberry, Green Alder, Rose	1,885	12
Near Level Overburden or Tailings Sand, Lower Slope Position	Soil Class 3-2-1, Subhygric, Mesic	Dogwood Pb-Sw (e2)	White Spruce Aspen Balsam Poplar White Birch	Dogwood, Low-bush, Cranberry, Raspberry, Green Alder, Rose	3	<1
Near Level Overburden or Tailings Sand, Lower Slope Position	Soil Class 3-2-1, Subhygric, Mesic	Dogwood Sw (e3)	White Spruce Aspen Balsam Poplar White Birch	Dogwood, Low-bush, Cranberry, Raspberry, Green Alder, Rose	277	2

1 Xeric = water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation.
Subxeric = water removed rapidly in relation to supply; soil is moist for short periods following precipitation.
Mesic = water removed somewhat slowly in relation to supply; soil may remain moist for significant but sometimes short periods of the year; available soil water reflects climatic input.
Subhygric = water removed slowly enough to keep the water table at or near the surface for most of the year; organic and gleyed mineral soils; permanent seepage less than 30 cm below the surface.

2 Target ecosite phases defined in *Draft* Guidelines for Terrestrial Vegetation in the Oil Sands Region (Oil Sands Vegetation Reclamation Committee 1998).

3 Propagation of some of the listed shrub species has not been verified to date.

Reclamation techniques are evolving as the oil sands industry grows. However, current plans are based upon existing oil sand reclamation research. This research suggests introduction of 'starter vegetation' and then, by the process of succession, target plant communities will develop. 'Starter vegetation' will include both tree and shrub species at an approximate total density of 2400 stems/ha. Specific techniques and information is provided in Section E of Volume 1 of the Application.

Two primary end land use objectives have been identified for the reclaimed landscapes:

- Commercial Forest re-vegetation to a mixed wood boreal forest, using native species, with equal or better forest capability than pre-development conditions. As such, communities that support species of merchantable timber, as well as accessibility issues (e.g. steeper slopes) will be addressed; and
- Wildlife Habitat: moose have been identified as an important wildlife species, from both an economic and social point of view. As such, maintenance of historic moose populations, restoration of moose habitat capability and populations to pre-development levels, and monitoring of moose populations upon closure, have been identified as goals. As such, reclamation landscapes will be selected that support moose populations. These would include early successional communities that support browse species, and mature mixedwood or conifer communities that provide winter shelter.

Other complimentary goals, include:

- development of self-sustaining ecosystems with an acceptable level of diversity; and
- drainage systems that have an acceptable level of impact in terms of issues such as erosion rates and contaminant loadings.

Analysis of Replacement of Plant Communities

Plans to establish plant communities on reclaimed landscapes involve the introduction of 'starter species'. Succession then acts as the mechanism for establishing the desired community type. As such, the diversity of reclaimed plant communities increases over time, resulting in associations and communities more similar to the pre-disturbed conditions than immediately following reclamation.

Thirteen community types have been selected for establishment on reclaimed landscapes after the closure (Table D3.2-2). These communities include:

- Blueberry Pj-Aw (b1)
- Blueberry Aw(Bw) (b2)
- Blueberry Aw-Sw (b3)
- Low-bush cranberry Aw (d1)
- Low-bush cranberry Aw-Sw (d2)
- Low-bush cranberry Sw (d3)

- Dogwood Pb-Aw (e1)
- Dogwood Pb-Sw (e2)
- Dogwood Sw (e3)
- Shrubby Swamp (SONS)
- Shrubland
- Constructed Wetlands
- Open Water

Ten of these communities represent terrestrial ecosite phases. Baseline information for the LSA, indicates that 36% of ecosite phases identified represent terrestrial (uplands), while 62% represent wetland ecosite phases. During construction and operation, 46% of terrestrial ecosite phase areas, and 65% of wetland areas within the LSA will be lost. Reclaimed landscapes will result in a net increase of 7,239 ha of ecosite phases within the LSA compared to full development. Approximately 1,115 ha of wetlands and riparian community types will be lost within the LSA. Thus, upon closure, relative to pre-disturbance areas, upland communities will increase to 64%, and wetlands will decrease to 28% within the LSA. A dominantly wetland (fen) area will be converted to a predominantly upland mixedwood forest area.

D3.2.7.3 Key Indicator Resources

At the plant community level, five plant community types have been identified as KIRs for Project Millennium. The terrestrial vegetation KIRs at the plant community level include old-growth forests, economic forests, riparian communities, rare plants and traditional plants.

Terrestrial Vegetation KIRs at the Plant Community Level

Old-growth Forests

The definition of mature, old-growth forest currently includes both the age of the dominant trees as well as structural features such as height, diameter, density and spacing patterns, snag density, cavity characteristics, nutrient cycling, energy flow patterns and structural heterogeneity (Franklin et al. 1981, Green 1988, Old-growth Definition Task Force 1986). Fairbarns (1991) used the definition identified through much of North America, i.e., the oldest 10% of the vegetation community within a given natural successional sequence (Golder 1996). Old-growth can also be defined as those forested areas where annual growth equals the annual losses, or where mean increment of timber volume equals zero. They are also defined as those stands that are self-regenerating, having specific structure that is maintained. This structure includes juvenile, mature, dying and decaying trees of the same species (BOVAR 1996a).

The LSA supports a few stands classified as "old-growth". This conclusion is based on field inventory results and a search of forest age records maintained by Alberta Environmental Protection(AEP). Tree age criteria for old-growth forests has been defined for this area as outlined in Table D3.2-5 (BOVAR 1996a). As part of the vegetation inventory of the LSA, old-growth sites were sought out for age determination.

D3.2-5 Tree Age Criteria for Dominant Tree Overstorey Species to Determine Old-Growth Forest Stands (Phase III Forest Inventory Data)

Dominant Forest Canopy Tree Species	Minimum Age
Balsam fir	160
White spruce	160
Black spruce	200
Tamarack	200
Jack pine	120
Trembling aspen	100
Balsam poplar	160

The forest communities most likely to support old-growth include: Lichen Jack Pine (a1), Blueberry Jack Pine-White Spruce (b1), Blueberry Aspen-White Spruce (b3), Low-bush Cranberry Aspen (d1), Low-bush Cranberry Aspen-White Spruce (d2), Low-bush Cranberry White Spruce (d3), Dogwood Balsam Poplar-Aspen (e1), Dogwood Balsam Poplar-White Spruce (e2) and Dogwood White Spruce (e3) forests.

Lichen-Jack Pine Forests

Mature jack pine plant communities represent a KIR given the criteria previously described for vegetation communities; however, in their old age or mature stage, their open canopy and characteristic understory are particularly important in providing a diversity of vegetation conditions and wildlife habitat within both the LSA and RSA. Jack pine communities are located in small stands on rapidly-drained, sandy deposits along slope crests. They are generally uncommon within the LSA and RSA. The open canopy of the lichen jack pine ecosite phase is dominated by jack pine. The shrub understory is typically composed of blueberry, bearberry, green alder, bog cranberry, Labrador tea, twin-flower, jack pine and sand heather. Wild lily-of-the-valley is commonly found in the herb layer. On the forest floor, reindeer lichen is dominant and Schreber's moss, awned hair cap and brown-foot cladonia are also found. Many of the understory species found within the lichen jack pine plant community are used by aboriginal people.

Lichen-jack pine forests are found within ecosite phase a1 and occupy an area of 1 ha within the LSA (Table D3.2-2) all of which will be cleared. This represents a loss of less than 1% of the LSA. No lichen Pj will be reclaimed within the LSA after mine closure (Table D3.2-2). However, the lichen jack pine stand located within the LSA does not support an "old growth" forest.

Aspen-White Spruce Forests

Old-growth white spruce forest is uncommon in the LSA and RSA and generally confined to river valley terrain and flood plains (Westworth 1990). Old-growth spruce forests have been designated as significant natural features in northeastern Alberta (Westworth 1990). These forests are generally considered to be diverse, maintaining a variety of age classes and stand structure components. These sites are very sensitive to physical development, taking more than 150 years to re-establish (BOVAR 1996a). Older spruce forests (>125 years of age) are valued for their commercial products as well as their value as an uncommon natural resource in the province. The diversity of these forests attracts a similar diversity of other resources, including uncommon wildlife species. This factor makes these forests important for hunting, trapping and non-consumptive resource uses.

The aspen-white spruce forests are found within blueberry aspen-white spruce, low-bush cranberry aspen-white spruce (d2) low-bush cranberry white spruce, (d3) ecosite phases. These ecosite phases occupy an area of 60 ha, 588 ha and 941 ha, respectively (Table D3.2-2). Within the LSA 14% or 83 ha of the d2 ecosite phase is classified as old-growth forests. The d3 ecosite phase represents 91 ha or 10% ha of the total low-bush cranberry aspen-white spruce ecosite phase within the LSA. Mine development will remove 27% (22 ha) of the old growth forest within the d2 ecosite phase. The Steepbank Mine would of removed 60 ha or 66% of d3 old growth forest, however, the east bank mining will remove 58 ha or 64%. The east bank mining areas does not disturb as much of the Athabasca floodplain as the Steepbank Mine (ELC Section D4.2) Old-growth forest is not found in the b3 ecosite phase within the LSA (Table D3.2-6).

Table D3.2-6 Old Growth Forests within the Local Study Area and Areas to be Cleared for the Project

Ecosite Phase and AWI Class	Pre-Development Area (ha/%)	Steepbank Impact Area (ha/%)	East Bank Mining Impact Area (ha/%)
Blueberry Pj-Aw (b1)	7 ha/3%	0	0
Low-bush cranberry Aw (d1)	170 ha/5%	1 ha/<1%	10 ha/6%
Low-bush cranberry Aw-SW (d2)	83 ha/14%	0	22 ha/27%
Low-bush cranberry Sw (d3)	91 ha/10%	60 ha/66%	58 ha/64%
Dogwood Pb-Aw (e1)	29 ha/14%	0	0
Dogwood Pb-Sw (e2)	10 ha/16%	0	0
Dogwood Sw (e3)	37 ha/29%	22 ha/59%	1 ha/3%
Coniferous Swamp (STNN)	3 ha/<1%	0	1 ha/33%
Total	**430**	**83**	**92**

Balsam Poplar-White Spruce Forests

The balsam poplar-white spruce forests are found within ecosite phases e2 (dogwood balsam poplar-white spruce) and e3 (dogwood white spruce), and occupy an area of 63 ha and 127 ha, respectively (Table D3.2-2). Of the area within the LSA occupied by the e2 ecosite phase, 10 ha or 16% is classified as old growth forest (Table D3.2-6). The e3 ecosite phase represents 29% or 37 ha of the total dogwood white spruce ecosite phase within the LSA. The Steepbank Mine development would of remove 59% (22 ha) of old growth forest within in the e3 ecosite phase. However, the east bank mining area will only result in the removal of one hectare. The old growth stands found within the e2 ecosite phase will not be affected by mine development.

Aspen and Balsam Poplar Forests

Aspen and Balsam Poplar forests are found within the low-bush cranberry aspen (d1) and dogwood balsam poplar-aspen (e1) and occupy an area of 3,348 ha and 212 ha, respectively (Table D3.2-2). Of the area within the LSA occupied by the d1 ecosite phase, 170 ha or 5% is classified old growth forest (Table D3.2-6). Mine development will remove 6% (10 ha) of the d1 ecosite phase old growth forest. The old growth stands found within the e1 ecosite phase will not be affected by mine development.

Summary

In summary, the overall impact of the east bank mining area development on "old-growth" forest is negative in direction and high in magnitude, given that 21% of the old-growth forest communities will be cleared by the project. However, the net increase of old growth forest impact over the approved Steepbank Mine area is only 9 ha or 2% of the old growth forest within the LSA. This net increase is low because certain old growth forested areas within the Athabasca River floodplain that were approved for the Steepbank development are not included in this Project Millennium application. The geographic extent is local and restricted to the local study area. The duration of the impact is long-term, greater than the life of the Project. The effect on the resource is considered irreversible in that the effect cannot be reversed in one human generation. The frequency of the impact is low, occurring once during the initial clearing of the Project. Therefore, based on the rating system, there is a high environmental consequence for development of the east bank mining area but a low consequence for the incremental increase due to Project Millennium.

Due to the creation of more upland conditions after closure, it is anticipated that there will be substantially greater old growth forest in the far future. Hence, the environmental consequence is largely a function of the time to re-establish old growth forest ecosystems. In addition, the loss of old growth forest (92 ha) is low in terms of the total amount in the RSA.

Based on the above-noted factors, the loss of old growth forests due to development of the east bank mining area, and particularly the loss due to Project Millennium development, is not considered to be significant in the regional context.

Plant Communities of Economic Importance

The white spruce (d3 and e3), aspen-white spruce (b3 and d2) and the successionally less mature aspen (b2 and d1) ecosite phases are common within the LSA (5,092 ha or 31% of LSA) (Table D3.2-2). These communities have no special status because of their abundance, (BOVAR 1996a); however, they are economically very important as a resource in the forest industry. The aspen-white spruce vegetation communities have a diversity of plant species because of a mixture of immature and mature species composition and structure. This diversity makes these communities resilient to natural or human-induced change. Aspen and white spruce are currently highly valued as economic species for the forestry industry. This type of mixed wood forest is also of high value for recreational pursuits such as hunting and camping.

The aspen-white spruce ecosite phases generally represent the productive timber in the LSA. A total of 5,196 ha of productive forest (fair to good TPR) will be cleared as a result of the Project, of which 942 ha is rated as good and 3,362 ha is rated as moderate and 892 ha is rated as fair (Table D3.2-7). In addition, 4084 ha of unproductive forest will be cleared.

Table D3.2-7 Timber Productivity Ratings (TPR) for the Project

Timber Productivity Rating	Pre-Development Area (ha) LSA	Steepbank Impact Area (ha)	East Bank Mining Impact Area (ha)
Good	2,298	406	942
Moderate	5,923	1,784	3,362
Fair	1,714	449	892
Unproductive	6,247	1,137	4,084
Total	**16,181**	**3,776**	**9,281**

Following mine closure, reclamation will result in a substantial increase in forest capability in the LSA. Approximately, 7,238 ha of the east bank mining area will be reclaimed to terrestrial ecosite phases. Assuming that the final timber productivity ratings for the terrestrial ecosite phases after closure will be in the good to moderate range, there will be approximately 11,154 ha of moderate to good productive forest in the LSA after closure. This represents a 35% increase over the pre-development case.

In summary, an increase in plant communities of economic importance following closure results in a positive impact which is low in magnitude and of local geographic extent. The duration is long-term, greater than 30 years, and considered reversible. The frequency of impact is low, occurring only during the initial clearing of the forest. Therefore the environmental consequence is rated as negligible.

Wetland KIRs at the Plant Community Level

Riparian Shrub Complexes

Riparian vegetation (i.e., willow and willow-alder shrub types) are of relatively low abundance in the LSA, but moderately abundant in the RSA. This ecosite is uncommon and of special importance for its habitat values. Riparian shrub communities are ecologically important and characterized by a diversity of vegetation communities. They are generally considered to be sensitive to disturbance because they are a transition zone between the upland, well drained sites and poorly drained wetlands. These communities are important in maintaining water quality, fish habitat and aesthetics because of their capability to stabilize streambanks and provide shade. Recreational values are also high, especially for fishing and camping.

Riparian shrub communities occur predominantly on the Athabasca and Steepbank River floodplain area, where it is the dominant wetlands type (SONS), occupying an area of 161 ha (Table D3.2-2). Riparian shrubs are dominated by willow, green alder and river alder. Other shrub species include low-bush cranberry, dogwood, alder-leaved buckthorn, labrador tea, twin-flower, bracted honeysuckle and wild red currant. The herb layer is characterized by sarsaparilla, dewberry, bunchberry, wild-lily-of-the-valley, bishop's-cap, marsh violet, wild strawberry and yellow marsh-marigold. Marsh reed grass and mud sedge are the characteristic graminoids.

Approximately 43 ha or 27% of riparian shrub complexes will be lost as a result of mine development (Table D3.2-2). However, at mine closure riparian shrub complexes (SONS) have been identified as a possible replacement community.

Riparian Poplars

Riparian poplars are found growing along the Athabasca River in the LSA and RSA. The vegetation communities found within the Athabasca floodplain are the dogwood Pb-Aw (e1) and dogwood Pb-Sw (e2) ecosite phases. This type is characterized by an overstorey of balsam poplar and aspen dominating an undergrowth of dense shrubs composed of dogwood, river and green alder, prickly rose and wild red raspberry.

The dogwood ecosite, although often covering only small areas, has high value for wildlife. It provides food and cover for a variety of species and is often used for travel. Ungulates such as deer browse young suckers and occasionally feed on the bark of older trees. Poplars and dogwood are also preferred browse species for moose. As well, songbird richness and diversity is quite high in this ecosite (Wildlife Baseline).

Dogwood Pb-Aw (e1) and dogwood Pb-Sw (e2) represent 275 ha which is approximately 1% of the LSA (Table D3.2-2). Losses due to project development, will affect 35 ha of dogwood Pb-Aw (e1) and 14 ha of dogwood Pb-Sw (e2) available in the LSA. Approximately 1,885 ha will be reclaimed back into the dogwood Pb-Aw (e1) ecosite. This will be an increase of 12% within the dogwood Pb-Aw (e1) ecosite phase (see Table D3.2-2).

Summary

The impact during operations on riparian shrub and poplar complexes is negative in direction and moderate in magnitude. However, the re-establishment of riparian vegetation at closure will result in an overall impact which will be positive. The geographic extent is local and restricted to the LSA. The duration of the impact is long-term (the life of the project) and the disturbance during operations is considered reversible. The frequency of the impact is low, occurring only during the initial clearing of the riparian vegetation. Because of the net positive direction after closure, the environmental consequence is considered to be negligible.

Vegetation KIRs at the Plant Species Level

Rare or Endangered Terrestrial Plant Species or Communities

A rare plant is any native species that, because of its biological characteristics, or because it occurs at the fringe of its range, or for some exists in low numbers or in very restricted areas in Alberta or in Canada (ANPC 1997).

Rare plants often require unique habitat types, a number of which were observed in the LSA. Rare plants are found to a limited extent in upland locations depending upon the species' requirements. Riparian wetland areas provide a number of unique microhabitats for rare plants, ranging from the associated bogs and fens along the shoreline to the cliff faces exposed by erosion. Habitats found within the LSA ranged from wooded fens and shrubby fens to swamps (coniferous and deciduous) and marshes. Each of these habitats provide the unique microhabitats required by rare plant species.

Within the LSA, seven rare plants have been identified as shown in Table D3.2-8. Two of the rare plants identified (turned sedge and prairie cord grass) are associated with uplands (terrestrial) habitat, for example dogwood Pb-Aw (e1). Mine development will remove 16% (35 ha) of the dogwood (e1) ecosite phase, however, the dogwood ecosite stand where turned sedge and prairie cord grass were observed will not be affected by the Project. Wool-grass, which was observed in a wooded fen in the Steepbank Mine Area and in a low-bush cranberry Aw (d1) stand above the Athabasca River, will be affected by the Project. The wooded fen and low-bush cranberry (d1) stands will be cleared by Project development. Small-water lily, which was observed in Shipyard Lake will not be affected by the Project.

Table D3.2-8 Rare Plants Observed Within the LSA During 1995 and 1997 Field Surveys

Common Name	Botanical Name	Status	Habitat Type	Location: 1995 Steepbank Mine Study	Location: 1997 Project Millennium LSA Study
cyperus-like sedge	*Carex pseudocyperus*	S2G5	bogs and fens	sedge fen on west side of Athabasca River	not observed
turned sedge	*Carex retrorsa*	S2S3	swampy woods and wet meadows	not observed	gravel bar on east side of Athabasca River
stemless lady's-slipper	*Cypripedium acaule* [(a)]	S2G5	jack pine forests	east-facing escarpment slope of Steepbank river	not observed
small water-lily	*Nymphaea tetragona*	S1G5T5	ponds and quiet waters	floodplain marsh immediately north of Steepbank-Athabasca confluence	2 locations; lake at end of McLean Creek and Shipyard Lake
pitcher-plant	*Sarracenia purpurea*	S2G5	bogs and fens	sedge fen on west side of Athabasca River	not observed
wool-grass	*Scirpus cyperinus*	S2G5	marshy areas	not observed	2 locations; cutline in Steepbank Mine area and Upland forest above Athabasca River
prairie cord grass	*Spartina pectinata*	S2G5	saline shores and marshes	not observed	2 locations; along edge of Athabasca River and north of Leggett Creek (southeast of Shipyard Lake)

[(a)] Denotes rare plants found primarily in uplands (terrestrial) ecosite phases, the remainder are primarily found in wetlands

Rare plant potential for the plant communities visited during the 1997 survey were rated as shown on Table D3.2-9. A rare plant potential was assigned to each ecosite phase and AWI Class based on field observations and literature review (Table D3.2-10). Those ecosite phases/AWI classes in which rare plants were observed were given higher ratings than those without. For example, other rare plant surveys in the RSA have identified rare plants within fens (Westworth 1990). As such, all fens were ranked as having high rare plant potential, regardless of whether rare plants were identified within these wetlands. In addition, those ecosite phases that are characteristic rare plant habitat, but were not inhabited by rare plants, were assigned higher ratings than those ecosites that are not typical rare plant habitat. Consequently, all habitat types identified were assigned rare plant habitat potentials ranging from "low potential" to "high potential".

Table D3.2-9 Rare Plant Potential Rating System

Rating	Potential	Description
0	No Potential	Habitat characteristics do not favor the establishment of rare plants. These areas often have dense, highly competitive and established communities or are areas under cultivation.
1	Low Potential	These areas were generally parts of large tracts of land with similar vegetation communities and ecological settings.
2	Moderate Potential	Habitats altered by natural forces such as eroded slopes or exposed rock outcrops. Also, areas with different slope aspects in rolling terrain. These areas often have sparse vegetation cover, less aggressive or competitive species and soil conditions that make plant establishment difficult.
3	High Potential	Habitats that were different from those in the same general area - alkaline sloughs, stream crossings or islands of native vegetation within large tracts of cultivated land which contain associations of uncommon or unusual plant species.
4	Rare Plant Potential	Habitats where rare plants were found.

Of the 11,437 ha within the LSA identified as having high rare plant potential, 7,023 ha, or 60%, will be lost as a result of mine construction and operation (Table D3.2-11). At mine closure 2,616 ha of terrestrial ecosite phases, rated as high rare plant potential, will be reclaimed. Fens which are rated as having a high rare plant potential habitat cannot be reclaimed. This is due to the fact that the peat accumulation associated with these wetland types takes several hundred years to develop. Given suitable landform and drainage conditions, these wetlands may eventually re-establish; however, the long periods of time associated with their development renders them outside the scope of closure analysis. It is possible that constructed wetlands may develop into marsh wetlands and increase rare plant potential.

Table D3.2-10 Rare Plant Potentials for the 1997 Survey Inspection Sites

Ecosite Phase	Rare Plant Potential[a]
Lichen Pj (a1)	M
Blueberry Pj-Aw (b1)	H
Blueberry Aw (b2)	M
Blueberry Aw-Sw (b3)	M
Blueberry Sw-Pj (b4)	H
Labrador Tea-mesic Pj-Sb (c1)	L
Low Bush Cranberry Aw (d1)	L
Low Bush Cranberry Aw-Sw (d2)	M
Low Bush Cranberry Sw (d3)	H
Dogwood Pb-Aw (e1)	H
Dogwood Pb-Sw (e2)	H
Dogwood Sw (e3)	H
Labrador Tea-subhygric Sb-Pj (g1)	M
Labrador Tea/Horsetail Sw-Sb (h1)	M
Black Spruce-Tamarack Complexes	M
Shrubland	M
Wooded Bog (BTNN/BFNN)	H
Wooded Fens (FTNN/FFNN)	H
Graminoid Fens (FONG)	H
Shrubby Fens (FONS)	H
Marshes (MONG/MONS)	H
Wooded Swamps (SFNN/STNN)	H
Shrubby Swamps (SONS)	M

[a] H = High, M=Moderate, L= Low

Table D3.2-11 Rare Plant Habitat Potential Impact Within the LSA

Rare Plant Potential	Pre-Development		Impact Area: Steepbank		Impact Area: East Bank Mining Area		Closure: East Bank Mining Area	Closure: LSA		% Change in LSA
	(ha)	%	(ha)	%	(ha)	%	(ha)	(ha)	%	
High	11,437	71	2,565	22	7,023	61	2,616	7,030	43	-28
Moderate	1,049	6	263	25	373	36	3,539	4,215	26	+20
Low	3,695	23	948	26	1,884	51	3,125	4,936	31	+7
Total	**16,181**	**100**	**3,776**		**9,280**		**9,280**	**16,181**	**100**	

While communities identified as having rare plant potential will be established at closure, in the short term, their ability to support rare plant habitat may be limited.

In summary, the impact of the Project Millennium operations on rare, vulnerable, threatened or endangered plant species or communities is negative in direction and high in magnitude, given that 61% of potential rare plant habitat (high potential) within the LSA will be cleared. However, losses will be offset by re-establishment of suitable habitat at closure. The total high and moderate rate plant habitat potential areas will decrease from 12,486 ha to 11,245 ha or a loss of slightly less than 10%. As a result the impact is considered negative in direction, low in magnitude and local in geographic extent. The frequency of the impact is low, occurring only during the initial clearing. The environmental consequence is considered low.

Traditional Plants (Food, Medicinal and Spiritual)

A variety of plants in the LSA are used for medicinal, spiritual and consumptive purposes. An investigation conducted by the Fort McKay First Nations people was used to develop a list of traditional plants in the LSA (Table D3.2-12). Each plant species was ranked as either high, high-moderate, moderate or low according to importance (Table D3.2-12). This ranking system was based on a review of traditional land uses completed by the Fort McKay First Nations (Fort McKay Environmental Services, 1995). High, moderate or low were assigned to each species based on the number of times a species was occurred within a specific region of the traditional land use maps (Golder 1996).

Table D3.2-12 Plants Gathered for Food, Medicine and Spiritual Purposes in the Area of the Project Millennium

Plant	Food	Medicine	Spiritual	Ranking
Alder		x		moderate
Aspen		x		high
Balsam fir		x		high
Bearberry	x		x	high
Black poplar (balsam poplar)		x		high
Blueberry	x			high
Bunchberry	x	x		high
Cranberry (low-bush and bog)	x			high
Labrador tea		x		high
Mint	x	x		high
Moss		x		high
Rose hips (prickly rose)	x	x		high
Senega Snakeroot		x		high
Spruce (white and black)	x	x		high
Strawberry	x	x		high
Sweet flag (rat root)		x		high
Sweet grass		x	x	high
Tamarack		x		high
Birch (white and bog)	x	x		moderate- high
Buffaloberry	x	x		low
Common juniper	x	x		low
Red currant and black gooseberry	x	x		low
Twisted stalk	x			low
Dogwood	x			moderate
Frying pan plant		x		moderate
Green frog plant (pitcher plant)		x		moderate
Hazelnuts	x			moderate
Nettles	x	x		moderate
Pin- and Chokecherry	x	x		moderate
Raspberry (dwarf and trailing)	x	x		moderate
Saskatoon berry	x	x		moderate
Fungi (Puffball)		x		moderate-high
Willow		x	x	moderate-high
Cattail	x			high

Beckingham and Archibald's (1996) classification system was used to assign ecosites to each identified plant species. The ecosites listed for each traditional plant are based on the list of *dominant* vegetation species for each ecosite. As such, a traditional plant species may not always be found in the assigned ecosites, although the probability is high that they will occur there. Conversely, traditional plant species may be found outside of the assigned ecosites. In short, assigning ecosites to each plant species is a tool to approximate the area where traditional plants may be found.

By using traditional plant species rankings for each ecosite phase within the LSA, impacts on traditional plant species were assessed by comparing pre-development, the Steepbank Impact and the Project Impact for each of the ecosites (Table D3.2-13). It is possible to quantify impacts on traditional plant species, by assessing ecosite losses associated with high, moderate and low traditional plant rankings.

Most of the traditional use of plants identified can be found in multiple ecosite phases within the LSA. Accordingly, many of the plants can potentially be found over large areas within the LSA. For example, prickly rose (rose hips), which is used for food or medicinal purposes, may be found in 84% of the LSA (Golder 1998l). A few traditional plants, including mint, nettle, hazelnut, pin-and choke cherry and cattail are found in only one or two ecosite phases or wetlands. In addition, two of the plants are only found in a small area (<5%) of the LSA (Table D3.2-13).

As most of the traditional plants in the LSA are widespread in the LSA, losses associated with construction and operation are equally distributed across all species. In addition, none of the plants occurring within only one ecosite, or having a limited distribution, will be severely effected. Indeed, none of the traditional plant habitats will be completely removed by project development.

As already discussed, plans to establish plant communities on reclamation landscapes involve the introduction of 'starter species' (see Section E of Volume 1 of the Application). Succession then acts as the mechanism for establishing the desired community type. As such, the diversity of reclaimed plant communities increases over time, resulting in vegetation associations and communities more similar to the pre-development conditions than immediately following reclamation. Once ecosites have re-established, it is assumed that traditional plant populations will eventually be similar to those found in pre-development ecosites.

Table D3.2-13 Losses/Alterations of Traditional Plant Species Within the LSA

Plant	Importance	Ecosite	Pre-Development		Steepbank Mine Impact		East Bank Mining Area		Closure		Final Landscape		% Change in the LSA
			(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)	%	
Balsam fir	H	d1, d2, d3, e2, e3	5,067	31	1,236	8	2,258	14	3,909	24	6,718	42	+10
Beaked hazelnut	M	d1	3,348	21	3,348	21	1,207	7	1,207	7	2,775	17	-4
Balsam poplar	H	d1, d2, d3, e1, e3	5,152	32	1,239	8	2,279	14	5,517	34	8,390	52	+20
Black gooseberry	L	d1, d3, e3	4,416	27	1,160	7	2,109	13	1,635	10	3,942	24	-3
Black spruce	H	b1, d1, FONS, FTNN, SFNN, STNN	13,024	80	3,136	19	8,340	52	1,503	9	6,187	38	-42
Bog birch	H	d1, FTNN, SFNN, STNN	12,372	76	2,928	18	7,870	49	1,318	8	5,820	36	-40
Bog cranberry	H	b1, b4, d3, FTNN, SFNN, STNN	10,241	63	2,352	15	6,600	41	444	3	4,085	25	-38
Buffaloberry	L	b1, b4, d1, d2, d3, e1, FTNN	12,343	76	3,150	19	7,403	46	5,749	36	10,689	66	-10
Choke cherry	M	d3	941	6	941	6	151	1	151	1	777	5	-1
Common bearberry	H	b1, b4, d2, d3	1,805	11	407	3	645	4	2,604	16	3,764	23	+12
Common blueberry	H	b4, d3	991	6	249	2	365	2	153	1	779	5	-1
Common cattail	H	FTNN, MONS, SFNN	6,921	43	1,721	11	4,799	30	56	0	2,178	13	-29
Dwarf blueberry	H	b1, b4, d1, d2, FTNN, SFNN, STNN	13,236	82	3,123	19	8,200	51	3,771	23	8,807	54	-27
Dwarf raspberry	M	d1, FONS, FTNN, STNN	11,145	69	2,725	17	7,270	45	1,300	8	5,175	32	-37
Labrador tea	H	b1, b4, d1, d2, d3, e3, FONS, FTNN, SFNN, STNN	14,730	91	3,470	21	8,854	55	4,204	26	10,080	62	-29
Low-bush cranberry	H	d1, d2, d3, e1, e3	5,152	32	1,239	8	2,279	14	5,517	34	8,390	52	+20
Moss species	H	d1, d3, e1, e3, FONS, FTNN, SFNN	12,095	75	3,106	19	7,426	46	3,581	22	8,250	51	-24
Pin cherry	M	d1	3,348	21	3,348	21	1,207	7	1,207	7	2,775	17	-4
Pitcher plant	M	FONS, FONG, FFNN, FTNN, BTNN	7,454	46	1,902	12	5,271	33	58	0	2,241	14	-32
Prickly rose	H	b1, b4, d1, d2, d3, e1, e3, FTNN, SFNN, STNN	14,516	90	3,388	21	8,564	53	6,084	38	12,036	74	-15
Red-osier dogwood	M	d1, d2, d3, e1, e3	5,216	32	1,248	8	2,279	14	5,791	36	8,728	54	+22
Saskatoon	M	d1, d2, e1	4,148	26	1,011	6	1,950	12	5,363	33	7,561	47	+21
Stinging nettle	M	FONS, MONG	533	3	122	1	339	2	6	0	200	1	-2
Sweet flag	H	MONG	107	1	107	1	1	0	1	0	94	1	0
Tamarack	H	b1, d1, FONS, FTNN, SFNN, STNN	13,024	80	3,136	19	8,340	52	1,503	9	6,187	38	-42
Velvet-leaved blueberry	H	b1, b4, d1, d2, d3	5,153	32	1,330	8	2,425	15	3,811	24	6,539	40	+9
White birch	M	d1, d2, d3, e1, e3	5,216	32	1,248	8	2,279	14	5,791	36	8,728	54	+22
White spruce	H	b1, b4, d1, d2, d3, e1, e3, FTNN	12,470	77	3,175	20	7,417	46	6,026	37	11,079	68	-9
Wild mint	H	FONS, MONG	430	3	110	1	328	2	5	0	107	1	-2
Wild strawberry	H	b4, d1, d2, d3, e3, FONS, FTNN, SFNN, STNN	14,504	90	3,372	21	8,709	54	4,024	25	9,819	61	-29

[a] H = High, MH - Moderate-high, M = Moderate, L = Low

Landscapes in the Project will largely be reclaimed to terrestrial (upland) communities. As such, upland traditional plants, such as balsam fir, balsam poplar, white spruce, prickly rose, currents, pin- and choke cherry and raspberry, will potentially be found over a much larger area in the future. Those traditional plants associated with wetland areas such as, black spruce, tamarack, bog birch, common cattail, dwarf raspberry, Labrador tea, moss, sweet flag, nettle and mint will have a more limited range than before project development.

The average reduction in area available to traditional use plant species having a rating of moderate or higher within the LSA (comparing pre-development to closure) is slightly less than 10%. The impact of Project Millennium on traditional plant habitat potential is therefore negative in direction and low in magnitude. The geographic extent is local and the duration is long-term (greater than 30 years). The frequency of the impact is low, occurring only once during the initial clearing for Project Millennium (Table D3.2-20). The environmental consequence is considered low.

Summary

A total of 9,281 ha of vegetation will be removed to develop the east bank mining area. A summary of the residual impacts affecting the Key Indicator Resources for terrestrial vegetation due to loss or alteration of habitat as a result of construction and operation is found in Table D3.2-14.

Table D3.2-14 Residual Impacts for Loss or Alteration Key Indicator Resources

KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
old-growth forests	negative	high	local	life of project	reversible	occurs once during life of mine	high
riparian shrub complexes	negative	low	local	life of project	reversible	occurs once during life of project	low
plant communities of economic importance (aspen-white spruce forest)	positive	high	local	life of project	reversible	occurs once during life of mine	negligible
rare/endangered plants or communities (high rare plant potential habitat)	negative	moderate	low	life of project	reversible	occurs once during life of mine	low
traditional use plants	negative	low	local	life of project	reversible	occurs once during life of mine	low

The primary residual impacts associated with replacement of plant communities includes:

- a change in dominant vegetation type from wetlands to terrestrial ecosite phases;
- a decrease in areas of old-growth spruce and lichen jack pine forests;
- a decrease in potential rare plant habitat;
- an increase in the plant communities of economic importance, such as aspen white spruce forest; and

- a decrease in traditional use plant species.

The only key indicator resource assessed as having both a high magnitude and negative direction is old growth forests. An assessment of old growth forests within the LSA is considered to have a high environmental consequence based on the rating system used.

In summary, the overall impact of the east bank mining area development on "old-growth" forest is negative in direction and high in magnitude, given that 21% of the old-growth forest communities will be cleared by the project. However this assessment must be tempered by the following:

- the net increase of old growth forest impact over the approved Steepbank Mine area is only 9 ha or 2% of the old growth forest within the LSA;
- the creation of more upland conditions after closure will ultimately allow for substantially greater old growth forest in the far future; and
- the loss of old growth forest (92 ha) is low in terms of the total amount in the RSA.

Based on the above-noted factors, the loss of old growth forests due to development of the east bank mining area, and particularly the loss due to Project Millennium development, is not considered to be significant.

D3.2.7.4 Ecosite Phase Impacts

The impact classification associated with the specific ecosite phases and wetlands is shown in Table D3.2-15. Impacts to lichen Pj (a1), blueberry Aw(Bw) (b2), blueberry Aw-Sw (d3), blueberry Sw-Pj (b4), Labrador tea-mesic Pj-Sb (c1) and Labrador tea-subhygric Sb-Pj (g1), are expected to be high. However, these ecosite phases comprise less than 1% of the LSA so the environmental consequence is moderate. Impacts to other ecosite phases will be high during construction and operation, however, re-establishment of these ecosite phases during reclamation will result in low residual impacts.

Impacts to all fens (FTNN/FFNN/FONG/FONS) are high both in magnitude and duration in the LSA. Shallow open-water wetlands are largely associated with fens systems and therefore, impacts to these systems are also high. Approximate 2,195 ha or 30% of fens will remain in the LSA following closure. In addition, fens are well represented in the RSA (approximately 40% of the RSA) as discussed in the Cumulative Effects Section of this EIA. As such the environmental consequence is not significant.

Impacts to swamps, including coniferous, deciduous and shrub are expected to be high. However, there will be less of an impact to riparian swamps. Swamps in the RSA are well-represented accounting for approximately 20% (Vitt et al. 1996). As such the environmental consequence although high is not considered significant.

It is predicted that impacts to marshes and bogs will be low since they are situated away from the mine development area and outside the aquifer drawdown area. The Hydrology Impact Section (C2.2) provides a detailed analysis of impact to rivers and lakes.

On-going research suggests that the impact of CT water on plant communities re-establishment is dependent upon plant species sensitivity. Preliminary data indicates that some tolerant species are able to grow in the presence of CT water. However, due to the high variability of CT water quality and lack of information concerning the effects on plant communities as a whole, the impact of CT water on reclamation plant communities is unclear. Future research will provide more information than presently available and monitoring of reclamation communities will be needed after closure to assess plant community health.

CT seepage water may also impact soils and therefore indirectly impact plants. The presence of CT water is linked with increasing soil salinity and build up of heavy metals in soils. The impact of increasing salinity and presence of heavy metals in soils on plants is dependent upon solid type/characteristics as well as plant species sensitivity.

The results of development of the Project are that large areas of wetlands are replaced with terrestrial ecosite phases. The net impact for wetlands communities in the LSA is of high magnitude. The net impact for terrestrial vegetation communities in the LSA is also of high magnitude in a positive direction. The environmental consequence of this change is rated as low, because of the off-setting negative and positive high magnitude impacts.

Table D3.2-15 Residual Impact Classification on Ecosite Phases and AWI Classes in the Local Study Area

Ecosite Phase	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Lichen Pj (a1)	negative	high*	local	life of project	reversible	occurs once during life of mine	moderate
Blueberry Pj-Aw (b1)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Blueberry Aw(Bw) (b2)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Blueberry Aw-Sw (b3)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Blueberry Sw-Pj (b4)	negative	high*	local	life of project	reversible	occurs once during life of mine	moderate
Labrador Tea-mesic Pj-Sb (c1)	negative	high*	local	life of project	reversible	occurs once during life of mine	moderate
Low Bush Cranberry Aw (d1)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Low Bush Cranberry Aw-Sw (d2)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Low Bush Cranberry Sw (d3)	negative	low	local	life of project	reversible	occurs once during life of mine	negligible
Dogwood Pb-Aw (e1)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Dogwood Pb-Sw (e2)	negative	low	local	life of project	reversible	occurs once during life of mine	negligible
Dogwood Sw (e3)	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Labrador Tea-subhygric Sb-Pj (g1)	negative	high*	local	life of project	irreversible	occurs once during life of mine	moderate
Labrador Tea/Horsetail Sw-Sb (h1)	negative	low	local	life of project	reversible	occurs once during life of mine	negligible
Black Spruce-Tamarack Complexes	negative	high*	local	life of project	reversible	occurs once during life of mine	moderate
Shrubland	positive	low	local	life of project	reversible	occurs once during life of mine	negligible
Wooded Bog (BTNN/BFNN)	neutral	low	local	life of project	reversible	occurs once during life of mine	negligible
Wooded Fen (FTNN/FFNN)	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Shrubby Fen (FONS)	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Graminoid Fen (FONG)	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Marsh (MONG/MONS)	negative	low	local	life of project	irreversible	occurs once during life of mine	low
Coniferous Swamps (STNN/SFNN)	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Deciduous Swamp (SONS)	positive	low	local	life of project	reversible	occurs once during life of mine	low
Shallow Open Water (WONN)	negative	high	local	life of project	irreversible	occurs once during life of mine	low

* High, however, these ecosite phases comprise less than 1% of LSA.

D3.2.7.5 Closure Drainage System

At mine closure, a drainage system will direct drainage of CT seepage water to the end pit lake. In the reclamation plans, CT deposits will be capped with either sand or overburden.

Primary issues of concern for terrestrial vegetation communities include:

- impact of the underlying CT deposits on plants;
- impact of CT water and CT drainage on plants; and
- impact of CT water and CT drainage on soils, and indirectly to plants.

Due to the depth of overlying sand and overburden layers (1 to 5 m), plant root systems will not penetrate to the underlying CT. Therefore, underlying CT is not expected to directly impact reclamation plant communities.

The end pit lake will be located at the southwest area of the mine footprint at closure. Terrestrial reclamation communities on the shore of the lake are not expected to be impacted by the CT water in the end pit lake.

D3.2.7.6 Monitoring

Soil sampling and monitoring of reclaimed plant communities will be needed both during operations and during the final reclamation period. The monitoring program will be designed to address:

- whether both primary (i.e., forest capability and moose habitat) and complementary (e.g. biodiversity, drainage) land use objectives are being met;
- impact of CT water on reclamation plant communities; and
- impact of CT water on soil (i.e., salinity and build-up of heavy metals) and therefore, reclamation plant communities.

D3.2.8 Key Question VE-2: What Impacts will Air Emissions and Water Releases from Project Millennium have on Vegetation Health?

D3.2.8.1 Emissions

Acidifying emissions from oil sands operations which may affect vegetation health include sulfur pollutants (SO_2, H_2S and H_2SO_4), NO_x and PAI). PAI is a measure of all potential acidic impacts, that takes into account deposition of SO_2 and NOx, as well as other relevant factors (see Air section, B3).

Varying concentrations of these acidifying emissions can potentially affect vegetation health, depending on dosage, plant sensitivity and environmental conditions. The sensitivity of plants to SO_2 fumigation is fairly well documented; numerous single species laboratory and field studies as well as a few whole ecosystem studies have been completed. The importance of NOx as an acidifying emission has only been recognized relatively recently.

While NOx contributes to the acidification, at low levels, it may also have a fertilizer effect (increase in growth) (Rochefort and Vitt 1988; Mansfield et al in Hutchinson 1987). However, this initial fertilizer effect may have deleterious effects in the long run; for example plants exposed to low levels of NOx may have reduced tolerance of frost, drought and heat stress (Levitt 1972 cited in Mansfeild et al 1987 in Hutchinson and Meema 1987).

D3.2.8.2 Mechanisms of Injury

Injury may occur as a result of direct effects, indirect effects and/or secondary effects.

Direct effects may result when plants absorb gases or liquids containing sulfur and/or other harmful compounds through their leaves. Direct effects may result in acute injury from exposure to relatively high concentrations for a short period of time (i.e., less than 24 hours), or chronic injury from exposure to relatively low concentrations over a long period of time (i.e., greater than days, months or years) (Linzon, 1978 cited in Federal-Provincial Advisory Committee on Air Quality 1987). In recent years, attention has been paid to subtle, long-term effects of relatively low concentrations of SO_2, as sulfur compounds can accumulate in plant tissues and soils and adversely affect plant growth after a number of years (Linzon, 1978 cited in Nriagu 1978).

Malhotra and Blauel (1980), Torn *et al.* (1987), Treshow (1984) and Legge et al (1988) have reviewed the direct effects of SO_2 on vegetation. SO_2 enters leaves mainly through the stomata. Injury initially takes place at the biochemical level (interference with photosynthesis, respiration and lipid and protein synthesis). This progresses to the ultra-structural level (disorganization of cellular membrane) and to the cellular level (cell wall, mesophyll and nuclear breakdown) and finally, visible symptoms (chlorosis and necrosis of foliar tissue). Other impacts include disruption of reproduction and decreases in growth and annual yields; both of these effects have been found in the absence of visible symptoms (Wilslicenus 1901 and Stoklasa 1923 cited in Nriagu 1978).

Diagnosis of air pollutant stress based on visible symptoms can be difficult. Visible symptoms caused by air pollutants are not highly specific, and often mimic symptoms caused by natural stress such as drought, excessive water, nutrient deficiency, diseases or insect infestation (Malhotra and Blaudel 1980; Treshow 1984).

Indirect effects are produced when acidifying emissions change the chemistry or biology of soil or water which, in turn, influences the amount and type of nutrients and toxic elements taken up by plants. The most common problem is a reduction in soil pH, which changes nutrient availability (Forest Soils Group Summary in Hutchinson an Meema 1987). A soil sensitivity rating for acidic emissions is presented in section D2.2.

Secondary effects are produced when stress or injury from SO_2 concentrations predisposes plants to another source of stress or injury such as insect infestation, disease, drought or frost (World Health Organization (WHO) 1987). Greater infestations of insect pathogens are documented for plants growing in atmospheres enhanced with SO_2 and NOx (Port and Thompson 1980; Dohmen et al 1984; cited in Hutchinson 1987). However, some degree of soil acidification may reduce incidence of disease (Gorham 1984).

D3.2.8.3 Responses of Plants to Air Pollution

Plant responses to air pollution depend on a number of factors, such as dose, species sensitivity (sensitive versus resistant), plant development, time of year (dormancy vs. active growth), atmospheric conditions (temperature, humidity, and wind speed and direction), soil and nutrient status and time of day (gas exchange capability or open versus closed stomata).

Dose-Response Relationships

Both concentration and the length of exposure are important in determining potential effects of acidifying emissions (Malhotra and Blauel 1980). Numerous SO_2 fumigation studies provide information on the types of symptoms observed at various concentrations over various periods of time (Linzon 1978). In general, the higher the concentration of acidifying emission, the less time needed to see visible symptoms (both acute and chronic) (Legge 1995). However, other factors such as recovery time between exposures or frequency of exposure events are also important. For example, one large scale event may not necessarily have a deleterious effect on vegetation, while longer exposures or short, intermittent exposures have both been found to cause chronic effects. Sensitivity of vegetation to air pollutant also increases with a history of exposure (Harvey and Legge 1979, Keller, 1984, Keller, 1985 and Mclaughlin and Tayler 1985 cited in Legge 1995; Mansfield et al 1987 cited in Hutchinson and Meema 1987).

Plant responses can also effect dose-response relationships. For example, Mansfield et al (1987 in Hutchinson and Meema 1987) found that higher concentrations of SO_2 and NOx caused less damage in some plants. They suggested that higher concentrations of airborne pollutants may cause stomatal closure, thereby reducing the actual dose received by the plant.

D3.2.8.4 Sensitivities

Single Species Sensitivity

Plants differ in their susceptibility to damage from emissions. This susceptibility is a function of plant type (vascular vs. non-vascular), species and genotype. Lichens and mosses are considered the most sensitive plant groups to air emissions because they absorb all their nutrients from the air and rain water (Addison *et al.* 1986, Anderson and Treshow 1984, Baker 1989, Malhotra and Blauel 1980 and Treshow 1984). In addition, trees with long life cycles suffer from long-term exposure, because subtle effects can build-up year after year to produce harmful effects (WHO 1987, Huttenen 1984). Deciduous species generally develop symptoms of stress to air emissions more rapidly than coniferous species (Malhotra and Blauel 1980, Addison *et al.* 1986). However, conifers, because of their long foliar retention time, can accumulate more contaminants than deciduous species, which lose their leaves annually (Addison *et al.* 1986).

Lichens

Lichens have been extensively studied, especially in Europe, due to their high sensitivity to air emissions. This sensitivity is due to a number of factors, including: lack of protective cuticle (that is found in higher plants); absorption of most nutrients requirements from the atmosphere (rather than the soils); relatively less chlorophyll than other plants; and the inability of lichens to excrete toxic elements coupled with efficient mechanisms for accumulating them (Hale, 1974). SO_2 is considered the primary cause of lichen loss. Laboratory studies have shown that the algal components of lichen are extremely sensitive to sulphurous acid and sulphates. Exposure to these compounds has been found to convert chlorophyll-*a* to phaeophytin-*a* by the loss of magnesium; this conversion disrupts photosynthesis by algal cells and the delicate balance between alga and fungal cells (Hale, 1974).

Loss of lichens from large urban centres was first documented 100 years ago in Europe (Hale 1974). Other notable decreases include drastic reduction of epiphytic lichens on balsam poplar at Sudbury where SO_2 levels were over 0.02 ppm or approximately 53 $\mu g/m^3$ (Leblanc et al 1972 cited in Nriagu 1978). Low lichen species diversity was found in the Tyne Valley in England when annual average SO_2 concentration was above 0.016 ppm or approximate 42 $\mu g/m^3$ (Gilbert 1969 cited in Nriagu 1978).

Hutchinson et al (1987) found that stimulated rain (acid sprays) with a pH to 2.5 to 3.0 resulted in declines in percent cover as well as decreases in height, dry weight, net photosynthesis of surviving lichens. Interestingly, small decreases in rain pH (pH=5.6 to 3.0) were found to stimulate growth; this is thought to be a result of NOx fertilizer effect.

General statements can be made about sensitivity of various lichen types. Growth form appears to be an important predictor of sensitivity; crustose has been found to be most resistant to air pollution, while foliose and fruiticose lichens are more sensitive (Hale 1974; Linzon 1978 in Nriagu 1978). Generally, soil inhabiting lichens are less sensitive than corticolous lichens, while saxicolous (rock-inhabiting) lichens sensitivity is somewhat dependent on substrate (Hale 1974). In addition, sensitivity is also dependent on species and genotype (Hutchinson et al 1987 in Hutchinson and Meema 1987).

Mosses (bryophytes)

Mosses have also been identified as particularly sensitive to acidifying emissions. Like lichens, mosses lack a cuticle. Experiments carried out be Hutchinson et al (1987 in Hutchinson and Meema 1987) found that feather moss (*Pleurozium schreberi*) was especially sensitive to acidic rains in the boreal forest, while lichens are somewhat less sensitive. Winner and Atkinson (cited in Hutchinson and Meema 1987) found that differences SO_2 absorption between mosses and vascular plants could be as much as 400 fold in any one habitat. Severe effects on feather moss were found at pH< 3.5, with pH 2.5 causing almost complete elimination of the feather moss mat. All acidic inputs (pH <5.6) were found to deplete Ca and Mg in shoot tips (Hutchinson et al 1987 in Hutchinson and Meema 1987).

However, low levels of acidifying emissions have been found to have a fertilizer effect on some species of mosses (Bayley et al 1987; Hutchinson et al 1987 in Hutchinson and Meema 1987; Rochefort and Vitt 1988). Small decreases in pH may not have a deleterious effect, if NOx is, at least partially, the source of this increased pH. This is because, particularly in oligotrophic environments where nitrogen may be limiting, the NOx acts as a nitrogen source. If pH decreases further, any fertilizer effect is outweighed by the damage caused by low pH (Rochefort and Vitt 1988). Both longer term exposure to acidic deposition and supra-optimal levels of nitrate have been cited as the cause of the virtually disappearance of Sphagnum species from bogs in the southern Pennines of England (Bayley et al 1987; Lee et al 1987 in Hutchinson and Meema 1987). As with lichens, other pollutants such as particulates may effect mosses (Pauls 1996).

Since the lichen/moss layer is an important moisture retaining layer in the boreal forest, any loss of integrity will cause increased downward leaching, increased soil temperature and drying, changes in microbial flora and fauna, and loss of seed bed material (Hutchinson et al in Hutchinson and Meema 1987).

Trees, Shrubs and Herbaceous Species

Based on both laboratory, field and ecosystems studies a number of trees have been identified as sensitive to SO_2, pH and total acidifying emissions.

Table 3.2-16 presents plant sensitivities based on a literature review. Although some evidence suggests that herbaceous species have a higher rate of recovery to pollutant exposure than woody species, the information on shrub and herbaceous species is incomplete (Mansfield et al 1987 in Hutchinson and Meema 1987). As such, they will not be included in the sensitivity assessment.

Table 3.2-16 Plant Sensitivity to Acidifying Emissions

Plant Species	Common Name	Ranking
TREES		
Balsam fir	*Abies balsamea*	Medium [a, b]
Balsam Poplar	*Populus balsamifera*	Low [a]
Black Spruce	*Picea mariana*	Unknown
Jack Pine	*Pinus banksiana*	High [a]
Paper birch	*Betula papyrifera*	High [a]
Tamarack	*Larix laricina*	Unknown
Trembling aspen	*Populaus tremuloides*	High [a]
White spruce	*Picea glauca*	Medium [a, b]
MOSSES		
Brown moss	*Drepanocladue* spp.	High [a]
Feather moss	*Pleurozium schreberi*	High [a]
Golden moss	*Tomenthypnum nitens*	Variable [a, g]
Knight's plume	*Ptilium crista-castrensis*	High [a]
Peat moss	*Sphagnum spp.*	Variable [a,d,e]
Stair-step moss	*Hyloconium splendens*	High [a]
LICHENS		
Lichen	*Cladina spp.*	High [a, b, f]
Lichen	*Stereocaulon lividum*	High [a, b, f]
Reindeer lichen	*Cladina spp.*	High [a, b, f]

a Linzon, 1978
b Treshow, 1984
c Hutchinson et al, 1987 in Hutchinson and Meema 1987
d Gorham et al, 1987 in Hutchinson and Meema 1987
e Bayley et al, 1987
f Hale, 1974
g Rochefort and Vitt, 1988

Relative Sensitivity and Shifts in Species Composition.

Due to relative sensitivity of different genotypes and species, acidifying emissions may act as a selective pressure both within species and between species (Hutchinson et al 1978 in Hutchinson and Meema 1978). Discussions of shifts in genotype frequency are beyond the scope of this discussion. Shifts in species composition and dominance could have an important effect on plant communities: a number of examples exist

The most sensitive tree species, eastern white pine (*Pinus strobus*), was not observed within 30 miles, of the sinter plant at Sudbury, while white spruce (*Picea glauca*), black spruce *(P. marianna),* Aspen *(Populus tremuloides)* were not found within 15 miles.

Analysis of spatial distribution of lichens around pollution sources has found that outside of the central 'no-lichen' zone falls zones of improvised and/or tolerant lichens species, beyond this is a transition to native lichen flora. In addition, some types of lichens are only found in polluted areas (Hale 1978).

The fertilizer effect of NOx will likely be differentially beneficial depending on moss species and microhabitat. For example, acidophillic Sphagnum species, especially when found in oligotrophic conditions, showed increased growth with artificial acid input (Bayley et al, 1987; Rochefort and Vitt 1988). As such, acidification may cause shifts in species composition, abundance and biodiversity. Shifts in bryophyte communities may have effects on peatlands (Rochefort and Vitt 1988).

D3.2.8.5 Ecosystem Sensitivity

The number of ecosystem studies is limited, Legge, 1995, identifies two important studies at Trail, B.C., and Sudbury, Ontario. However, existing data indicate that species occurring in natural ecosystems are less sensitive to emissions than individual species (for example Linzon 1978 cited in Nriagu 1978). Studies carried out in Trail, B.C. by Katz and McCallum (1984) found that transplanted conifers grown under artificial conditions were more susceptible to SO_2 exposure than the same conifers in their natural environment (Cited in Legge 1995).

D3.2.8.6 Terrestrial Ecosystems

Study of acidifying emissions and terrestrial ecosystems has largely focused on agro-ecosystems and forest ecosystems. Generally, studies focus on specific sensitive species, and make few conclusions with regard to sensitive community types or ecosystems. However, a number of studies have focused on general trends observed in areas of forest dieback.

Airborne pollutants, including acidifying emissions and ozone, have been identified as a factor in large scale forest dieback in northern Europe and the northeastern United States (Forest Soils Group Summary in Hutchinson an Meema 1987). Studies have focused on nutrient deficiency as a primary cause of forest decline. Thomlinson (1987 in Hutchinson and Meema 1987) found that leaf colour changes that precede early abscission and premature tree death were the result of nutrient deficiency. Specifically, foliar concentrations of magnesium, calcium and potassium were found to be low in effected trees. Acidifying emissions have been identified as a possible cause of nutrient leaching and subsequent deficiency in foliar tissue. Furthermore, replacement of nutrients in leached foliar tissue is limited by changes in nutrient availability in increasingly acidic soil.

Acidic imputs may also effect tree root systems, causing them to move closer the soil surface; this would increase susceptibility to drought and blow-downs (Legge, A., per. comm.)

As such, forest ecosystems with nutrient poor soils have been identified as particularly sensitive (Forest Soils Group Summary in Hutchinson an Meema 1987).

D3.2.8.7 Wetland Ecosystems

The impact of acidic emissions on peatlands has been ignored in the past, as the naturally acidic ecosystems were deemed 'resistant' to acidic emissions. Gorham et al (1984 and 1987 in Hutchinson and Meema 1987) found sensitivity of peatlands to acidic inputs depends upon level of buffering.

Wetlands can be subdivided into mineral wetlands and peatlands based on annual peat accumulation. Peatlands are defined as a wetland ecosystem depositing of >30cm of peat and include fens and bogs (Gorham et al 1984). Peatlands systems can be further subdivided into rich fen, poor fen, and bog. Fens are minerotrophic, receiving mineral-rich water from groundwater sources; with rich fens being relatively more minerotrophic/nutrient rich than poor fens. Bogs are ombrotrophic, receiving water and nutrients from rain water only; as such they are relatively nutrient poor. Rich fens are high in base ions and thus, have relatively high alkalinity. Bogs are buffered by humic substances and aluminum species. As such, both rich fens and bogs are thought to be relatively resistant to acidic inputs. Poor fens, whose surface waters have low alkalinity, are about pH 6 and whose peats are wholly organic with very little input of silt are expected to be susceptible to acidification. (Gorham 1967 cited in Gorham 1984).

Rapid change in pH in unbuffered fens have not been documented. However, natural peatland succession from fens to bogs, with accompanying rapid changes in pH can be inferred from the bimodal frequency distribution of pH in peatlands. A study of peatlands in Minnesota shows the bog mode at pH 4 and fen mode at pH 6, with relatively few sites in the intermediate range (Gorham et al 1987 in

Hutchinson and Meema 1987; Gorham et al 1984). With these shifts in pH come shifts in species composition and abundance.

The invasion of vulnerable fens by Sphagnum species as pH decreases has been identified as a potentially serious effect of acidification. As Sphagnum species produces organic (polyuronic) acids, invasion by Sphagnum would likely further acidification (Gorham et al (1987 in Hutchinson and Meema 1987).

Recent studies find that peatlands, at least in the short term, are somewhat resistant to acidic inputs. Braekke (1981 cited in Gorham 1984) found that peatlands were more efficient sinks for sulphate, nitrate and hydrogen ion than other terrestrial ecosystem studied. Bayley et al (1987) found that monthly acid additions to a poor fen in northwestern Ontario over two growing seasons did not result in any long term changes (i.e. > than 14 days) in nitrate, sulphate or pH. They concluded that over the year and a half study, the poor fen acted as a sink for SO_4^{2-} and NO_3^-. However, they also found that the growth of acidophillic Sphagnum increased, especially in oligotrophic microenvironments (i.e. hummock-tops which are isolated from groundwater). This increase in growth was largely attributed to the fertilizer effect of nitrogen input.

The long term effect of acidic deposition on peatlands is unknown. Loss of Sphagnum species from bogs in the southern Pennines of the U.K. has been attributed to long term exposure to extreme acidic deposition (Bayley et al 1987; Gorham et al 1984; Gorham et al 1987 in Hutchinson and Meema 1987).

Both hydrology and the presence of permafrost can change the effect of acidic emissions. Groundwater drawdown or drainage of peatlands associated with mine development may result in an 'acid pulse' as many years' deposition of reduced sulfur to reoxidized in a short period of time. Alternately, peatlands where permafrost is present may be less effected by acidic deposition as permafrost restricts the volume of peat accessible to peat deposition (Gorham et al 1984).

D3.2.8.8 Other Factors

Plants are constantly exposed to natural stresses such as drought, excessive water, nutrient deficiency, diseases or insect infestation. Among the many natural stresses that plants experience, acidifying emissions are probably minor (Forest Soils Group Summary in Hutchinson an Meema 1987). Studies of forest dieback in Europe and the northeast United States suggest that severe and prolonged drought followed by a colder than normal winter may have initiated large scale forest dieback in certain areas (Forest Soils Group Summary in Hutchinson and Meema 1987). However, the effects of acidification may cause forest ecosystems to be more sensitive to other stresses (Forest Soils Group Summary in Hutchinson an Meema 1987).

Vegetation damage due to acidifying emissions can occur on a number of different fronts, therefore numerous other factors must be considered to accurately assess effects (Linzon 1978 cited in Nriagu 1978). Damage from gaseous emissions occurs primarily through gas exchange at leaf stoma, therefore, time of day (gas exchange capability or open versus closed stomata), time of year (dormancy vs. active growth) and atmospheric conditions (temperature, humidity, and wind speed and direction) must be considered. Katz and McCallum found trees to be extremely resistant to SO_2 outside of active growing season (cited in Legge 1995). Evidence indicates that acidifying emission alter nutrient cycling within effected ecosystems; as such, existing soil and nutrient status must be taken into consideration (Forest Soils Group Summary in Hutchinson an Meema 1987; Gorham et al 1984).

In the field, plants experience total air emissions. Unfortunately sensitivity data is typically developed in labs, and based on one emission source at a time. As emissions rarely occur in isolation, possible synergistic, additive, or antagonistic effects of emissions should be considered. For example, emissions of SO_2 are often accompanied by NO_x and heavy metals. The presence of other air pollutants such as NO_x and/or ozone can reduce the effective concentration of SO_2 for the onset of acute foliar injury (U.S. EPA, cited in Legge 1995).

D3.2.8.9 Analysis of Potential Linkages

The primary constituents contributing to acidifying emissions associated with Project Millennium include SO_2, and No_x. A moderate increase in these emissions can potentially affect vegetation communities occurring near oil sands facilities. Therefore, this linkage is valid.

D3.2.8.10 Analysis of Key Question

Airborne emissions from oil sands can have both short and long-term effects on vegetation vigor and health. Short-term exposure effects are usually restricted to a localized area and can include chlorosis or necrosis of plant tissues which can decrease growth rates or eventually result in plant mortality. Long-term effects can occur over a much larger area and may result from the accumulation of contaminants in plant issues, either by direct absorption into plant tissues from the air, or indirectly through deposition into the soil and into the roots. Once incorporated in the plant tissues, the chemicals can alter internal biochemical processes and consequently can reduce productivity, vigor or health. Other chemicals (and dust) may be adsorbed onto the surface of the plant tissues, reducing respiration and reception of radiation or photosynthesis. These processes may again reduce plant vigor and productivity.

Water-borne pollutant releases can also result in changes to vegetation productivity, vigor and health. Water emissions may include the release of light to heavy hydrocarbons during Project development. These chemicals, once released into water systems and soils can affect plant health and vigor once they are adsorbed onto the plant tissues.

Sulfur Dioxides (SO_2)

SO_2 emissions are predicted to have an overall moderate impact on air quality in the LSA (Air Quality Impact Assessment, Section B). The Alberta, Federal and UN/ECE (1993) guidelines for SO_2 are presented in Table D3.2-17. A predicted maximum of 30 $\mu g/m^3$ is predicted to occur immediately over the Syncrude Development Area. A critical sensitivity level 20 $\mu g/m^3$ for forest trees is suggested by the UN/ECE (1993). This level will occur within undisturbed, forested areas in the vicinity of the Project Millennium area. Mosses and lichens are considered sensitive to SO_2 emissions. Low lichen species diversity was found in the Tyne Valley in England only when annual average SO_2 concentration was above 0.016 ppm or approximate 42 $\mu g/m^3$ (Gilbert 1969 cited in Nriagu 1978). This average is only predicted to occur over the Syncrude Development Area.

Diagnosis of air pollutant stress based on visible symptoms is difficult to detect. Visible symptoms caused by air pollutants are not highly specific, and often mimic symptoms caused by natural stress such as drought, excessive water, nutrient deficiency, diseases or insect infestation (Malhotra and Blaudel 1980; Treshow 1984). Studies in the Fort McMurray area have not confirmed any symptoms in jack pine stands, which are highly sensitive (Table D3.2-16) (Conor Pacific 1997).

It is difficult to determine the effects of predicted SO_2 emissions on vegetation health. The direction is expected, however, to be negative. The geographical extent will be regional, the duration will be the life span of mining operations and frequency will be high.

Table D3.2-17 Province of Alberta Guidelines, Federal Government of Canada Air Quality Objectives and UN/ECE Critical Levels For Vegetation for SO_2

Period	Alberta Guidelines $\mu g/m^3$(ppm)	Federal Government Guidelines			UN/ECE[a]
		Desirable $\mu g/m^3$	Acceptable $\mu g/m^3$	Tolerable $\mu g/m^3$	Critical Levels Forest Trees $\mu g/m^3$
Annual	30 (0.01)	30	60	n/a	20
24 Hour	150 (0.06)	150	300	800	n/a
1 Hour	450 (0.17)	450	900	n/a	n/a

[a] UN/ECE (1993)

Table D3.2-18 Maximum Predicted SO_2 Concentrations Associated With Project Millennium

	Project Millennium and Existing Facilities		
	Annual	% RSA	Area (ha)
SO_2 ($\mu g/m^3$)	30	0.02 %	409
SO_2 ($\mu g/m^3$)	20		

Nitrogen Dioxide (NO_2)

Oxides of nitrogen (NO_x) emissions occur primarily as NO and are converted to NO_2 through reactions with ambient ozone. A comparison of the Alberta and Federal Government air quality objectives for NO_2 is presented in Table D3.2-19. The Alberta Guideline and the Federal Desirable Limit for NO_2 is 60 $\mu g/m^3$. The maximum predicted concentration of 60 $\mu g/m^3$ is predicted to occur directly over the Syncrude and Suncor Development Areas and occupies and maximum area of 8343 ha (see Section B3). This does not occur in naturally vegetated areas outside the development area. The critical levels identified by UN/ECE (1993) for forest trees is 30 $\mu g/m^3$. This will extend into areas of undisturbed forested lands within the RSA. As with SO_2, the effects of NO_2 on vegetation is difficult to assess.

NOx and other emissions such as particulates have been shown to effect lichens. A recent study of the corticolous (tree dwelling) lichens, *Evernia mesomorpha and Usnea* spp. and in the Athabasca oils sands area found that concentrations of some elements showed a trend of decreasing concentration with increasing distance from oil sands developments. Concentrations of the elements Ni, V, S are much higher than occur in uncontaminated areas. The source of these elements in thought to be particulates from exposed soil surfaces, tailings disposal areas and fly-ash particulates emitted from oil sands' development stacks (Pauls 1996). However, examination of jack pine plots near Fort McMurray did not find any substantial difference in general tree health in plots observed in high and low deposition sites (Conor Pacific 1997). Hanson and Turner (1992) indicate that NO_2 concentrations seldom occur at concentrations high enough to induce injury to plants (>0.5 ppm). Studies of plant species native to Alberta indicate that, at low concentration levels, NO_x may be beneficial to plants. This "fertilizer effect" of NOx will likely be differentially beneficial depending on moss species and microhabitat. For example, acidophillic Sphagnum species, especially when found in oligotrophic conditions, showed increased growth with artificial acid input (Bayley et al., 1987; Rochefort and Vitt 1988). As such, acidification may cause shifts in species composition, abundance and biodiversity. Shifts in bryophyte communities may have effects on peatlands (Rochefort and Vitt 1988).

Table D3.2-19 Province of Alberta Guidelines, Federal Government of Canada Air Quality Objectives and UN/ECE Critical Levels For Vegetation for NO_2

Period	Alberta Guidelines $\mu g/m^3$(ppm)	Federal Government Guidelines Desirable $\mu g/m^3$	Acceptable $\mu g/m^3$	Tolerable $\mu g/m^3$	UN/ECE[a] Critical Levels Forest Trees $\mu g/m^3$
NO_2 ($\mu g/m^3$)					
Annual	60 (0.03 ppm)	60	100	n/a	30
24 Hour	200 (0.11 ppm)	n/a	200	300	n/a
1 Hour	400 (0.21 ppm)	n/a	400	1000	n/a

(a) UN/ECE (1993)

Table D3.2-20 Maximum Predicted NO_2 Concentrations Associated With Project Millennium

Project Millennium and Existing Facilities			
	Annual	% RSA	Area (ha)
NO_2 ($\mu g/m^3$)	60	0.34%	8343
NO_2 ($\mu g/m^3$)	30		

It is difficult to determine the effects of NO_2 on vegetation health as a result of increased emissions. The direction is expected, however, to be negative. The geographical extent will be regional, the duration will be the life span of mining, extraction and upgrading operations and frequency will be high.

Potential Acid Input (PAI)

Potential Acid Input (PAI) from combined developments, including fully disclosed, is predicted to be centered around oil sands development areas. The World Health Organization (1994) has proposed a PAI critical loading factor of 0.25 keq/ha/a for sensitive ecosystems and 0.5 keq/ha/a for moderately sensitive ecosystems. The Target Loading Subgroup recommends an interim Critical Load of 0.25 keq ha-1 yr-1 for sensitive areas and recommends that the effects of development scenarios on deposition loading be analyzed; this information should be used in the selection of Target Loads (Target Loading Subgroup 1996). The Target Loading Subgroup (1996) provides a definition for the terms Critical Load and Target Load. These definitions are used by most countries in the northern hemisphere:

Critical Load is the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems. Target Load is the maximum level of acidic atmospheric deposition, that affords long-term protection from adverse ecological consequences, and that is practically and politically achievable.

The areas of the dominant vegetation communities that are predicted to be subjected to different levels of PAI are shown in Table D3.2-21. Vegetation communities not occurring within isopleths of 0.25 keq/ha/a are the shrubland (low shrub recolonization). All other dominant vegetation communities occur within isopleths of 0.25 keq/ha/a. Within isopleths of 0.25 keq/ha/a, Project Millennium will have the highest impact on the mixed coniferous (Sw-Pj/Pl dominant) and mixed coniferous (Pj/Pl dominant) vegetation types. The lowest impacts will occur within the mixed coniferous (Sb-Lt) vegetation type.

Table D3.2-21 Predicted PAI for Baseline and the Project within the RSA

Vegetation Type	Baseline			Impact		
	1.0	0.5	0.25	1.0	0.5	0.25
Open Pine-Lichen	2	927	4,580	5	988	6,020
Mixed Coniferous (Sw dominant)	18	4,918	32,754	232	6,527	40,195
Mixed Deciduous (Aw dominant)	48	12,133	79,008	515	15,870	92,382
Mixedwood (Sw-Aw dominant)	24	10,481	108,869	307	22,381	136,058
Mixed Coniferous (Pj/Pl dominant)	0	108	434	0	110	947
Mixed Coniferous (Sw-Pj/Pl dominant)	0	0	1,988	0	0	5,181
Mixed Coniferous (Sb-Lt)	18	7,758	28,317	524	9,075	30,819
Shrubland (low shrub recolonization)	0	0	0	0	0	0
Pine Recolonization	0	3	20,780	0	19	23,459
Wet Closed Coniferous (Sb)	191	28,903	159,578	1,340	62,068	194,437
Wet Open Coniferous (Sb)	5	3,494	49,283	108	11,179	64,870
Shrubby Fen	53	7,233	62,180	228	13,021	103,062
Graminoid Fen	28	4,405	27,725	75	8,292	41,698
Bog (Sphagnum)	0	0	233	0	0	242
Low Shrub Wetland (bog)	0	0	7,263	0	0	13,895
Marsh Emergent	0	590	1,108	20	635	1,582
Forestry Activity	0	1,092	8,623	0	2,580	8,802
Barren Ground/Exposed Bedrock	13	1,082	3,853	30	1,506	4,402
Water	24	2,522	11,267	337	3,471	15,434
Municipalities	0	426	3,112	0	782	3,356
Open Pit Mines	2,655	25,294	42,716	5,230	30,124	48,360
Other Disturbances	105	2,491	2,796	345	2,461	2,796
In-Situ	0	0	0	0	0	0
Additional Linear Disturbances	45	1,024	3,289	110	1,660	3,724
Unclassified	8	815	10,756	16	1,991	19,434

It is difficult to determine the effects of PAI on vegetation health as a result of increased emissions. The direction is expected, however, to be negative. The geographical extent will be regional, the duration will be the life span of mining operations and frequency will be high. The degree of uncertainty is undetermined due to the difficulty in assessing magnitude.

D3.2.8.11 Residual Impact Classification and Environmental Consequence

The residual impacts are presented in Table D3.2-22. Impacts from air emissions on vegetation health are difficult to assess. According to predicted SO_2 and NO_2 emissions, critical levels are largely situated over existing or proposed oil sands development areas. However, there will be some forested areas around the oil sands developments that may be exposures to the levels set by the UN/ECE (1993). It will be important to monitor these areas in the future to determine if air emissions are affecting sensitive plant species.

Accordingly, the direction of impact is negative, the magnitude is undetermined, the geographic extent is regional and the frequency is high. The environmental consequence is undetermined and therefore monitoring is recommended to further assess this effect.

Table D3.2-22 Residual Impact Classification and Environmental Consequence

Impact	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Concentrations of SO_2 on vegetation	Negative	Undetermined	Local	Moderate-term	Reversible	High	Undetermined
Concentrations of NO_X on vegetation	Negative	Undetermined	Local	Moderate-term	Reversible	High	Undetermined
Acidification on vegetation	Negative	Undetermined	Local	Moderate-term	Reversible	High	Undetermined
Acidification of fens	Negative	Undetermined	Local	Moderate-term	Reversible	High	Undetermined

D3.2.8.12 Monitoring

With so many factors involved, and so many yet-to-be-researched areas of study, a high level of uncertainty exists in the assessment of the effects of acidifying emissions on vegetation. A monitoring program which focuses on the 'early warning' signals of acidification is needed in order to attempt to quantify acidifying effects, if any, in the oil sands region. Such 'early warnings' include:

- nutrient deficiency, specifically the loss of magnesium and concentrations in the tissue of sensitive species such as lichens and mosses;
- invasion of sphagnum mosses into poor fens, monitoring of Sphagnum percent cover in poor fens.

Monitoring air emission effects on vegetation within the LSA and RSA will determine if there are impacts to plant communities as a result of acidifying emissions. The monitoring program could be linked to existing environmental effects monitoring programs such as the Regional Airshed Monitoring Plans for the Southern Wood Buffalo Zone (RAQCC 1996).

D3.2.9 Key Question VW-3: What Impacts will Development and Closure of Project Millennium have on Vegetation and Wetlands Diversity?

D3.2.9.1 Analysis of Potential Linkages

Losses or alteration of terrestrial vegetation and wetlands due to site clearing, and other developments associated with the Project will change diversity in the LSA. Diversity, which is an expression of plant community level heterogeneity, will be altered due to the partial or complete removal of ecosite phases and wetlands classes. Thus, this is a valid linkage for assessment as identified in the linkage diagrams (Figures D3.2-1 to D3.2-4).

D3.2.9.2 Impact Analysis

An assessment of the Project impacts on terrestrial vegetation and wetlands diversity is complex. The issue can be examined at a variety of levels (e.g. landscape, plant community and species level) and interactions between levels using indicators and indices of diversity to help quantify the nature and degree of change through construction, operation and mine closure phases. Readers are referred to Section D4.4.42 in the ECL Section where diversity is examined at primarily the landscape level. This section also includes an assessment of ecosite diversity within landscape or macroterrain units which is especially relevant to this Key Question.

This assessment of diversity is focused on the plant community level as expressed by the number and size of ecosite phases which currently exist and those which are anticipated following mine closure. Species level diversity is discussed in the Terrestrial Vegetation Wetlands Environmental Setting (Section D3.1).

The impact classification will describe the relative amount of change from pre-development conditions to closure. Closure planning is the mitigation that is applied before determining the residual impacts to diversity on the parameters measured.

D3.2.9.3 Community Level Diversity

Community level diversity can best be assessed by examining vegetation polygon or patch dynamics. Patches or polygons refers here to the ecosite phases which have been mapped within the RSA. Patch dynamics examines vegetation communities as mosaics of different areas (patches) in which disturbances and biological interactions proceed. A patch habitat therefore is an environment within which there are significant variations in size and/or number of patches of various types (ecosite phases). The variability (range) in patch size provides some indication of diversity at the landscape and community level. The number and size of patches (ecosite phases) within the LSA are quantified in hectares.

D3.2.9.4 Richness

Terrestrial Vegetation

The number of ecosite phase patches or polygons represented in the LSA before and after Project development (closure) are presented in Table D3.2-23. This provides a measure of vegetation richness. The number of patches following mine closure are described by superimposing the mine plan over the ecosite phase map to quantify the loss of individual ecosite phases or alternatively an increase in those areas where patches may be fragmented (i.e. at the margins of the development area). Reclamation following mine closure has also been included in the number of patches presented in Table D3.2-23. For example, in the ecosite phase b3 (blueberry Aw-Sw) three patches are increased to 5 patches during mine construction and operation, and subsequently, increased to 27 patches following reclamation of this ecosite phase at mine closure.

The percent loss of patches is low for the dogwood ecosites (13% in e1; 9% in e2; and 4% in e3). For the low-bush cranberry ecosites (d1; d2; and d3), the percent loss of patches ranges between 18 to 22 percent. Ecosite phases consisting of lichen Pj (a1); Labrador tea-mesic Pj-Sb (c1); and Labrador tea-subhygric Sb-Pj (g1), have a high loss of patches (100%). However, these areas each occupy less than 1% (3 ha) of the LSA. The blueberry ecosites consisting of blueberry Aw(Bw) (b2) and blueberry Aw-Sw (b3) will increase in the number of patches following closure as a result of better drainage conditions on the reclaimed landscape (Table D3.2-23).

Following mine closure there will be an overall reduction in ecosite phase patch number from 452 to 377. According to this index, diversity is reduced by 17 percent of the pre-disturbance conditions. The reclaimed landscapes in general will support a fewer number of large reclaimed vegetation types as previously discussed in section D3.2.7.

Table D3.2-23 Number of Vegetation Type (Ecosite Phase) Patches or Polygons

Map Code	Ecosite Phase (Vegetation Types)	Baseline	Closure	
		Number of Vegetation Patches	Number of Vegetation Patches	Percent Loss within Ecosite Phases
a1	Lichen Pj	1	0	100
b1	Blueberry Aw-Sw	26	13	50
b2	Blueberry Aw(Bw)	1	4	75(a)
b3	Blueberry Aw-Sw	3	27	89(a)
b4	Blueberry Sw-Pj	7	1	86
c1	Labrador tea-mesic Pj-Sb	1	0	100
d1	Low-bush cranberry Aw	104	81	22
d2	Low-bush cranberry Aw-Sw	55	45	18
d3	Low-bush cranberry Sw	123	97	21
e1	Dogwood Pb-Aw	45	39	13
e2	Dogwood Pb-Sw	23	21	9
e3	Dogwood Sw	28	27	4
g1	Labrador tea-subhygric Sb-Pj	1	0	100
h1	Labrador tea/horsetail Sw-Sb	15	11	27
Sb/Lt	Black spruce-Tamarack Complexes	2	0	100
shrub	Shrubland	17	11	35
Terrestrial Total		**452**	**377**	**17**

[a] increase in polygon or patch number

Wetlands Resources

Overall, the number of wetlands patches within the LSA will be reduced from 559 to 378 patches (Table D3.2-24) The percent loss of patches is low for wooded fens (FTNN) (11%) and marshes (MONS) (15%) . There are also no losses of patches for the wooded bogs (BTNN/BFNN). Graminoid fens (FONG), shrubby swamps (SONS) and forested fens (FFNN) will each be reduced by 50% of the pre-disturbance patch number. Shrubby fens (FONS) show the greatest loss in the number of patches (71%). There are also no increases in the number of patches after reclamation (closure). The number of wetlands patches is much more affected than terrestrial patches.

Table D3.2-24 The Number of Wetlands Class Patches or Polygons within the LSA

Map Code	Ecosite Phase (Vegetation Types)	Baseline	Closure	
		Number of Wetland Patches	Number of Wetland Patches Remaining	Percent Loss within Wetland Classes
FTNN	Wooded Fen	172	153	11
FFNN	Wooded Fen	46	23	50
FONG	Graminoid Fen	2	1	50
FONS	Shrubby Fen	41	12	71
BTNN	Wooded Bog	4	4	0
BFNN	Wooded Bog	5	5	0
STNN	Coniferous Swamp	153	95	38
SFNN	Coniferous Swamp	51	28	45
SONS	Deciduous Swamp	24	12	50
MONG	Marsh	18	11	39
MONS	Marsh	27	23	15
WONN	Shallow Open Water	16	11	31
Wetlands Total		**559**	**378**	**32**

D3.2.9.5 Patch Size

Terrestrial Vegetation

The mean, minimum and maximum patch size of each ecosite phase patch or polygon in the LSA is presented in Table D3.2-25. In some ecosite phases, mean patch size changes after development but the range is constant. Changes in the range of patch size is an expression of heterogeneity in ecosite phase polygons. Range and average patch sizes will change for some of the ecosite phases as a result of the Project. The mean patch size within the LSA will change from 2 to 77 ha, which indicates that smaller patches will be lost due to Project development. For example, the mean patch size will increase within the Baseline from 1 to 27 ha, to 2 to 77 ha after closure. This will result in the mean patch size initially being larger in the reclaimed landscape, however, it is expected that smaller patches will develop within these areas as successional processes and site variability interact over time.

When patch size at the baseline is compared to patch size at closure, there is an increase in average patch size. For example, the blueberry Aw(Bw) ecosite phase average patch size for the baseline is 27 ha, whereas at closure the average patch size is 77 ha. This increase in average patch size can be observed in the low-bush cranberry (d1, d2, and d3) and dogwood (e1, e2 and e3) ecosites. The Project development will also result in reductions of average patch size.

A reduction in patch size ranges may potentially equate to a temporary loss in diversity. Reductions in patch size range are recorded in ecosite phases lichen Pj (a1), Labrador tea-mesic Pj-Sb (c1) and Labrador tea-subhygric Sb-Pj (g1). However, these ecosite phases comprise less than 1% (3 ha) of the LSA.

Table D3.2-25 Mean, Minimum and Maximum Vegetation Polygon or Patch Size

Map Code	Ecosite Phase (Vegetation Types)	Baseline			Impact			Closure		
		Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)	Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)	Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)
a1	Lichen Pj	1	1	1	0	0	0	0	0	0
b1	Blueberry Aw-Sw	1	9	47	5	<1	47	20	<1	166
b2	Blueberry Aw(Bw)	27	27	27	<1	<1	<1	77	<1	160
b3	Blueberry Aw-Sw	3	20	36	3	3	3	32	1	269
b4	Blueberry Sw-Pj	1	7	16	<1	<1	<1	2	2	2
c1	Labrador tea-mesic Pj-Sb	1	1	1	0	0	0	0	0	0
d1	Low-bush cranberry Aw	<1	32	678	17	<1	244	34	<1	924
d2	Low-bush cranberry Aw-Sw	<1	10	150	9	<1	150	60	<1	2,312
d3	Low-bush cranberry Sw	<1	8	114	7	<1	114	8	<1	135
e1	Dogwood Pb-Aw	<1	5	44	5	<1	44	53	<1	883
e2	Dogwood Pb-Sw	<1	3	7	2	<1	6	2	<1	6
e3	Dogwood Sw	<1	4	18	4	<1	18	14	<1	275
g1	Labrador tea-subhygric Sb-Pj	1	1	1	0	0	0	0	0	0
h1	Labrador tea/horsetail Sw-Sb	<1	4	10	3	<1	8	3	<1	8
Sb/Lt	Black spruce-Tamarack Complexes	9	10	11	0	0	0	0	0	0
shrub	Shrubland	1	8	24	7	1	24	14	1	82

Wetlands Resources

The mean, minimum and maximum patch size for wetland patches within the LSA is presented in Table D3.2-26. The mean patch size will increase within the Baseline from 1 to 2 ha, to 1 to 19 ha after closure. For some wetland classes, the average patch size will increase, for example, wooded fens (FTNN/FFNN) and coniferous swamps (STNN/SFNN). However, for others the maximum patch size will decrease as a result of Project development. In the baseline, for example, the maximum patch size for wooded fens (FTNN) is 4,667 ha, however, after closure the maximum patch size is 1,200 ha. Maximum patch size decreases for all wetland classes. Wetland classes not affected by Project development are the wooded bogs (BTNN/BFNN).

Table D3.2-26 Mean, Minimum and Maximum Wetlands Polygon or Patch Size

		Baseline			Impact			Closure		
Map Code	Ecosite Phase (Vegetation Types)	Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)	Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)	Mean Patch Size (ha)	Min. Patch Size (ha)	Max. Patch Size (ha)
FTNN	Wooded Fen	<1	35	4,667	11	<1	1,200	11	<1	1,200
FFNN	Wooded Fen	1	21	116	19	<1	61	19	61	<1
FONG	Graminoid Fen	1	2	3	1	1	1	1	1	1
FONS	Shrubby Fen	1	10	64	11	1	35	9	35	<1
BTNN	Wooded Bog	2	5	12	5	2	12	5	2	12
BFNN	Wooded Bog	1	5	12	5	1	11	5	1	12
STNN	Coniferous Swamp	<1	9	100	7	<1	88	7	<1	88
SFNN	Coniferous Swamp	<1	13	93	10	<1	93	11	<1	93
SONS	Deciduous Swamp	<1	7	33	9	<1	33	10	<1	33
MONG	Marsh	<1	6	67	8	<1	67	9	<1	67
MONS	Marsh	1	8	85	8	1	85	8	1	85
WONN	Shallow Open Water	<1	1	3	1	<1	1	1	<1	1

Summary

In summary, the impact of Project Millennium on terrestrial vegetation and wetlands diversity using the indices of patch number and patch size provides only one component of the assessment. Further assessment is provided in the ELC Section (D4.2). However, patch number can be demonstrated to decrease for both terrestrial and wetlands patches following mine closure. The overall impact on the terrestrial patches can be described as moderate in magnitude based on percentages of change from baseline conditions while for wetlands it is high (Table D3.2-27). The geographic extent is local while the direction of the impact will extend throughout the life of the Project. While the patch number for terrestrial ecosite phases can be increased through reclamation design and methods, the number of wetlands patches will not return to baseline conditions and is therefore classified as an irreversible impact. The environmental consequence is considered high for wetlands, however the number of wetlands patches in the RSA indicates that the impact is not significant.

The overall change in patch size is negative for both terrestrial ecosite phases and wetlands, however the magnitude is low for terrestrial patches given that there will be both an increase and decrease in patch size as reclamation proceeds. Flexibility in reclamation planning and design allows for the size of reclaimed terrestrial ecosite phases to adjust with the sequential phases of development and reclamation. This flexibility is much less in the case of wetlands reclamation since fens cannot be reclaimed and therefore the magnitude of the impact is higher. The geographical extent is local for both terrestrial ecosite phases and wetlands, reversible for terrestrial and irreversible for wetlands (Table D3.2-27). The potentially high environmental consequence associated with the reduction of wetlands diversity is tempered by the fact that unique wetlands will not be removed and that there is a large quantity and diversity of wetlands on a regional scale. Therefore, the environmental impact due to reduction of wetland diversity in the closure landscape is not considered to be significant.

Table D3.2-27 Residual Impacts for Change in Terrestrial Vegetation and Wetlands Diversity

Diversity Indicator	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Patch Number Terrestrial Vegetation	negative	moderate	local	life of project	reversible	occurs once during life of project	moderate
Wetlands	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Patch Number Terrestrial Vegetation	negative	low*	local	life of project	reversible	occurs once during life of project	low
Wetlands	negative	high	local	life of project	irreversible	occurs once during life of mine	high

* Patch size will both increase and decrease following reclamation.

D3.3 TERRESTRIAL VEGETATION AND WETLANDS CONCLUSION

D3.3.1 Introduction

Development of an open pit oil sands mine results in the removal of vegetation and wetlands in the immediate area of the development footprint. The primary mitigation for this action is the development and implementation of a comprehensive conservation and reclamation plan as part of mine closure.

Knowledge on the terrestrial vegetation and wetlands communities native to the development area has been documented through an extensive field assessment prior to development. This assessment, coupled with the knowledge on the landforms, soils, and groundwater and surface hydrological systems that will be included in the closure plan allows prediction of the replacement terrestrial vegetation and wetlands communities.

At closure, thirteen community types have been selected for establishment on the reclaimed landscapes of the Project. These communities include:

- Blueberry Pj-Aw (b1)
- Blueberry Aw(Bw) (b2)
- Blueberry Aw-Sw (b3)
- Low-bush cranberry Aw (d1)
- Low-bush cranberry Aw-Sw (d2)
- Low-bush cranberry Sw (d3)
- Dogwood Pb-Aw (e1)
- Dogwood Pb-Sw (e2)
- Dogwood Sw (e3)
- Deciduous Swamp (SONS)
- Shrubland
- Constructed Wetlands
- Open Water

The terrestrial vegetation and wetlands impact assessment predicted the incremental effects of Project Millennium on top of existing and approved oil sands operations. The assessment considered the issues, as addressed through the key question approach in Section D3.2 of the EIA. The issues and environmental consequences are summarized in Table D3.3-1.

Table D3.3-1 Terrestrial Vegetation and Wetlands Issues and Environmental Consequences

Environmental Issues	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Key Indicator Resources							
old-growth forests	negative	high	local	life of project	reversible	occurs once during life of mine	high
riparian shrub complexes	negative	low	local	life of project	reversible	occurs once during life of project	low
plant communities of economic importance (aspen-white spruce forest)	positive	high	local	life of project	reversible	occurs once during life of mine	negligible
rare/endangered plants or communities (high rare plant potential habitat)	negative	moderate	low	life of project	reversible	occurs once during life of mine	low
traditional use plants	negative	low	local	life of project	reversible	occurs once during life of mine	low
Acidifying Emissions							
Concentrations of SO_2 on vegetation	negative	undetermined	regional	life of project	reversible	occurs over life of project	undetermined
Concentrations of NO_X on vegetation	negative	undetermined	regional	life of project	reversible	occurs over life of project	undetermined
Acidification on vegetation	negative	undetermined	regional	life of project	reversible	occurs over life of project	undetermined
Diversity Indicators							
Patch Number							
Terrestrial Vegetation	negative	moderate	local	life of project	reversible	occurs once during life of project	moderate
Wetlands	negative	high	local	life of project	irreversible	occurs once during life of mine	high
Patch Size							
Terrestrial Vegetation	negative	low*	local	life of project	reversible	occurs once during life of project	low
Wetlands	negative	high	local	life of project	irreversible	occurs once during life of mine	high

* Patch size will both increase and decrease following reclamation.

D3.3.2 Impact Assessment

The Project will result in the clearing of 9,281 ha or 57% of the LSA. Baseline information for the LSA, indicates that 36% of community types identified represent terrestrial ecosite phases, while 62% represent wetlands. During construction and operation, 46% of terrestrial ecosite phases and 65% of wetlands community types will be lost in the development area.

Reclaimed landscapes will result in the addition of 7,239 ha of terrestrial ecosite phases and loss of 5,387 ha of wetlands community types in the LSA. Thus, upon closure, relative to pre-development, terrestrial ecosite phases will increase by 28% and wetlands communities will decrease by 34% within the LSA. An end pit lake of approximately 935 ha will account for 6% of the area Hence, a dominantly wetlands community area will be converted to a dominantly upland mixedwood forest area.

Key Indicator Resources

The only key indicator resource assessed as having both a high magnitude and negative direction is old growth forests. An assessment of old growth forests within the LSA is considered to have a high environmental consequence based on the rating system used.

In summary, the overall impact of the east bank mining area development on "old-growth" forest is negative in direction and high in magnitude, given that 21% of the old-growth forest communities will be cleared by the project. However this assessment must be tempered by the following:

- the net increase of old growth forest impact over the approved Steepbank Mine area is only 9 ha or 2% of the old growth forest within the LSA;
- the creation of more upland conditions after closure will ultimately allow for substantially greater old growth forest in the far future; and
- the loss of old growth forest (92 ha) is low in terms of the total amount in the RSA.

Based on the above-noted factors, the loss of old growth forests due to development of the east bank mining area, and particularly the loss due to Project Millennium development, is not considered to be significant.

Terrestrial Vegetation and Wetlands Community Changes

Within the uplands (terrestrial) ecosite phases, the greatest impacts occur within the: lichen Pj (a1); Labrador tea-mesic Pj-Sb (c1); and Labrador tea-subhygric Sb-Pj (g1) ecosite phases, where 3 ha or 100% of the ecosite phases within the LSA will be cleared. The blueberry ecosite, will experience a loss of 279 ha or 77% of the blueberry ecosite within the LSA. The low-bush cranberry ecosites will experience a loss of 2,230 ha or 46% within the LSA. In addition, the dogwood ecosites will experience a loss of 16% or 63 ha within the LSA.

Reclamation of the development area will result in the development of a much greater area of uplands terrestrial vegetation. The residual impact of the development on terrestrial vegetation is therefore positive in direction and high in magnitude.

Non-patterned, wooded fens (FTNN/FFNN), the dominant wetlands types in the LSA, collectively occupy 43% or 6,976 ha. The Project will remove 71% or 4,943 ha of non-patterned, wooded fens, representing a loss of 30% of the LSA. Similarly, 76% of all non-patterned shrubby fens will be directly lost to Project development. Wooded swamps (STNN/SFNN) and shrubby deciduous (SONS) swamps represent 14% or 2,207 ha of the LSA. Clearing of these swamps will result in a loss of 54% (1,190 ha). Wooded bogs without internal lawns (BTNN/BFNN) represent less than 1% or 46 ha of the LSA and will not be affected by the Project. Graminoid (MONG) and shrubby (MONS) marshes represent 2% or 318 ha of the LSA. Losses due to the Project, will affect 13% or 14 ha of graminoid marshes (MONG) and 8% or 18 ha of shrubby marshes (MONS) within the LSA. Shallow open water (WONN) represent less than 1% or 15 ha of the LSA. Mine development will affect 53% or 8 ha of the shallow open water areas in the LSA.

Wetlands are the dominant community types lost to the development because they occupy 62% of the LSA. The Project will remove 6,502 ha or 65% of wetlands. Reclamation and closure of the development area will result in return of some wetlands types, with 12% of the development area returned to wetlands. The net impact to the LSA is that 34% of the area wetlands will be lost. This is a high magnitude, irreversible residual impact. The environmental consequences are high. However, the wetlands areas lost to development are common throughout the region and are unlikely to have a high magnitude impact on wetlands in the region. Therefore, the loss of wetlands has been assessed as not significant on a regional basis.

The replacement of the wetlands areas by uplands areas with higher forest capability can be viewed as directionally positive. Some wetlands areas as well as shallow open water areas and lakes will be replaced as part of the closure plan. The residual impacts of the changes to terrestrial and wetlands vegetation communities has been rated as low in environmental consequence. There is a moderate degree of uncertainty associated with this rating as the effectiveness of some of the reclamation practices is yet unproved.

Impacts of Air Emissions and Water Release on Vegetation

Airborne emissions from oil sands developments can have both short and long-term effects on vegetation vigour and health. Short-term exposure effects are usually restricted to a localized area and can include chlorosis or necrosis of plant tissues which can decrease growth rates or eventually result in plant mortality. Long-term effects can occur over a much larger area and may result from the accumulation of contaminants in plant issues, either by direct absorption into plant tissues from the air, or indirectly through deposition into the soil and into the roots. Once incorporated in the plant tissues, the chemicals can alter internal biochemical processes and consequently can reduce productivity, vigour or health. Other chemicals (and dust) may be adsorbed onto the surface of the plant tissues, reducing respiration and reception of radiation or photosynthesis. These processes may again reduce plant vigour and productivity.

Studies on the impacts of air emissions in the oil sands area to vegetation have included specific research on effects to forest vegetation from sulphur dioxide. Recently, efforts to characterize effects of air emissions on regional vegetation have been initiated. The environmental effects monitoring program component of the Regional Airshed Monitoring Plan for the Wood Buffalo Zone (BOVAR 1996d), of which Suncor is a member, included selection of sites to complete studies on soils and vegetation sampling. The first sets of results for this study focus around site characterizations for aspen and jack pine plots.

Although monitoring of the effects of air emissions is proceeding, the lack of current data on the potential effects of air emissions on regional vegetation means that the assessment of residual impacts is currently undetermined.

Water-borne pollutant releases can also result in changes to vegetation productivity, vigour and health. Water emissions may include the release of light to heavy hydrocarbons during Project development. These chemicals, once released into water systems and soils can affect plant health and vigour once they are adsorbed onto the plant tissues.

Suncor has completed a number of studies to assess the impacts of process-affected waters on terrestrial and aquatic plants (as detailed in section E of Volume 1 of the Application). The results to date indicate that impacts are of low magnitude. However, the research to assess the impacts of waters associated with the consolidated tailing (CT) materials has just been initiated, with few results available. Therefore, continuing research is recommended.

Diversity of Terrestrial Vegetation and Wetlands

In summary, the impact of Project Millennium on terrestrial vegetation and wetlands diversity using the indices of patch number and patch size provides only one component of the assessment. Further assessment is provided in the ELC Section (D4.2). However, patch number can be demonstrated to decrease for both terrestrial and wetlands patches following mine closure. The overall impact on the terrestrial patches can be described as moderate in magnitude based on percentages of change from baseline conditions while for wetlands it is high (Table D3.2-27). The geographic extent is local while the direction of the impact will extend throughout the life of the Project. While the patch number for terrestrial ecosite phases can be increased through reclamation design and methods, the number of wetlands patches will not return to baseline conditions and is therefore classified as an irreversible impact. The environmental consequence is considered high for wetlands, however the number of wetlands patches in the RSA indicates that the impact is not significant.

The overall change in patch size is negative for both terrestrial ecosite phases and wetlands, however the magnitude is low for terrestrial patches given that there will be both an increase and decrease in patch size as reclamation proceeds. Flexibility in reclamation planning and design allows for the size of reclaimed terrestrial ecosite phases to adjust with the sequential phases of development and reclamation. This flexibility is much less in the case of wetlands reclamation since fens cannot be reclaimed and therefore the magnitude of the impact is higher. The geographical extent is local for both terrestrial ecosite phases and wetlands, reversible for terrestrial and irreversible for wetlands (Table D3.2-27). The potentially high environmental consequence associated with the reduction of wetlands diversity is tempered by the fact that unique wetlands will not be removed and that there is a large quantity and diversity of wetlands on a regional scale. Therefore, the environmental impact due to reduction of wetland diversity in the closure landscape is not considered to be significant.

D3.3.3 Monitoring

Monitoring programs to verify impact predictions or to allow resolution of undetermined impacts will include:

- continuation of Suncor's routine program of monitoring reclamation areas, including both terrestrial and aquatic sites;
- continuation of monitoring of the impacts of CT waters on terrestrial and aquatic vegetation;

- development of a field-scale CT reclamation demonstration in 2000, following completion of preliminary design studies (three year program initiated in 1997); and
- participation in efforts to monitor the potential impacts of oil sands development air emissions on regional vegetation, as part of Suncor's participation in RAQCC and its environmental effects monitoring program.

D4 ECOLOGICAL LAND CLASSIFICATION

D4.1 ECOLOGICAL LAND CLASSIFICATION BASELINE/ENVIRONMENTAL SETTING

D4.1.1 Introduction

An Ecological Land Classification is an approach to categorizing and delineating, at different levels of resolution, areas of land and wetlands having similar characteristic combinations of physical environment (such as geomorphic processes, geology soil and hydrologic function) and biological communities (plant, animals and microorganisms). As such a number of information sources were utilized to define and delineate ELC units in the local and regional study areas. This approach has also been utilized by Strong (1992) to develop a 1:1,000,000 scale Provincial Ecoregions.

The ELC component mapping was undertaken at a scale of 1:20,000 to assess impacts within the LSA for the Project and also to facilitate a local scale review. Airphoto interpretation, existing databases and field survey data of terrain, soil, vegetation and drainage conditions were used in the development of the ELC units.

The objective of the ELC component is to provide an integrated, comprehensive land classification scheme of the Project area so that the landscape, soil, vegetation and drainage conditions can be evaluated at a variety of scales and levels of complexity. By comparing similar ELC types within the context of the Local and Regional Study Areas, the potential impacts on the terrestrial resources of the Project are more easily understood. ELC mapping is particularly useful in examining such issues as cumulative effects and biodiversity.

Biodiversity or ecological diversity is as difficult to define as it is to measure. This assessment offers five general measurements, richness, diversity, patch size and patch shape to assess how unique or rare ELC units are. It does not intended to provide the "final answer" on biodiversity but attempts to merely quantify the baseline parameters measured. For the purpose of this EIA, the working definition of biodiversity adopted from Noss and Cooperrider (1994) is:

"the variety of life and its processes; it includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur and the ecological and evolutionary processes that keep them functioning yet ever changing and adapting."

This section describes the ELC units identified within the LSA. This pre-development information is then used to quantify impact to ELCs as a result of the Project. In addition, this section provides a summary of the terrain, soil, vegetation and wetlands resources as they pertain to the ELC. More detailed information on these resources, however, are described in the Soils and Terrain, and Terrestrial Vegetation and Wetlands sections of this EIA (Sections D2 and D3).

An ELC approach to mapping and describing an area has been recognized by Noss and Cooperrider (1994) as important for assessing biodiversity at the "landscape level". Alberta Environmental Protection (AEP 1995c) recognizes the importance of biodiversity and has identified it as one of the Terms of Reference for this EIA. A description of baseline biodiversity estimates are provided in the Ecological Land Classification (ELC) Baseline for Project Millennium (Golder 1998c).

D4.1.2 Study Areas for ELC

The macroterrain and ecological land classification (ELC) units were classified in two study areas, the Regional Study Area (RSA) and Local Study Area (LSA). These areas are described in detail in Section D1 and shown in Figures D1-3 and D1-2. Further details on the ELC units within the LSA are provided below.

Terrestrial Local Study Area

The Terrestrial LSA is located approximately 30 km from Fort McMurray, east of the Athabasca River. The LSA is bordered to the north and west by the Steepbank River and occupies an area of 16,181 ha.

The LSA is located in the Central Mixedwood Natural Subregion (AEP 1994a), referred to as the Boreal Mixedwood Ecoregion by Beckingham and Archibald (1996). This area is characterized by low relief and level to undulating landforms. Upland forests consist of coniferous, deciduous and mixedwood communities. Trembling aspen occurs in both pure and mixed stands, both with balsam poplar and white birch. Successionally, white spruce and balsam fir will replace trembling aspen and balsam poplar as stand dominants. However, recurrent forest fires seldom permit this succession. Forest fires in 1840 and 1940 have affected most of the LSA. River flats have trembling aspen, white spruce or white spruce-balsam poplar forests, which often contain large trees that have benefited from the favorable nutrient and moisture regimes. In the LSA, heights of 31 m have been recorded for white spruce and balsam poplar, with these large trees occurring primarily in the Athabasca floodplain or escarpment slopes.

The majority of the study area, however, occurs on a large organic plain which is dominated by fens, swamps, marshes, shallow open water and to a lesser extent bogs. These wetlands areas, which are the most abundant in the Boreal region of Alberta (Halsey and Vitt 1996), are characterized by extensive complexes of nonpermafrost wooded fens and wooded bogs. The dominant tree species in these areas are black spruce and tamarack.

Regional Study Area

The Regional Study Area (RSA) occupies an area of 2,428,645 ha. This area is predominantly situated within the Central Mixedwood Natural Subregion referred by Beckingham and Archibald (1996) as the Boreal Mixedwood Ecological Area. In the northwest portion of the RSA, in the area of the Birch Mountains, both Boreal Highlands and Subarctic Natural Subregions are represented.

The Boreal Highlands is situated on the slopes of the Birch Mountains while the Subarctic Ecoregion extends along the plateau of the mountain. The Boreal Highlands is similar to the Boreal Mixedwood with some differences. Jack pine hybridized with lodgepole pine occurs in mixtures with white spruce, trembling aspen and balsam poplar. The cooler climate and more moist summer conditions may promote more white spruce relative to aspen. Black spruce forests occur frequently in upland sites and pure coniferous forests are common at higher elevations. Soils are similar to the Boreal Mixedwood with the exception that crysolic soils, which are associated with permafrost are found more frequently. In general, the Boreal Highlands can be considered as a transition area between the Boreal Mixedwood and the Subarctic.

The Subarctic subregion is dominated by black spruce with an understory of Labrador tea and lichen on peat. Lodgepole pine, jack pine, trembling aspen and white spruce occur in better-drained soils. Much of the area can be classified as poorly-drained black spruce bogs. Organic and crysolic soils are the dominant soil series occurring on wet or frozen organic terrain. Gleysols are common on poorly-drained mineral soils with luvisols and brunisols occurring on better-drained upland sites.

D4.1.3 Methods

D4.1.3.1 Ecological Land Classification

The ecological land classification was developed from existing maps on terrain, soil, vegetation, forestry and wetlands resources, complemented by field surveys. The LSA was pre-stratified according to the Alberta Vegetation Inventory (AVI) (AEP 1997b), which represents the most detailed level of forest mapping. All the thematic layers were overlain through ARCINFO, a Geographic Information System (GIS). Due to the complexity of the LSA, broad terrain or physiographic units were delineated first. These units form the coarsest level of detail and were further refined by delineating soil units and finally, vegetation and wetlands polygons within each physiographic unit. In addition, Global Positioning System (GPS) was employed in the field by terrestrial component teams so that ground-truthing information on abiotic and biotic resources could be used to verify the ELC map units.

The methodology employed to develop each of the biophysical maps is summarized below, and presented in detail in Section D2 (Soils and Terrain) and D3 (Terrestrial Vegetation and Wetlands).

D4.1.3.2 Terrain or Physiographic Units

Terrain classification was based on integrating data from the surficial geology map sources, soil map units, AVI map units and a digital elevation model of the LSA with a contour interval of 2 m. The initial terrain amalgamation was derived by combining soil units with similar soil parent materials. For example, all the soil units developed on glaciofluvial deposits were merged to produce larger units with similar biophysical characteristics.

Due to the complexity of the LSA, broad physiographic units or macroterrain units were developed. These were delineated based on the predominant type of terrain unit, elevation, slope and modifying processes. Macroterrain units were named after known geographic features, for example, Athabasca Floodplain and Steepbank Organic Plain.

D4.1.3.3 Soils

Soil sampling locations were selected from an AVI pre-stratification map of the LSA on 1997, 1:20,000 black and white aerial photographs. Information from soil sampling was extrapolated to representative soil map units using the principles of geomorphology and surficial geology, in combination with the vegetation patterns and interpretation of aerial photographs. Soil types naturally grade into one another so that the map units identified within the LSA are in fact a complex of soil units.

D4.1.3.4 Vegetation

The preliminary delineation of the vegetation communities was based on the AVI polygons that were reclassified to the Beckingham and Archibald (1996) system, as described in the 1996 Field Guide to Ecosites of Northern Alberta. Beckingham and Archibald Classification is presented in Figure D3.1-1 (Section D3.1). The classification is based on a hierarchical system where each ecosite is identified from the nutrient and moisture regimes, while ecosite phases are identified by the dominant tree species, or the tallest vegetation layer. The next layer, plant community types, is defined by the understory species composition and abundance. There are 12 terrestrial ecosites (a to l) in the boreal mixedwood forest of Alberta. In the LSA, there are 7 ecosites represented. The wetlands ecosites (i-l) were not employed, rather the Alberta Wetland Classification (AWI) was used to classify wetlands types.

D4.1.3.5 Wetlands

The Alberta Wetlands Inventory (AWI) classification system (Halsey and Vitt 1996) uses variables that are distinguishable on aerial photographs to classify wetlands. The wetlands classes were assigned to pre-stratified AVI polygons. Following field surveys, wetlands classes were defined as required.

The AWI classification system uses similar classes to those developed by the National Wetlands Working Group (NWWG 1988). However, the subdivision of the AWI classes follows a more simplified scheme than that of NWWG (1988). The classification system contains four levels: the wetlands class, the vegetation modifier, the wetlands complex landform modifier and the local landform modifier. This classification allows more detailed definition of the wetlands in the Project area and in the LSA.

D4.1.3.6 Forestry Resources (Alberta Vegetation Inventory)

Old growth or mature forests and timber productivity ratings detailed in the AVI was incorporated into the ELC descriptions.

Old-growth may be defined as those forested areas where the annual growth equals annual losses, or where mean annual increment of timber volume equals zero. They can also be defined as those stands that are self regenerating, having a specific structure that is maintained. The structure, typically includes a mixture of juvenile, mature, dying and decaying trees of the same species.

Old growth forest minimum ages, as reported in BOVAR (1996c) are 100 years for aspen, 160 years for white spruce and 120 years for jack pine. Old growth forests were identified from the AVI mapping. Origin or stand age was compared to the old growth minimum age standards.

A Timber Productivity Rating (TPR) provides a general estimate of productivity of a forested stand. The TPR is assessed on the basis of species age height-age data collected as part of the AVI (AEP 1997b).

D4.1.3.7 Biodiversity

An assessment of biodiversity or ecological diversity is as difficult to measure as it is to define. The intent of the biodiversity section is to provide some quantitative estimates of ecological diversity within the LSA. These measurements can be used as a reference point for future monitoring to assess the relative reclamation success on the reclaimed landforms. According to the literature, a description of biodiversity should include reference to the scale at which the diversity is being described (Iacobelli et al. 1995). Noss and Cooperrider (1994) state that there are four scales of biodiversity to be considered:

- landscape (macroterrain);
- plant communities (ELC, ecosite phases, wetlands);
- species (species richness, rare plant occurrence); and
- genes.

In addition, each scale of biodiversity can be described in terms of its levels:

- composition;
- structure; and
- function.

Composition refers to the number of types and abundance of each unit (e.g., ELC units, plant communities, wetlands types and species) and can be measured using indices of richness and diversity. Structure refers to the vertical and/or horizontal layering of these units, and the abundance and distribution of these layers and/or the distribution of patches across the landscape. Function refers to the climatic, geologic, hydrologic, ecological and evolutionary processes that occur within each scale. For the purposes of this report, function is discussed qualitatively.

Indices measured included patch size, patch shape, richness, expressed as the number of units present, and diversity, which is calculated using the Shannon Index. This index is a measure of the equitability (H) calculated to incorporate the sum of the proportional contributions of an individual species, ELC or patch to the total population (Art 1993). Minimal values occur when one species, ELC or patch has a disproportionate dominance whereas maximum values occur when all species, ELC or patches share equally in the dominance. The Shannon Index, H, is expressed as:

$$H = \sum_{i=1}^{k} P_i \log P_i$$

Where,

k = number of categories (i.e., ELC units or species); and

P_i = proportion of the observations found in i.

D4.1.4 Structure

Patch Size

Measurements of patch size and patch shape will provide some indication of the natural variability in size and shape of patches that currently exists in the LSA. This information can be used as a reference point for reclamation design and monitoring. A landscape is comprised of many patches of habitats that influence, for example, the distribution, abundance, and movement of wildlife (Wildlife Baseline Report; Golder 1998n). Patch size refers to the size or shape of a landform, ELC unit, ecosite phase or stand.

Patch Shape

The patch shape index of a polygon is the ratio between the actual perimeter length and the minimum perimeter length of the same polygon if it were a true circle. The Shape Index is expressed as:

$$\text{Shape perimeter} = \text{perimeter} / [\, 2 \text{ x } (\text{area x perimeter})^{0.5} \,]$$

Table D4.1-1 outlines the scale, level indices and measures of assessment for assessing ELC diversity. Ecological diversity has been evaluated in this section at the landscape and community scale for ELC units in the LSA. The terrestrial vegetation and wetlands sections (D3) will discuss diversity at the plant species scale based on field survey information. Impacts to diversity at the species scale are only discussed conceptually since it is difficult to determine how species composition and structure will change following development. Discussion of genetic scale biodiversity is beyond the scope of this EIA.

In summary, ecological diversity indices were developed for: ELC richness, plant community richness, wetland richness, patch size, patch shape, rare plant potential, species richness and diversity (Shannon Index).

D4.1.5 ELC Results

In total, five landforms or macroterrain are defined for the study areas based on the integration of terrain, soil, vegetation and wetlands units (Table D4.2-2). Macroterrain units in the LSA are presented in Figure D4.1-1 while ELC units are shown in Figure D4.1-2.

Table D4.1-1 ELC Diversity Assessment

Scale	Level	Indices	Measures of Assessment
Landscape (ELC Section)	Composition	Richness • number of macroterrain units Diversity • macroterrain	 decrease = loss in diversity decrease = loss in diversity
	Structure	Patch size (macroterrain) • mean • range (min-max) Patch Shape • mean • range (min-max)	 increase/decrease = change in biodiversity decrease = loss in diversity increase/decrease = change in diversity decrease = loss in biodiversity
Community (ELC Section)	Composition	Diversity • number of types of ELC units in each macroterrain) Richness • number of polygons in each macroterrain	decrease = loss of diversity decrease = loss of diversity decrease = loss of diversity
	Structure	Patch size (ELC) • mean • range (min-max) Patch Shape • mean • range (min-max)	 increase/decrease = change in biodiversity decrease = loss of biodiversity increase/decrease = change in diversity decrease = loss in diversity
Species	Composition	Species Richness and Diversity	See Terrestrial Vegetation and Wetlands (Section D3)
	Structural	Richness in Layers Diversity in Layers	

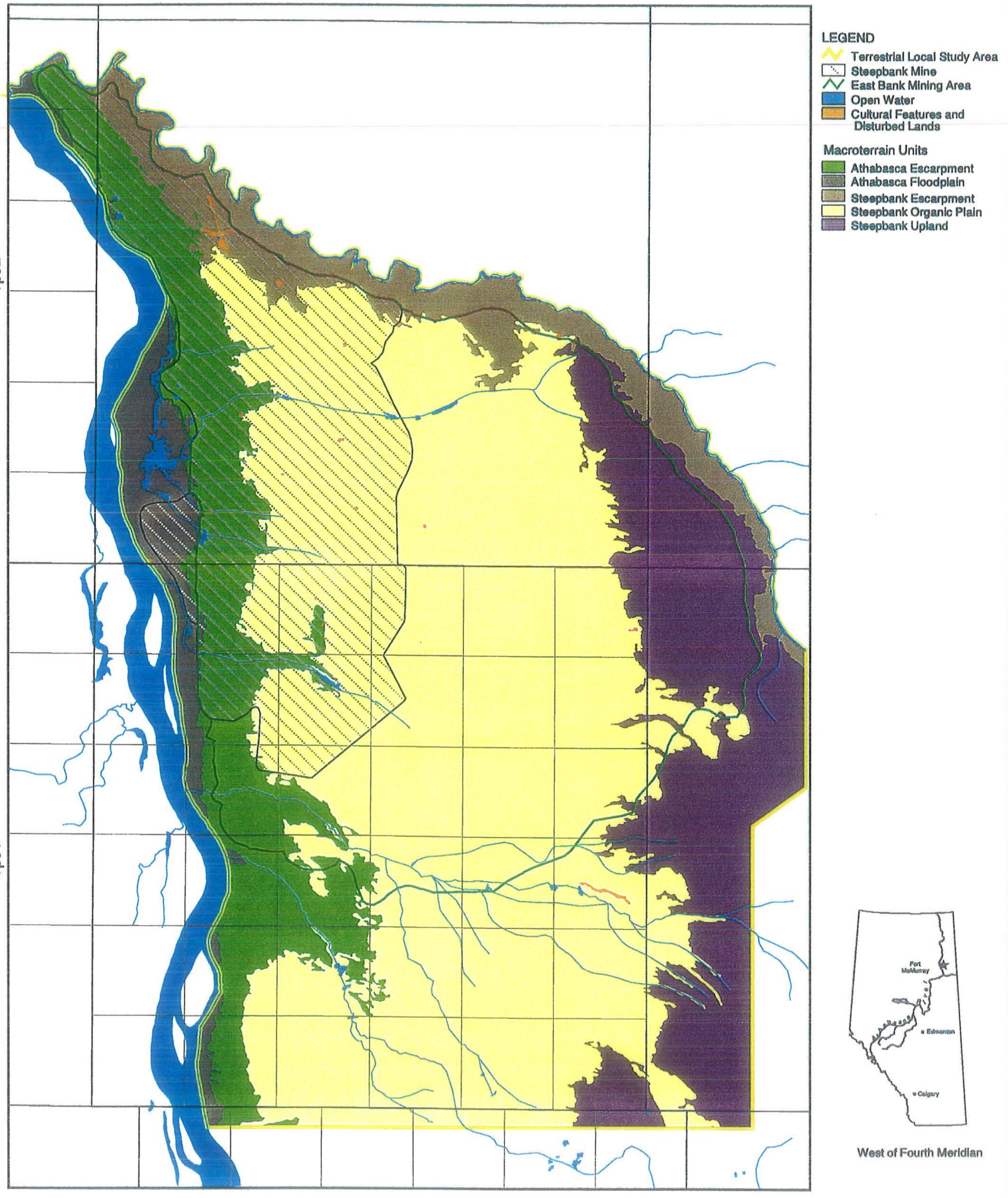
For the purposes of the ELC analysis, the terrestrial local study area (LSA, 16,182 ha) has been divided into five macroterrain units based on terrain, soil series, ecosite phase, wetlands and drainage. These five units include the: Athabasca Floodplain, Athabasca Escarpment, Steepbank Escarpment, Steepbank Upland and Steepbank Organic Plain. Details on the macroterrain units are provided in the ELC Baseline for Project Millennium (Golder 1998c).

D4.1.6 Athabasca Floodplain

The Athabasca Floodplain (ATF) occupies an area of 691 ha or 4% of the LSA. This relatively flat land is situated adjacent to the east bank of the Athabasca River in a narrow discontinuous strip (approximately 19 km long and 1.2 km across at the widest point). The average slope percent is approximately 4%.

Table D4.1-2 Macroterrain and Component ELC Units

Macroterrain	Area (ha)	% of LSA	Dominant Terrain Units	Soil Unit	Vegetation Unit	% Cover	Wetlands Unit	% Cover
Athabasca Floodplain (ATF)	691	4	Fluvial (97%)	Mineral (98%)	b1	2	FTNN	1
					d1	9	MONG	11
					d2	1	MONS	6
					d3	11	SONS	17
				Organic (2%)	e1	19	STNN	4
					e2	3		
					e3	7		
					shrub	7		
Athabasca Escarpment (ATE)	2,307	14	Rough Broken (67%)	Mineral (95%)	a1	<1	FTNN	2
					b1	3	MONG	<1
					b2	1	MONS	<1
					b3	2	SFNN	<1
			Morainal/Till (24%)	Organic (5%)	b4	1	SONS	1
					d1	62	STNN	3
					d2	4		
					d3	13		
					e1	2		
					e2	1		
					e3	1		
					h1	1		
					shrub	2		
Steepbank Escarpment (STE)	1,135	7	Morainal/Till (40%)	Mineral (97%)	b1	5	FONS	<1
					b3	2	FTNN	4
					b4	<1	SFNN	<1
					d1	49	STNN	<1
			Rough Broken (30%)	Organic (3%)	d2	19		
					d3	11		
					e1	3		
					e2	1		
					e3	2		
					h1	<1		
Steepbank Organic Plain (STOP)	9,201	57	Shallow fens (32%)	Mineral (11%)	b1	<1	BTNN	<1
					b4	<1	FFNN	10
					d1	1	FONG	<1
					d2	<1	FONS	5
			Fens (17%)	Organic (89%)	d3	1	FTNN	63
					e1	<1	MONG	<1
					e2	<1	MONS	2
			Bogs (37%)		e3	<1	SFNN	6
					g1	<1	SONS	<1
					h1	<1	STNN	11
					Sb/Lt	<1		
					shrub	<1		
Steepbank Upland (STU)	2,707	17	Morainal/Till (72%)	Mineral (91%)	b1	2	BFNN	1
					b3	<1	BTNN	<1
					d1	46	FFNN	1
					d2	10	FONS	<1
			Glaciofluvial (15%)	Organic (9%)	d3	14	FTNN	6
					e1	<1	MONS	<1
					e2	<1	SFNN	4
					e3	1	SONS	<1
					h1	1	STNN	8
					shrub	<1		



SOURCES: Suncor
Golder
Klohn-Crippen
CAN-AG
The Forestry Corp

Map Projection: UTM 12
Datum: NAD 83

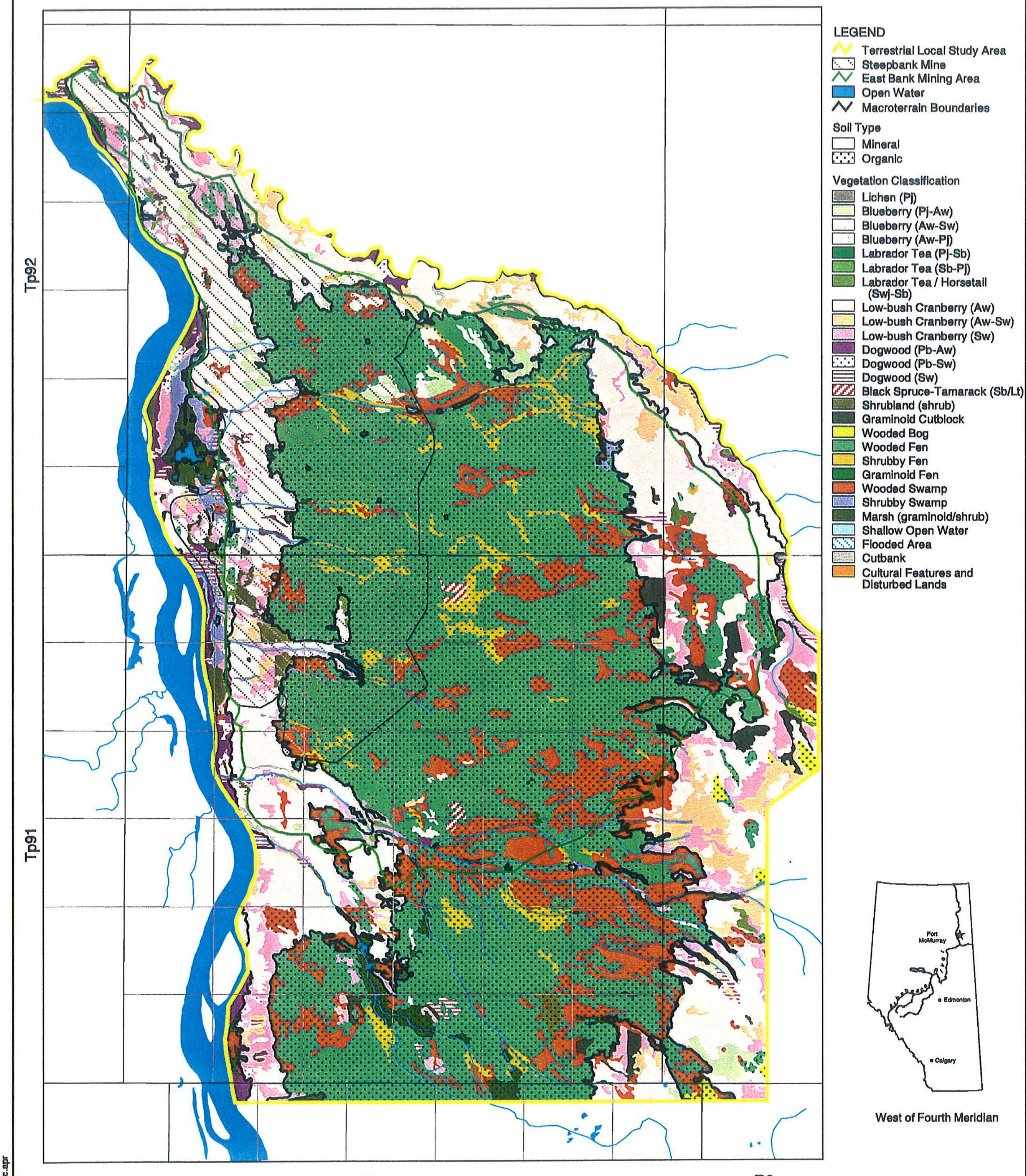
SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
MACROTERRAIN CLASSIFICATION

15 Apr. 1998 | Figure D4.1-1 | PRODUCED BY: JS REVIEWED BY:

/data14/suncor/local/8700/9740/arcview/lsa_macro.apr



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SOURCES: Suncor
Golder
Klohn-Crippen
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Datum: NAD 83

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LOCAL STUDY AREA ECOLOGICAL LAND CLASSIFICATION

15 Apr. 1998	Figure D4.1-2	PRODUCED BY: JS REVIEWED BY:

As expected in a floodplain, the terrain is dominated by unconsolidated fluvial material deposited by periodic flooding and lateral migration of the river channel. Accordingly, the floodplain is dominated by regosols (mineral) of the McMurray series. Regosols are thin, immature soils which develops on newly deposited unconsolidated deposits that are typical of floodplains.

There are 17 ELC units in the Athabasca Floodplain. The ATF is a mixture of both upland (53%) and wetlands vegetation (47%) communities (Table D4.1-2). Upland areas are dominated by the dogwood (e) and low-bush cranberry (d) ecosites; specifically, dogwood balsam poplar-trembling aspen (e1), low-bush cranberry white spruce (d3), low-bush cranberry trembling aspen (d1), dogwood white spruce (e3), and shrub. Wetlands communities are dominantly shrubby swamp (SONS), graminoid marsh (MONG) and shrubby marsh (MONS).

This mosaic of vegetation types is reflected in the range of stand age and timber productivity ratings (TPR) recorded within the Athabasca floodplain. Old growth stands, including those dominated by stands of balsam poplar or white spruce, occur within the Athabasca floodplain as documented in the Project Millennium Forestry Baseline Report (Golder 1998e). The TPR ratings range from 38% classified as unproductive, to 53% classified as productive (medium 26% and good 27%). Similar patterns are found in the Steepbank area, however, none of the Millennium area is ranked as good for TPR; rather the area is split between medium TPR (51%) and unproductive TPR (49%).

D4.1.7 Athabasca Escarpment

The Athabasca Escarpment (ATE) occupies 2,307 ha or 14% of LSA. This macroterrain unit is situated adjacent to the Athabasca floodplain and extends for the length of the LSA. The escarpment is approximately 19 km long and 3.5 km across at the widest point. There is a wide range of slopes (0 to >27%), with the average being 6%.

Dominant terrain types include rough broken (RB, 67%) associated with the escarpment slopes; and morainal/till (Mor/T, 24% of the ATE) that is typically associated with the escarpment crest. The Athabasca escarpment is dominated by mineral soils, specifically, rough broken soil units which are generally composed of regosols on the slopes and brunisols on the crest. In addition, the poorly developed regosols of the McMurray series occupy 21% of the ATE unit.

Twenty-six ELC units have been identified for the Athabasca Escarpment. Low-bush cranberry-trembling aspen (d1) and low-bush cranberry-white spruce (d3) are the most dominant ecosite phases occurring on the escarpment. All other upland ecosite phases, occupy less than 5% of the unit area. Less than 5% of the unit consists of wetlands, which include swamps, marshes and fens.

The Athabasca Escarpment, supports some white spruce-dominant, old growth forest (age of stand >160 years). There is also one old growth stand of trembling aspen-dominated (age of stand >100 years) which occurs on the crest of the escarpment. The escarpment supports 92% productive timber indicated by TPR ratings that range from medium (58% of the ATE) to good (34% of the ATE). Some areas of the escarpment, however, would not be merchantable because of the relatively steep slopes.

D4.1.8 Steepbank Escarpment

The Steepbank Escarpment (STE) occupies 1,135 ha or 7% of the LSA. This unit is a narrow relatively continuous strip, approximately 16 km long and 2 km across at the widest point. The unit extends from the northwest region of the LSA, along the west bank of the Steepbank River. Due to the limited development of a floodplain, the Steepbank escarpment and floodplain have been lumped into a single macroterrain unit.

As with the other units, slope percent varies widely (0 to >29%), with an average slope of about 5%. This area is dominated by rough broken terrain units which are characterized by steep, eroding slopes (30% of the STE). On the crest of the escarpment, morainal/till terrain units dominate (40% of the STE).

The overlying soils are a mosaic of luvisols in the kinosis series as well as rough broken types. Both these soil types support upland ecosite phases.

Eighteen ELC units have been identified within the Steepbank Escarpment. The Steepbank Escarpment is dominated by upland ecosite phases, specifically low-bush cranberry-trembling aspen (d1), low-bush cranberry-trembling aspen-white spruce (d2) and low-bush cranberry white spruce (d3). Trembling aspen-dominated, old growth forest occupy a small proportion of the slope. The TPR is predominantly medium (78% of the STE) to good (18% of the STE).

D4.1.9 Steepbank Organic Plain

The Steepbank Organic Plain (STOP) is situated in the center of the LSA, and is by far the largest macroterrain unit (9,201 ha or 57% of the LSA). This unit is level, as reflected in it's relatively limited slope percent, which ranges from 0 to 10%, with an overall average slope of 1%.

The Steepbank Organic Plain is dominated by shallow bogs, fens and shallow fens. Overlying soils are organic, with the Mildred and Muskeg soils dominating the unit.

Thirty-two ELC units have been identified within the Steepbank Organic Plain. The STOP is dominated by wetlands vegetation types. Fens make up 78% of the unit; specifically wooded fens (FTNN), which occur on 5,752 ha or 63%, forested fens (FFNN) which occupy 948 ha or 10% and shrubby fens (FONS), which occupy 419 ha or 5%. Other significant wetlands types include wooded swamp (STNN) and forested swamp (SFNN). Differences in the distribution of fen and bog types between the terrain and wetlands is a result of differences in the classification methodology employed.

No old growth forests were documented to occur within this macroterrain unit. The majority, 5,513 ha or 60%, of the STOP has been classified as unproductive timber.

D4.1.10 Steepbank Upland

The Steepbank Upland (STU) is 2,707 ha or 17% of the LSA. This macroterrain unit extends north-south, along the eastern boundary of the LSA; it is approximately 14.2 km long and 3 km across at the widest point.

Relative to the Athabasca and Steepbank escarpment, the Steepbank Upland macroterrain unit has a smaller range (0 to 15%) and average (2%) slope. This upland unit is dominantly morainal/till (72% of the STU). Overlying soils are mineral, with luviosols of the kinosis series dominant (72% of the STU).

Twenty-six ELC units have been identified within the Steepbank Upland. The Steepbank Upland is dominated by upland ecosite phases, specifically low-bush cranberry-trembling aspen (d1), low-bush cranberry trembling aspen-white spruce (d2) and low-bush cranberry white spruce (d3). Wetlands occupy a small proportion of this unit and include bogs, fens, marshes and swamps. As with the Steepbank escarpment, TPR values associated with these ecosite phases are productive, with areas rated as medium (54% of the STU) and good (32% of the STU) dominating.

The remainder of the LSA is comprised of water classes (120 ha or <1% of the LSA) and disturbed land (22 ha or <1% of the LSA). Water classes consist of lakes, rivers and ponds, but not shallow open water. Disturbed land is comprised of roads, gravel pits, pipelines, transmission lines and well sites.

D4.1.11 Ecological Diversity

Ecological diversity has been evaluated in this section at the landscape and community level scale for both macroterrain and ELC units. The Terrestrial Vegetation (Golder 1998l) and Wetlands (Golder 1998m) baseline reports discuss diversity at the plant species scale.

Ecological diversity indices were developed for: richness, community richness, community diversity (Shannon Index), patch size and patch shape.

D4.1.11.1 Landscape Level Diversity

The use of landscape or macroterrain units as a framework for the setting of landscape scale diversity objectives is considered by Iacobelli et al. (1995) to be the best ecological framework for the conservation of biodiversity. Such landscape units are enduring features of the earth's surface, versus the more changeable biotic features such as vegetation cover. The ELC developed for the Project uses a combination of terrain, soils and vegetation features to map macroterrain units (Figure D4.1-1). The macroterrain richness in the LSA is 5. The size of the macroterrain ranges from 691 to 9,201 ha.

D4.1.11.2 Composition

Richness, diversity index, and a comparison of the size of landscape units were used to determine the changes in the overall diversity at the landscape level (Table D4.1-3). There are five macroterrain units in the LSA with an overall diversity of 0.54, which suggests that there is a disproportionate distribution of macroterrain units. The Steepbank Organic Plain (STOP) occupies 57% of the LSA, whereas the Athabasca Floodplain occupies only 4% of the LSA.

Table D4.1-3 Macroterrain Diversity Measures at the Landscape Scale in the LSA

Measures	Pre-Development
Richness	5 types
Shannon Index	0.54
Shape	2.16

D4.1.11.3 Structural Diversity

The landscape level structural diversity can be assessed by polygon (patch) number, size and shape distribution across the LSA. Stand level structural impacts within forested areas are focused on the changes in living and dead structure (i.e., residual patches) within the LSA. This is discussed in the Vegetation and Wetlands (Section D3.1) Section of this EIA.

D4.1.11.4 ELC Unit Richness and Diversity

The number of ELC units represented in the LSA are presented in Table D4.1-4. Patch number and size provided an assessment of structural changes in diversity at the landscape scale. The Steepbank Organic Plain has the largest number of ELC types (soil/ecosite phase) occurring within this macroterrain unit. The Athabasca Escarpment and Steepbank Upland both have 26 ELC types and the Athabasca Floodplain have the least number of ELC types (17). The Shannon Index indicates that ELC units within the Athabasca Floodplain share equally in the dominance whereas there appears to be a disproportionate distribution or dominance in ELC units within other macroterrain units. The Steepbank Organic Plain, for example, is largely occupied by wooded fens (STOP/O/FTNN), which is a disproportionately dominant ELC unit within the macroterrain. Similarly, low-bush cranberry trembling aspen (d1) on organic soils (ATE/O/d1) is disproportionately dominant within the Athabasca Escarpment (Figure D4.1-2).

Table D4.1-4 ELC Richness and Diversity Indices

Landscape Units	Pre-Development	
	Richness (ELC Types) = series /phase combinations	Shannon Index
Athabasca Floodplain	17	1.02
Athabasca Escarpment	26	0.70
Steepbank Escarpment	18	0.74
Steepbank Organic Plain	32	0.70
Steepbank Upland	26	0.84
Total	**119**	

Table D4.1-5 shows the number of ELC unit patches or polygons associated with each macroterrain units. This provides some indication of the total number of individual patches that are represented within each macroterrain unit. The Steepbank Organic Plain, the largest macroterrain unit, has 446 ELC unit polygons. The Athabasca Floodplain, the smallest macroterrain, has the least number of polygons at 140. The Athabasca Floodplain, however, has a higher distribution in ELC units per macroterrain area than the Steepbank Organic Plain.

Table D4.1-5 Number of ELC Patches

Landscape Units	Pre-Development Number of ELC Polygons
Athabasca Floodplain	140
Athabasca Escarpment	193
Steepbank Escarpment	156
Steepbank Organic Plain	446
Steepbank Upland	191
Total	**1,126**

D4.1.12 Species Level Richness, Diversity, Rare Plants and Old Growth Forests For ELC Units

A summary of the richness, diversity, rare plant species and old growth forests associated with each ELC unit is shown in Table D4.1-6. The Terrestrial Vegetation (Golder 1998l) and Wetland (Golder 1998m) baseline reports provides a full description of richness, diversity, rare plants and old growth forests in the LSA. Table D4.1-6, however, provides this species level information as it relates to ELC units. Not all ELC units within the LSA were surveyed in the field. There are differences in the range of species richness and diversity of ecosite phases and wetlands based on macroterrain location. Five rare plants were observed in the LSA. Three of the rare plants occurred within the Athabasca Floodplain macroterrain. One rare plant occurred in the Athabasca Escarpment and one rare plant occurred within the Steepbank Organic Plain. Old growth-aspen dominant forests were restricted to the escarpments and upland. On the data collected it appears that the spatial location, macroterrain, influences some of the parameters measured. This information is useful on determining the most suitable analogs for assessing plant diversity on reclaimed landforms.

According to this assessment, the most "unique" ELC units are those that support either rare plants, old growth forest or both. There are 19 ELC units that are considered "unique" in the LSA. Eight of these ELC units occur in the Athabasca Floodplain; 4 occur in the Athabasca Escarpment; 3 occur in the Steepbank Escarpment; 2 occur in the Steepbank Organic Plain; and 2 occur within the Steepbank Upland.

D4.1.13 Structure

ELC unit patch size and patch shape indices were used to assess structural diversity. Structural diversity refers to variations in the physical characteristics of the environment that create a variety of habitats within the LSA, thereby indicating the diversity of species that can potentially live there.

Table D4.1-6 Summary of Species Level Richness, Diversity, Rare Plants and Old Growth Forests

ELC	Number of ELC units surveyed	Richness Range				Total Diversity Range	Rare Plants	Old Growth Forest (dominant tree species)
		Tree	Shrub	Herb	Total			
ATF/M/b1	n/a	n/a	n/a	n/a	n/a	n/a		balsam poplar
ATF/M/d1	n/a	n/a	n/a	n/a	n/a	n/a		aspen
ATF/M/d3	n/a	n/a	n/a	n/a	n/a	n/a		white spruce
ATF/M/e1	3	0 - 2	8 -10	6 -10	14 - 21	0.91 - 1.07	turned sedge, prairie cord grass	aspen, balsam poplar
ATF/M/e2	n/a	n/a	n/a	n/a	n/a	n/a		balsam poplar, white spruce
ATF/M/e3	1	3	11	5	17	1.05		white spruce
ATF/M/Mong	1[(a)]	n/a	n/a	n/a	n/a	n/a	small water-lilly	
ATF/M/Stnn	n/a	n/a	n/a	n/a	n/a	n/a		white spruce
ATE/M/d1	4	1 - 3	9 -10	5 - 11	17 - 22	0.95 - 1.20	wool-grass	aspen
ATE/M/d2	1	1	18	8	26	1.29		
ATE/M/d3	1	3	8	5	14	1.02		white spruce
ATE/M/e1	n/a	n/a	n/a	n/a	n/a	n/a		balsam poplar
ATE/M/e3	1	0	11	11	22	1.13		white spruce
STE/M/b1	1	2	9	7	17	1.04		
STE/M/d1	4	1 -2	7 - 13	5 - 13	10 - 26	0.77 - 1.19		aspen
STE/M/d2	8	2 - 4	3 - 12	2 - 17	7 - 27	0.64 - 1.22		aspen
STE/M/d3	1	1	9	6	15	0.97		
STE/M/e1	n/a	n/a	n/a	n/a	n/a	n/a		aspen
STOP/M/b1	1	5	8	5	18	1.12		
STOP/M/b4	4	2 - 3	6 - 9	1 - 8	11 - 17	0.88 - 1.05		
STOP/M/d1	5	2 - 3	10 - 13	5 - 9	18 - 22	1.06 - 1.20		
STOP/M/e2	2	2 - 3	7	9	17 - 19	0.91 - 1.06		
STOP/M/d3	n/a	n/a	n/a	n/a	n/a	n/a		balsam poplar
STOP/M/STNN	1	2	9	8	19	1.00	wool-grass	
STOP/O/FONS	4	0 - 2	4 - 8	7 - 18	14 - 25	0.86 - 1.21		
STOP/O/FTNN	20	0 - 2	1 - 15	1 - 14	6 - 23	0.56 - 1.06		
STOP/O/MONS	3	0	2 - 4	7 - 19	11 - 21	0.89 - 1.09		
STOP/O/SFNN	2	0 - 2	2 - 9	9 - 14	16 - 19	0.85 - 0.87		
STOP/O/STNN	2	2	9 - 14	4 - 7	13 - 21	0.91 - 0.96		
STU/M/d1	4	2 - 4	5 - 13	4 - 12	10 - 22	0.78 - 1.16		aspen
STU/M/d2	n/a	n/a	n/a	n/a	n/a	n/a		aspen
STU/M/d3	3	2 - 4	8 - 11	6 - 9	17 - 20	0.94 - 1.14		
STU/O/FTNN	1	1	3	3	6	0.50		

[(a)] An additional rare plant species, small water-lily (Nephew tetragona), was found in Shipyard Lake as part of RAMP.

ELC Unit Size (Patch Size)

The mean, minimum and maximum patch size of each ELC polygon or patch in the LSA is presented in Table D4.1-7. Patch number and patch

Table D4.1-7 Mean, Minimum and Maximum ELC Polygon Patch Size

Landscape Units	Baseline (ha)		
	Mean Size	Min Size	Max Size
Athabasca Floodplain	5	<1	67
Athabasca Escarpment	12	<1	565
Steepbank Escarpment	7	<1	265
Steepbank Organic Plain	21	<1	3,047
Steepbank Upland	14	<1	502

size are used in the forest industry to assess maximum cutblock sizes and reforestation efforts. In mining, an assessment of natural patch number and size distribution provides a target for assessing and monitoring reclamation efforts.

Range and average patch sizes of ELC units may change for some of the macroterrain units as a result of the Project. Variability in patch size may be used as one indicator of landscape level diversity. For example, a larger range in patch sizes of ELC units may indicate a higher landscape level diversity with increases in ecotonal variation.

The Steepbank Organic Plain is the largest polygon in the LSA with an area of 9,201 ha. The ELC units, within this macroterrain ranges from <1 to 3,047 ha, with a mean of 21 ha. This range supports the Shannon Index results in that there are a few large ELC units, for example, one wooded fen on organic soil (STOP/O/FTNN) is 3,047 ha in size. The Steepbank Upland is 2,707 ha in size with ELC unit range from <1 to 502 ha, with a mean of 14 ha. The small mean indicates that there are more small patches than large patches. For example, there are a few large low-bush cranberry trembling aspen on mineral soils (STU/M/d1) patches with several small patches of wooded swamps on mineral soils (STU/M/STNN). Steepbank Escarpment is 1,135 ha with ELC units that range from <1 to 565 ha, with a mean of 7 ha. The Athabasca Escarpment is 2,307 ha in size. The ELC unit patches range from <1 to 565 ha, with a mean size of 12 ha. The range indicates that patch size are evenly distributed throughout the macroterrain. The smallest macroterrain unit is the Athabasca Floodplain at 691 ha. The ELC unit patches range from <1 to 67 ha, with a mean of 5 ha. This range indicates that there is a relatively small difference in the size of ELC unit patches within this macroterrain unit.

Patch Shape

Table D4.1-8 and Table D4.1-9 shows the patch shape for macroterrain and ELC units in the LSA. The patch shape index of a polygon is the ratio between the actual perimeter length and the minimum perimeter length of the same polygon if it were a true circle. The measure of sphereocity is

Table D4.1-8 Mean, Minimum and Maximum Patch Shape for Macroterrain Units

Landscape Units	Minimum and Maximum Shape of Macroterrain Units Baseline Mean Shape Index
Athabasca Floodplain	2.73
Athabasca Escarpment	3.27
Steepbank Escarpment	2.68
Steepbank Organic Plain	2.31
Steepbank Upland	3.15

Table D4.1-9 Mean, Minimum and Maximum Patch Shape for ELC Units

Landscape Units	Minimum and Maximum Shape of ELC Polygons		
	Baseline Mean Shape Index	Baseline Minimum Shape Index	Baseline Maximum Shape Index
Athabasca Floodplain	2.45	1.03	5.88
Athabasca Escarpment	2.04	1.03	6.56
Steepbank Escarpment	2.21	1.11	5.81
Steepbank Organic Plain	2.17	1.04	12.39
Steepbank Upland	1.99	1.03	6.37

used to assess the amount of edge effect or ecotonal boundaries between polygons. The natural landscape is comprised of varying amounts of ecotonal areas, however, anthropogenic disturbances often result in the creation of straight line borders. These straight line or linear disturbance features often result in less ecotonal area than natural disturbances such as fire. A high ecotonal area often equates to high ecological diversity since this area supports more habitat types (i.e., vegetation communities). Many wildlife species, for example, are often found in ecotones that rapidly transition among forest, wetlands and open habitats because it provides both cover and food sources in close proximity (Golder 1998e).

The mean shape index of the Athabasca Floodplain is 2.73 which indicates relatively high ecotonal area but less than the Athabasca Escarpment. The Athabasca Floodplain is bordered by the Athabasca River, which at the scale of mapping, is relatively less irregular than the boundary between the floodplain and the escarpment. The ELC unit patches associated with the Athabasca Floodplain, indicate high ecotonal area. The mean shape index of the Athabasca Escarpment is 3.27, which indicates that it may have the highest ecotonal area of all the macroterrain. The ELC unit patches range in shape from 1.03 to 6.56, with a mean of 2.04. This indicates that the majority of ELC patches are irregular in shape.

The Steepbank Escarpment includes the floodplain, slope and crest of the escarpment. The irregular boundary of this macroterrain can be attributed to the transition between a predominately upland area to a lowland area associated with the Steepbank Organic Plain. The transition or boundary is irregular due to, for example, the distribution of parent materials and the drainage patterns. The ELC unit patches range in shape from 1.11 to 5.81, with a mean of 2.21.

The mean shape index for the Steepbank Organic Plain is 2.31 which is lower than the other macroterrain. This lower value indicates that the STOP has less irregular shaped boundaries.

This is an irregular shaped macroterrain unit primarily because it forms a gradual transition from the Organic Plain to upland communities associated with morainal till. The boundaries are a reflection of landform, topography and drainage. The ELC unit patches range in shape from 1.03 to 6.37, with a mean of 1.99.

D4.1.14 Functional Diversity

Function can be defined as the physiological action or activity of an organism or a part of an organism and/or the rate of flow through an ecosystem such as the rate of energy flow or nutrient cycling. In this report, functional diversity is only assessed qualitatively.

The Athabasca Floodplain, Athabasca Escarpment and Steepbank Escarpment functions as a wildlife movement corridor as described in the Wildlife Baseline Report (Golder 1998n) or Section 5.2 of the EIA. Corridors are essentially strips of land linking one or more vegetation types to another or providing contiguous wildlife habitat. Corridors may be narrow but they effectively enlarge wildlife habitat utilization, even when they connect small parcels of land. In addition, these macroterrain units can serve as migratory pathways or channels for animals in annual migrations.

The Steepbank Organic Plain is largely a wetlands complex that potentially serves a number of functions within the LSA. This area, for example, may serve to purify water that may recharge the surficial aquifer. In addition, the macroterrain unit provides food and habitat for many different species.

D4.2 ECOLOGICAL LAND CLASSIFICATION PROJECT IMPACT ASSESSMENT

D4.2.1 Introduction

The potential impacts of Project Millennium on ELC units was assessed using a linkage diagram and key impact question which focus on the impacts of both the development and closure phases of the project.

The system of impact classification employed was described previously in Section A2. The ELC assessment focused primarily on the LSA. Macroterrain and component ELC units affected by the project were described and impacts quantified by superimposing the mine development plan on the ELC base map for the LSA. The ELC map delineates firstly macroterrain units identified largely on the basis of physiographic criteria, recognizable on satellite imagery and small scale photography (e.g. Steepbank Organic Plain). Impacts on each macroterrain units were quantified separately to identify the nature and extent of impacts to that unit within a local and regional context. This was then used in the discussion of impacts to diversity at the landscape level.

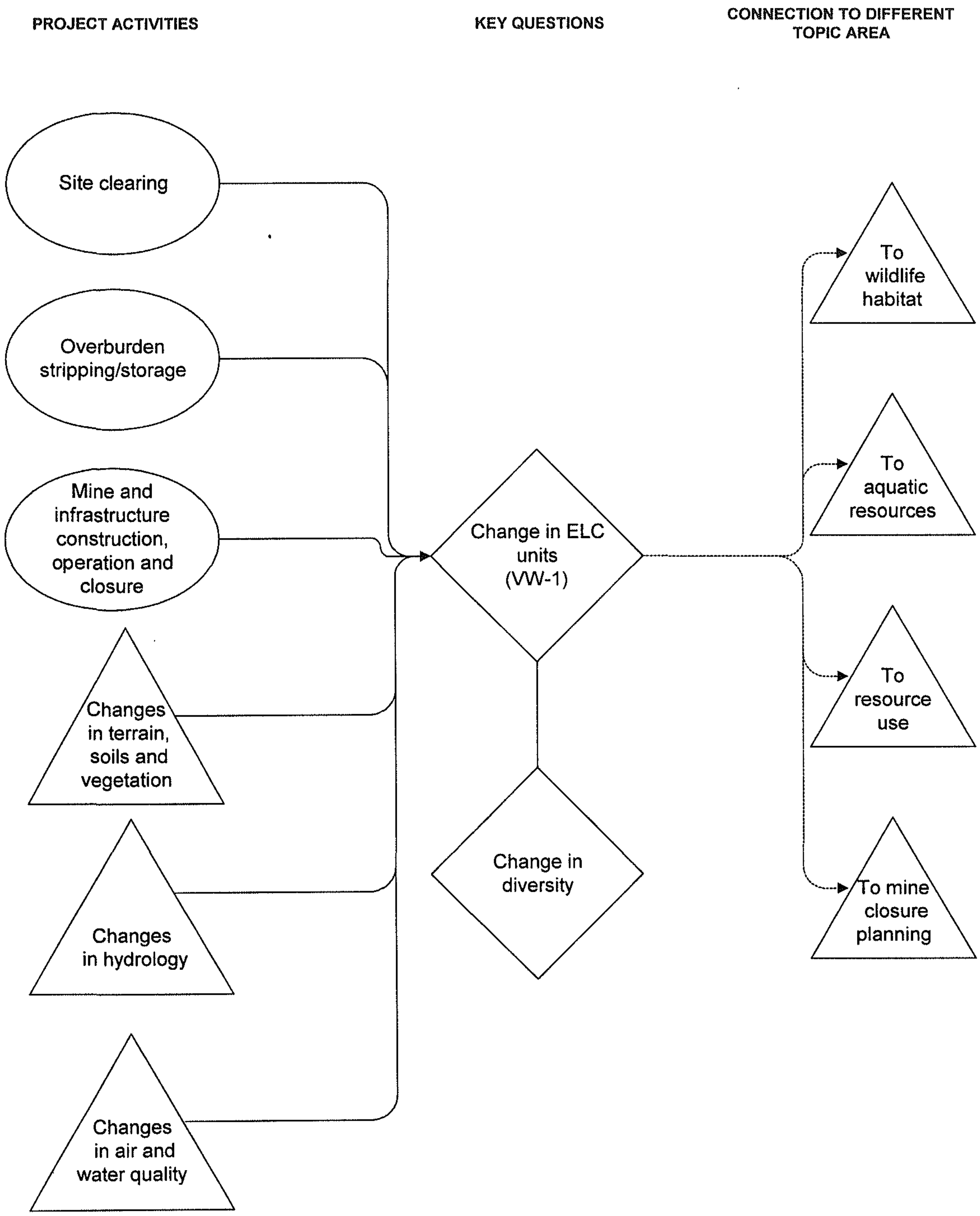
The ELC map secondly identifies ELC units, or smaller divisions of each macroterrain unit, on the basis of soil and vegetation (ecosite phase) conditions recognizable on large-scale aerial photography. Impacts are similarly quantified for each discrete ELC unit within each macroterrain unit. The ELC units were used to assess community level diversity. The existing ELC database was also used in the design of the reclamation landscapes as outlined in the mine closure plan (Section E).

D4.2.2 Potential Linkages and Key Question

An ELC linkage diagram was prepared for the Project to demonstrate the connections between the Project and the environment in which the mine will be developed and reclaimed. In this section, the focus of the linkage diagrams is on the connections between the project and the ELC units of the LSA. They are used to help understand and explain the often complex interactions that can take place between the mine and the environment over the life of the Project. Impacts more specific to each biophysical resource (terrain, soils and vegetation) will be discussed in those particular impact assessment sections.

The ELC linkage diagram (Figure D4.2-1) is used to demonstrate the potential impacts of Project construction and operation, as well as closure, on the ELC units in the LSA. Project activities that may affect ELC units

Figure D4.2-1 Linkage Diagram for Ecological Land Classification for Development and Closure Phases of Project Millennium



include, but are not limited to: site clearing, overburden stripping and storage and construction, operation and closure of the mine and infrastructure. Changes in the hydrology of the LSA and in the macroterrain diversity may also result from the construction, operation and closure phases of the Project. The impacts from these activities are expected to include direct losses or alteration of ELC units as a result of site clearing and physical removal of some ELC units, while the indirect losses may result primarily from air emissions and/or water releases as discussed in the Vegetation and Wetlands Impact Assessment (Section D3.2).

The linkage diagrams further demonstrate the potential pathways of change in other related resources, such as soil and vegetation, wildlife habitat and resource use, as a result of changes at the landscape or macroterrain ELC level.

Reclamation activities will determine which ELC units will be re-established through grading, replacement of overburden and topsoil materials, re-establishment of surface drainage patterns and revegetation. The landform, soil type and moisture regimes established on reclamation sites will determine which ecosite phases will become re-established. The ELC databases for the LSA provides a frame of reference for the desired type of reclaimed landscapes within the LSA. The effects of re-established plant communities on resource use and wildlife habitat within the Project area are discussed in Sections D3.2.

Issues related to macroterrain and component ELC units may be summarized as follows:

- loss or alteration of macroterrain and ELC units in the LSA; and
- change in diversity at the landscape level (macroterrain units) and the community level (ELC unit).

A key question for ELCs was developed based on the issues previously identified. It provides a focus in data collection and analysis to help determine the magnitude and significance of the effects of each potential impact on ELCs. One key question was developed for ELCs:

VW-1: **What impacts will development and closure of Project Millennium have on ecological land classification (ELC) units, vegetation communities and wetlands?**

During development and closure of Project Millennium, landscapes and their associated soil and vegetation may be substantially altered due to development. The loss and/or alteration of macroterrain and ELC units are examined at the landscape level while loss of plant community (ecosite phase) and plant species level are examined in the Terrestrial Vegetation section (Section D3.2).

The LSA is characterized by a diversity of landscapes, vegetation, soils and drainage conditions. As a consequence of the Project construction and operation phases, as well as subsequent reclamation, there is a concern that the LSA will not be as diverse as the pre-development conditions. The time required for reclamation and revegetation to replace terrain, soils and vegetation conditions to a previous level of diversity is an issue. Although species richness (one indicator of diversity) may actually decrease as succession proceeds (i.e. old growth forests), the change in diversity of reclaimed landscapes over time can be examined in a more holistic sense, utilizing the concepts of ELC, in combination with a variety of biotic and abiotic indicators. This issue is examined further in the design of reclamation monitoring programs.

D4.2.3 Key Question VW-1: What Impacts Will Development and Closure of Project Millennium Have on Ecological Land Classification (ELC) Units, Vegetation, Communities and Wetlands?

The evaluation of impacts to ELC units has been completed by examining:

- the nature and extent of physical changes to macroterrain units; and
- associated potential changes to diversity.

D4.2.3.1 Changes to Macroterrain Units

Analysis of Potential Linkages

A loss or alteration of ELC units has been identified in the linkage diagram (Figures D4.2-1) as a result of development, operation and closure phases. The primary direct impacts on ELC units will be through site clearing, and overburden stripping/storage. Changes in terrain, soil and vegetation will occur along with changes in hydrology, air and water quality. These changes are examined in an holistic sense through the use of ELC. Aquifer drawdown will primarily affect wetlands as discussed in Section D3.2.

The closure phase of the Project will result in changes to the landforms or macroterrain units and replacement of some pre-disturbance vegetation communities. As a result, some new ELC units will be re-established on the reclaimed landscapes. This is discussed in the mitigation section.

D4.2.3.2 Impact Analysis

The first level of this impact analysis is to examine losses to predominant landforms or macroterrain units within the LSA. The macroterrain is the broadest level of ELC mapping of terrestrial resources within which the impacts on the landscape can be identified and analyzed in terms of function and processes.

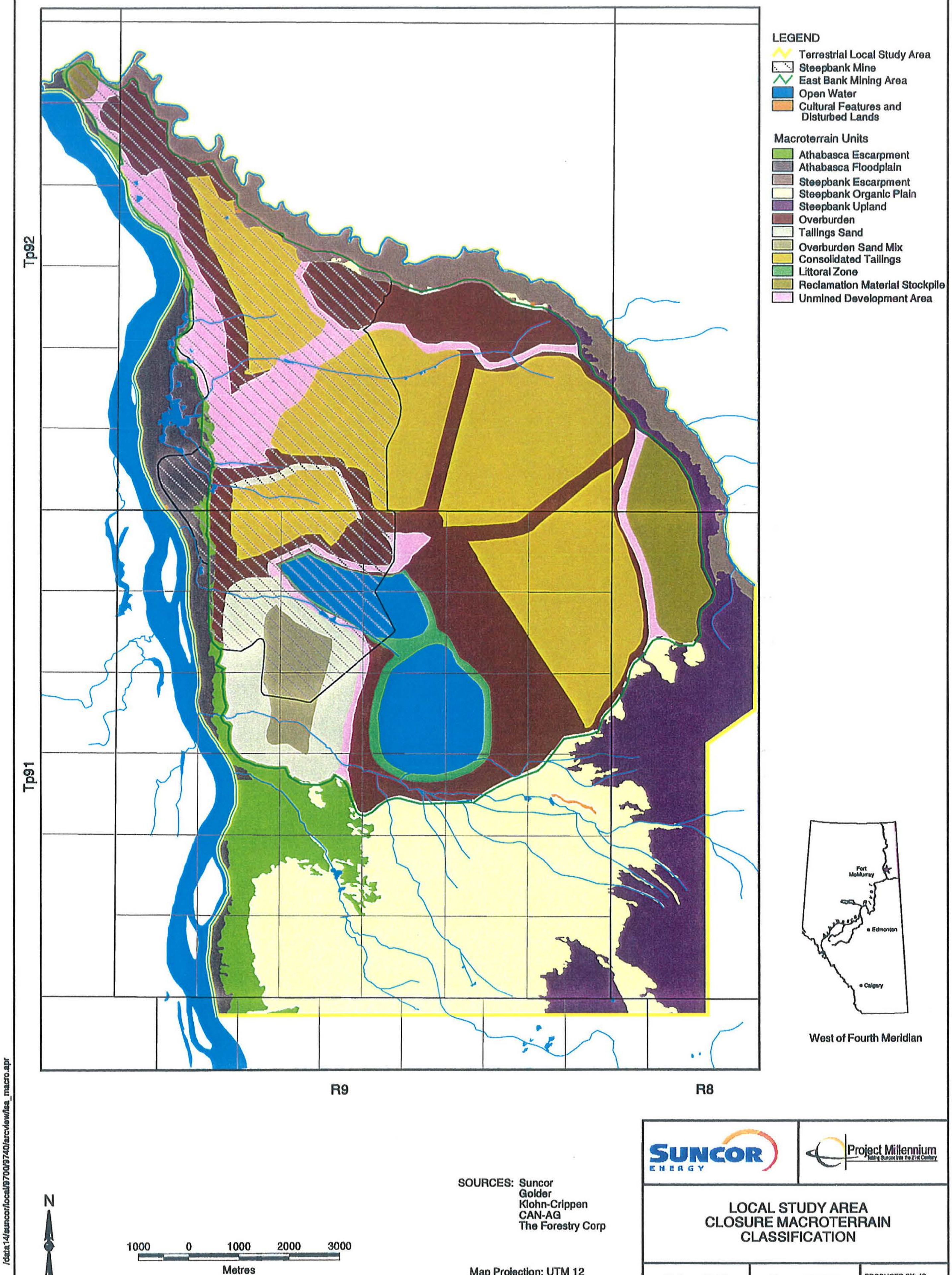
These broad macroterrain units serve a variety of functions, for example, the Athabasca Floodplain and Escarpment serve as a linear corridor for wildlife movement in the region, as documented in the Winter Wildlife Survey Baseline Report (Golder 1997s). In addition, the Athabasca Floodplain is documented to support rare plant species and old growth forests, as documented in the Terrestrial Vegetation and Wetlands section of this EIA.

Table D4.2-1 presents areas of macroterrain units in the LSA, and the area and percent of each unit lost through clearing for the Project. This table provides predevelopment, impact and closure areas for each macroterrain unit. The closure areas are the predevelopment areas minus the impact areas. Figure D4.2-2 shows the macroterrain units on the reclaimed landscape. Figure D4.2-3 shows the size and distribution of component ELC units on the reclaimed landscape in the LSA. Tables D4.2-2 to D4.2-6 describe the pre-development macroterrain and component ELC units, the disturbances to these units from the approved Steepbank Mine Project and the cumulative disturbance from the east bank mine area. The closure column presents the final representation of macroterrain and component ELC units in the post-development landscape. It is not expected that lost macroterrain and component ELC units will be returned to pre-development conditions, but rather reclamation will create new macroterrain and ELC units using the pre-disturbance ELC conditions as analogs to help design appropriate reclamation landscapes within a local and regional context. The mitigation section describes the new closure macroterrain and component ELC units that will be reclaimed following closure of the Project. The reclamation process is detailed in the Closure Plan (Section E).

Table D4.2-1 Macroterrain Units Within the TLSA

Macroterrain Units	LSA		Steepbank Mine			East Bank Mining Areas			Closure		
	ha	% LSA	ha	% LSA	% Resource	ha	% LSA	% Resource	ha	% LSA	% Resource
Athabasca Floodplain	691	4	148	1	21	32	<1	5	659	4	95
Athabasca Escarpment	2,307	14	1,229	8	53	1,561	10	68	746	5	32
Steepbank Escarpment	1,135	7	303	2	27	422	3	37	713	4	63
Steepbank Organic Plain	9,201	57	2,073	13	23	6,189	38	67	3,012	19	33
Steepbank Upland	2,707	17	<1	<1	<1	1,048	7	39	1,659	10	61
Water	120	1	8	<1	7	14	0	12	106	<1	88
Developed Land	22	<1	14	<1	63	15	0	69	7	<1	31
Reclaimed Macroterrain	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9,281	57	100
TOTAL	**16,181**	**100**	**3,776**	**23**	**n/a**	**9,281**	**57**	**n/a**	**16,181**	**100**	**n/a**

The percent losses are expressed as the percent loss of each macroterrain or ELC unit described within the LSA. The percent losses of each unit described is expressed in the tables as "% resource". Impacts are assessed for each macroterrain unit based on percent loss of this resource and its component ELC units.



SOURCES: Suncor
Golder
Klohn-Crippen
CAN-AG
The Forestry Corp

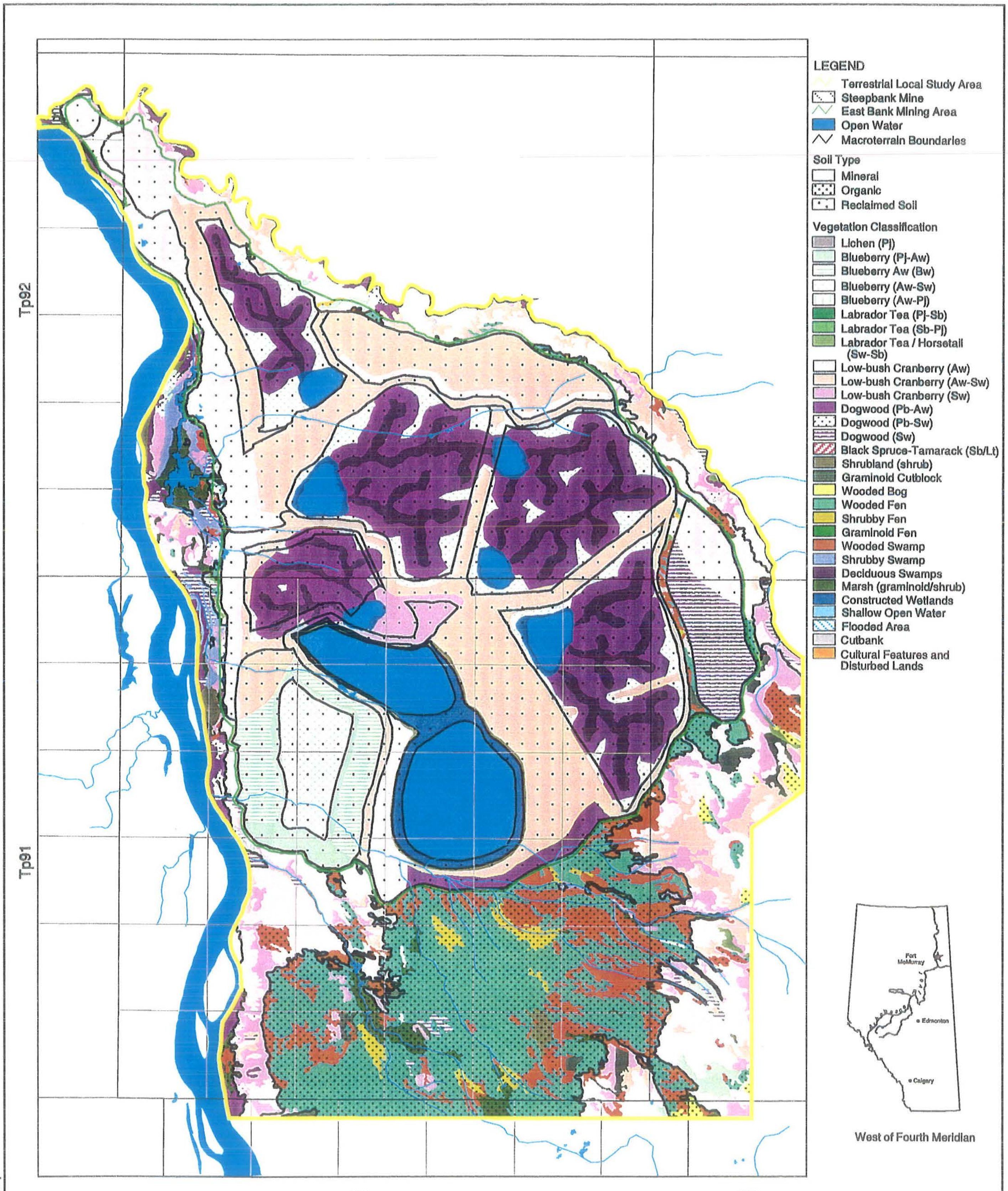
Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
CLOSURE MACROTERRAIN
CLASSIFICATION

15 Apr. 1998 | Figure D4.2-2 | PRODUCED BY: JB REVIEWED BY:



SOURCES: Suncor
Golder
Klohn-Crippen
The Forestry Corp
CAN-AG

Map Projection: UTM 12
Datum: NAD 83

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LOCAL STUDY AREA
CLOSURE ECOLOGICAL LAND
CLASSIFICATION

15 Apr. 1998	Figure D4.2-3	PRODUCED BY: JB REVIEWED BY:

Table D4.2-2 Ecological Land Classification Units for the Athabasca Floodplain (ATF) Macroterrain

	Pre-development		Steepbank Mine		East Bank Mining Areas		Closure		
ELC Unit	ha	% ATF	ha	% ELC	ha	% ELC	ha	% ATF	% ELC
ATF/M/b1	15	2	4	27	3	20	12	2	80
ATF/M/d1	65	9	19	29	0	0	65	9	100
ATF/M/d2	8	1	6	75	0	0	8	1	100
ATF/M/d3	74	11	31	42	7	9	67	10	91
ATF/M/e1	134	19	4	3	1	1	133	19	99
ATF/M/e2	22	3	8	36	3	14	19	3	86
ATF/M/e3	51	7	17	33	1	2	50	7	98
ATF/M/FTNN	4	1	0	0	0	0	4	1	00
ATF/M/MONG	78	11	4	5	2	3	76	11	97
ATF/M/MONS	30	4	13	43	2	7	28	4	93
ATF/M/NMS	1	<1	0	0	0	0	1	<1	100
ATF/M/Shrub	45	7	0	0	0	0	45	7	100
ATF/M/SONS	121	18	34	28	8	7	113	16	93
ATF/M/STNN	25	4	4	16	5	20	20	3	80
ATF/O/FTNN	1	<1	1	100	0	0	1	<1	100
ATF/O/MONS	14	2	0	0	0	0	14	2	100
ATF/O/STNN	3	<1	3	100	0	0	3	<1	100
TOTAL	**691**	**100**	**148**	**21**	**32**	**5**	**659**	**95**	**95**

Table D4.2-3 Ecological Land Classification Units for the Athabasca Escarpment (ATE) Macroterrain

	Pre development		Steepbank Mine		East Bank Mining Areas		Closure		
ELC Unit	ha	% ATF	ha	% ELC	ha	% ELC	ha	% ATF	% ELC
ATE/M/a1	1	<1	1	100	1	100	0	0	0
ATE/M/b1	67	3	60	90	62	93	5	<1	7
ATE/M/b2	28	1	26	93	27	96	1	<1	4
ATE/M/b3	36	2	36	100	36	100	0	0	0
ATE/M/b4	32	1	31	97	31	97	1	<1	3
ATE/M/d1	1,425	62	733	51	1,013	71	412	18	29
ATE/M/d2	83	4	30	36	44	53	39	2	47
ATE/M/d3	307	13	129	42	150	49	157	7	51
ATE/M/e1	36	2	24	67	29	81	7	<1	19
ATE/M/e2	23	1	8	35	11	48	12	1	52
ATE/M/e3	18	1	8	44	4	22	14	1	78
ATE/M/FTNN	3	<1	2	67	2	67	1	<1	33
ATE/M/h1	21	1	21	100	18	86	3	<1	14
ATE/M/HG/CC	12	1	0	0	0	0	12	1	100
ATE/M/MONS	4	<1	3	75	3	75	1	<1	25
ATE/M/NMC	15	1	2	13	6	40	9	<1	60
ATE/M/SFNN	3	<1	3	100	3	100	0	0	0
ATE/M/Shrub	55	2	51	93	51	93	4	<1	7
ATE/M/SONS	9	<1	2	22	8	89	1	<1	11
ATE/M/STNN	21	1	3	14	11	52	10	<1	48
ATE/O/FTNN	41	2	27	66	24	59	17	1	41
ATE/O/MONG	7	<1	7	100	5	71	2	<1	29
ATE/O/MONS	2	<1	2	100	2	100	0	0	0
ATE/O/SFNN	8	<1	8	100	8	100	0	0	0
ATE/O/SONS	6	<1	6	100	6	100	0	0	0
ATE/O/STNN	43	2	6	14	7	16	36	2	84
TOTAL	**2,306**	**100**	**1,229**	**53**	**1,562**	**68**	**744**	**32**	**32**

Table D4.2-4 Ecological Land Classification Units for the Steepbank Escarpment (STE) Macroterrain

ELC Unit	Pre development		Steepbank Mine		East Bank Mining Areas		Closure		
	ha	% STE	ha	% ELC	ha	% ELC	ha	% STE	% ELC
STE/M/b1	53	5	20	38	47	89	6	1	11
STE/M/b3	20	2	20	100	20	100	0	0	0
STE/M/b4	4	<1	0	0	4	100	0	0	0
STE/M/d1	566	49	157	28	192	35	364	32	65
STE/M/d2	215	19	24	11	60	28	155	14	72
STE/M/d3	127	11	52	41	52	41	75	7	59
STE/M/e1	37	3	0	0	0	0	37	3	100
STE/M/e2	15	1	0	0	0	0	15	1	100
STE/M/e3	26	2	0	0	0	0	26	2	100
STE/M/FTNN	20	2	0	0	15	75	5	<1	25
STE/M/h1	2	<1	0	0	0	0	2	<1	100
STE/M/HG/CC	1	<1	0	0	0	0	1	<1	100
STE/M/NMC	19	2	0	0	0	0	19	2	100
STE/M/STNN	5	<1	0	0	0	0	5	1	100
STE/O/FONS	4	<1	3	75	3	75	1	<1	25
STE/O/FTNN	28	2	24	86	26	93	2	<1	7
STE/O/SFNN	2	<1	2	100	2	100	0	0	0
STE/O/STNN	1	<1	0	0	0	0	1	<1	100
TOTAL	**1,135**	**100**	**302**	**27**	**421**	**37**	**714**	**63**	**63**

Table D4.2-5 Ecological Land Classification Units for the Steepbank Organic Plain (STOP) Macroterrain

	Pre development		Steepbank Mine		East Bank Mining Areas		Closure		
ELC Unit	ha	% STE	ha	% ELC	ha	% ELC	ha	% STE	% ELC
STOP/M/b1	33	<1	14	42	33	100	0	0	0
STOP/M/b4	14	<1	6	43	14	100	0	0	0
STOP/M/c1	1	<1	1	100	1	100	0	0	0
STOP/M/d1	47	1	14	30	43	91	4	<1	9
STOP/M/d2	3	<1	0	0	3	100	0	0	0
STOP/M/d3	61	1	0	0	23	38	38	<1	62
STOP/M/e1	3	<1	0	0	3	100	0	0	0
STOP/M/e2	2	<1	0	0	0	0	2	<1	100
STOP/M/e3	12	<1	0	0	0	0	12	<1	100
STOP/M/FFNN	67	1	37	55	51	76	16	<1	24
STOP/M/FONS	14	0	14	100	14	100	0	0	0
STOP/M/FTNN	289	3	38	13	224	78	65	1	22
STOP/M/g1	1	<1	0	0	1	100	0	0	0
STOP/M/h1	4	<1	0	0	3	75	1	<1	25
STOP/M/HG/CC	6	<1	0	0	0	0	6	<1	100
STOP/M/Sb/Lt	11	<1	0	0	11	100	0	0	0
STOP/M/SFNN	118	1	0	0	62	53	56	1	47
STOP/M/Shrub	3	<1	0	0	3	100	0	0	0
STOP/M/STNN	381	4	28	7	230	60	151	2	40
STOP/O/BTNN	12	<1	0	0	0	0	12	<1	100
STOP/O/FFNN	881	10	226	26	478	54	403	4	46
STOP/O/FONG	4	<1	0	0	3	75	1	<1	25
STOP/O/FONS	404	4	93	23	304	75	100	1	25
STOP/O/FTNN	5,463	59	1,435	26	3,981	73	1,482	16	27
STOP/O/HG/CC	12	<1	0	0	0	0	12	<1	100
STOP/O/MONG	21	<1	1	5	6	29	15	<1	71
STOP/O/MONS	151	2	4	3	7	5	144	2	95
STOP/O/Sb/Lt	9	<1	0	0	9	100	0	<1	0
STOP/O/SFNN	461	5	39	8	254	55	207	2	45
STOP/O/Shrub	24	<1	0	0	0	0	24	<1	100
STOP/O/SONS	19	<1	4	21	16	84	3	<1	16
STOP/O/STNN	667	7	119	18	411	62	256	3	38
Total	**9,198**	**100**	**2,073**	**23**	**6,188**	**67**	**3,010**	**33**	**33**

Table D4.2-6 Ecological Land Classification Units for the Steepbank Upland Macroterrain

ELC Unit	Pre development		Steepbank Mine		East Bank Mining Areas		Closure		
	ha	% STE	ha	% ELC	ha	% ELC	ha	% STE	% ELC
STU/M/b1	58	2	0	0	0	0	58	2	100
STU/M/b3	3	0	0	0	0	0	3	0	100
STU/M/d1	1,255	46	0	0	532	42	723	27	58
STU/M/d2	279	10	0	0	29	10	250	9	90
STU/M/d3	372	14	0	0	82	22	290	11	78
STU/M/e1	2	0	0	0	2	100	0	0	0
STU/M/e2	1	0	0	0	0	0	1	<1	100
STU/M/e3	21	1	0	0	9	43	12	<1	57
STU/M/FONS	2	0	0	0	2	100	0	0	0
STU/M/FTNN	33	1	0	0	27	82	6	<1	18
STU/M/h1	32	1	0	0	11	34	21	1	66
STU/M/HG/CC	139	5	0	0	69	50	70	3	50
STU/M/MONS	6	0	0	0	4	67	2	<1	33
STU/M/SFNN	86	3	0	0	50	58	36	1	42
STU/M/Shrub	4	0	0	0	3	75	1	<1	25
STU/M/SONS	3	0	0	0	2	67	1	<1	33
STU/M/STNN	145	5	0	0	97	67	48	2	33
STU/O/BFNN	26	1	0	0	0	0	26	1	100
STU/O/BTNN	8	0	0	0	0	0	8	<1	100
STU/O/FFNN	18	1	0	0	18	100	0	0	0
STU/O/FONS	1	0	0	0	1	100	0	0	0
STU/O/FTNN	128	5	0	0	97	76	31	1	24
STU/O/MONS	4	0	0	0	0	0	4	<1	100
STU/O/SFNN	10	0	0	0	0	0	10	<1	100
STU/O/SONS	3	0	0	0	3	100	0	0	0
STU/O/STNN	68	3	0	0	10	15	58	2	85
Total	**2,707**	**100**	**0**	**0**	**1,048**	**39**	**1,659**	**61**	**61**

There are five macroterrain units in the LSA, namely, the Athabasca Floodplain (ATF), Athabasca Escarpment (ATE), Steepbank Escarpment (STE), Steepbank Organic Plain (STOP) and Steepbank Upland (STU). For consistency with other terrestrial assessments, water and developed areas have been separated into their own distinct units and are not described as component ELC units. Descriptions of each macroterrain is presented in Section D4.1 and in the Ecological Land Classification Baseline Report (Golder 1998c). The following provides a detailed description of each macroterrain unit and component ELC units.

Athabasca Floodplain

The Athabasca Floodplain consists of the relatively flat land situated immediately adjacent to the Athabasca River. It is composed of unconsolidated sediments deposited by periodic flooding and lateral migration of the river channel. The vegetation changes from shrubby swamp to upland ecosite phases with marsh and wooded swamp wetlands occupying depressional areas.

In the Steepbank Mine EIA, 148 ha of the Athabasca Floodplain was to be disturbed through mine development within the LSA; however, only 32 ha or 5% will be affected as part of the east bank mining areas (Table D4.2-1 Figure D4.2-2). This is the least affected macroterrain unit as a result of Project development in the LSA.

This impact can be further defined through the assessment of component ELC units within this macroterrain. ELC units are defined by dominant soils type (mineral or organic), the ecosite phase (vegetation type) and/or wetland types (Table D4.2-2). There are 17 ELC units in the Athabasca Floodplain. The most dominant ELC units include dogwood balsam poplar-trembling aspen on mineral soils (ATF/M/e1) which occupies 134 ha or 19%, shrubby swamp on mineral soils (ATF/M/SONS) which occupies 121 ha or 18%; graminoid marsh on mineral soils (Shipyard Lake) which occupies 78 ha or 11% and low bush cranberry white spruce which occupies 74 ha or 11% of the unit. All other ELC units occupies less than 10% of the macroterrain unit.

The Project will not completely remove any ELC unit within the Athabasca Floodplain, however there will be some clearing to 9 ELC units. Specifically, mine development will clear 3 ha of the blueberry jack pine-trembling aspen on mineral soils (ATF/M/b1) , 5 ha of the wooded swamp on mineral soils (ATF/M/STNN) and 3 ha of the dogwood balsam poplar-white spruce on mineral soils (ATF/M/e2). Losses to other ELC units, including the dominant ELC units, are minimal or less than 10% of the pre-development area (Table D4.2-2). The closure values indicate that the Athabasca Floodplain will occupy an area of 659 ha following development and reclamation.

Athabasca Escarpment

The Athabasca Escarpment is a sloping embankment that forms the boundary to the Athabasca Floodplain (Figure D4.2-2). The Escarpment was formed as a result of erosion processes associated with the Athabasca River. The macroterrain is characterized by relatively steep slopes with a veneer of predominantly colluvial mineral soils. The vegetation communities are predominantly upland ecosite phases with fens, swamps and marshes occupying depressional areas. The Athabasca Escarpment comprises 2,307 ha or 14% of the LSA (Table D4.2-1 and Figure D4.2-2).

Project development will affect 1,561 ha or 68% of the Athabasca Escarpment macroterrain within the LSA (Table D4.2-1). The areas affected are largely restricted to the upper slopes and crest of the escarpment (Figure D4.2-2). The 26 component ELC units associated within this macroterrain or landform are presented in Table D4.2-4. The Steepbank Mine plan would have resulted in a loss of 8 ELC units. A total of 6 component ELC units, however, will be lost due to the Project. These units include: lichen jack pine on mineral soil (ATE/M/al); blueberry trembling aspen-white spruce (ATE/M/b3); forested swamp on mineral and organic soil (ATE/M/SFNN, and ATE/O/SFNN); shrubby swamps on organic soil (ATE/O/SONS); and shrubby marshes on organic soil (ATE/O/MONG). These ELC units comprise a relatively small percentage of the macroterrain unit (less than 5%). The dominant ELC unit is low bush cranberry trembling aspen (ATE/M/d1) which represents 1,425 ha or 62% of the macroterrain unit. This unit dominates the upper slopes and crest of the escarpment. The Project will clear 1,013 ha or 71% of the unit. At closure, the ELC unit will occupy an area of 412 ha or 18% of the macroterrain unit.

Overall, the Project will result in a 68% loss to the Athabasca Escarpment. The majority of the disturbance, 1,229 ha or 53%, is attributed to the Steepbank Mine. Project Millennium's contribution will be 332 ha or 14% of the escarpment. Following development, the Athabasca Escarpment will occupy an area of 746 ha and some of the component ELC units will be less than pre development areas (Table D4.2-3).

Steepbank Escarpment

The Steepbank Escarpment (STE) includes the floodplain of the Steepbank River. This macroterrain consists primarily of upland ecosite phases with some organic wetlands in transitional areas or along drainages. Losses to the Steepbank Escarpment include 1,048 ha or 37% of the macroterrain within the LSA. This represents a 7% loss in the LSA (Table D4.2-1). The 18 ELC types within this landform and the relative distribution are presented in Table D4.4-4. Three ELC types: blueberry trembling aspen-white spruce on mineral soils (STE/M/b3); blueberry white spruce-jack pine on mineral soils (STE/M/b4); and forested swamps on organic soils (STE/O/SFNN) will be completely lost as a result of project development. These units, however, comprise less than 2% of the macroterrain unit. Seven other ELC types will also be affected. The majority of the loss is on the crest and upper slopes of the escarpment. There will be no fragmentation of the Steepbank Escarpment as a result of the Project (Figure D4.2-2). At closure, the Steepbank Escarpment will occupy an area of 713 ha or 4% of the LSA.

Steepbank Organic Plain

The Steepbank Organic Plain (STOP) is situated in the centre of the LSA, and is by far the largest macroterrain unit defined (9,201 ha or 57%, Table D4.2-1). This unit is level, and largely supports wetlands, (predominantly wooded fens). Losses to the Steepbank Organic Plain macroterrain are estimated to be 6,189 ha or 67% of its pre-development area (Table D4.2-1). The Steepbank Mine will contribute 27% to this loss. The 32 ELC types comprising this landform are presented in Table D4.2-5. Ten ELC types will be removed as a result of project development. All of these comprise less than 1% of the macroterrain unit. A total of 3,981 or 73% of wooded Fens (FTNN), which occupy the majority of the macroterrain (5,463 ha or

59%) will be lost due to project development. The remaining ELC types affected occupy less than 5% of the macroterrain unit.

The east bank mine will largely be situated within the Steepbank Organic Plain, however, this is a relatively large macroterrain unit that extends beyond the LSA boundaries. Component ELC units lost as a result of the Project represent a minor loss to this resource in a regional context. At Closure, the Steepbank Organic Plain will occupy an area of 3,012 ha or 19% of the LSA.

Steepbank Upland

The Steepbank Upland (STU) is 2,707 ha or 17% of the LSA. This macroterrain unit extends north-south, along the eastern boundary of the TLSA; it is approximately 14.2 km long and 3 km across at the widest point. The vegetation is composed of a mosaic of upland ecosite phases and wetlands on both mineral and organic soil. Project development will result in the loss of 1,048 ha or 39% of this unit within the LSA (Table D4.2-1).

The 26 ELC unit within the Steepbank Upland are presented in Table D4.2-6. A total of 19 ELC types will be affected due to project development. Five ELC types will be completely removed; however, these units comprise less than 5% of the macroterrain unit. The majority (1,255 ha or 46%) of this upland landform is occupied by low bush cranberry trembling aspen on mineral soil (STU/M/d1). A total of 532 ha or 42% of this ELC unit will be lost to project development.

Overall, 39% of this macroterrain will be lost to project development. This macroterrain extends beyond the LSA boundary. Losses to specific ELC units in the LSA do not represent a permanent loss of this resource in the region. At closure, the Steepbank Upland macroterrain will occupy an area of 1,659 ha or 10% of the LSA.

D4.2.4 Mitigation Measures

The loss/alteration of macroterrain and component ELC units can be mitigated through reclamation and revegetation of reclaimed landscapes (Closure Plan Assessment, Section E). Reclamation will be phased throughout the mining operations. Following development, seven reclaimed landform or macroterrain types (Figure D4.2-2) will be established. These reclaimed landforms include the following:

- reclaimed tailings settling pond;
- tailing sand dykes;
- CT backfilled mine cells;

- above ground overburden disposal areas;
- other overburden areas including dykes;
- reclaimed reclamation material storage areas; and
- end pit lake including lake, littoral zone, and the intralake wetland.

In addition, approximately 942 ha of unmined area will remain within the development area.

Physical characteristics such as topography, slope, drainage and soil texture will determine the type of sustainable ecosite phase the reclaimed unit can support. ELC units were used in reclamation planning to provide analogs or a reference point in the design of the reclamation landscape. The reclaimed units (with associated ecosite phases) represent the new macroterrain and component ELC units in the LSA, and are presented in Figure D4.2-3 and in Tables D4.2-7 to D4.2-13.

Table D4.2-7 Ecological Land Classification Units for the Reclaimed Tailing Sands (TAS)

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
TAS/R/b1	155	26	1
TAS/R/b2	301	50	2
TAS/R/b3	12	2	<1
TAS/R/d1	9	1	<1
TAS/R/d2	106	18	1
TAS/R/d3	2	<1	<1
TAS/R/e1	16	3	<1
TAS/R/shSONS	2	<1	<1
Total	**603**	**100**	**4**

Table D4.2-8 Ecological Land Classification Units for the Consolidated Tailings (COT)

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
COT/R/b1	<1	<1	<1
COT/R/b3	512	16	3
COT/R/c_wet	91	3	1
COT/R/d1	4	<1	<1
COT/R/d2	82	2	1
COT/R/d3	3	<1	<1
COT/R/e1	1,684	51	10
COT/R/shSONS	699	21	4
COT/W/c_wet	<1	<1	<1
COT/W/water	204	6	1
Total	**3,279**	**100**	**20**

Table D4.2-9 Ecological Land Classification Units for the Reclaimed Overburden Disposal Areas (OVB)

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
OVB/O/FTNN	<1	<1	<1
OVB/R/b3	75	3	0
OVB/R/c_wet	13	<1	<1
OVB/R/d1	502	19	3
OVB/R/d2	1,673	64	10
OVB/R/d3	73	3	<1
OVB/R/e1	173	7	1
OVB/R/FFNN	<1	<1	<1
OVB/R/FONS	<1	<1	<1
OVB/R/FTNN	2	0	0
OVB/R/h1	<1	<1	<1
OVB/R/HG/CC	<1	<1	<1
OVB/R/MONS	<1	<1	<1
OVB/R/SFNN	1	<1	<1
OVB/R/shrub	60	2	<1
OVB/R/shSONS	14	1	<1
OVB/R/SONS	<1	<1	<1
OVB/R/STNN	2	<1	<1
OVB/W/water	22	1	<1
Total	**2,609**	**100**	**16**

Table D4.2-10 Ecological Land Classification Units for the Reclaimed Overburden Sand Mix (OSM) Area

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
OSM/R/b1	11	4	0
OSM/R/b3	263	96	2
Total	**274**	**100**	**2**

Table D4.2-11 Ecological Land Classification Units for the Reclamation Storage Area (RES)

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
RES/R/d1	166	38	1
RES/R/e3	270	62	2
RES/R/FFNN	<1	<1	<1
RES/R/FTNN	1	<1	<1
RES/R/HG/CC	<1	<1	<1
RES/R/STNN	<1	<1	<1
Total	**437**	**100**	**3**

Table D4.2-12 Ecological Land Classification Units for the Reclaimed Littoral Zone (LIZ)

ELC Type	Area (ha)	% of Reclaimed Landform	% LSA
LIZ/R/b3	<1	<1	<1
LIZ/R/c_wet	170	90	1
LIZ/R/d1	<1	<1	<1
LIZ/R/d2	<1	<1	<1
LIZ/R/d3	<1	<1	<1
LIZ/R/e1	<1	<1	<1
LIZ/R/shrub	19	10	0
Total	**189**	**100**	**1**

Reclaimed Tailing Sands (TAS)

The reclaimed tailings pond and tailing sands dykes will be backfilled with overburden and tailings sands and recontoured. The predominant material in this reclaimed unit will be tailing sands on the side slopes and tailing sands and overburden in the centre of the unit. The fine textured material is relatively well drained with a subxeric to submesic moisture regime. Pre-development ELC units indicate the blueberry ecosite (b) should adapt to these site conditions. The backfilled pond (12 ha) will support blueberry trembling aspen-white spruce (b3); the crest and south-facing slopes (155 ha) will support blueberry jack pine-trembling aspen (b1); and the north, east and west-facing slopes (301 ha) will support blueberry trembling aspen-white birch (b2). Table D4.2-7 shows the component ELC areas on this reclaimed landform.

Table D4.2-13 Ecological Land Classification Units for the Undeveloped Mine Area (UDA) Macroterrain

ELC Units	Area (ha)	% of Macroterrain Unit	% LSA
UDA/M/d1	<1	<1	<1
UDA/R/b1	<1	<1	<1
UDA/R/b2	1	<1	<1
UDA/R/b3	8	1	<1
UDA/R/b4	<1	<1	<1
UDA/R/c_wet	2	<1	<1
UDA/R/d1	431	46	3
UDA/R/d2	379	40	2
UDA/R/d3	59	6	<1
UDA/R/e1	8	1	<1
UDA/R/e3	5	1	<1
UDA/R/FFNN	5	<1	<1
UDA/R/FONS	2	<1	<1
UDA/R/FTNN	8	1	<1
UDA/R/h1	2	<1	<1
UDA/R/HG/CC	6	1	<1
UDA/R/MONG	<1	<1	<1
UDA/R/SFNN	<1	<1	<1
UDA/R/shrub	2	<1	<1
UDA/R/shSONS	<1	<1	<1
UDA/R/SONS	1	<1	<1
UDA/R/STNN	24	2	<1
Total	**943**	**100**	**6**

Reclaimed Consolidated Tailings (COT)

The CT backfilled mine cell or reclaimed consolidated tails (COT) will be the dominant landform after the Project closure. The CT will be capped with 1m of tailings sand or overburden with increased thickness in the hummocky areas between drainage channels. The dentritic drainage will transport water flowing into and out of constructed wetlands. Table D4.2-8 shows the component ELC for the reclaimed macroterrain unit.

Pre-development ELC units, indicate that shrubby swamp (699 ha) will re-establish within drainage channels and will transition to a dogwood balsam poplar-trembling aspen (e1) ecosite phase (1,684 ha or 51%) on the slightly elevated slopes. On the upper slopes, 512 ha of blueberry trembling aspen-white spruce (b3) ecosite phase will be re-established. The constructed wetlands (c_wet) will likely be a combination of shallow open water and graminoid marsh.

Reclaimed Overburden Disposal Areas (OVB) and Overburden Sand Mix (OSM)

The northwest and northeast overburden dump are situated above ground. The overburden dykes will be designed to be berms. Although site-specific conditions will determine the final design of these reclaimed units, the final slopes are anticipated to be in the range of 3H:1V. Since the Clearwater formation materials are likely to have chemical properties (i.e. high salinity) not conducive to revegetation, these material will be placed in the centre of the dumps and dykes. The non-Clearwater materials will be placed on the slopes. The physical characteristic of reclaimed units indicate that the moisture regime will likely be mesic with variable aspects. Pre-development ELC units in the area indicate that low bush cranberry trembling aspen-white spruce (d1) will re-establish. It is difficult to predict, however, the affects Clearwater material will have on site-specific growing conditions. As such site-specific modifications may be necessary in the centre of the dumps and dykes to improve growing conditions on the Clearwater materials. Table D4.2-9 and Table D4.2-10 shows the component ELC units associated with this macroterrain unit.

Reclamation Storage Areas (RES)

The reclamation material storage areas are separated into muskeg and muskeg with overburden dumps. As reclamation progresses, muskeg will be hauled from the storage area to areas undergoing reclamation. After the muskeg is removed, the area will be graded and a soil amendment will be placed over the area. It is anticipated that water will drain from the slightly elevated northern portion of the dump resulting in a mesic moisture regime. The southern half will likely be somewhat saturated having a moisture regime approximating subhygric. The pre-development ELC units, indicate that low bush cranberry trembling aspen (d1) will establish on the northern half of this landform and will transition into a dogwood white spruce (e3) in the south. These reclaimed ELC units will provide a transition with the adjacent, non-disturbed ELC units associated with the Steepbank Escarpment. Table D4.2-11 shows the reclaimed ELC units associated with this macroterrain unit.

End Pit Lake and Littoral Zone

The end pit lake will consist of two water bodies interconnected by constructed wetlands. The shoreline of the lake will be constructed to allow for a littoral zone which, with the intralake wetlands, will comprise 20% of the lake volume. This littoral zone will consist of gently-sloping topography. There may be some opportunity for graminoid aquatic plants to re-establish in this area over time. The constructed wetlands are expected to resemble pre-disturbance shrubby swamps or marshes over time. Table D4.2 -12 shows the reclaimed ELC units on this macroterrain unit.

Undeveloped Mine Areas (UDA)

Undeveloped areas will provide a refugia for native plants. These refugia areas consist of a number of upland ecosite phases such as low bush cranberry trembling aspen (d1), low bush cranberry trembling aspen-white spruce (d2), blueberry trembling aspen-white birch (b1), blueberry trembling aspen-white birch (b2), blueberry trembling aspen-white spruce (b3), dogwood balsam poplar-trembling aspen (e1), and wetland types such as wooded (STNN) and shrubby (SONS) swamps. These refugia areas will be maintained to enhance recolonization of the reclamation areas with native species. Table D4.2-13 shows the reclaimed ELC units associated with this macroterrain unit.

Residual Impact Classification and Environmental Consequence

A summary of residual impacts of Project Millennium on the macroterrain or general landscape is provided in Table D4.2-14. All macroterrain units will be affected to some degree as a result of the Project. The impacts are high in magnitude for all the macroterrain units except the Athabasca Floodplain. The duration will be long-term since macroterrain units will not be returned exactly to pre-development areas. The frequency is low because the disturbance will only occur once. The geographical extent is restricted to the LSA but is considered irreversible. The environmental consequence is low to moderate. However, within the regional context of macroterrain impacts, the residual impacts are rated as not significant.

Table D4.2-14 Residual Impact Classification on the Loss/Alteration of ELC Macroterrain Units in the Terrestrial Local Study Area

Macroterrain Unit	Magnitude (Severity)	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Athabasca Floodplain	Low	Long-Term	Low	Local	No	Low
Athabasca Escarpment	High	Long-Term	Low	Local	No	Low to Moderate
Steepbank Escarpment	High	Long-Term	Low	Local	No	Low to Moderate
Steepbank Organic Plain	High	Long-Term	Low	Local	No	Low to Moderate
Steepbank Upland	Moderate	Long-Term	Low	Local	No	Low to Moderate

D4.2.4.2 Changes to Ecological Diversity

Analysis of Potential Linkages

Losses or alteration of landforms or macroterrain units due to site clearing, overburden stripping and storage, and other developments associated with the Project will change diversity in the LSA. Diversity, which is an expression of landscape level heterogeneity, will be altered due to the partial removal of landforms or macroterrain units. Thus, this is a valid linkage for assessment.

Impact Analysis

This assessment of biodiversity or ecological diversity is intended to provide some estimates of change on the parameters measured. These estimates can be used for future monitoring of the reclamation following Project closure.

The assessment of changes in diversity has been divided into a number of issues that examine changes at the landscape, community and species scales, in terms of composition and structure. Species scale diversity is discussed in the Terrestrial Vegetation Wetlands section (D3). Each issue is examined by reviewing current values of diversity and the changes expected during the construction and operations phases of the Project.

The impact classification will attempt to describe the relative amount of change from pre-development conditions to closure. As stated the closure planning is the mitigation that is applied before determining the residual impacts to diversity on the parameters measured.

Landscape Level Diversity

The loss of areas in each macroterrain unit is presented in Table D4.2-15. The use of landscape or macroterrain units as a framework for the landscape scale biodiversity objectives is considered by Iacobelli et al. (1995) to be the best ecological framework for the conservation of diversity. Such landscape units provide the basic building block for soil and vegetation development over time. The ELC developed for Project Millennium uses a combination of terrain, soils and vegetation features to map macroterrain units.

Table D4.2-15 Changes in Macroterrain at the Landscape Scale in the LSA

Parameter	LSA	Closure
Richness	5 types	12 types
Shannon Index	0.54	0.98
Shape	2.16	2.34

All of the five macroterrain units will have portions disturbed as a result of the Project. Some macroterrain units will be fragmented into smaller patches.

D4.2.4.3 Composition

Species richness, diversity index and a comparison of the shape of landscape units were the parameters measured to assess the overall change in diversity at the landscape level. These parameters are presented in Table D4.2-15.

The Project will not completely remove any one macroterrain unit, but only portions of areas or ELC types within macroterrain units. As such, the Project does not alter the richness values for macroterrain units during the impacts. An additional, reclamation macroterrain unit will be constructed as part of Project closure. The Shannon Index does indicate a change in macroterrain diversity from 0.54 to 0.98 after construction. This indicates that there is a more even distribution of macroterrain following closure. This is due to an increase in macroterrain units, from 5 types to 12 types, following closure. This does not equate to an increase in diversity but rather does provide the opportunity during mine closure to design a number a different landforms that may support a variety of different vegetation communities following succession. The shape index indicates that there will be a shift from 2.16 to 2.34 following closure.

D4.2.4.4 Structural Diversity

The impacts to landscape level structural diversity can be estimated by polygon (patch) number, size and shape distribution across the LSA.

ELC Unit Richness and Diversity Indices

The number of ELC units (polygons or patches) represented in the LSA before and after Project development closure are presented in Table D4.2-10. Changes in the number of ELC units present in each macroterrain unit before and after Project development and closure is an expression of compositional diversity. Richness and Shannon diversity measures of ELC types are presented in Table D4.2-16. The Shannon Index for the Athabasca Floodplain shows a pre-development and closure index of 1.02. This suggests that the distribution in ELC units within this macroterrain unit will not vary as a result of the Project. Moreover, only small changes in the diversity values are detected from pre-development conditions versus closure. This suggests that distribution of ELC units within the macroterrain is similar between pre and post-closure. The ELC units within the Athabasca Floodplain will be reduced from 17 to 11 as a result of project development. The Athabasca Escarpment ELCs will be reduced from 26 to 25 and the Steepbank Escarpment ELCs will be reduced from 18 to 10. The Steepbank Organic Plain ELCs will be reduced from 32 to 26 and the Steepbank Upland ELCs will lose 7 types. The Shannon Index indicates a slight reduction in the Athabasca Escarpment, Steepbank Escarpment, and Steepbank Upland. This suggests that there will be disproportionate dominance in ELC units at closure within each of these macroterrain units. The Steepbank Organic Plain, however, indicates that diversity will change from 0.70 to 0.80 following closure. This suggests that ELC units will share in dominance.

Table D4.2-16 ELC Richness and Diversity Indices

Landscape Units	LSA		Steepbank Mine		East Bank Mining Areas		Closure	
	Richness (ELC Types)	Shannon Index	Richness (ELC Types)	Shannon Index	Richness (ELC Types)	Shannon Index	Richness (ELC Types)	Shannon Index
Existing Units								
Athabasca Floodplain	17	1.02	15	0.99	11	0.93	11	1.02
Athabasca Escarpment	26	0.70	25	0.68	25	0.73	25	0.68
Steepbank Escarpment	18	0.74	8	0.72	10	0.65	10	0.68
Steepbank Organic Plain	32	0.70	17	0.59	26	0.45	26	0.80
Steepbank Upland	26	0.84	0	0.80	19	0.74	19	0.81
Reclaimed Units								
Consolidated Tailings	n/a	n/a	n/a	n/a	n/a	n/a	10	0.58
Littoral Zone	n/a	n/a	n/a	n/a	n/a	n/a	7	0.16
Overburden	n/a	n/a	n/a	n/a	n/a	n/a	19	0.51
Tailings Sand	n/a	n/a	n/a	n/a	n/a	n/a	8	0.55
Reclaimed Storage	n/a	n/a	n/a	n/a	n/a	n/a	6	0.30
Overburden Sand Mix	n/a	n/a	n/a	n/a	n/a	n/a	2	0.07
Undeveloped Areas	n/a	n/a	n/a	n/a	n/a	n/a	23	0.55

Losses to unique or rare ELC units are difficult to estimate. However, in Table D4.1-6, a summary of unique ELC units based on rare plant and old growth forests is provided. In the Athabasca Floodplain, for example dogwood balsam poplar-trembling aspen on mineral soils (ATF/M/e1) was identified as supporting two rare plant species (turned sedge and prairie cord grass); however only 1 ha of this ELC unit will be lost to project development. One rare plant species was also found within the ELC unit graminoid marsh on mineral soil (ATF/M/MONG). Losses to this ELC unit is 11%. Old growth forest were associated with the blueberry trembling aspen-white birch (b1), low bush cranberry trembling aspen (d1), low bush cranberry trembling aspen-white spruce (d2) ecosite phase within the Athabasca Floodplain. Only the low bush cranberry trembling aspen on mineral soils (ATF/M/d1) will be lost due to project development.

One rare plant, wool-grass, was identified within the Athabasca Escarpment macroterrain unit within the low bush cranberry trembling aspen ecosite phase on mineral soils (ATE/M/d1). This unit will be reduced by 71% from the LSA. Old growth forests associated with other ELC units, for example, low bush cranberry white spruce (ATE/M/d3) will not be removed as a result of project development.

Within the Steepbank Escarpment one ELC unit, dogwood white spruce on mineral soil (STE/M/e3), supports old growth forests. This unit will be completely cleared by the Project. However, two other ELC units, low bush cranberry trembling aspen on mineral soil (STE/M/d1) and dogwood balsam poplar-trembling aspen (STE/M/e1) which also support old growth forests, will remain following closure.

Within the Steepbank Organic Plain, a rare plant (wool-grass) was observed in the wooded swamp on mineral soils unit. This unit, however, will be reduced but not completely removed from the LSA. Old growth forests were also identified within the low bush cranberry white spruce on mineral soil unit (STOP/M/d3). This unit will be reduced but not completely cleared in the LSA.

In the Steepbank Upland unit, aspen old growth forests were identified within the low bush cranberry trembling aspen and low bush cranberry trembling aspen-white spruce units. Both units will be partially cleared but not completely removed from the LSA.

ELC Patches and Patch Size

The number of ELC unit patches is presented in Table D4.2-17. The number of patches will increase in number, from 1,169 to 1,222 patches, following mine closure. This is due in part to the fragmentation of large polygons into several small patches due to project development. For example, the number of ELC unit patches will increase in the Steepbank Escarpment from 191 to 249. However, the overall patch number will also increases due to mine closure following ELC unit re-establishment.

The mean, minimum and maximum patch size of each ELC polygon or patch in the LSA is presented in Table D4.2-18. Patch number and patch size are used in the forest industry to assess maximum cutblock sizes and reforestation efforts. In mining, an assessment of natural patch number and size distribution provides a target for assessing and monitoring reclamation efforts.

Table D4.2-17 Number of ELC Polygons (Patches)

Landscape Units	LSA	Steepbank Mine	East Bank Mining Areas	Closure
Athabasca Floodplain	140	47	34	102
Athabasca Escarpment	193	130	154	145
Steepbank Escarpment	156	29	46	130
Steepbank Upland	191	0	70	249
Steepbank Organic Plain	446	100	285	155
Consolidated Tailings	n/a	n/a	n/a	102
Littoral Zone	n/a	n/a	n/a	10
Overburden	m/a	m/a	m/a	155
Tailings Sand	n/a	n/a	n/a	37
Reclaimed Storage	n/a	n/a	n/a	11
Overburden Sand Mix	n/a	n/a	n/a	10
Undeveloped Areas	n/a	n/a	n/a	116
Total	**1,169**	**322**	**614**	**1,222**

Table D4.2-18 Mean, Minimum and Maximum Patch Shape for Macroterrain

Landscape Units	Mean Shape of Macroterrain Pre-Development and Closure	
	Baseline Mean Area (ha)	Closure Mean Area (ha)
Athabasca Floodplain	2.73	2.77
Athabasca Escarpment	3.27	2.92
Steepbank Escarpment	2.68	1.95
Steepbank Organic Plain	2.31	2.15
Steepbank Upland	3.15	2.24
Consolidated Tailings	n/a	1.27
Littoral Zone	n/a	6.07
Overburden	n/a	3.53
Tailings Sand	n/a	2.69
Reclaimed Storage	n/a	1.18
Overburden Sand Mix	n/a	1.27
Undeveloped Areas	n/a	3.32

Range and average patch sizes of ELCs will change for some of the macroterrain units as a result of the Project. The mean patch size of ELCs within the Athabasca Escarpment will change from 2 to 6 ha, which indicates that smaller patches will be lost due to Project development, thereby increasing the mean patch size. The range in patch size will, however, not be affected. The mean patch size will also increase within the Steepbank Escarpment (1 to 6 ha) and the Steepbank Upland (4 to 11 ha). The mean ELC unit patches are larger in the reclaimed landscape, however, it is expected that over time smaller patches will develop in these areas.

ELC Unit Patch Shape

The patch size and shape in the pre-development, post-development and closure areas is presented in Table D4.2-19 and Table D4.2-20. Patch shape is of each macroterrain unit indicates slightly higher values in the baseline estimates for the Athabasca Escarpment, Steepbank Escarpment, and Steepbank Upland.

D4.2.4.5 Residual Impact Classification and Environmental Consequence

At the landscape and community levels, disturbance (Table D4.2-21) of the Athabasca Floodplain will be low, however there will be a loss to one ELC unit in which old growth forests occur. Old growth forests will not be completely removed from this area. In addition, there was little change in the other parameters measured. As such, the impacts to this macroterrain unit is classified as low in magnitude, long-term in duration, low in frequency and of local geographic extent. The impact is considered reversible due to the fact that the site conditions will not be altered to the point that ELC units could not re-establish in other undisturbed areas.

Project development will remove a large portion of the Athabasca Escarpment. However, there were no unique ELC units completely removed from this macroterrain unit. In addition, the other diversity measurements do not indicate a large change in the macroterrain or component ELC units.

In the Steepbank Escarpment one ELC unit which supports old growth forests will be removed. However, old growth forests were represented in other ELC units which will not be eliminated by the Project. Impacts to the Steepbank Escarpment, therefore, are classified as moderate in magnitude, of local geographic extent, long-term in duration, reversible and of low frequency.

The Steepbank Organic Plain is a large macroterrain unit which extends beyond the boundary of the LSA. No unique ELC units will be lost due to project development. The impacts to the Steepbank Organic Plain, therefore, are classified as moderate in magnitude, of local geographic extent, long-term in duration, reversible and of low frequency.

The Steepbank Upland was classified as having an impact of moderate magnitude, of local geographic extent, long-term in duration, reversible and of low frequency. No old growth forest ELC units will be completely removed as a result of the project. In addition, there is minimal change in the other diversity indices measured.

Table D4.2-19 Mean, Minimum and Maximum Patch Size

Landscape Units	Minimum and Maximum Size of ELC Polygons Pre- and Post-Development and Closure								
	Baseline Mean Area (ha)	Baseline Minimum Area (ha)	Baseline Maximum Area (ha)	Impact Mean Area (ha)	Impact Minimum Area (ha)	Impact Maximum Area (ha)	Closure Mean Area (ha)	Closure Minimum Area (ha)	Closure Maximum Area (ha)
Athabasca Floodplain	4	<1	61	4	<1	61	7	<1	67
Athabasca Escarpment	2	<1	25	2	<1	24	6	<1	249
Steepbank Escarpment	1	<1	38	2	<1	38	6	<1	138
Steepbank Organic Plain	6	<1	292	6	<1	292	12	<1	1,197
Steepbank Upland	4	<1	54	4	<1	54	11	<1	244
Consolidated Tailings	n/a	n/a	n/a	n/a	n/a	n/a	32	<1	455
Littoral Zone	n/a	n/a	n/a	n/a	n/a	n/a	19	<1	170
Overburden	n/a	n/a	n/a	n/a	n/a	n/a	17	<1	961
Tailings Sand	n/a	n/a	n/a	n/a	n/a	n/a	16	<1	159
Reclaimed Storage	n/a	n/a	n/a	n/a	n/a	n/a	40	<1	270
Overburden Sand Mix	n/a	n/a	n/a	n/a	n/a	n/a	27	<1	263
Undeveloped Areas	n/a	n/a	n/a	n/a	n/a	n/a	8	<1	374

Table D4.2-20 Mean, Minimum and Maximum Patch Shape

Landscape Units	Minimum and Maximum Shape of ELC Polygons			Pre- and Post-Development and Closure		
	Baseline Mean Area (ha)	Baseline Minimum Area (ha)	Baseline Maximum Area (ha)	Closure Mean Area (ha)	Closure Minimum Area (ha)	Closure Maximum Area (ha)
Athabasca Floodplain	2.45	1.03	5.88	2.18	1.03	8.56
Athabasca Escarpment	20.4	1.03	6.56	2.13	1.09	7.03
Steepbank Escarpment	2.21	1.11	5.81	2.07	1.11	5.08
Steepbank Organic Plain	2.17	1.04	12.39	2.23	1.04	7.91
Steepbank Upland	1.99	1.03	6.37	1.96	1.03	9.05
Consolidated Tailings	n/a	n/a	n/a	2.60	1.07	5.98
Littoral Zone	n/a	n/a	n/a	3.75	1.50	6.82
Overburden	n/a	n/a	n/a	2.80	1.20	10.82
Tailings Sand	n/a	n/a	n/a	2.95	1.12	7.24
Reclaimed Storage	n/a	n/a	n/a	2.09	1.03	3.32
Overburden Sand Mix	n/a	n/a	n/a	2.65	1.27	3.90
Undeveloped Areas	n/a	n/a	n/a	2.64	1.08	7.57

Table D4.2-21 Residual Impact Classification on the Diversity of ELC Macroterrain Units in the Terrestrial Local Study Area

Macroterrain Unit	Magnitude (Severity)	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Athabasca Floodplain	Low	Long-Term	Low	Local	Yes	Low
Athabasca Escarpment	Moderate	Long-Term	Low	Local	Yes	Low
Steepbank Escarpment	Moderate	Long-Term	Low	Local	Yes	Low
Steepbank Organic Plain	Moderate	Long-Term	Low	Local	Yes	Low
Steepbank Upland	Low	Long-Term	Low	Local	Yes	Low

D4.2.5 Monitoring

The establishment and development of revegetated communities (ELCs) on a variety of reclamation surfaces will be monitored as part of the far future environmental monitoring program for the Project. Diversity will be monitored at the landscape level using an ELC approach that will include an assessment of terrain (slope, slope aspect), drainage, reclamation soil type and revegetated plant community development, over time.

D4.3 ECOLOGICAL LAND CLASSIFICATION CONCLUSION

D4.3.1 Introduction

Project Millennium has been designed to mitigate macroterrain, ELC units and diversity impacts through reclamation and closure planning that will result in the creation of new macroterrain units and ELC units. The reclamation landforms or macroterrain units include:

- reclaimed tailings settling pond (248 ha);
- tailings sand dykes (520 ha);
- CT backfilled mine cells (3,278 ha);
- above ground overburden disposal areas (573 ha);
- other overburden areas including dykes (2,117 ha);
- reclaimed reclamation material storage areas (437 ha);
- end pit lake including lake, littoral zone, and the intralake wetlands (883 ha); and
- unmined developed areas (943 ha).

These engineered landforms will be amended with topsoil and revegetated through seeding of native plant species and ecosystem transplanting as required to approximate reclaimed ecosite phase. Over time these new component ELC units will gradually re-establish and will approximate pre-development conditions (species richness, patch size, shape, diversity and function).

The ELC assessment predicted the incremental effects of the Project on top of existing and approved oil sands operations. The assessment considered the issues, as addressed through the key question approach in Section D4.2 of the EIA. The issues and environmental consequences are summarized in Table D4.3-1.

Table D4.3-1 Ecological Land Classification Issues and Environmental Consequences

Issue	Environmental Consequence
Physical changes to macroterrain units	Low to Moderate
Potential changes to ELC Diversity	Low

D4.3.2 Impact Assessment

Ecological Land Classification Units

The five macroterrain units identified in the LSA are Athabasca Floodplain, Athabasca Escarpment, Steepbank Escarpment, Steepbank Organic Plain, and the Steepbank Upland. Project development will result in a 5% loss to the Athabasca Floodplain, a 68% loss to the Athabasca Escarpment, a 37% loss to the Steepbank Escarpment, a 67% loss to the Steepbank Organic Plain and a 39% loss to the Steepbank Upland. Some ELC associated with these macroterrain units will be permanently lost as a result of project development. However, the majority of these units represent a relatively small proportion of the associated macroterrain units.

The Ecological Land Classification (macroterrain and component ELC units) impact assessment was based on mitigation inherent in the Project Millennium closure plan design. That is, the impact assessment included residual impacts after mitigation was applied. Impacts of low to high magnitude are expected for the macroterrain units. All impacts are long-term and irreversible. The re-establishment of new reclamation macroterrain units means the environmental consequences of the residual impacts are rated as low to moderate. The moderate impact to some macroterrain units, while certain for the LSA, is of lower regional impact. Therefore, the residual impact has been rated as not significant.

ELC Diversity

There will be changes to ELC diversity as a result of project development. The assessment focuses on changes to richness, diversity, rare plant habitat loss, old growth forest loss, patch size and patch shape. There will be some changes to richness, diversity, patch size and patch shape as a result of the Project. There will be some losses to ELC units within the Athabasca Floodplain, Athabasca Escarpment and Steepbank Escarpment, which were assessed primarily on rare plant habitat and old growth forest associations.

Moderate impacts to diversity are expected for all macroterrain units. However, there are uncertainties associated with predicting changes to diversity. The residual impact of the changes in ELC units is of low to moderate magnitude, of local geographic extent and reversible. The environmental consequence of the residual impacts was assessed as low.

D4.3.3 Monitoring

Suncor will address these uncertainties by further studies or monitoring as appropriate for the key question. In addition, Suncor will integrate adaptive management strategies in their reclamation planning and will continue to work with the Oil Sands Terrestrial Vegetation and Wetlands Reclamation Committees.

D5 WILDLIFE

D5.1 BASELINE ENVIRONMENTAL SETTING

This section of the Project Millennium (the Project) EIA provides baseline information on wildlife. Project-specific impacts on wildlife are addressed in Section D5.2. As well, strategies to minimize impacts on habitat and wildlife, various monitoring programs, and bird deterrent systems are discussed in Section D5.2. Cumulative effects on wildlife are addressed in Section D6. The potential to return the area to pre-disturbed wildlife habitat conditions is discussed in Section E, Closure Plan Assessment.

During the past two decades, the following baseline studies have been conducted within the regional study area, including:

- the wildlife component of the Alsands EIA (Alsands Project Group 1978);
- the Alberta Oil Sands Environmental Research Program (AOSERP) from 1975 to 1984;
- the Other Six Leases Operations (OSLO) baseline inventory (Salter et al. 1986, Salter and Duncan 1986, Eccles and Duncan 1988);
- wildlife surveys conducted by Westworth, Brusnyk and Associates (1996a,c), Westworth and Associates (1996a,c), Fort McKay Environment Services Ltd. (1996b), and wildlife habitat modelling conducted by AXYS (1996) in support of an EIA for the Aurora Mine (BOVAR 1996e);
- Alsands survey conducted by Fort McKay Environment Services Ltd. (1997b);
- wildlife surveys conducted by Golder Associates (1997r,t) in support of the Shell Muskeg River Mine EIA;
- winter track counts and owl surveys (Golder 1997s);
- spring ungulate fecal pellet group count and browse use/availability surveys, spring waterfowl and raptor nest surveys, spring songbird surveys, and spring amphibians surveys conducted by Golder (1998n); and
- an ungulate monitoring program, including browse pellet group surveys and winter track count survey conducted by Golder and Suncor in 1997/98 (Golder 1998b).

For this EIA, an ecosystem-based management approach was used for assessing the impact of Project Millennium on wildlife in the local study area. Species, and the communities formed by species assemblages, are dependent on the characteristics of particular habitats (plant communities and physical attributes). The interaction among habitat types and wildlife communities produces the type of ecosystem present in the environment. Consequently, linking habitat type with species associations is fundamental to forming an ecosystem-based management plan.

Key Indicator Resources (KIRs) were selected for the EIA based on the selection process used for the Suncor Steepbank Mine EIA (Westworth and Associates 1996d), the Syncrude Aurora Mine EIA (BOVAR 1996e), and the Shell Muskeg River Mine EIA (Shell 1998), and input from Alberta Environmental Protection (AEP) (Table D5.1-1). Details on the KIR selection process are provided in Section A2 (EIA Approach).

Table D5.1-1 Wildlife Key Indicator Resources and the Selection Rationale

Key Indicator Resource (KIR)	Selection Rationale
moose	economic importance, early successional species
fisher	use of late seral stages, economic importance, carnivore
black bear	economic importance, carnivore
beaver	economic importance, semi-aquatic habits
red-backed vole	importance in food chain
snowshoe hare	importance in food chain
dabbling ducks	importance in food chain, economic/recreational importance
ruffed grouse	economic and recreational importance
Cape May warbler	use of white spruce forests, neotropical migrant
western tanager[a]	use of open forest mixedwood, neotropical migrant
pileated woodpecker[a]	use of late seral stages, large diameter trees and snags
great gray owl	raptor, use of wetlands

[a] KIRs added to those used for the Steepbank and Aurora mines; based on input from AEP.

D5.1.1 Traditional Importance of Wildlife Species

D5.1.1.1 Ungulates

Moose

Information from the Fort McKay community indicates that moose are found throughout their traditional lands and are a valued resource to the people (Fort McKay First Nations 1994). Moose are important for food, medicine and a variety of other necessities. The LSA has limited access because of muskeg and peat bogs (Fort McKay 1996d). For this reason, it is believed that game numbers within the LSA are higher than other areas (Fort McKay 1996b). It has been reported that the occasional moose has been taken off the Athabasca river near the LSA (pers. comm. K. Schmidt, AEP in Fort McKay, 1996). A trapper reported that moose are numerous in his trapping area within the RSA (Fort McKay 1996d, Fort McKay 1997a).

Food

Moose are a valuable source of protein for members of the Fort McKay community. In a survey of the community, 55 of 60 people stated they ate moose. The median number of days per year that moose was consumed in the community was 90 (Fort McKay 1997a).

Moose flesh, heart, kidney, liver, tripe, marrow, tongue, fat, and nose are all consumed (Fort McKay 1997a). Another food obtained from moose is crackling (Indian popcorn) which is made from the cape around the stomach of the moose. The contents of the stomach or rumen can also be used for human food. It is reported that moose brains can be eaten with cranberries and the milk of a recently killed cow. Additionally, moose eyes, ears, jaws, noses, and tongues are considered delicacies (Fort McKay First Nations 1994).

The average weight of edible meat on a moose is 204 kg (Fort McKay Tribal Administration 1983). The average mass of female moose in Alberta is 377.5 kg, and the average mass of a male moose is 384.2 kg (Smith 1993). Thus, approximately 54% of a moose is used for food. In 1983 the calculated value of a moose was $2,327.50 (Fort McKay Tribal Administration 1983).

Medicine

Moose parts have some medicinal value. Moose fat mixed with beaver castor is used as medicine for human wounds. Parts of the female's reproductive system (the womb) can be used to treat snow or sun blindness. Moose rumen is a medicine used to prevent wound infections (Fort McKay First Nations 1994).

Other Uses

The hide of a moose can be used for a variety of purposes (Fort McKay First Nations 1994). Mattresses and drum covers can be made with moose hides. Moose hide rope is used for rat (muskrat) traps. Strings and thongs from moose hide are used for handles, moccasin laces, belts, rope, mitts, jackets, vests and sewing lacing. Moose brains can be used for tanning hides. Dog harnesses, horse and dog packs, water bags, backpacks and door hinges are made of moose hide. It is estimated that a single moose hide can produce approximately 13 pairs of moccasins, which could potentially be sold at local stores. Moose hides were valued at $400- $500 in 1994 (Fort McKay First Nations 1994).

Many other uses of moose parts are outlined in "There is Still Survival Out There" (Fort McKay First Nations 1994). Ashes are mixed with bear or moose fat for soap. Moose bladders can be used for the storage of animal fat. Sinew (tendons) from moose can be used for sewing threads. Moose antlers are used for knife handles, and fleshers, a tool used for skinning, are made from the lower leg bones of moose. Moose hair can be dyed and used in fancy sewing or mixed with mud for the chinking of log houses. As well, moose teeth can be used to make necklaces.

Deer

Both white-tailed and mule deer occur in the RSA (Smith 1993). White-tails are the most common deer in the Fort McKay area (Fort McKay 1997a). Mule deer have also been observed (Fort McKay 1996b).

In a survey of food use, less than one third of people ate deer. The same survey showed that members of the Fort McKay community preferred white-tailed deer over mule deer (Fort McKay 1997a).

Tanned deer hide can be used to make bags to collect and store moss and water. The hide below the knee of a deer can be used for pack sacks, and fawn hides can be used for decorative handbags (Fort McKay First Nations 1994).

Deer have limited medicinal use. However, the cud of deer can be eaten or used as medicine to reduce infection (Fort McKay First Nations 1994).

Caribou

Woodland caribou are known to occur within the RSA (Smith 1993). However, there are no woodland caribou harvest sites reported east of the Athabasca, although Caribou have been observed there (Fort McKay 1996d). West of the Athabasca River the caribou range extends from the Thickwood Hills and Dunkirk River to Snipe Creek and Mikkwa River in the North (Fort McKay First Nations 1994). Harvest location may be dictated by naturally occurring salt licks. Salt licks are reported at Saline Lake, north of Fort McKay, on the east bank of the Athabasca River, near Muskeg Mountain, on the east shore of McClelland Lake, near Dalkin on the west bank of the Athabasca, and also at Ronald Lake (Fort McKay First Nations 1994).

There are several reports of barren ground caribou migrating into the Fort McMurray area. In 1948, there was a migration of barren ground caribou to Fort McMurray along the east side of the Athabasca (Fort McKay First Nations 1994). More recently, in 1955, thousands of barren ground caribou also came as far south as Fort McMurray (Fort McKay 1996b, c).

Buffalo (Bison)

Wild buffalo (bison) are considered very rare in Alberta with only a limited number of records (Smith 1993). No buffalo harvest sites occur south of Fort McKay, but buffalo harvest sites were reported near the Maybelle

River, Chipewyan IR 201G, Range 10 western baseline, Alice Creek, Raymond Creek, Edra Creek, Elliot River and between Gardiner Lakes and Clausens Landing (Fort McKay First Nations 1994). The Fort Chipewyan people described buffalo numbers as dropping progressively. Possibly contributing to these low number was a reported mass drowning in 1974 (NRBS 1996b).

Buffalo are not considered a regular staple in the diet of the Fort McKay people (Fort McKay 1997a). However, when needed, buffalo have been killed in the past by chasing them on to the ice to drown (NRBS 1996b).

D5.1.1.2 Terrestrial Furbearers

Wolves

Gray wolves occur throughout the RSA (Smith 1993). However, wolves, coyote and foxes do not occur in great numbers in the Fort McMurray area (NRBS 1996b). In a survey, wolves were identified by 25% of questionnaire respondents as a source of income (NRBS 1996b). It was reported that wolves have a strong odour and were skinned outside (Fort McKay First Nations 1994).

Mr. John Rigney, the band manager of the Athabasca First Nation recently expressed views on wolves and how they are viewed by northern aboriginal people (Edmonton Journal March 23, 1998). The column was focused on questions about the northern wolf kill. The aboriginal view is that wolves, besides killing young and weak animals, also can and will kill healthy animals. The local aboriginal people believe wolves are responsible for significantly reducing the local moose population. Mr. Rigney states that aboriginal people believe that the wolves have reached the limit of their numbers, that there are just enough large prey animals to support the local population of wolves. Some even believe the current population of prey animals cannot support the wolf population. Mr. Rigney states that hunting is still a form of survival for northerners, and wolves are viewed as competition for food resources. It is believed that part of wildlife husbandry of northern aboriginals is to control wolf populations, as it is their right to influence the wildlife populations upon which they are so dependent. This right includes the right to control populations of animals that negatively impact other resources upon which the people depend.

Wolverine

Wolverines are considered to be in the shortest supply of the sixteen furbearers found in the Fort McKay area. Only five harvest sites have been reported: east of Namur Lake, east of Sand Lake, between the Birch Mountains and the Athabasca River, south of Redclay Creek, and one on the east bank of the Steepbank River. The Steepbank River harvest site is the only site reported east of the Athabasca River (Fort McKay First Nations 1994).

Fisher

Fisher numbers in the Steepbank Mine area are low. A trapper feels it is because of timber harvesting in the area (Fort McKay 1996d).

Marten

Marten are found in the Steepbank Mine area. However, one of the elders feels that marten numbers are low due to low squirrel numbers resulting from logging (Fort McKay 1996d).

Canada Lynx

Canada lynx are found throughout the Fort McKay area and have a close association with rabbits (Fort McKay First Nations 1994). The last peak in Canada lynx population reported in the Steepbank mine area was in 1982/83 (Fort McKay 1996d).

Typically, lynx are trapped for their fur. However their meat can be boiled, fried or dried (Fort McKay First Nations 1994).

Bear

Black bears were once numerous in the Steepbank mine area (Fort McKay 1996d), and bears were traditionally trapped and killed (Fort McKay First Nations 1994). Typically, hunting occurs along the area rivers during the berry season. This is when bear meat is the most palatable and fatty (NRBS 1996b). There is some concern that bears can no longer be eaten because of the garbage bears consume (Fort McKay 1996d).

Bears have many other uses. Ashes can be mixed with bear grease and used for soap. Bear fat can be used for cooking. Bear meat can be eaten boiled, dried or roasted. As well, bear guts can be used for the storage of fat. The hides are used for blankets or mattresses. Medicinally, bear grease can be used on sores, cuts and infections (Fort McKay First Nations 1994).

Grizzly bear are not common in the area although physical indications of the presence of a grizzly was reported near Saline Lake in 1990 (Fort McKay 1996d).

D5.1.1.3 Semi-Aquatic Furbearers

Beaver

Few beaver occur on the west side of the Steepbank River because there are very few poplars, aspen and willow, the preferred food of beavers (Fort McKay 1996a). Some people feel that beaver populations are stable due to less trapping because of poor fur prices. However, exploratory activities (e.g., seismic activity) may alter drainage which negatively impacts beaver populations (Fort McKay 1996d). Predators of beavers include otters, black bears and wolves (Fort McKay 1996a, d).

Beavers are also consumed. The preferred organs are the flesh and the tail (Fort McKay 1997a). Beaver castor from the anal scent glands has many medicinal uses. The castor can be dried and scraped into a powder form. The smoke of heated castor provides relief for sore throats and headaches. When mixed with moose or bear fat, it is used as a medicine on wounds or it can be used to treat toothaches. Beaver castor mixed with sugar and water is boiled and used as a cold medication. Undried castor contains a gum like substance that can be chewed (Fort McKay First Nations 1994). Beaver castor is also used on traps as lynx bait or it can also be sold as an ingredient in perfume (Fort McKay First Nations 1994).

Some concerns about the quality of beaver flesh in the RSA have been expressed. One trapper suggested that beavers from the Athabasca River taste different than beaver trapped to the west (Fort McKay 1996d). There is concern that pollution has contaminated beavers and led to reduced consumption (Fort McKay 1996a, d).

Muskrat

There may be muskrats in the Steepbank River (Fort McKay 1996a). Rats (i.e., muskrats) are trapped for their fur, and the pelts can be used for jackets, mitts, and hats or for trim on clothing or as decoration (Fort McKay First Nations 1994). Muskrat are a main staple food of some traditional users (NRBS 1996b). However in a survey of the Fort McKay community, less than one quarter of the respondents ate muskrat (Fort McKay 1997a).

It has been stated that muskrat numbers have been low in the last few years. An example is Kearl Lake. A trapper believes that seismic activity on the lake may have impacted the population (Fort McKay 1996d). Pollution in the area may have a negative impact on muskrat populations (Fort McKay 1996a).

River Otter

An increase in otter numbers was reported on a trapline in the Steepbank area (Fort McKay 1996a). It is believed that otters prey on young beavers (Fort McKay First Nations 1994).

Mink

It is believed that mink numbers are lower than they used to be in the Fort McKay area. It is reported that there are few mink in the Steepbank River system (Fort McKay 1996d). Mink can be trapped using fish, rotting duck or beaver castor as bait (Fort McKay First Nations 1994).

D5.1.1.4 Small Mammals

Skunk

Striped skunks are found throughout Alberta (Smith 1993). The primary use of skunks appears to be medicinal. A drink of one drop of skunk juice in hot water is a treatment for the flu. Skunk oil mixed with water is also used as an application on itchy skin, sore teeth or a sore chest. The skunk juice/oil is taken from the glands of the skunk. The mixture is put in a can and hung outside to prevent illness. As well, skunk scent sacks or hides may be hung outside homes to prevent illness (Fort McKay First Nations 1994).

Porcupine

Porcupines are found throughout Alberta (Smith 1993). Porcupine have meat that is considered white with similar texture to chicken and can be prepared by boiling, roasting or frying (Fort McKay First Nations 1994).

Snowshoe Hare (Rabbit)

Snowshoe hares are found throughout the Fort McKay area. Numbers of hare are thought to influence lynx abundance. They are reported to cycle every seven years (Fort McKay First Nations 1994).

Rabbits (e.g., snowshoe hares) are snared for their meat and pelts. Forty-five of 60 people surveyed consumed rabbit in the year prior to the survey. Snowshoe hares are taken opportunistically to develop hunting skills of young people. Virtually the whole hare is consumed (Fort McKay 1997a). Approximately 300 pelts are needed for a rabbit-pelt jacket. Pelts are also used for other clothing, lining for mitts, decorations and blankets (Fort McKay First Nations 1994).

D5.1.1.5 Waterbirds

Waterbird habitat and harvest sites are found along the Athabasca River corridor, the Clearwater River, lower reaches of the Steepbank and Muskeg Rivers, the Firebag River, Richardson Lake, the Legend-Namur-Gardiner-Sand-Eaglenest Lakes corridor, and the Chipewyan, Mink and Green Lakes areas (Fort McKay First Nations 1994).

Several species of waterfowl (e.g., ducks, geese and swans) in the RSA are harvested in the spring and fall. Shipyard Lake is a staging area for waterfowl, and Saline Lake has been used as a harvest area for American coot and duck eggs. It is reported that waterfowl are plentiful during the spring migration. Sandhill cranes, American white pelicans, and great blue herons are hunted in spring and fall. Sandhill cranes, snow geese, Ross' geese and Canada geese migrate through the Steepbank Mine area in spring and fall. Great blue herons moved into the area in 1970 (Fort McKay 1996a).

Birds are hunted for their meat, and the eggs of ducks, geese and gulls are used as food during early nesting (Fort McKay 1996a). In a survey of the Fort McKay community, greater than half the people interviewed ate ducks and geese. The flesh, gizzards and livers of the birds are consumed. It was reported that some members of the community ate swans (Fort McKay 1997a). Duck, goose and gull eggs can be used for food preparation or eaten hard-boiled (Fort McKay First Nations 1994). Spring waterfowl are preferred over autumn birds because they taste better, and the feathers are considered to be in better condition (Fort McKay 1996a).

Several other parts of waterbirds are used. Duck and goose feathers can be used for insulation or stuffing in pillows, blankets and sleeping robes. Duck, goose and loon skins can be made into waterproof bags. Loon skins are preferred because of their attractive colour and feather design. The bags can be used to store food, needles, thread, scissors and sewing material. Loon skins can also be used as decorative wall pieces. Goose wings can be used as brooms and dusters. Pelican pouches can be made into small water proof pouches used for small items or carrying water (Fort McKay First Nations 1994).

D5.1.1.6 Upland Game Birds

Sharp-tailed and ruffed grouse populations are considered high in the Steepbank Mine area. In the winter, willow ptarmigan will migrate into the area. A trapper feels the ptarmigan are more likely to migrate south into the area during cold winters (Fort McKay 1996a).

Grouse are considered an important and easily accessible source of food (Fort McKay 1996a). Forty-one of 60 people ate grouse and ptarmigan in the year prior to the survey. Ptarmigan were eaten by 10 of 60 people (Fort McKay 1997a). As well, tails can be spread out and dried and used as fans or wall decorations (Fort McKay First Nations 1994).

D5.1.1.7 Song Birds

Few observations on song birds have been made in the traditional knowledge literature. Snowbirds (possibly snow buntings) and blackbirds pass through the region in flocks. Barn swallows nest on the Athabasca River (Fort McKay First Nations 1994). In the Steepbank Mine area, Canada jays are common. Black-billed magpies are new in the area, and ravens are present in relatively large numbers. American crows are numerous in the summer and fall (Fort McKay 1996a).

It has been observed that there are fewer song birds in the forest than before, and that numbers are constantly dropping (Fort McKay 1996d). In the Steepbank Mine area it has been stated that the forest is quieter than it was fifteen years ago (Fort McKay 1996a).

D5.1.1.8 Raptors (Owls)

Two species of large owls inhabit the study area: the great horned owl and the great gray owl. Although owls tend to be scarce, occasionally large owls are killed and eaten (Fort McKay 1996a). Owls are roasted and reportedly taste like turkey. As well, wings can be used for brooms or dusters (Fort McKay First Nations 1994).

D5.1.2 Wildlife Species of the Project Area

Investigations on various wildlife species found within the Project Local Study Area (LSA) and the Regional Study Area (RSA) were discussed in Golder (1998n) and Golder (1997s) and are summarized below. The Project LSA and RSA are discussed in Section A2 (EIA Approach).

D5.1.2.1 Ungulates

Importance

Ungulates (e.g., moose, white-tailed deer, and woodland caribou) are important to the public from both a consumptive and non-consumptive viewpoint. These large herbivores also play important roles in the boreal ecosystem. As discussed above, ungulates are also important from a traditional perspective.

Abundance

Moose

A number of aerial and winter track count surveys have been conducted in the oil sands area of northeastern Alberta in the last 25 years. Early estimates of moose density were 0.09/km^2 for the Lease 13 area (Shell 1975), and 0.31/km^2 for the larger Alsands area (Bibaud and Archer 1973). Current estimates for the Lease 12, 13 and 34 study area are approximately 0.10/km^2 (Westworth and Associates 1996b). Westworth, Brusnyk and Associates (1996a) reported moose density estimates of 0.27/km^2 in December and 0.24/km^2 in February for the Suncor study area. Thus, moose populations in the region have remained low and relatively stable. Low moose densities may reflect the shortage of preferred winter habitat (deciduous and mixedwood forest) in the area (BOVAR 1996c). Prime moose habitat, with minimal hunting mortality, such as that of the Peace Athabasca Delta, can support moose populations of 0.1 to 1.0 moose/km^2 (Telfer 1984).

Deer

Mule deer are traditional residents of the western boreal forest, and are frequently associated with cleared or disturbed habitats. Populations are generally small and localized. At one time, white-tailed deer were not found in the oil sands area. However, recent changes to access and the creation of open habitat has resulted in a northern range expansion (BOVAR 1996c). Mule deer (Alsands Project Group 1978) and white-tailed deer (Westworth and Associates 1980) have been observed during aerial surveys. Seven deer were recorded during aerial surveys conducted within the Suncor study area in 1995-1996 (Westworth, Brusnyk and Associates 1996a). Westworth and Associates (1996b) estimated white-tailed deer populations in the Lease 12, 13 and 34 study area at 0.08/km^2.

Other Ungulates

At one time, woodland caribou and elk were residents of the oil sands area. Currently, caribou exist at low densities 60 km northwest of the Aurora Mine site, while elk are restricted to the Athabasca River valley south of Fort McMurray (BOVAR 1996c).

Habitat

Moose

Moose within the oil sands area preferentially use deciduous forest, mixedwood forest and riparian areas. Alsands Project Group (1978) and Westworth and Associates (1979, 1980, 1996b, d) found that moose were most often associated with aspen and mixedwood forests during the winter. Skinner and Westworth (1981), using both aerial and winter track count surveys, indicated that moose preferred riparian shrub areas. Of the moose tracks observed within the LSA, the greatest number were recorded in the riparian shrubland communities (Golder 1997s).

Deer

Westworth and Associates (1996b) mainly recorded deer tracks in cleared peatland and aspen forest in the Lease 12, 13 and 34 study area. Westworth (1980) also noted the presence of deer in regenerating areas. Westworth, Brusnyk and Associates (1996a) recorded high track frequencies in closed deciduous forest and disturbed habitats. It is expected, therefore, that any deer present in the study area should be found primarily in early regenerating or open stands with abundant deciduous browse.

D5.1.2.2 Terrestrial Furbearers

Importance

Terrestrial furbearers (e.g., coyotes, Canada lynx, marten, and weasels) are important from both an economic and ecological perspective within the LSA. Most are trapped for their pelts or other traditional uses. These forest carnivores also play important roles in the boreal ecosystem.

Abundance

Canids: Wolves, Coyotes, and Foxes

Wolves, coyotes, and foxes are all found in the boreal forest. Due to the low population size and large home ranges, low track densities were previously recorded for wolves. Track densities ranged from 0.01 tracks/km-track day for the Lease 88 and 89 study area (Skinner and Westworth 1981), to 0.05 tracks/km-track day for the Lease 12, 13 and 34 area (Westworth and Associates 1996b). Earlier estimates of density for the Lease 17 and 22 study area were 1 wolf/100 km^2 (Westworth and Associates 1979). Penner (1976) found a wolf track density of 0.1 tracks/km-track day. A study in northeastern Alberta estimated wolf density at 11.1 wolves/1,000 km^2 (Fuller and Keith 1980a). Wolf track densities for the Steepbank River study area were 22.8 tracks/km-track day for the month of January 1997 (Golder 1997s). No wolf tracks were observed in February or March.

Previous studies have found the coyote to be the most abundant large carnivore in the oil sands area. Track densities encountered during past winter track count surveys have ranged from a low of 0.1 tracks/km-track day (Westworth and Associates 1996b) in the Lease 12, 13 and 34 study area, to a high of 0.3 tracks/km-track day for the general Syncrude lease area (Alsands Project Group 1978). Golder (1997t) recorded 0.1 tracks/km-track day in the Shell Lease 13 study area. In a 1997 study, coyotes were recorded at track densities of 1.3 tracks/km-track day in January and 5.87 tracks/km-track day in February (Golder 1997s).

Foxes, like wolves, are present in the oil sands area at low densities. Track densities ranged from 0.01 tracks/km-track day in the Lease 12, 13 and 34 study area (Westworth and Associates 1996b), to 0.08 tracks/km-track day in the Lease 88 and 89 study area (Skinner and Westworth 1981). No fox tracks were recorded during the 1997 winter field study (Golder 1997s).

Terrestrial Mustelids: Wolverines, Fishers, Martens and Weasels

Wolverines, due to their solitary nature and large home range (100-900 km^2; Banci 1994), are considered to be the most uncommon carnivore in the oil sands area. Skinner and Westworth (1981) found a track density of 0.005 tracks/km-track day for the Lease 88 and 89 area. No wolverine tracks were observed during the winter track count surveys (Golder 1997s). Estimated population density for the Lease 17 area was calculated at 0.1 animals/100 km^2 (Westworth and Associates 1979).

Fishers, although relatively more numerous, are similarly considered uncommon in the area. Track densities for the Lease 12, 13 and 34 area were 0.02 tracks/km-track day (Westworth and Associates 1996b). Fisher track densities during the Steepbank River winter track counts were fairly high with densities up to 37.4 tracks/km-track day (Golder 1997s). In the 1997 study, Golder (1997s) recorded a track density of 22.2 tracks/km-track day in the Lease 29 uplands. A density of 0.4 fishers/100 km^2 was estimated for the Fort McMurray area, based on trapping data (Westworth and Associates 1979).

Westworth and Associates (1979) classified martens as scarce in the Lease 17 area. Recently, Westworth and Associates (1996b) reported that track densities for the Lease 12, 13 and 34 study area were 0.2 tracks/km-track day, suggesting a possible resurgence of martens in the area. Marten were recorded at densities of up to 18.3 tracks/km-track day in the 1997 Steepbank River surveys and up to 181.1 tracks/km-track day in the surveys in the Lease 29 uplands (Golder 1997s). This high number may be indicative of the continued resurgence of marten.

Weasels are the most common carnivores in the oil sands area. Ermines are considered to be abundant and least weasels uncommon, although the inability to distinguish the species based on tracks makes this speculative. Combined track densities for the two species were 1.1 tracks/km-track day for the Lease 88 and 89 study area, and 1.2 tracks/km-track day for the Lease 12, 13 and 34 study area (Westworth and Associates 1996b). For the Shell Lease 13 study area, a track density of 1.1 tracks/km-track day was recorded by Golder (1997t). Weasels were recorded at up to 30.5 tracks/km-track day in the 1997 Steepbank River surveys, and up to 61.6 tracks/km-track day in the Lease 29 uplands area (Golder 1997s).

Canada Lynx

Lynx are not abundant in the oil sands area. They typically have large home ranges (8.3-51.0 km^2, Koehler and Aubry 1994) which makes detection within the boundaries of a particular study area difficult. Penner (1976) recorded a density of 0.002 tracks/km-track day in the Lease 17 area. A higher than expected density of 0.06 tracks/km-track day was recorded in Leases 88 and 89 (Skinner and Westworth 1981). Lynx tracks were recorded at densities up to 2.5 tracks/km-track day in the 1997 Steepbank River surveys (Golder 1997s).

Black Bears

Black bears are relatively common in the oil sands area, with populations remaining fairly stable from year to year. Fuller and Keith (1980b) estimated bear density to be 25-50/100 km^2. Young and Ruff (1982) provided a lower estimation of bear density (18-25/100 km^2), based on habitat availability and densities recorded previously for the Cold Lake area.

Habitat

Canids: Wolves, Coyotes, and Foxes

Wolves tend to prefer open areas, avoiding heavy coniferous cover in winter (Penner 1976). No wolf tracks were encountered in the upland study transects during the winter track count survey (Golder 1997s), thus habitat preferences could not be determined.

Coyotes are generalist predators that tend to prefer cleared and agricultural fringe sites, while avoiding densely forested areas (Boyd 1977). Previous studies found a preference for riparian white spruce areas and cleared peatlands (Skinner and Westworth 1981, Westworth and Associates 1996b). The 1997 track count survey indicated that coyotes preferred disturbed areas (4.3 tracks/km-track day), wooded fens (1.6 tracks/km-track day) and wooded bogs (1.3 tracks/km-track day, Golder 1997s).

Red foxes are more commonly found in grassland regions (Banfield 1987). Previous studies have discovered tracks in jack pine and riparian white spruce areas (Skinner and Westworth 1981), and near garbage dumps (Alsands Project Group 1978). Red fox tracks were only recorded during the 1997 Steepbank River surveys, thus habitat preferences could not be determined (Golder 1997s).

Terrestrial Mustelids: Wolverines, Fishers, Martens and Weasels

Due to the short duration of the survey and the large size of a wolverine's home range, occasional use of the Project area by wolverines cannot be discounted, although recent surveys have failed to record the species.

Wolverines are thought to prefer undisturbed areas of coniferous forest (Pasitschniak-Arts and Larivière 1995).

Martens and fishers are thought to prefer middle to late stage coniferous forests (Buskirk and Ruggiero 1994; Powell and Zielinski 1994). Inventory work in the Lease 12, 13 and 34 study area (Westworth and Associates 1996b) showed that fisher tracks were found in the greatest frequency in riparian balsam poplar forest. On the Shell Lease 13 study area, closed aspen and mixed coniferous stands were more frequently used by fisher and marten than were peatland and fen habitats (Golder 1997d). In the 1997 Upland Lease 29 study, fisher avoided lichen-jackpine (a1), low-bush cranberry-white spruce (d3), low-bush cranberry-aspen-poplar (d1), and Labrador tea/subhygric-white spruce-black spruce (h1) (Golder 1997s). Martens preferred low-bush cranberry white spruce (d3).

The ermine and least weasel prefer riparian, deciduous and early successional habitats, due in part to the abundance of small mammal prey usually found in these areas (Banfield 1987). In the Lease 88 and 89 study area, Skinner and Westworth (1981) found the majority of tracks in black spruce muskeg, riparian white spruce and mixedwood areas. Westworth, and Associates (1996b) found a preference for open tamarack/bog-birch, black spruce/tamarack and cleared peatlands in the Lease 12, 13 and 34 study area. Golder (1997t) found a preference for closed mixedwood-white spruce dominant forests in the Shell Lease 13 study area. In this study, weasels avoided riparian shrubland (shrub) and open, shallow water (Wonn) (Golder 1997s).

Canada Lynx

Previous observations of lynx were made in black spruce muskeg (Skinner and Westworth 1981) and in black spruce (Penner 1976). Lynx are thought to prefer dense climax boreal forest, although their distribution is linked to the distribution of snowshoe hares, their preferred prey choice (Skinner and Westworth 1981). Habitat preference for snowshoe hares is discussed in Section D5.1.2.4.

Black Bears

Bears are omnivores, and rely on a variety of foods. Food and shrub diversity is generally higher in deciduous stands or recently disturbed areas. For this reason, bears are most often found in aspen or mixedwood stands (Young and Ruff 1982, Banfield 1987). No information is available for black bear habitat use within the LSA.

D5.1.2.3 Semi-Aquatic Furbearers

Importance

Semi-aquatic furbearers (e.g., beavers, muskrats, mink, and river otters) are important from both an economic and ecological perspective within the LSA. All are trapped for their pelts, and mink and otters are important carnivores in the boreal ecosystem. Beavers, through their dam-building activities, act as agents of change and thus are also important components of the ecosystem.

Abundance

Beavers

Penner (1976) estimated beaver density in the Lease 17 area to be 1.9 animals/km^2. Beaver density on the east side of the Athabasca River is thought to be lower, due to less favourable habitat. Skinner and Westworth (1981) recorded 0.11 colonies/km^2 during an aerial survey of the Lease 88 and 89 study areas. Based on an estimate of 6.3 beavers/lodge (Searing 1979), this would yield an estimate of 0.69 beavers/km^2. A density of 1.2 lodges and caches per km^2 was found for the Suncor Steepbank Mine LSA by Fort McKay Environment Services (1996b). Most (77%) of the lodges were observed on rivers and streams, with the remainder on lakes or ponds. Active beaver lodges have been reported on Shipyard Lake (Golder 1996p), and an active lodge was observed along Unnamed Creek during the amphibian surveys (Golder 1998n).

Muskrats

Muskrats are smaller aquatic rodents, common in marshes and other waterbodies throughout the parkland and boreal forest region (Banfield 1987). Two separate areas in Lease 17 were found to have densities of 2.5 muskrats/ha and 0.3 muskrats/ha (Penner 1976). Density of muskrats on the east side of the Athabasca River is thought to be low, due to poor-quality habitat. During an aerial survey of the Lease 88 and 89 study area, Skinner and Westworth (1981) recorded 0.03 muskrat houses/km^2. No muskrat houses or pushups were observed during a November 1995 study of the Aurora Mine area (Fort McKay 1996c). No muskrat houses or push-ups were observed during the Project Millennium surveys.

Mink

Mink are considered to be common along watercourses in the oil sands area. Pelts collected in the Fort McMurray area for the years 1970 to 1975 were twice the provincial average (Westworth and Associates 1979). Track count densities have ranged from 0.1 tracks/km-track day in the Leases 17, 88 and 89 study area (Penner 1976; Skinner and Westworth 1981) to 0.2 tracks/km-track day for the Lease 12, 13 and 34 study area (Westworth and Associates 1996b). Only 0.03 tracks/km-track day were recorded during the Shell Lease 13 winter track count survey (Golder 1997t). In the 1997 surveys on Lease 29 uplands, mink tracks were recorded at a density of 10.47 tracks/km-track day (Golder 1997s). Mink tracks were also recorded at Shipyard Lake in the 1997 study.

River Otters

Current and historic local abundance of river otters in the oil sands area is low. Golder (1997t) recorded the frequency abundance of river otters in the Lease 13 area at 0.01 tracks/km-track day. Westworth and Associates (1979) estimated otter density for the Lease 17 area to be 0.2/100 km^2. Track count densities ranged from 0.01 tracks/km-track day (Skinner and Westworth 1981) in the Lease 88 and 89 study area to 0.02 tracks/km-track day (Westworth and Associates 1996b) in the Lease 12, 13 and 34 study area. River otters were not recorded in this study (Golder 1998n).

Habitat

Beavers

Beavers prefer relatively deep waterbodies, near stands of early deciduous vegetation. Preferred food includes aspen, birch and willow (Banfield 1987). The LSA is dominated by conifer bogs and fens, and provides generally poor habitat. Beavers are expected along creeks and in marshy areas near aspen stands.

Muskrats

Muskrats prefer waterbodies with relatively deep water. Good muskrat habitat is provided by waterbodies (most often marshes) with a well-developed zone of emergent plants, used for food and lodge construction (Banfield 1987). Wetlands in the LSA are generally shrubby bogs and fens rather than marshes. For this reason, the LSA is thought to be poor-quality habitat for muskrats.

Mink

Mink are semi-aquatic carnivores that hunt in and along watercourses. They are found most commonly along stream banks, lakeshores, forest edges and large marshes (Banfield 1987). Previous studies have found that most tracks were within riparian shrub and riparian white spruce communities (Skinner and Westworth 1981, Westworth and Associates 1996b). In the 1997 study on the Lease 29 uplands, mink preferred riparian shrublands (Golder 1997s).

River Otters

River otters are aquatic carnivores that feed almost exclusively on fish in streams and lakes. Tracks are most frequently encountered along the shores of deep lakes, rivers and large marshes (Banfield 1987). Previous studies have recorded tracks along the Muskeg and Athabasca rivers (Alsands Project Group 1978, Skinner and Westworth 1981; Westworth and

Associates 1996b; Westworth, Brusnyk and Associates 1996b). No river otter tracks were observed during this study (Golder 1998n).

D5.1.2.4 Small Mammals

Importance

Small mammals (e.g., hares, squirrels, shrews, voles, and mice) form an important component of the food chain. They are also one of the more diverse mammal groups in the LSA, making them good indicators of biodiversity. Numerous species of small mammals are likely to occur in the LSA. For the purposes of this study, only red-backed voles, snowshoe hares, and red squirrels will be discussed. Red-backed voles and snowshoe hares were selected as KIRs for the EIA, and snowshoe hares and red squirrels are important economically and traditionally.

Abundance

Red-backed voles

The red-backed vole is one of the most common and abundant small rodents throughout most of the forested areas of Alberta (Smith 1993). The red-backed vole is a diurnal species that remains active throughout the year with regular cyclic fluctuations in population numbers occurring every four to five years (Green 1979). Summer population density estimates for the red-backed vole in mixedwood habitat ranged from 9.3 to 19.1 animals/ha (Westworth and Associates 1979). In 1980, Westworth and Skinner estimated red-backed vole populations to vary between 8.6 and 19.7 animals/ha within the Syncrude Mildred Lake leases (AXYS 1996).

Snowshoe Hares

Snowshoe hares are common throughout the oil sands area, and usually account for most of the observations during track count surveys. Populations of snowshoe hares generally fluctuate on a 9- to 11-year cycle, leading to large variations in track count data from year to year (Boutin 1995). Figures from years near the trough of the population cycle display track densities of 2.9 tracks/km-track day (Syncrude 1973) and 3.5 tracks/km-track day (Westworth and Associates 1996b). In years of peak populations, densities can be 8 to 10 times higher. For example, Skinner and Westworth (1981) estimated track count frequencies at 21.2 tracks/km-track day, and the 1997 study produced estimates of 22.4 tracks/km-track day (Golder 1997s).

Red Squirrels

Red squirrel observations from track counts in the oil sands area are usually second only to snowshoe hares. Early surveys of Lease 17 (Alsands Project Group 1978) and Leases 88 and 89 (Skinner and Westworth 1981) yielded densities of 2.3 and 2.1 tracks/km-track day, respectively. An estimate of

1.2 squirrels/ha, based on a study in Lease 17, was made by Penner (1976). A more recent track count survey yielded a density of 0.6 tracks/km-track day (Westworth and Associates 1996b), suggesting a drop in squirrel numbers. However, in this study, densities of up to 1,671 tracks/km-track day were recorded (Golder 1997s).

Habitat

Red-backed voles

Aspen and mixed white spruce jack pine communities provide prime habitat for red-backed voles (AXYS 1996). Green (1980) also described balsam poplar, aspen and jack pine communities as providing high-quality habitats for the red-backed vole. Golder (1997t) reported that the abundance of red-backed voles within the Shell Lease 13 area was greatest in wetland, riparian and coniferous habitats.

Snowshoe Hares

Snowshoe hares are most often found in areas with a well-developed shrub layer. Observations made at the peak of the snowshoe hare cycle were most often made in riparian white spruce, mixedwood and black spruce muskeg areas (Skinner and Westworth 1981), all areas with a prominent shrub component. In the current study, snowshoe hares preferred low-bush cranberry-aspen poplar-white spruce (d2) and Labrador tea/horsetail-white spruce-black spruce (h1). Hares avoided lichen-jackpine (a1), low-bush cranberry-white spruce (d3), low-bush cranberry-aspen poplar (d1), and wooded-fens (ftnn) (Golder 1997s).

Red Squirrels

Red squirrels rely on conifer cones for the majority of their food supply, and are therefore typically found in conifer-dominated forests. Earlier studies found that red squirrels preferred upland white spruce and riparian white spruce areas (Alsands Project Group 1978, Skinner and Westworth 1981, Westworth and Associates 1996b). Red squirrels in the Shell Lease 13 area showed a similar, significant preference for these habitat types (Golder 1997t). In the 1997 study, red squirrels preferred low-bush cranberry-white spruce (d3) and avoided lichen-jackpine (a1), Labrador tea/horsetail-white spruce-black spruce (h1), low-bush cranberry aspen poplar (d1), and low-bush cranberry-white spruce-aspen poplar (d2) (Golder 1997s).

D5.1.2.5 Waterfowl

Importance

Waterfowl commonly found in the LSA can be categorized as dabbling or diving ducks. Dabbling ducks feed on aquatic insects and plant material on the surface and within the first 20 to 30 cm of the water column. Diving ducks, in contrast, forage deeper in the water column, enabling them to exploit different food resources than dabblers. Both dabbling and diving ducks are important economically and traditionally.

Abundance

Thirteen species of waterfowl as well as five waterbird species were observed during the 1997 aerial survey within the LSA (Golder 1998n). This is comparable to the studies conducted for Shell on Lease 13 (Golder 1997r), but much lower than other studies in the regional study area (BOVAR 1996e). Lesser scaup were the most abundant waterfowl species recorded during 1997 aerial surveys. Other species observed in relatively large numbers were mallards, ring-necked ducks, blue-winged teals, and buffleheads (Golder 1998n).

Habitat

The migration of most birds through the LSA may be an indication that the nesting habitat is limited or insufficient to meet the requirements of many species. The lack of suitable nesting habitat for both ground nesting and overwater nesting species is the main reason for the low density of waterfowl in the LSA. With the exception of Shipyard Lake, most of the wetlands did not have much emergent vegetation, which is required for overwater nesting species for nest construction as well as shelter. Although the density of waterfowl in the LSA was relatively low, observations indicated that the wetlands do support breeding populations and provide a staging area for migrating waterfowl.

D5.1.2.6 Upland Game Birds

Importance

Upland game birds (e.g., grouse, ptarmigan) are important game species, are enjoyed by non-consumptive users and form an important part of the food chain.

Three species of upland game birds potentially occur in the LSA: spruce, ruffed and sharp-tailed grouse. Willow ptarmigan may also be observed infrequently in the area. However, due to the difficulty involved in differentiating grouse tracks, all grouse/ptarmigan species were combined for analysis in the 1997 winter track count study (Golder 1997s). The following discussion is focused on ruffed grouse, the species which was chosen as a KIR.

Abundance

The ruffed grouse is common throughout the deciduous and mixedwood forests of North America. They are year-round residents, and are considered the second most abundant upland game bird in the Athabasca region after the spruce grouse (Francis and Lumbis 1979). Ruffed grouse density in northeastern Alberta ranges from 0.02 individuals/km^2 in poor-quality aspen jack pine and young black spruce habitat, to 0.3 and 0.5 grouse/km^2 in aspen and bottomland willow habitat (Francis and Lumbis 1979). Up to 45.88 tracks/km-track day were recorded in the 1997 winter surveys (Golder 1997s).

Habitat

Grouse distribution is tied to deciduous and mixedwood forest, particularly those seral stages that possess a well-developed shrub component (Bergerud and Gratson 1988). Young grouse feed almost exclusively on insects, but forage on plant matter as they mature (Ehrlich et al. 1988). Adults feed on berries and sedges during the summer, fruiting shrubs in the fall, and buds, twigs and catkins in the winter (Edminster 1954). Berry-producing shrubs and forbs are typically more abundant in deciduous and mixedwood stands. In addition to providing forage, deciduous stands are also used for cover during and after the breeding season. Grouse showed a preference for wooded fens during the 1997 winter surveys and avoided the lichen-jackpine (a1), low-bush cranberry (d1, d2, d3), and wood bog (btnn) community types (Golder 1997s).

D5.1.2.7 Breeding Birds

Importance

Breeding birds (i.e., birds which are resident to the area or which migrate to the area to breed) are an important group to wildlife biologists because the number of species and abundance of breeding birds make them suitable for studies of biodiversity. Breeding birds are particularly valued by non-consumptive users.

Abundance

The boreal forest of Canada has one of the highest diversities of breeding birds north of Mexico (Robbins et al. 1986). In terms of total number of species, approximately 72% of the total vertebrate fauna of the mixedwood boreal forest of western and northern Canada consists of avian species, and a total of 252 avian species has been recorded in the western boreal forest (Semenchuk 1992, Smith 1993). Thus, the boreal forest represents an important ecosystem for sustaining breeding populations of North American birds. Such diversity is a result of the wide variety of niches available to songbirds within the boreal forest.

In the LSA, 79 songbird species were detected in 318 point counts (Golder 1998n). These numbers were similar to those observed by Westworth and Associates (1996c) and McLaren and Smith (1985). In a literature review, BOVAR (1996e) reported 80 species within the Mildred Lake Facility area. Over 60% of the species recorded within the LSA had less than ten detections, suggesting that, although diversity was high, the relative abundance of species was moderate (Golder 1998n).

Cape May Warblers

Based on the number of detections during the breeding bird surveys, the number of Cape May warblers in the LSA appears to be low (Golder 1998n).

Western Tanagers

Western tanagers were recorded by Westworth and Associates (1996c) as part of a breeding survey conducted within the Suncor LSA. Based on the number of detections recorded within the Project Millennium LSA (Golder 1998n), the number of western tanagers in the LSA appears to be low.

Pileated Woodpeckers

Pileated woodpeckers have been previously recorded in the oil sands region of northeastern Alberta, with observations in 14.3% of the terrestrial point counts in the Suncor Lease area (Westworth and Associates 1996c). Pileated woodpeckers were not recorded during the 1997 surveys completed for Project Millennium (Golder 1998n).

Habitat

Bird species strongly associated with the wetlands community types (e.g., i1, ftnn, fons, ffnn, stnn, and sfnn) included palm warblers, white-throated sparrows, chipping sparrows, yellow-rumped warblers, white-winged crossbills, dark-eyed juncoes, gray jays, ruby-crowned kinglets, Tennessee warblers, hermit thrushes, magnolia warblers, Lincoln's sparrows, Wilson's warblers, least flycatchers and yellow-bellied flycatchers (Golder 1998n). Common snipes and solitary sandpipers were also recorded.

Bird species associated with riparian community types (e.g., e1, e2, e3, and f2) included red-eyed vireos, white-throated sparrows, white-winged crossbills, winter wrens, least flycatchers, Tennessee warblers, Canada warblers, ovenbirds, rose-breasted grosbeaks, American robins, western tanagers, solitary vireos, Swainson's thrushes, cedar waxwings, American redstarts, black-and-white warblers, bay-breasted warblers, and northern waterthrushes (Golder 1998n).

Bird species associated with the upland hardwood, softwood, and mixedwood stands (e.g., b2, b3, d1, d2, d3) included ovenbirds, Tennessee warblers, red-eyed vireos, Canada warblers, hermit thrushes, Swainson's thrushes, yellow-rumped warblers, red-breasted nuthatches, chipping sparrows, white-winged crossbills, bay-breasted warblers, winter wrens, and pine siskins (Golder 1998n).

Bird species associated with mixed softwood and closed black spruce bogs (e.g., a1, b1, g1) included yellow-rumped warblers, ovenbirds, pine siskins, ruby-crowned kinglets, dark-eyed juncoes, hermit thrushes, bay-breasted warblers, Tennessee warblers, Swainson's thrushes, red-eyed vireos, and gray jays (Golder 1998n).

Bird species associated with cutblocks or open shrubland included white-throated sparrows, chipping sparrows, mourning warblers, clay-coloured sparrows, white-winged crossbills, winter wrens, orange-crowned warblers, brown-headed cowbirds and alder flycatchers (Golder 1998n). Spruce grouse and American kestrels were also recorded.

Species richness and diversity was greatest in the dogwood balsam poplar-aspen poplar (e1) stands, a riparian community type (Golder 1998l). High richness and diversity were also seen in the low-bush cranberry white spruce (d3), an upland softwood community. The lowest richness and diversity were seen in the mixed softwood and closed black spruce bogs, including lichen jackpine (a1), blueberry jackpine-aspen poplar (b1), and Labrador tea/subhygric (g1) (Golder 1998l). Generally, studies in the RSA have found that species abundance, richness and diversity were greater in upland hardwood and mixedwood habitats than softwood communities associated with bog-fen complexes (Niemi and Hanowski 1984, Morgan and Freedman 1986, Westworth and Telfer 1993, Schieck et al. 1995).

Cape May Warblers

Prime habitat for Cape May warblers consists of late stage coniferous stands with good canopy closure. Mature white spruce is preferred for nesting sites, but these warblers will also nest in balsam fir, black spruce, and tamarack (POYRY 1992). Cape May warblers were recorded in the upland hardwood, softwood and mixedwood stands (e.g., b2, b3, d1, d2, d3). Westworth and Associates (1996c) also found that Cape May warblers were associated with closed mixedwood and white spruce stands. Few Cape May warblers were sighted during the Project Millennium study (Golder 1998n).

Western Tanagers

Western tanagers prefer open mixedwood forest or pure coniferous boreal forests (Peterson 1961), but are occasionally found in pure deciduous stands in Alberta (Semenchuk 1992). Suitable foraging and nesting habitat is found in open coniferous and mixedwood forests (Godfrey 1986). Western tanagers were recorded in four habitat types within the Suncor Steepbank Mine study area in 1995 (Westworth and Associates 1996c). The majority of records were made in mixedwood and coniferous vegetation communities. For the Project Millennium study, tanagers were mainly detected in upland hardwood, softwood and mixed stands (e.g., b2, b3, d1, d2, d3) (Golder 1998n).

Pileated Woodpeckers

Pileated woodpeckers require mature to old growth, dense-canopied forests, particularly mixed and deciduous woods, for nesting, roosting and foraging. Due to their large body size and the fact that they are primary cavity nesters, pileated woodpeckers require large-diameter snags to construct nesting and roosting cavities (Bull 1987, Harestad and Keisker 1989, Renken and Wiggers 1989, Bull and Jackson 1995).

D5.1.2.8 Raptors

Importance

Raptors (birds of prey) are important carnivores within the boreal ecosystem and are highly valued by birdwatchers. They are also important for indigenous cultures.

Abundance

Hawks, Eagles and Falcons

Observations of diurnal raptors are relatively rare in the LSA (Golder 1998n). Only one raptor nest, a bald eagle nest, was recorded during the waterfowl aerial survey. Other sightings included a red-tailed hawk at Shipyard Lake. During studies for the Aurora Mine EIA several migratory raptor species were recorded during a two-day survey, including: seven bald eagles, five northern harriers, and six red-tailed hawks (BOVAR 1996e).

Owls

Owl surveys conducted by Golder early in 1997 (Golder 1997s) indicated the presence of great gray owls in the LSA. Great gray owls were also observed during completion of other winter field studies. A great horned owl was recorded in the Shipyard Lake area during ungulate monitoring surveys (Golder 1998b). No boreal owls were recorded.

Habitat

Hawks, Eagles and Falcons

Bald eagles normally nest in proximity to a large body of water. Breeding areas must have suitable tall trees near shore for nesting and roosting, good fish populations, and relatively little human disturbance (Semenchuk 1992). Red-tailed hawks prefer woodland near open country. Thus, they are often found at the edges of mixed, deciduous or coniferous woods (Semenchuk 1992). Sharp-shinned hawks prefer thick deciduous and mixed wood forests to heavy coniferous growth. American kestrels are usually found in open country such as woodland edges, burns, meadows, and wooded lakeshores. Peregrine falcons nest on cliffs near water, and they hunt over open fields, swamps, and marshes (Semenchuk 1992).

Owls

Great gray owls rely on relatively open habitat. Owls breed and hunt in open coniferous, deciduous and mixed forest, interspersed with muskeg, marsh and wet meadow (Semenchuk 1992). Great gray owls were recorded in a wooded swamp (stnn), a lichen-jackpine (a1) stand, and in a riparian area near the confluence of the Steepbank and Athabasca Rivers (Golder 1997s).

Great horned owls live in a variety of habitats, including deciduous and coniferous woodlands, from extensive heavy forests to isolated groves (Semenchuk 1992). Northern hawk owls are found in open coniferous or mixed woodlands, muskeg, brushy edges of clearings, and old burns. Boreal owls prefer coniferous and mixedwood forests, avoiding large unbroken stands of pine (Semenchuk 1992).

D5.1.2.9 Amphibians and Reptiles

Importance

Although represented by relatively few species, amphibians are primary components in the structure of healthy boreal ecosystems. In the temporary (spring run-off type) and smaller permanent ponds of the boreal forest, they transfer the nutrients of these productive, though ephemeral wetland systems, to terrestrial food webs (Russell and Bauer 1993). As well, adult amphibians are predators, consuming many times their weight in insects, several of which are regarded as harmful or annoying to people (Bishop et al. 1994). Amphibians are particularly vulnerable to changes in an ecosystem and are invaluable as indicator species (Bishop et al. 1994; deMaynadier and Hunter 1995).

Abundance

Westworth, Brusnyk and Associates (1996c) recorded two species of amphibians in the Suncor Steepbank Study Area. These were the boreal chorus frog and the wood frog. Similar results were obtained during the 1997 surveys for Project Millennium (Golder 1998n) and by Roberts and Lewin (1979). Canadian toads have been observed on the west side of the river (J. Gulley, pers. comm.). As well, Roberts and Lewin (1979) found that Canadian toads were common in the Fort McMurray area during their 1977 study. The red-sided garter snake may also be present; as records for this species include observations at Kearl Lake and the Birch Mountains (Roberts et al. 1979).

Habitat

Amphibians require secure hibernation sites, breeding sites and summer ranges rich in food items, as well as safe migration pathways. Although all boreal amphibians undergo these migrations, the habitat requirements of each species is unique (see Table D5.1-2).

Table D5.1-2 Amphibian Habitat Requirements [(a)]

	BREEDING	SUMMER HABITAT	HIBERNATION
Boreal chorus frog	Favours temporary ponds, will use more permanent sites under some conditions.	Near water margins; under leaf litter, prone to desiccation. Establishes homerange.	Under stumps, leaf litter. Glycoprotectant, can survive temperatures as low as -6 °C.
Wood frog	Uses natural ponds, pits, stream back waters. Will breed in bogs. Early breeders, rapid metamorphosis. Site fidelity.	Moist terrestrial habitat. Prefers canopy closure, wet litter. Moves to lowland bogs after breeding. Establishes home range. Site fidelity.	Under stumps, leaf litter. Glycoprotectant, can survive temperatures as low as -6 °C. Site fidelity. Dry, upland sites favoured.
Canadian toad	Wide range of breeding habitats: lake margins, slow streams, ponds. Site fidelity.	Water's edge (including lakes and streams), tends to avoid forests. Most stay by breeding areas. Establishes home range.	Burrows in loose earth, under frostline. Communal areas. Site fidelity.

[(a)] See Golder 1998n for source.

D5.1.3 Vulnerable, Threatened and Endangered Species

Species with vulnerable, threatened or endangered status according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 1997), or listed on Alberta's blue or red list (AEP 1996c) and which may occur within the LSA, are described in the following sections.

D5.1.3.1 Mammals

The wolverine is considered at risk by Alberta (blue-listed) and vulnerable by COSEWIC. AEP (1996c) estimates up to 1,000 wolverines may occur in the province. No wolverine tracks were observed during 1996 (Westworth, Brusnyk and Associates 1996a) or 1997 (Golder 1997s) winter track count studies.

Woodland caribou are listed as vulnerable by COSEWIC and are blue-listed by Alberta. However, no woodland caribou are known to reside within the LSA. Woodland caribou tracks were not observed during the winter track count surveys (Golder 1997s).

D5.1.3.2 Birds

Red-listed bird species that may occur within the LSA are the peregrine falcon and the whooping crane. These species are also listed as endangered by COSEWIC (1997). The peregrine falcon was not observed during 1997 field surveys, but is known to nest in the Fort Chipewyan-Lake Athabasca area (Munson et al. 1980). The whooping crane only nests in Wood Buffalo National Park and was observed migrating within Lease 17 in small numbers in 1973-75 (McLaren and Smith 1985).

Blue-listed bird species that potentially occur within the LSA include the bay-breasted warbler, black-throated green warbler, Cape May warbler, and the short-eared owl. COSEWIC (1997) considers the short-eared owl to be vulnerable but does not list the other blue-listed species.

The bay-breasted warbler is blue-listed by AEP (1996c) due to its dependency on old-growth habitats and its unknown population status. The black-throated green warbler has similar old-growth habitat requirements to the bay-breasted warbler. Both species were considered in this EIA to be represented by the Cape May warbler and the pileated woodpecker.

The abundance of the Cape May warbler, a KIR for this EIA, is discussed in Section D5.1.2.7. It is listed by AEP (1996c) due to its dependency on old-growth forests for breeding and its neotropical migratory habits. Habitat on its wintering grounds is under development pressures.

Two short-eared owls were observed in the Aurora LSA by AXYS (1996) during a 1995 survey. Golder Associates (1997s) did not record any during a late winter owl survey of the LSA. Short-eared owl populations are highly variable in specific areas, which makes them a difficult species to monitor (AEP 1996c).

D5.1.3.3 Amphibians and Reptiles

No COSEWIC-listed amphibian or reptile species occur in the LSA. However, the Canadian toad, red-listed by AEP, may occur in the LSA (AEP 1996c).

D5.1.4 Introduced Species

The wood bison is an introduced species that was present in the area before increased colonization of the area by man. Wood bison are currently found in the region as part of a Syncrude Canada Ltd. research project at their Mildred Lake Site.

D5.1.5 Biodiversity

Biodiversity has been defined as "...the variety of life and its processes; it includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting" (Noss and Cooperrider 1994). There are four levels of biodiversity: landscape (e.g., regional), community (e.g., ELC units), species, and genes. Assessing biodiversity at the landscape and community levels can account for biodiversity at the species and genetic levels (Golder 1998n).

Biodiversity at the landscape level refers to the pattern of vegetation and wildlife species communities distributed across the landscape (Noss and Cooperrider 1994). The ELC developed for Project Millennium (Golder 1998c) uses a combination of terrain, soils, vegetation and moisture regime features to map landscape units. Good surrogates for measuring biodiversity at the landscape level include ELC unit abundance and distribution, ELC patch size, ELC shape and ELC connectivity.

Biodiversity must be considered at the community level, as well as the landscape level. A community refers to all the organisms, including plants, wildlife, insects, and microbes that live together in an area and interact together. Good surrogates for measuring biodiversity at the community level include the relative abundance, frequency, richness and diversity of species within ELC units and habitat suitability index (HSI) variables that are important for the KIRs for the LSA.

Biodiversity for wildlife was assessed at the landscape and community levels for the LSA. A discussion of landscape level indicators and structural components at the community level is provided in the ELC report (Golder 1998c). The remainder of this section focuses on the composition at the community level.

D5.1.5.1 Biodiversity Habitat Modelling

A biodiversity habitat model was developed to address wildlife species-level diversity and then link these values to habitat types in an attempt to understand community level diversity. The goal of biodiversity analysis for the EIA is to assess current levels of diversity and then predict any changes associated with the development, reclamation and closure. Then, the maintenance of biodiversity can be incorporated into development and reclamation/closure planning.

A habitat-based approach was used to quantify baseline species composition at the community level. Wildlife diversity was first measured by species richness in habitat types. These values were then used to create a relative richness index which is the ratio of species richness in each habitat type to the maximum species richness among all habitat types.

Vegetation communities were rated as to their species richness based on the number of species found, or expected to be found, within a unit relative to other units (Table D5.1-3). A richness index was developed, as follows:

Richness Index = (Number of Species in the Community)/(Maximum Number in Any Community)

Table D5.1-3 Number Of Species Found or Expected to be Found Per Broad Vegetation Type

Broad Vegetation Type	Mammal	Bird	Reptile/ Amphibian
Open Water	8	63	0
Jack Pine Forest	21	48	2
Mixedwood Forest	27	81	2
Black and White Spruce Forest	25	57	2
Aspen (Poplar) Forest	20	67	2
Graminoid/Shrubby Fen	16	70	4
Riparian	18	97	4
Marsh	10	78	4
Wooded Fen/Bog	28	112	4
Birch	20	67	2

This was done to allow comparison with the rankings for HSI scores, which also range from 0 to 1.0 (Golder 1998o). The relative richness values (Table D5.1-4) were then assigned to each habitat type throughout the study areas, multiplied by the area in hectares and summed to determine richness habitat units (HUs) (Table D5.1-5).

Table D5.1-4 Relative Richness Index Values By Forest Type

Group	Name	Mammal	Bird	Amphibian/Reptile
A	Open Water	0.29	0.56	0.00
B	Jack Pine Forest	0.75	0.43	0.50
C	Mixedwood Forest	0.96	0.72	0.50
D	Black and White Spruce Forest	0.89	0.51	0.50
E	Aspen (Poplar) Forest	0.71	0.60	0.50
F	Graminoid/Shrubby Fen	0.57	0.63	1.00
G	Riparian	0.64	0.87	1.00
H	Marsh	0.36	0.70	1.00
I	Wooded Fen/Bog	1.00	1.00	1.00
J	Birch	0.71	0.60	0.50

The relative richness of species per forest type (Table D5.1-4) indicates that wooded fens and bogs (1.0), mixedwood forests (0.96) and spruce forests (0.89) had the highest richness indices for mammals. For birds, the highest richness values were for wooded fens and bogs (1.0), riparian areas (0.87) and mixedwood forests (0.72). For reptiles and amphibians, the highest richness values were for graminoid/shrubby fens (1.0), riparian areas (1.0), marshes (1.0) and wooded fens and bogs (1.0).

The above richness values were then assigned to each of the vegetation phases present in the LSA (Table D5.1-5). This was done by matching overstorey species composition in the broad vegetation classes to the ecological phases. The disturbance vegetation values were then chosen based on professional judgement.

Table D5.1-5 Richness Index Values for the Suncor Millennium Local Study Area

Phase	Description	Mammal	Bird	Amphibian/Reptile
a1	Lichen Pj	0.75	0.43	0.50
AIG	Gravel Pits	0.00	0.00	0.00
AIH	Roads and Rights of Ways	0.25	0.25	0.00
b1	Blueberry Pj-Aw	0.75	0.43	0.50
b2	Blueberry Aw(Bw)	0.71	0.60	0.50
b3	Blueberry Aw-Sw	0.96	0.72	0.50
b4	Blueberry Sw-Pj	0.89	0.51	0.50
BFNN	Wooded bog (tree cover >70%)	1.00	1.00	1.00
BTNN	Wooded bog (tree cover >10% and <=70%)	1.00	1.00	1.00
c1	Labrador Tea - mesic Pj-Sb	0.75	0.43	0.50
CIP	Revegetated Industrial Lands	0.25	0.25	0.00
CIW	Well Sites - vegetated	0.25	0.00	0.00
d1	Low-bush Cranberry Aw	0.71	0.60	0.50
d2	Low-bush Cranberry Aw-Sw	0.96	0.72	0.50
d3	Low-bush Cranberry Sw	0.89	0.51	0.50
e1	Dogwood Pb-Aw	0.71	0.60	0.50
e2	Dogwood Pb-Sw	0.96	0.72	0.50
e3	Dogwood Sw	0.89	0.51	0.50
FFNN	Wooded Fen (tree cover >70%)	1.00	1.00	1.00
FONG	Graminoid Fen	0.57	0.63	1.00
FONS	Shrubby Fen	0.57	0.63	1.00
FTNN	Wooded Fen (tree cover >10% and <=70%)	1.00	1.00	1.00
g1	Labrador Tea - subhygric Sb-Pj	0.89	0.51	0.50
h1	Labrador Tea/Horsetail Sw-Sb	0.89	0.51	0.50
HG/CC	Herbacious Graminoid Cutblock	0.25	0.25	0.00
MONG	Graminoid Marsh	0.57	0.63	1.00
MONS	Shrubby Marsh	0.36	0.70	1.00
NMC	Cutbanks	0.00	0.00	0.00
NMS	Sand	0.00	0.00	0.00
NWF	Flooded Area	0.00	0.00	0.00
NWL	Lake	0.29	0.56	0.00
NWR	River	0.29	0.56	0.00
Sb/Lt	Black Spruce - Larch Complexes	0.89	0.51	0.50
SFNN	Swamp (tree cover >70%)	0.64	0.87	1.00
Shrub	Shrubland	0.57	0.63	1.00

Phase	Description	Mammal	Bird	Amphibian/Reptile
SONS	Swamp (deciduous shrub)	0.64	0.87	1.00
STNN	Swamp (tree cover >10% and <=70%)	0.64	0.87	1.00
WONN	Shallow open water	0.29	0.56	0.00

Relative Species Richness Index Summaries

The relative richness of a community type is the ratio of species richness in one type compared to the maximum value of species richness among all types. The richness index ranges from 0 - 1, and is used to indicate high, medium, and low community or landscape types, using the same criteria as used in HSI modelling (Golder 1998o):

Rank	Value Range
No Richness	0.00
Low	0.01 - 0.33
Moderate	0.34 - 0.66
High	0.67 - 1.00

The area of each vegetation type was multiplied by the index value to determine richness Habitat Units (HUs). These units are then summed to determine total richness habitat of the study area. The advantage of this approach is that the change in species richness during impact and closure phases of the project can also be predicted and compared to these baseline values.

D5.1.5.2 Biodiversity Results

Baseline Conditions

The area of each vegetation type within the LSA is provided in Table D5.1-6, while the number of biodiversity HUs per vegetation type within the Millenium Project LSA are shown in Table D5.1-7. A comparison of biodiversity HUs by low, medium and high potential is provided in Table D5.1-8.

Table D5.1-6 Area of Each Forest Type Within the LSA

Phase	Predisturbance Area (ha)	Steepbank Mine Impact (ha)	East Bank Mining Area Impact (ha)
a1	1	1	1
AIG	0	0	0
AIH	5	0	0
b1	226	98	145
b2	28	26	27
b3	60	57	57
b4	50	37	50
BFNN	26	0	0
BTNN	20	0	0
c1	1	1	1
CIP	12	11	11
CIW	5	3	4
d1	3,348	923	1,780
d2	588	60	135
d3	941	212	315
e1	212	28	35
e2	63	16	14
e3	127	25	14
FFNN	966	262	547
FONG	4	0	3
FONS	426	110	325
FTNN	6,010	1,528	4,396
g1	1	0	1
h1	59	21	32
HG/CC	170	0	69
MONG	107	12	14
MONS	211	22	18
NMC	33	2	6
NMR	0	2	0
NMS	1	0	0
NWF	6	0	0
NWL	20	0	3
NWR	79	0	2
Sb/Lt	20	0	20
SFNN	687	51	378
Shrub	131	51	57
SONS	161	47	43
STNN	1,359	162	769
WONN	15	6	8
Total	**16,181**	**3,776**	**9,281**

A total of 13,441 mammal, 12,996 bird and 12,971 reptile/amphibian biodiversity HUs were calculated for the LSA (Tables D5.1-7 and D5.1-8). For mammals, areas with particularly high diversity potential included low-bush cranberry-white spruce (d1) and wooded fens (FTNN). For birds, areas with particularly high diversity potential included wooded fens (FTNN), swamps (STNN), and low-bush cranberry-white spruce (d1). The same results were seen for amphibians and reptiles. Areas with low potential for diversity included the following for all taxonomic groups:

- lichen-jackpine (a1);
- gravel pits (AIG);
- roads and right-of-ways (AIH);
- Labrador tea-mesic-jackpine-black spruce (c1);
- revegetated industrial lands (CIP);
- vegetated well sites (CIW);
- graminoid fens (FONG);
- Labrador tea-subhygric-black spruce-jackpine (g1);
- cutbanks (NMC);
- sand (NMS);
- flooded areas (NWF);
- lakes (NWL); and
- shallow open water (WONN).

Table D5.1-7 Number of Biodiversity HUs Within the LSA for Each Taxonomic Group

Phase	MAMMALS			BIRDS			REPTILES AND AMPHIBIANS		
	Pre-disturbance Hus	Steepbank Mine (Hus)	East Bank Mining Area (HUs)	Pre-disturbance Hus	Steepbank Mine (Hus)	East Bank Mining Area (HUs)	Pre-disturbance Hus	Steepbank Mine (Hus)	East Bank Mining Area (HUs)
a1	0	0	0	0	0	0	0	0	0
AIG	0	0	0	0	0	0	0	0	0
AIH	1	0	0	1	0	0	0	0	0
b1	170	73	109	97	42	62	113	49	72
b2	20	18	19	17	16	16	14	13	14
b3	57	54	54	43	41	41	30	28	28
b4	45	33	44	26	19	25	25	18	25
BFNN	26	0	0	26	0	0	26	0	0
BTNN	20	0	0	20	0	0	20	0	0
c1	0	0	0	0	0	0	0	0	0
CIP	3	3	3	3	3	3	0	0	0
CIW	1	0	1	0	0	0	0	0	0
d1	2,377	656	1,264	2,009	554	1,068	1,674	462	890
d2	564	57	130	423	43	97	294	30	68
d3	837	189	280	480	108	161	470	106	157
e1	150	20	25	127	17	21	106	14	17
e2	60	15	14	45	11	10	31	8	7
e3	113	22	12	65	13	7	64	12	7
FFNN	966	262	547	966	262	547	966	262	547
FONG	2	0	2	2	0	2	4	0	3
FONS	243	63	185	268	69	205	426	110	325
FTNN	6,010	1,528	4,396	6,010	1,528	4,396	6,010	1,528	4,396
g1	1	0	1	0	0	0	0	0	0
h1	53	19	28	30	11	16	30	11	16
HG/CC	43	0	17	43	0	17	0	0	0
MONG	61	7	8	67	8	9	107	12	14
MONS	76	8	6	148	15	12	211	22	17
NMC	0	0	0	0	0	0	0	0	0
NMR	0	0	0	0	0	0	0	0	0
NMS	0	0	0	0	0	0	0	0	0
NWF	0	0	0	0	0	0	0	0	0
NWL	6	0	0	11	0	2	0	0	0
NWR	23	0	0	44	1	1	0	0	0
Sb/Lt	18	0	18	10	0	10	10	0	10
SFNN	440	33	242	598	45	329	687	51	378
Shrub	75	29	33	82	32	36	131	51	57
SONS	103	30	27	140	41	37	161	47	43
STNN	870	104	492	1,182	141	669	1,359	162	769
WONN	4	2	2	9	4	5	0	0	0
Total	**13,441**	**3,228**	**7,963**	**12,996**	**3,024**	**7,807**	**12,971**	**2,998**	**7,863**

Table D5.1-8 Number of Biodiversity HUs Within the Project Millennium LSA

Mammal Habitat Areas	TLSA Pre-development	Steepbank Mine	East Bank Mining Area
Mammal Habitat Units			
Low	81	6	25
Med	1,869	273	995
High	11,491	2,949	6,943
Total	**13,441**	**3,228**	**7,963**
Bird Habitat Units			
Low	47	3	20
Med	3,347	894	1,647
High	9,602	2,128	6,140
Total	**12,996**	**3,025**	**7,807**
Reptile/Amphibian Habitat Units			
Low	0	0	0
Med	2,863	752	1,313
High	10,108	2,246	6,549
Total	**12,971**	**2,998**	**7,863**

Thus, it appears that the TLSA contains an abundance of areas with moderate to high potential for diversity.

D5.1.6 Bird Deterrent Program

Suncor recognized soon after operations began, that birds may interact with tailing ponds and become fouled by bitumen. The bitumen has three potential effects on birds, including:

- reduction in the waterproofing capability of the feathers, thus allowing water to penetrate the outer feathers, contact the bird's skin, and lead to hypothermia;
- waterlogging of the feathers, thus reducing the bird's capability to stay above water; and
- fouling the feathers with hydrocarbon/bitumen, which could be ingested by the bird as it preens.

The impacts of tailings ponds are mitigated in two ways. Firstly, birds can be deterred by devices designed to keep them from landing. Secondly, if birds can be captured alive after becoming fouled by the bitumen, they can often be cleaned, rehabilitated and released.

D5.1.6.1 Background

The Suncor bird deterrent program is focused on restricting the number of birds that interact with tailings ponds. The program was initiated in 1975 as a University of Alberta study during which the effectiveness of three waterfowl deterrent devices were tested on natural and tailings ponds (Boag and Lewin 1980). Research on the effectiveness of deterrent systems on tailings ponds was continued between 1976 and 1979 by Gulley as part of a Master of Science thesis study at the University of Alberta.

Tailings Ponds

The Suncor facility currently has five tailings ponds (Ponds 1, 1A, 2/3, 4 and 5; Ponds 2 and 3 were separate ponds until 1994). Bird interactions with the ponds have been monitored since 1976. During this period the numbers of waterbirds observed on, or over the tailings ponds, the number of birds found dead and the number of birds rehabilitated have been recorded.

Deterrent Systems

To prevent birds from landing on the tailings ponds, Suncor has employed a variety of techniques, including:

- Human effigies - human forms (scarecrows) mounted on floating platforms placed on the ponds each year.
- Scare cannons - propane-fired scare cannons produce a shotgun-like blast through ignition of a volume of propane. The noise deters birds from settling on the ponds.
- Rotating light beacon - in 1978 a light was mounted on a pumphouse that floats on the surface of Pond 1. The light is a 61 cm, single-drum, 800,000 beam candlepower beacon that rotates in a counter-clockwise direction at 12 rotations per minute. This system is used in conjunction with the human effigies on Pond 1 because migrating birds are common at dawn and dusk. The light aids in illuminating the effigies to improve their effectiveness.
- The electronic sound system - initially involved a computer-based noise system with broadcast speakers. Currently the sound system includes a Phoenix Wailer, which is a device that emits ultrasonic audible and non-audible sounds. This system was modified in 1996 through addition of a chip which emits raptor sounds (e.g., eagle, hawk, owls).

Suncor annually installs and maintains the deterrent systems at the various ponds. Table D5.1-9 summarizes the types and numbers of devices at each pond. The effectiveness of the deterrent systems was the subject of detailed annual surveys between 1976 and 1990. Since 1990, the operational efficiency of the systems is monitored through assessment of the numbers of effigies available on each pond as well as the number of cannons firing.

Table D5.1-9 Avifauna Deterrent Systems and Bird Recoveries for Suncor Tailings Ponds

Pond	Year	Deterrent System[a]		Bird Recoveries
		Effigies	Cannons	
Pond 1	1975	0	0	87
	1976	0	0	77
	1977	30	0	71
	1978	30	0	79
	1979	30	0	270
	1980	30	0	160
	1981	31	2	119
	1982	20	10	45
	1983	24	16	39
	1984	21	16	36
	1985	30	15	30
	1986	31	12	74
	1987	30	19	74
	1988	26	20	39
	1989	30	25	127
	1990	33	25	94
	1991	34	25	92
	1992	40	25	185
	1993	40	25	129
	1994	39	25	82
	1995	47	25	41
	1996	54	25	71
	1997	54	25	70
Pond 1A	1977	0	0	43
	1978	0	0	31
	1979	0	0	33
	1980	9	0	71
	1981	8	2	14
	1982	9	5	9
	1983	8	4	8
	1984	7	3	6
	1985	10	4	6
	1986	10	2	2
	1987	8	3	2
	1988	10	5	3
	1989	14	5	2
	1990	16	5	3
	1991	16	5	0
	1992	22	10	5
	1993	22	5	0
	1994	21	5	0
	1995	21	5	0
	1996	20	5	0
	1997	20	5	0
Pond 2	1980	9	0	2
	1981	6	1	3
	1982	7	5	3
	1983	10	8	1
	1984	11	9	1
	1985	15	8	6
	1986	18	5	3

Pond	Year	Deterrent System[a]		Bird Recoveries
		Effigies	Cannons	
	1987	18	6	3
	1988	20	5	4
	1989	23	10	3
	1990	25	10	4
	1991	35	10	1
	1992	22	10	2
	1993	28	10	3
Pond 3	1985	15	5	2
	1986	14	6	3
	1987	16	6	2
	1988	13	5	1
	1989	18	10	2
	1990	29	10	2
	1991	33	10	0
	1992	42	10	0
	1993	32	10	0
Pond 2/3	1994	57	20	1
	1995	64	25	2
	1996	65	25	1
	1997	61	25	0
Pond 4	1993	14	5	0
	1994	6	5	4
	1995	5	5	0
	1996	8	5	0
	1997	11	10	0
Pond 5	1995	17	0	0
	1996	10	15	0
	1997	17	15	1

(a) Rotating light beacon system on Pond 1 has been operating since 1978 and a sound system between 1988 and 1989. From 1993 until present, Suncor used a Phoenix wailer emitting ultrasonic audible and non-audible sounds. In 1996, a chip was installed which emits raptor sounds (e.g., eagle, owl, hawk).

Source: Boag and Lewin 1980; Gulley 1977, 1978, 1979, 1980a-d, 1981a,b, 1982a-c, 1983a,b, 1985, 1986, 1987a-c, 1988, 1990a,b, and 1992.

Avifauna Permits

Suncor has obtained permits from Canadian Wildlife Service and AEP, Wildlife Management Division, to salvage, capture and rehabilitate wild birds. Suncor applies to renew these permits on an annual basis. Permit conditions state reporting requirements, all of which are complied with by Suncor.

Avifauna Surveys

Suncor has completed routine avifauna surveys at its Lease 86/17 site since 1976. Between 1976 and 1990 these surveys included detailed censusing of avifauna use of areas of the Suncor operation, including surveys of avian activity over Pond 1.

Surveys of the shorelines of the tailings ponds are completed routinely from April through October each year, for the purposes of recovering birds that have entered the ponds, become fouled with bitumen and made their way to shore.

Rehabilitation Program

In response to the recovery of live, oiled birds from the tailings ponds, Suncor began operating a rehabilitation facility in 1980. The facility is equipped to treat birds that become covered in bitumen. Suncor personnel are trained to examine, feed, medicate and clean birds that become fouled. The rehabilitation centre is equipped with drying and heating equipment to help birds recover from washing and exposure. The rehabilitation centre is also equipped with a cage with fresh water for recovery prior to release.

When an oiled rare or endangered species is recovered, Suncor follows the requirements of the permits and ensures that local Wildlife Management Division personnel are notified. A joint decision is made on the handling of the bird. Suncor, on occasion, has flown rare and endangered bird species to rehabilitation centres in other parts of the province. For example, in 1982 Suncor used their jet to fly an American white pelican to a rehabilitation centre in Brooks, Alberta for rehabilitation and release (Gulley 1982b).

D5.1.6.2 Results of the Bird Deterrent Program

The collection of data on birds, tailings ponds and deterrent programs began in 1975 when research on bird deterrent programs began (Gulley 1980c). The results for the program are reviewed below by tailings pond.

Pond 1

Deterrent Systems

Pond 1 deterrent systems have included:

- Effigies - numbers have ranged from 30 in 1977 to 54 since 1996 (Table D5.1-9).
- Light system - in 1978, a large rotating light (61 cm, 800,000 beam candlepower beacon) was added to increase the visibility of the human effigies.
- Scare cannons - in 1981, two scare cannons were added to the deterrent system. Twenty-five scare cannons have been operated at Pond 1 since 1989 (Table D5.1-9).
- Sound systems - a broadcast sound system in 1988 and 1989, then starting in 1993, a Phoenix Wailer was added to the Pond 1 bird deterrent system.

- Beach effigies - in 1995, eight effigies were placed on the beach area around the south end of Pond 1 to aid in deterring shorebirds.

Bird Recoveries

In 1975, 87 dead birds (including 77 waterbirds) were found at Pond 1. Four years later, in 1979, 270 dead birds (237 waterbirds) were found at Pond 1. Since 1975, the maximum number of dead birds recovered from the pond in a year was 270, recorded in 1979, while the minimum was 30 in 1985. The average number recovered per year since 1976 is 91, of which 54 were waterbirds (Table D5.1-9).

Pond 1A

Deterrent Systems

Pond 1A deterrent systems have included:

- Effigies - numbers have ranged from 7 in 1984 to >20 since 1992 (Table D5.1-9).
- Scare cannons - in 1981, two scare cannons were added to the deterrent system. A minimum of five scare cannons have been operated at Pond 1A since 1988 (Table D5.1-9).

Bird Recoveries

Since monitoring began on Pond 1A, the maximum number of dead birds recovered was 71 in 1980. In 1991, 1993, 1994, 1995, 1996 and 1997 no dead birds were reported at Pond 1A. The average number recovered per year since 1977 is 11.3 (Table D5.1-9).

Pond 2

Deterrent Systems

Pond 2 was initially commissioned in 1979. The pond was merged with Pond 3 in 1994. Pond 2 deterrent systems have included:

- Effigies - numbers have ranged from nine in 1980 to >20 since 1992 (Table D5.1-9).
- Scare cannons - in 1981, one scare cannon was added to the deterrent system. A minimum of ten scare cannons were operated at Pond 2 between 1989 and 1993 (Table D5.1-9).

Bird Recoveries

Monitoring and the bird deterrent program started on Pond 2 in 1980. Since 1980, the maximum number of dead birds recovered in a year was 6 in

1985. The average number recovered per year between 1980 and 1993 at Pond 2 was 2.8 (Table D5.1-9).

Pond 3

Deterrent Systems

Pond 3 was developed in 1984. Pond 3 was merged with Pond 2 in 1994. Pond 3 deterrent systems have included:

- Effigies - numbers have ranged from 15 in 1985 to >30 after 1991 (Table D5.1-9).
- Scare cannons - in 1985, five scare cannons were added to the deterrent system. A minimum of ten scare cannons were operated at Pond 3 between 1989 and 1993 (Table D5.1-9).

Bird Recoveries

Monitoring and the bird deterrent program started on Pond 3 in 1985. Since 1985, the maximum number of dead birds recovered in a year was 3 in 1986. The average number recovered per year between 1980 and 1993 at Pond 3 was 1.3 (Table D5.1-9).

Pond 2/3

Deterrent Systems

Pond 2/3 was created in 1994 when Ponds 2 and 3 were raised to a level such that a dyke area between the ponds was covered. Pond 2/3 deterrent systems have included:

- Effigies - numbers have ranged from 57 to 65 (Table D5.1-9).
- Scare cannons - in 1994, 20 scare cannons were added to the Pond 2/3 deterrent system. A minimum of 25 scare cannons were operated at Pond 2/3 since 1995 (Table D5.1-9).

Bird Recoveries

Monitoring and the bird deterrent program started on Pond 2/3 in 1994. Since 1994, the maximum number of dead birds recovered in a year was 2 in 1995. The average number recovered per year between 1994 and 1997 at Pond 2/3 was one (Table D5.1-9).

Pond 4

Deterrent Systems

Pond 4 was created in 1990 but functioned for the first few years as a mine drainage/oversize area. Pond 4 deterrent systems have included:

- Effigies - numbers have ranged from 5 to 14 (Table D5.1-9).
- Scare cannons - in 1994 five scare cannons were added to the deterrent system. Between 5 and 10 scare cannons have been operated at Pond 4 since 1993 (Table D5.1-9).

Bird Recoveries

The maximum number of dead birds recovered from the pond was 4 in 1994. No dead birds were recovered in 1995, 1996 and 1997. The average number of birds recovered per year since 1994 is 1.5 (Table D5.1-9).

Pond 5

Deterrent Systems

Pond 5 was created in 1995. Pond 5 deterrent systems have included:

- Effigies - numbers have ranged from 10 to 17 (Table D5.1-9).
- Scare cannons - in 1996 and 1997 15 scare cannons were operated at Pond 5 (Table D5.1-9).

Bird Recoveries

The maximum number of dead birds recovered from the pond was one in 1997. No dead birds were recovered in 1996 (Table D5.1-9).

D5.1.6.3 Bird Protection Committee

The Bird Protection Committee was formed to monitor bird/tailings pond interactions in the oil sands area. The Bird Protection Committee was comprised of members from Suncor, Syncrude, AEP, Wildlife Management Division and Environment Canada (Canadian Wildlife Service). The committee last met in 1994. Regular meetings were discontinued with agreement of the Canadian Wildlife Service, AEP, Suncor and Syncrude because the programs were deemed comprehensive and consistent. Both the regulatory agencies remain updated on the results of the bird deterrent program through the regular reporting completed as part of the permit requirements.

D5.1.7 Wildlife Health Risk Assessment Methods

D5.1.7.1 Sources of Data

A large database of historical data, recent data and technical reports were reviewed and incorporated, where appropriate, into this assessment. The primary sources of pertinent information include:

- water quality data summarized in Section C3;
- fish quality data summarized in Section C4;
- air quality data summarized in Section B;
- plant tissue quality data summarized in Sections D5.1.8 and Appendix VI.7; and
- animal tissue concentration data summarized in Section F1.2.5.

The first step of the wildlife health impact analysis was to determine whether a certain Project-related activity has the potential to cause a change in environmental chemical exposure that might affect wildlife health. Initially, potential links between environmental changes (e.g., water releases, air releases) and wildlife health were qualitatively evaluated using principles of a screening level risk assessment to determine the validity of each linkage (i.e., whether a certain Project-related activity could result in an environmental change that might adversely affect wildlife health). Subsequently, quantitative risk assessments were conducted, and the results evaluated against criteria defining the degree of concern.

The overall risk assessment approach used to evaluate the linkages is summarized in the following section. Supporting documentation for the risk assessment is provided in Appendix VI.

D5.1.7.2 Risk Assessment Methodology

This risk assessment was conducted according to established ecological risk assessment protocols endorsed by the Canadian Council of Ministers of the Environment and Environment Canada (CCME 1996, Environment Canada 1994). A detailed discussion on risk assessment methodology is provided in Section F1.1.4.3. This section highlights specific risk assessment considerations for the wildlife health assessment.

Problem Formulation

Details of activities during construction, operation and closure of the Project have been fully described in Volume 1 of the Application.

Use of the Project site by wildlife will change over the life of the Project. During the construction and operation phases, wildlife will not have direct access to the site, but may inhabit nearby areas. Nearby waterbodies, such as the Athabasca River, McLean Creek and Shipyard Lake, may be used as sources of drinking water, fish and invertebrates by aquatic wildlife. In addition, terrestrial wildlife may feed on local plants and animals near the site. Following closure, wildlife will re-inhabit the reclaimed landscape. Aquatic wildlife will continue to use local waterbodies following closure.

The wildlife health component focused on the operation phase rather than the construction phase because of its substantially longer time frame, additional emission sources and larger area of effect. In respect of applicable and relevant regulatory policies/criteria, the approach adopted here embraced various provincial and federal environmental quality standards.

Screening Process

In a risk assessment, it is not possible or practical to evaluate every potential chemical, receptor and exposure pathway. Therefore, for the current assessment, a comprehensive screening process was carried out in the problem formulation phase to focus the assessment on those chemicals, receptors and exposure pathways of greatest concern (i.e., chemicals with the greatest toxic potential; receptors with the greatest likelihood of being exposed and with the greatest sensitivities; exposure pathways that account for the majority of exposure to the chemical releases). If no unacceptable health risks are predicted for these, it is highly likely that no unacceptable health risks would exist for other chemicals, receptors or exposure pathways.

Three screening procedures were conducted in the problem formulation phase:

- chemical screening;
- receptor screening; and
- exposure pathway screening.

Chemical Screening

The process of chemical screening is discussed in detail in Section F1.1.4.3. In brief, this procedure involved comparison of predicted and/or measured chemical concentrations in various environmental media to reference levels considered to be acceptable. If a given chemical concentration exceeded the reference level, the chemical in question was examined further in the risk assessment. Otherwise, it was excluded from further consideration.

Receptor Screening

The objective of the receptor screening process was to identify wildlife receptors currently using the area or that may use the reclaimed landscape in the future. The receptors identified here were carried forward into the Risk Analysis phase.

All receptors were selected based on a wildlife inventory of the area, discussions with wildlife biologists conducting baseline studies and guidance from the literature (Suter 1993, Algeo et al. 1994). The overall emphasis of the ecological receptor screening was the selection of representative receptors that would be at greatest risk, that play a key role in the food chain (web) and that have sufficient characterization data to facilitate calculations of exposure and health risks. Consideration was also given to include animals that have societal relevance and that are a food source for people. Wildlife KIRs for the Project EIA were given extra weight in the evaluation. An attempt was also made to represent various trophic levels and to maintain continuity with previous oil sands EIAs.

Details of the receptor screening process are provided in Appendix VI.2.1. Briefly, wildlife receptors were selected based on maximum likely exposure to the media being evaluated. For water exposures, aquatic wildlife (i.e., water shrew, killdeer, river otter, great blue heron) were selected for evaluation of exposure through ingestion of water, aquatic invertebrates and fish. In addition, several terrestrial wildlife species were evaluated, since they may drink water from local rivers. For plant ingestion, herbivorous or omnivorous wildlife species were selected. For the reclaimed landscape scenario, a variety of terrestrial and wetland wildlife species were selected. These wildlife species are likely to inhabit the reclaimed landscape following closure of the Project and represent various trophic levels of the food chain. Details of the receptor screening process are provided in Appendix VI.2.1. Table D5.1-10 lists the wildlife species selected for each key question.

Table D5.1-10 Potential Receptors for Each Wildlife Health Key Question

Key Question W-2 Operation Phase	Key Question W-3 Closure Phase
water shrew	moose
river otter	snowshoe hare
killdeer	beaver
great blue heron	deer mouse
moose	ruffed grouse
black bear	mallard
snowshoe hare	
ruffed grouse	
mallard	
beaver	
deer mouse	

Exposure Pathway Screening

The objective of the exposure pathway screening process was to identify the major pathways by which wildlife may be exposed to chemicals from the site. Details of the exposure pathway screening process are provided in Section F1. Table D5.1-11 lists the potential exposure pathways considered for each key question.

Table D5.1-11 Potential Exposure Pathways for Consideration

Exposure Pathway	Key Question W-2	Key Question W-3
ingestion of water	✓	✓
dermal contact with water	✓	✓
ingestion of fish	✓	✓
ingestion of aquatic invertebrates	✓	✓
ingestion of terrestrial plants	✓	✓
ingestion of aquatic plants	✓	✓
ingestion of terrestrial invertebrates		✓
inhalation of volatiles and particulates	✓	✓

Conceptual Models

The results of chemical, receptor and exposure pathway screening were used to develop conceptual models for the risk assessment. Separate conceptual models were developed for evaluation of each key question and are presented in Sections D5.2.7 and D5.2.8. The exposure pathways and receptors indicated in the conceptual models were assessed where chemicals of concern were identified through the chemical screening process.

Assessment and Measurement Endpoints

Information compiled in the first stage of problem formulation was used to help select ecologically-based endpoints relevant to decisions about protecting the environment (U.S. EPA 1992a). Endpoints are characteristics of ecological components that may be affected by exposure to a stressor (e.g., chemical). Assessment endpoints are explicit expressions of the actual ecological value that is to be protected and are the ultimate focus in risk characterization. For this investigation, the assessment endpoints included protection of the viability of populations of wildlife previously selected as receptors. Since these receptors encompass different taxa and trophic levels, it was assumed that these receptors also serve as surrogates to other levels of organization and/or receptors not directly included in this evaluation. Assessment endpoints tend to be qualitative or semi-qualitative, and are rarely directly measurable. As a result, measurement endpoints are usually defined as surrogates for assessment endpoints. Measurement endpoints are the quantitative response of the receptor to the stressor, which is related to the characteristics of the assessment endpoint. In other words, it is the response to which exposure to the chemicals of potential concern is related, so that one can identify whether a specific exposure scenario might adversely affect the receptor. For this study, measurement endpoints were sub-lethal adverse health effects (e.g., reproduction, growth) that are relevant for stabilizing adverse effects on populations or communities. The measurement endpoints were based on laboratory, field and modelling studies of various surrogate species.

Exposure Assessment

Exposure assessment is the process of estimating the daily intake rate (dose) of a chemical received by a receptor under a given exposure scenario. An exposure assessment was conducted for each key question where chemicals of concern, receptors and exposure pathways were identified. Exposure equations, receptor parameters and chemical-specific parameters used in the exposure assessment are provided in Appendix VI.4. Further details of the exposure assessment conducted for each key question are provided in Sections D5.2.7 and D5.2.8.

Toxicity Assessment

Toxicity Assessment is the identification and quantification of the chemical concentration or dose (i.e., daily intake), above which exposure to a receptor might cause an adverse effect (U.S. EPA 1988a).

In the toxicity assessment, toxicity information for each chemical was used to provide qualitative and quantitative estimates of health effects associated with exposure to site chemicals. The toxicity assessment for wildlife health differs from that conducted in a human health risk assessment, since the concern level for wildlife health is directed toward protection of populations, while the concern level for human health is directed toward protection of the individual. The toxicity assessment for wildlife health was based primarily on consideration of the threshold for adverse reproductive effects within members of each the evaluated receptors. The potential for reproductive effects for individual receptors was then applied to the population of those receptors in the region. Reproductive effects were chosen, where data were available, as the most relevant endpoint to use for evaluating potential adverse health effects to wildlife populations, since adverse effects on reproduction have a direct impact on maintenance of populations.

Toxicity reference values for wildlife are daily exposure rates that could occur over a lifetime of an animal without causing any measurable, adverse reproductive effects. These values are based on dose-response toxicity evaluations available through the toxicological databases for wildlife (Sample et al. 1996) and various other sources in the toxicological literature.

Carcinogenic endpoints are not typically considered in an ecological risk assessment for several reasons:

- carcinogenic effects occur on an individual level rather than a population level;
- due to the relatively short lifespan of some animals, other types of adverse effects may be manifested earlier than carcinogenic effects;

- there is limited toxicological information concerning carcinogenic effects in wildlife; and
- carcinogenic effects may not necessarily lead to reduction of populations.

Toxicity reference values were conservatively derived for each wildlife receptor evaluated in the risk assessment. Toxicity reference values for mammalian wildlife were calculated based on estimated No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) reported for laboratory animals, using dose-scaling techniques recommended by Sample et al. (1996), which are briefly described below. NOAELs and LOAELs are daily dose levels normalized to body weight (i.e., expressed as mg of chemical per kg body weight per day) to allow comparison between test species and wildlife species, with consideration of differences in body weight. Smaller animals have higher metabolic rates and may be more resistant to toxic chemicals because of faster detoxification rates. Several studies have been conducted to investigate the relationship between body size and responses to toxic chemicals. For avian species, extrapolation of NOAELs and LOAELs from test species to wildlife species (i.e., dose-scaling) based on body weight has been shown to be appropriate. However, for mammals, body surface area dose-scaling between test and wildlife species may be more appropriate than scaling according to body weight. Dose-scaling according to body surface area results in more conservative wildlife NOAELs and LOAELs for larger mammals (Sample et al. 1996). In addition to dose-scaling, a 10-fold uncertainty factor was applied to LOAELs to derive conservative NOAELs, where none were reported in the study. Toxicity reference values for wildlife species used in this assessment were derived based on these dose-scaling techniques.

Based on insight from previous oil sands EIAs, it was recognized that naphthenic acids, a component of CT water, would be an important group of chemicals to evaluate with respect to wildlife health. However, to date, there are insufficient mammalian toxicological data to calculate defensible wildlife toxicity reference values for naphthenic acids, a component of CT water. Toxicity reference values are normally calculated based on chronic or subchronic studies in laboratory animals; however, there are only acute toxicity mammalian data available for naphthenic acids. The acute lethal toxicity data suggests that naphthenic acids have a relatively low potency with respect to lethality following acute exposure. Further characterization of chronic toxicity in mammals from naphthenic acids or CT solids/water is being conducted by Suncor to resolve this data gap. Refer to Section F1.1.4.3, Toxicity Assessment, for a discussion of the naphthenic acids toxicity studies being carried out by Suncor.

Tables D5.1-12 and D5.1-13 provide summaries of the toxicity reference values used in this assessment for mammals and birds, respectively. Further details on the toxicology of these chemicals and selection of the toxicity reference values for this assessment are provided in Appendix VI.5.1. Since the majority of the toxicity reference values for wildlife are based on reproductive endpoints, additive effects were considered for chemical mixtures, where possible. A discussion of the toxicity of chemical mixtures is provided in Section F1.1.4.3, Toxicity Assessment.

Table D5.1-12 Mammalian Toxicity Reference Values Used in the Risk Assessment

Chemical	ReferenceStudy NOAEL (mg/kg/d)	Extrapolated Receptor-Specific NOAELs (mg/kg/d)	Measurement Endpoint (effect)	Reference
antimony	0.125 (mice)	hare: 0.047 moose: 0.012 bear: 0.015	lifespan and longevity	Schroeder et al. 1968, Sample et al. 1996
barium	5.06 (rats)	shrew: 12.2 hare: 3.7 moose: 0.93 bear: 1.2 mouse: 11.1	growth; food and water ingestion; hypertension	Perry et al. 1983
boron	28 (rats)	moose: 4.9	reproduction	Weir and Fisher 1972
cadmium	1 (rats)	moose: 0.018 hare: 0.7	reproduction	Sutou et al. 1980
cobalt	0.24 (cattle)	shrew: 3.0 hare: 0.92 moose 0.23	maximum tolerable dose	NAS 1980
copper	11.7 (mink)	shrew: 34.6 hare: 10.6 moose: 2.7 bear: 3.5	reproduction	Aulerich et al. 1982
manganese	88 (rats)	shrew: 200.5 hare: 61.1 moose: 15.3 bear: 20	reproduction	Laskey et al. 1982
mercury	1 (mink)	mouse: 2.7	reproduction	Aulerich et al. 1974
molybdenum	0.26 (mice)	moose: 0.024 hare 0.1 bear: 0.03 mouse: 0.29	reproduction	Schroeder and Mitchener 1971, Sample et al. 1996
nickel	80 (rats)	mouse: 83.2	reproduction	Ambrose et al. 1976
selenium	0.2 (rats)	moose: 0.035 mouse: 0.4	reproduction	Rosenfeld and Beath 1954
strontium	263 (rats)	mouse: 547	body weight changes	Skoryna 1981
vanadium	0.21 (rats)	moose: 0.034 mouse: 0.41 bear: 0.04 hare: 0.14 beaver: 0.07	reproduction	Domingo et al. 1986, Sample et al. 1996
zinc	160 (rats)	shrew: 346.5 mouse: 333	reproduction	Schlicker and Cox 1968

Table D5.1-13 Avian Toxicity Reference Values Used in the Risk Assessment

Chemical	Reference Study NOAEL (mg/kg/d)	Extrapolated Receptor-Specific NOAELs (mg/kg/d)	Measurement Endpoint (effect)	Reference
barium	20.8 (chicken)	killdeer: 20.8 grouse: 20.8 mallard: 20.8	mortality in day-old chicks	Johnson et al. 1960, Sample et al. 1996
cadmium	1.45 (mallard)	grouse: 1.45	reproduction	White and Finley 1978
chromium	1 (black duck)	killdeer: 1	reproduction	Haseltine et al. 1983
cobalt	0.7 (chicken)	killdeer: 0.7 grouse: 0.7	maximum tolerable dose	NAS 1980
copper	47 (chicken)	killdeer: 47 grouse: 47	mortality in day-old chicks	Mehring et al. 1960
manganese	977 (quail)	killdeer:977	growth	Laskey and Edens 1985
selenium	0.5 (mallard)	grouse: 0.5	reproduction	Heinz et al. 1987
zinc	14.5 (chicken)	killdeer: 14.5 mallard: 14.5 grouse: 14.5	reproduction	Stahl et al. 1990

Risk Characterization

In the risk characterization step, Exposure Ratios (ERs) were calculated as the ratio of the predicted chemical intake (dose) to the toxicity reference value, according to the following equation:

$$ER = \text{estimated daily intake / toxicity reference value}$$

An ER is calculated for each chemical of concern and for each exposure pathway, based on the estimated intake rates (dose) and the toxicity reference values.

An ER value of less than 1 represents exposure scenarios that do not pose a significant health risk to exposed receptors (CCME 1996). When the ER is greater than 1, the scenarios pose a potential concern and require further investigation. It is important to note that ER values greater than 1 do not necessarily indicate that adverse health effects will occur. Rather, they are a signal for closer scrutiny of the potential for such risks.

Ecological risks are a function of the severity of ecological effects, the area over which effects occur, and the duration of effects (Suter et al. 1995). However, there is no standard scale for defining bounds that represent *de minimis* or *de manifestis* risk. *De minimis* risks include mild, transient or localized effects on ecological entities. *De manifestis* risks include risks that are severe, long-lasting or widespread. The severity, extent and duration of estimated effects on these entities are characteristics that help define whether risks are *de minimis* or *de manifestis* (Suter et al. 1995).

Suter et al. (1994) outlined a convincing argument suggesting that a 20% reduction in ecological parameters (e.g., growth, fecundity) would be indistinguishable from normal variability and should be considered as an "effect threshold" in characterizing ecological risks. This argument is based on the limitations in measuring changes in wild populations, statistical changes in laboratory studies, and the basic principles of population ecology.

Citing examples from currently accepted practices in aquatic and terrestrial assessments, a change of 20% or greater is required to distinguish the change from normal background variability, implying that a 20% or less reduction in ecological parameters could be considered *de minimis* with respect to potential severity of the estimated effect.

Similarly, the extent of the potential impact also is important in characterizing risk. For example, a potential effect on only a few individuals is insignificant with respect to populations of small mammals such as deer mice but may be significant with respect to threatened and endangered species. For this assessment, *de minimis* risks were defined as those in which 20% or fewer of the individuals in a non-threatened or non-endangered population are potentially affected by exposure to the site. *De manifestis* risks were defined as those in which greater than 20% of the individuals in a non-threatened or non-endangered population are potentially affected by exposure to the site. None of the wildlife species evaluated in the wildlife risk assessment are currently threatened or endangered.

Similarly, the duration of exposure and the effect is of importance in characterizing risks. For example, potential effects that are short-lived (e.g., less than one generation) will have no long-term impact on a population. In contrast, the same effect sustained over several generations may pose significant ecological risks to the population. In this risk assessment, exposures greater than toxicity reference values based on reproduction endpoints are considered long-term impacts.

This information is brought together in the Risk Characterization phase of the assessment, using a weight of evidence approach to assess whether the site poses a *de minimis* or *de manifestis* health risk to wildlife populations. For the impact assessment classification, a *de manifestis* risk to wildlife populations is considered to be an adverse impact.

D5.1.7.3 Residual Impact Classification and Environmental Consequences

For the wildlife health component, the environmenatal consequence was primarily determined by the magnitude of impact, although duration, geographic extent, reversibility and frequency were also factors (see Section A2, Table A2-8). For the wildlife health assessment, magnitude of impact is based exclusively on whether or not the Project activity might adversely affect wildlife health. The magnitude of impact was based on quantitative risk estimates for Key Questions W-2 and W-3. ER values greater than 1 represent scenarios that pose a potential concern. However, since many conservative factors are typically used to derive both the intake rates and the toxicity reference values, the ER estimates will tend to overestimate the potential for risk. This is consistent with a protective approach to risk evaluation. Thus, an ER value of greater than 1 indicates a potential health concern that needs further scrutiny to identify the reason for the elevated ER; this may lead to additional data collection to more accurately quantify risks. Alternatively, closer scrutiny may indicate that a marginal ER exceedance of 1 is an artifact of the various conservative assumptions employed, and, in fact, the true ER is very likely to be acceptable (i.e., less than 1). In addition, ER values that are greater than 1 for *individual* animals may not necessarily result in measurable effects to wildlife *populations*. Hence, the magnitude of impact has been defined as follows:

Negligible	ER < 1 and no data gaps *or* ER marginally greater than 1 (i.e., 1<ER<10) due to naturally elevated background exposures and/or conservative exposure assumptions. Individual risk estimates would not be expected to result in a significant impact (i.e., >20% change to the population).
Low	No ER because of lack of data, although enough evidence to suggest that exposure unlikely to adversely affect health; additonal information is necessary to support this conclusion.
Moderate	10<ER<20 and no immediately apparent mitigation options are available; individual risks may result in population impacts.
High	ER<20 and no immediately apparent mitigation options are available; individual risks likely to result in population impacts.
Unresolved	Insufficient information to draw any conclusions.

Duration, geographic extent and frequency are defined in Section A2, Table A2-8. The term reversibility requires further clarification with respect to the wildlife health assessment. Wildlife health impacts were classified as reversible if the exposure pathways were considered to be controllable. For example, exposure to end pit lake water is considered to be a reversible impact, since access to this waterbody can be controlled by erecting barriers, or by implementing future mitigation measures to reduce or prevent wildlife exposure. Similarly, the uncertainty associated with naphthenic acids toxicity is reversible, since research is underway to resolve this uncertainty, and potential impacts, if identified, will be mitigated.

For a full description of the criteria for defining impacts and degree of concern, the reader is referred to Section A2.

D5.1.8 Wildlife Health Baseline

A study to evaluate baseline health conditions in local wildlife populations was beyond the scope of this EIA. Rather, this section summarizes the results of a baseline wildlife health risk assessment which was conducted to:

- evaluate the potential for wildlife health risks in the area due to baseline chemical concentrations in water and vegetation; and
- compare predicted baseline risk estimates with future predicted risk estimates for Project Millennium.

D5.1.8.1 Effects of Baseline Water Quality on Wildlife Health

The baseline water quality of McLean Creek, Shipyard Lake and the Athabasca River was evaluated in terms of wildlife health, assuming these sources may provide drinking water for local wildlife. Detailed chemical screening tables are presented in Appendix VI.1.2. The results of chemical screening indicated that baseline chemical concentrations in all waterbodies were less than one-tenth of the RBCs for wildlife. Therefore, baseline water concentrations do not currently pose an adverse impact to wildlife health.

Groundwater chemical concentrations were also evaluated as a surrogate for chemical concentrations likely to be found in mineral licks used by local wildlife. Barium was the only chemical identified in the chemical screening process, since the maximum barium concentration measured in groundwater exceeded one-tenth of the RBCs for moose and black bears. Exposure ratios (ERs) for moose and black bears were less than the critical ER of 1 (ER=0.2 and 0.4, respectively), based on the maximum barium concentration of 3 mg/L. The median barium concentration of 0.75 mg/L resulted in ERs of 0.04 and 0.1 for moose and black bear, respectively. Therefore, if concentrations in mineral licks are similar to those measured in local groundwater, these concentrations would not currently pose an adverse impact to wildlife health.

D5.1.8.2 Effects of Baseline Vegetation Quality on Wildlife Health

Herbivorous and omnivorous wildlife species (such as moose, snowshoe hare, black bears and ruffed grouse) consume large quantities of plants daily. Air emissions from the oil sands developments may deposit onto plant surfaces and soils and subsequently be taken up into plant tissues. Stakeholders have expressed concern over the potential for chemical uptake by wildlife who consume plants growing in oil sands areas near Project

Millennium. For this reason, the potential for adverse effects to wildlife health from ingestion of local plants was evaluated.

Vegetation Sampling Program

A vegetation sampling program was conducted for the purpose of addressing both human and wildlife health concerns. For this reason, the selected plant species are those traditionally harvested by the local aboriginal people and which may also be consumed by local wildlife. Although wildlife may consume many more types of plants than these, the data from this sampling program were used as surrogates for chemical concentrations in other plant species consumed by wildlife. Samples of blueberries, Labrador tea leaves and cattail roots, along with separate but corresponding soil and/or sphagnum samples at the base of the plants, were collected during August 1997 from the following areas:

- Suncor Lease 25 (area within the deposition zone of air emissions from existing Suncor operations; refer to Figure F1.2-1 in the Human Health Baseline Section);
- Muskeg River Mine Project area (pre-development);
- Mariana lakes area, approximately 65 km south of Fort McMurray (control location); and
- West of Syncrude, outside the zone of influence of air emissions (control location).

Five composite samples of each species (composed of berries, leaves or roots from three different plants) were collected from each test area and from control areas. Similarly, composite soil samples were obtained from the base of the plants which had been sampled in each test and control area. Plant and soil samples were collected and analyzed for metals and PAHs. The results of chemical analysis are tabulated in Appendix VI.7, Table VI.7-1.

PAHs were not detected in blueberries or cattail roots. Small quantities (i.e., levels at or slightly exceeding the limit of detection) of naphthalenes and phenanthrene/anthracene were detected in some samples of Labrador tea leaves collected within Suncor Lease 25 and the Muskeg River Mine Project site. However, these PAHs were also detected in control samples of Labrador tea leaves, and concentrations in the test areas do not differ significantly from concentrations found in control areas. It is possible that these observations reflect the natural prevalence of petroleum hydrocarbons in this region. There is historical evidence of a forest fire in the Mariana Lakes region, which may have contributed to the observed concentrations of PAHs in Labrador tea leaves from this region, since PAHs may be released naturally from burning wood. It should also be noted that naphthalenes, phenanthrene and anthracene are non-carcinogenic PAHs, which have relatively low toxic potency compared with carcinogenic PAHs, such as benzo[a]pyrene, and they are not bioaccumulative. Observed levels in Labrador tea leaves are much less than those that would be associated with adverse effects to wildlife health.

Inorganic chemical concentrations in blueberries collected from Suncor Lease 25 were generally within the range of measured concentrations in control locations and the Muskeg River Mine Project area, with the exception of copper, sodium and zinc, which were slightly elevated in samples collected from Suncor Lease 25 in comparison to controls. All of these compounds are essential elements for wildlife nutrition and the measured concentrations in blueberries from test areas would not be associated with any adverse effects to wildlife health.

Several inorganic chemical concentrations in Labrador tea leaves and cattail roots were elevated in samples collected from Suncor Lease 25 and the Muskeg River Mine project site in comparison to control samples (i.e., aluminum, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, selenium, sodium, strontium, vanadium and zinc). As discussed previously for blueberries, many of these compounds are essential elements for wildlife nutrition and are ubiquitous in the environment. Others (i.e., barium cadmium, lead, nickel and vanadium) are not essential elements and elevated levels in test areas warrant further investigation in the risk assessment.

Overall, plant tissue residues were not consistently elevated in areas where oil sands air emissions are a factor. In addition, among the three plant species tested there was no consistent subset of metals that were elevated compared with control plant concentrations. Therefore, the observed plant concentrations cannot be solely attributed to oil sands operations. This, however, may also be a consequence, in part, of the limited number of replicates and power of the sampling program.

Chemical concentrations in blueberries collected in 1997 were compared to concentrations reported for blueberries collected in 1989 from similar locations (Aquatic Resource Management Ltd. 1989). Briefly, metal concentrations in blueberries do not appear to have increased since 1989. However, sulphur concentrations in 1997 are significantly greater than concentrations measured in 1989 in both control and potentially impacted areas. The higher sulphur concentrations may be due to slight differences in analytical techniques or may reflect the added contribution of sulphur in dust deposited onto the berries, which was not removed by washing prior to chemical analysis in 1997, but was removed by pre-washing in 1989. Chemical analysis of unwashed berries is more conservative and is a realistic exposure scenario for wildlife. Regardless, sulphur is a natural constituent of proteins and concentrations in blueberries do not present a health hazard to wildlife. Please refer to Section F1.2.4 of the human health impact assessment for more details.

Baseline Wildlife Health Risk Assessment for Vegetation Consumption

The data from the vegetation sampling program was further evaluated in the a baseline wildlife health risk assessment. A chemical screening process was conducted to evaluate whether the observed concentrations in plant samples may have any adverse effect on wildlife. The following herbivorous and omnivorous wildlife receptors were identified: moose, snowshoe hare, black bear, ruffed grouse and mallards. The diet of moose and snowshoe hare may consist of 100% vegetation, while the diet of black bears, ruffed grouse and mallards consists of approximately 75, 80 and 25% vegetation, respectively. Concentrations in aquatic vegetation (i.e., cattail roots) were screened for exposure to moose and mallards, since these are the only two selected species that would consume aquatic plants. Concentrations in terrestrial vegetation (i.e., blueberries and Labrador tea leaves) were screened for exposure to moose, snowshoe hare, black bear and ruffed grouse.

The chemical screening was based on the above data and receptor-specific vegetation ingestion rates for moose, snowshoe hare, black bears, ruffed grouse and mallards (see Appendix VI.4.2 for wildlife receptor parameters).

Chemical concentrations in plant tissues were screened against risk-based concentrations (RBCs), based on the following conservative assumptions:

- 100% of the daily vegetation requirements for each receptor were assumed to consist of blueberries, Labrador tea and/or cattail root; and
- chemical concentrations in plant tissue were conservatively screened against receptor-specific RBCs, based on a target exposure ratio (ER) of 0.1 (i.e., ten-fold lower than concentrations associated with the reference acceptable ER value of 1).

The list of chemicals identified for further evaluation in the baseline risk assessment is presented in Table D5.1-14.

Table D5.1-14 Chemicals Identified for Further Evaluation in Baseline Risk Assessment

Species	Blueberries	Labrador Tea Leaves	Cattail Root
Moose	manganese	antimony barium copper manganese	barium boron cadmium cobalt molybdenum selenium vanadium
Snowshoe hare	manganese	antimony barium copper manganese	
Black bear	manganese	antimony barium copper	

		manganese	
Ruffed grouse		barium copper	

No chemicals of concern were identified for mallards. A baseline ecological health risk assessment was conducted according to the method described previously. Key aspects of the risk assessment are presented here; additional details are presented in Appendix VI.

Snowshoe hares, black bears and ruffed grouse were assumed to consume equal amounts of blueberries and Labrador tea leaves to satisfy their total daily vegetation requirements, every day of the year for their entire lifespan. Moose were assumed to consume equal amounts of blueberries, Labrador tea leaves and cattail root to satisfy their total daily vegetation requirements, every day of the year for their entire lifespan. Maximum measured concentrations in plants from Suncor Lease 25 or the Muskeg River Mine Project site were used in calculating the risk estimates to ensure a conservative assessment. In addition, although a chemical may have been retained only because of concentrations in one plant type, it was conservatively evaluated in all plant types, where concentrations were measurable, to address concerns associated with combined exposure from all plant types.

Exposure ratios for each species are presented in Table D5.1-15 for the combined exposure to all relevant plant types. All ER values for black bears and ruffed grouse were less than the critical ER of 1, indicating that predicted conservative exposures likely to be incurred by bears and grouse who consume local plants are well within acceptable limits. Most ER values for moose and snowshoe hare were also less than 1, with a few chemicals equal to or marginally exceeding 1 (i.e., barium, manganese, vanadium). Based on the conservative assumptions used in the assessment (i.e., 100% of the diet consisting of these three plant species from impacted areas), the marginal exceedance of 1 for moose and snowshoe hare indicates a *de minimis* risk to individual animals. Furthermore, risks to moose and hare populations are considered to be *de minimis*, since exposures to plants from impacted areas are unlikely to contribute to greater than 20% change in wildlife populations (refer to Section D5.1.7, risk characterization for definitions of *de minimis* and *de manifestis*). Therefore, based on the present data, baseline plant tissue concentrations do not pose an adverse impact to wildlife health.

Table D5.1-15 Exposure Ratio Values for Wildlife

Chemical	Moose	Snowshoe Hare	Black Bear	Ruffed Grouse
Antimony	0.33	0.57	0.39	n/a [(a)]
Barium	1.1	1.4	0.98	0.24
Boron	0.07	n/a [(a)]	n/a [(a)]	n/a [(a)]
Cadmium	0.11	n/a [(a)]	n/a [(a)]	n/a [(a)]
Cobalt	0.14	n/a [(a)]	n/a [(a)]	n/a [(a)]
Copper	0.20	0.29	0.20	0.09
Manganese	0.83	1.1	0.72	n/a [(a)]
Molybdenum	0.46	n/a [(a)]	0.07	n/a [(a)]
Selenium	0.12	n/a [(a)]	n/a [(a)]	n/a [(a)]
Vanadium	1.2	n/a [(a)]	n/a [(a)]	n/a [(a)]

[(a)] n/a = not applicable; these chemicals were not identified in the screening process for these wildlife species and therefore were not evaluated in the risk assessment.

D5.1.8.3 Effects of Baseline Small Mammal Tissue Quality on Wildlife Health

The results of small mammal sampling programs conducted in 1987 and 1994 are summarized in the human health baseline assessment, Section F1.2.5 (Pauls and Arner 1989, Conor Pacific Environmental Technologies 1998a Draft). In general, concentrations of trace metals in small mammals have remained constant or have decreased between 1987 and 1994. A raptor, the red-tailed hawk, was chosen as an appropriate receptor for evaluation of potential adverse wildlife health effects from consumption of small mammals. In the exposure assessment, hawks were assumed to consume small mammals with the maximum measured tissue concentrations in 1994 as 100% of their diet. All ERs were less than 1.0. Therefore, in spite of assuming worst case exposure conditions, no adverse health effects are predicted for raptors from consumption of small mammals near the oil sands developments.

D5.2 WILDLIFE PROJECT IMPACT ASSESSMENT

D5.2.1 Introduction

This wildlife impact assessment for the Project addresses the requirements listed in the Project Terms of Reference (AEP 1998). The wildlife terms of reference requirements are listed in Section D1.

Discussions on the potential cumulative effects on wildlife associated with the Project are addressed in Section D6. Section D5.1 provided details on the wildlife baseline for the Project. Additional details on the wildlife baseline for the Project Millennium Area are provided in Winter Wildlife Surveys for the Steepbank Mine, Shipyard Lake, and Lease 25 and 29 Upland (Golder 1997s) and Wildlife Baseline Conditions for Project Millennium (Golder 1998n).

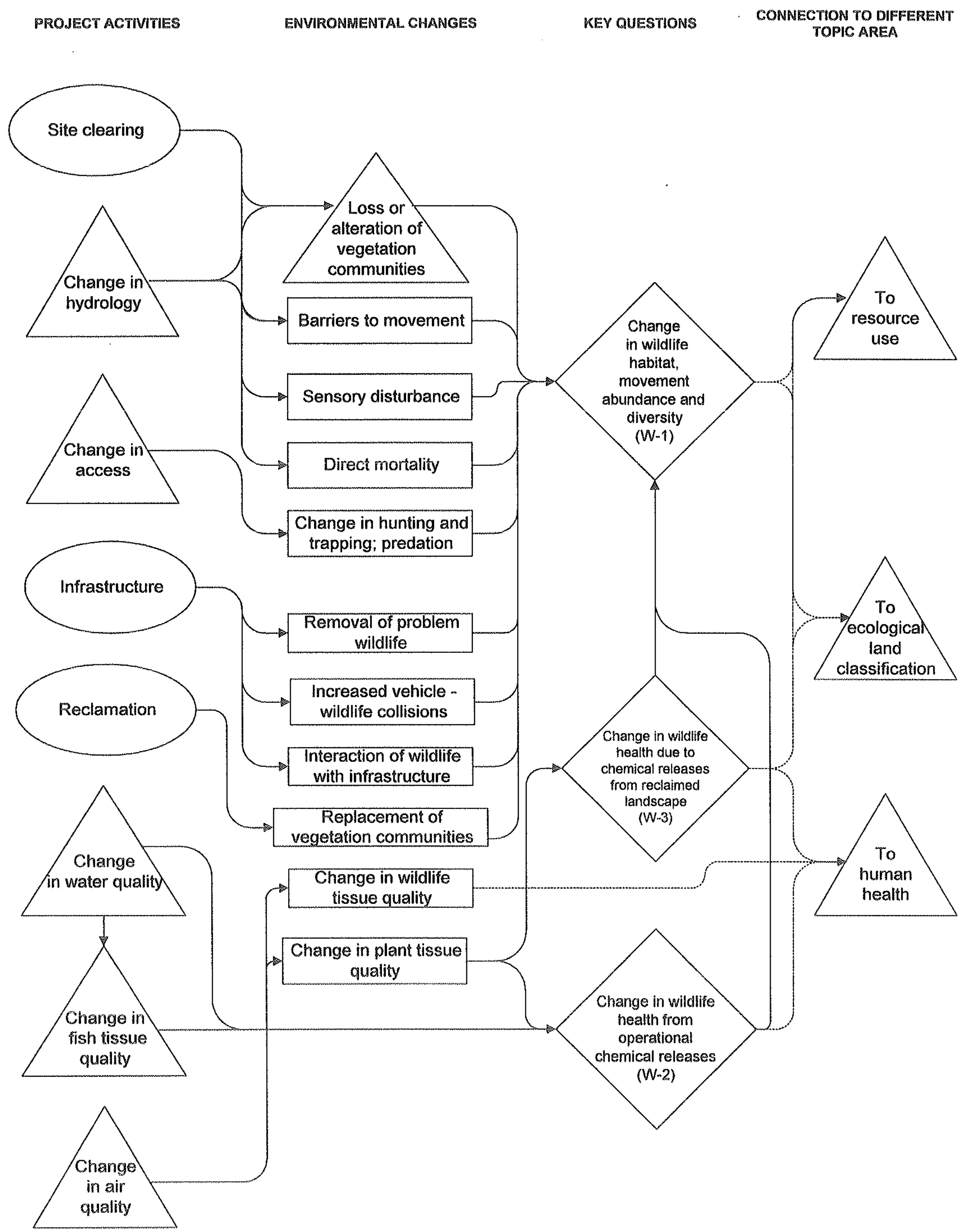
The approach for the evaluation of impacts to wildlife included:

- confirmation of Key Indicator Resources (KIRs);
- delineation of Local and Regional Study Areas (LSAs and RSAs);
- development of impact Key Questions;
- development of linkage diagrams for each Key Question;
- development of impact assessment criteria;
- determination of the validity of each linkage within each Key Question for each KIR;
- evaluation of the impact assessment criteria for each valid linkage;
- development of mitigation strategies for each valid linkage;
- risk assessment of exposure to chemicals that may be released in water or that may accumulate in plants, fish and invertebrates; and
- recommendation of various monitoring plans.

D5.2.2 Potential Linkages And Key Questions

As the first stage of the assessment, all possible interactions between the KIRs and the proposed development were identified and discussed. This component of the assessment used Key Questions and flow charts, or linkage diagrams (Figure D5.2-1) to detail potential impacts of the proposed development on wildlife. The EIA process involved formulation and assessment of three Key Questions that describe potentially significant effects of the project on wildlife.

Figure D5.2-1 Linkage Diagram for Wildlife for Project Millennium Construction, Operations and Closure



W-1: What impacts will development and closure of Project Millennium have on wildlife habitat, movement, abundance, and diversity?

The amount of suitable habitat within the LSA for each KIR was calculated using Habitat Suitability Index (HSI) procedures (see Section D5.5.2 and Golder 1998o). This was then compared with the amount of habitat projected to be altered due to construction and operation of the Project. Changes considered included direct habitat loss due to physical disturbance, habitat change due to changes in hydrology, indirect habitat loss due to barriers to movement and indirect habitat loss due to sensory disturbance (e.g., noise) (Figure D5.2-1).

Potential impacts to wildlife can be categorized as leading to either direct or indirect mortality, which in turn leads to a change in wildlife populations (Figure D5.2-1). Indirect impacts can include the removal or alteration of vegetation communities, creation of barriers to movement and sensory disturbance, and the release of air or water emissions (Key Question W-2). Direct mortality impacts can include the effects of increased hunting and trapping due to increased access, removal of problem wildlife (e.g., beavers and bears), increased traffic-caused mortality of wildlife and interactions of wildlife with mine infrastructure (e.g., bird collisions with transmission lines or towers) and facilities (e.g., waterfowl use of tailings ponds). Both wildlife abundance and diversity (species richness and diversity) are considered under this question. Ultimately, changes in wildlife populations can lead to changes in the consumptive and non-consumptive use of the wildlife resource and to changes in biodiversity.

Replacement of vegetation communities during reclamation of the development site will lead to a change in wildlife habitat (Figure D5.2-1). Assumptions regarding the habitat variables for the KIR habitat models were made for each proposed reclamation vegetation community so that quantity and quality of wildlife habitat at closure could be estimated.

W-2: What impacts will chemicals in operational air and water releases from Project Millennium have on wildlife health?

During the operational phase, wildlife may be exposed to chemicals through inhalation of air, ingestion of water, and consumption of vegetation, fish and aquatic invertebrates which have been exposed to air and/or water emissions. In this key question, a wildlife health risk assessment was conducted to evaluate the potential for adverse impacts to wildlife health as a result of these chemical exposures during the operational phase of the Project.

W-3: **What impacts will chemicals in soils, plants, and waters from the Project Millennium reclaimed landscapes have on wildlife health?**

Following closure of the Project, the land will be reclaimed and revegetated, allowing wildlife to re-inhabit the area, where they will be exposed to chemicals in soils, water, vegetation and prey species. In this key question, a wildlife health risk assessment was conducted to evaluate the potential for adverse impacts to wildlife health in the far future after reclamation of the site.

D5.2.3 Study Areas

The spatial considerations for assessing wildlife included consideration of both a local study area (LSA) and a regional study area (RSA). These areas and the temporal considerations for the EIA are defined in Section D1. Although a significant level of ongoing reclamation will occur at the time of maximum development, the impact analysis is based on the total disturbance of the maximum development area.

D5.2.4 Key Indicator Resources

As it is nearly impossible to study all species within an area, species representative of public and scientific values can be chosen for management purposes. Species selected in this fashion are referred to as Management Indicator Species (MIS) (Salwasser and Unkel 1981), Valued Ecosystem Components (VECs) (Sadar 1994), key species and other terms. For the purposes of this EIA, they are termed Key Indicator Resources (KIRs), following the terminology of the Aurora EIA (BOVAR 1996e) and the Muskeg River Mine Project EIA (Shell 1997).

Species chosen as KIRs for the Steepbank Mine EIA, the Aurora Mine EIA and the Muskeg River Mine EIA were selected based on a scoring of species' legislated importance (endangered status), commercial and subsistence economic importance, non-consumptive importance and ecological importance (Golder 1996m, BOVAR 1996e, Shell 1997). Rather than repeat this selection process in its entirety, the study team reviewed previous selections and adopted the same KIRs for the Project Millennium EIA. The western tanager and the pileated woodpecker were not included in the Steepbank Mine EIA or the Aurora Mine EIA, however, they were added to the KIR list for the Muskeg River Mine EIA following review with Alberta Environmental Protection (AEP) (Shell 1997). In addition to representing their respective species groups, KIRs were chosen for the reasons listed in Table D5.2-1.

Table D5.2-1 Key Indicator Resources and the Selection Rationale

KIR	Selection Rationale
Moose	economic importance, early successional species
Fisher	use of late seral stages, economic importance, carnivore
Black bear	economic importance, carnivore
Beaver	economic importance, semi-aquatic habits
Red-backed vole	importance in food chain
Snowshoe hare	importance in food chain
Dabbling ducks	importance in food chain, economic and recreational importance
Ruffed grouse	economic and recreational importance
Cape may warbler	use of white spruce forests, neotropical migrant
Western tanager	use of open forest mixedwood, neotropical migrant
Pileated woodpecker	use of late seral stages, large-diameter trees and snags
Great gray owl	raptor, use of wetlands

D5.2.5 Methods

D5.2.5.1 Validation of Linkages

Linkages between project activities and environmental changes that affect the Key Questions were assessed as to their validity. In particular, potential effects on KIR species were evaluated where possible. Assessments were based on literature, field data collected within the Project study area, and professional judgment.

D5.2.5.2 Habitat Suitability Index Modelling

Habitat Suitability Index (HSI) models were used to assess the baseline habitat conditions for KIRs in the LSA. Models were adapted from AXYS (1996), Westworth, Brusnyk and Associates (1996b) and Golder (1998p). A brief description of the HSI process follows. Detailed model descriptions are found in the above-mentioned reports, and a more detailed description of the HSI process for the Project is found in the Wildlife Habitat Suitability Indices Modelling for Project Millennium report (Golder 1998o).

HSI models are analytical tools for determining the relative potential of an area to support individuals (or populations) of a wildlife species. They are frequently used to quantify potential habitat changes for wildlife species as a result of various land uses. Today, many EIAs use HSI modelling to determine potential impacts of project activities on wildlife resources.

HSI models evaluate the potential of an area to support a wildlife species, based on a number of known or assumed relationships between elements of habitat structure and their ability to support a species' biological needs (e.g., food, cover). These relationships are then combined mathematically into models. The HSI models are used to calculate a relative value ranging from 0 to 1, where 0 indicates that an area is unsuitable and 1 indicates optimum suitability, for each habitat type. HSI values for each habitat type are multiplied by the area (ha) of the habitat type or area under consideration to determine the number of habitat units (HUs) for each wildlife species. The number of HUs both pre- and post-development can then be compared to assess impacts of habitat change on wildlife.

Disturbance Coefficients

Wildlife species may avoid or reduce their use of habitat adjacent to areas of human activity. Impacts are greater if the adjacent habitat is of high quality and if the total supply of habitat in the area is limited. One way to estimate the amount of habitat affected by disturbance (i.e., habitat effectiveness) is to determine disturbance zones of influence (ZI) and disturbance coefficients (DC) for each KIR and each activity type. A ZI is the maximum distance to which a disturbance (e.g., traffic noise) is felt, and a DC is the effectiveness of the habitat within the ZI in fulfilling the requirements of the species (e.g., a DC of 0.9 represents 90% habitat effectiveness). ZIs and DCs are used with HSI mapping to estimate the quantity and quality of habitat (expressed in HUs) that could be affected by a development.

Different species react differently to developments. Most work on this subject has been done for grizzly bears. Numerous studies (e.g., Mattson et al. 1987, McLellan and Shackleton 1988, 1989a,b, Purves et al. 1992, Mace et al. 1996) have measured the displacement of grizzly bears by different levels of human activities. Horejsi (1979) found that moose were disturbed by active seismic line work to within one kilometre, while other researchers have found that moose avoid areas of human activity, although a zone of influence was not determined (e.g., Hanock 1976, Rolley and Keith 1980). Still others have found that moose can habituate to human disturbance (e.g., Pauls 1987).

Unfortunately, results of such studies are often highly variable due to the difficulties associated with studying wide-ranging and often reclusive species, and most study designs are based on arbitrary buffer distances around disturbance features (e.g., bear locations analyzed less than and greater than 500 m from roads: Mace et al. 1996). Therefore, most displacement models have relied on professional judgment, using empirical data as a guide only.

BOVAR (1996e) used a ZI of 500 m for moose and 100 m for snowshoe hares for the Aurora Mine EIA. They made a conservative assumption that displacement was complete within the ZI for these species (i.e., DC was zero for all activity types). In contrast, they assumed that all other KIRs were not displaced by the Aurora Mine development. Westworth, Brusnyk and Associates (1996b) used a ZI of 250 m and a DC of zero for all KIRs for the Suncor EIA, due to sensory disturbance, reduced hiding and thermal cover, reduced forage palatability due to the accumulation of dust, and increased risk of predation from edge-adapted species.

The ZIs and DCs used for the Project Millennium EIA are shown in Table D5.2-2. These variables were determined through professional judgment, based on literature review and other oil sands EIAs (see Golder 1998p). The calculation of these variables included the analysis of the effects of hunting and trapping on the various game and furbearer species. Thus, ZIs for moose were fairly high to account for hunting which may occur up to 1 km from roadsides. Habitat alienation from disturbance was not considered to be a factor for red-backed voles, and thus, ZIs and DCs were not calculated.

D5.2.5.3 Wildlife Health Analysis

Methods for the wildlife health risk assessment were presented previously in Section D5.1.7.

D5.2.6 Key Question W-1: What Impacts Will Development and Closure of Project Millennium Have on Wildlife Habitat, Movement, Abundance and Diversity?

D5.2.6.1 Analysis of Potential Linkages

Habitat Loss

This Key Question is focused on the effects of direct and indirect alteration of wildlife habitat, alteration of wildlife movement corridors, and changes in the abundance and diversity of wildlife species. Direct habitat change occurs through the removal or alteration of vegetation communities during construction of project facilities (e.g., site clearing). These habitat changes can be calculated using a Geographic Information System (GIS), and the number of HUs (see Section D5.2.5.2 Golder 1998e and Golder 1998o) affected can be determined. Indirect habitat change can occur through changes in hydrology, creation of barriers to movement, and sensory disturbance. These impacts can be assessed using predicted changes to surface water hydrology (Section C2) and habitat modelling and zones of disturbance around project facilities. Direct and indirect impacts of habitat loss, including site clearing, changes in hydrology, barriers to movement, and sensory disturbance, on each of the KIRs are discussed below.

Site Clearing

Background

Mining activities that may result in habitat loss, alteration and fragmentation include:

Table D5.2-2 Displacement Variables for Wildlife KIRs for Project Millennium

Activity Code	Zone of Influence/Disturbance Coefficient [a]																	
	Moose		Snowshoe hare		Black bear		Fisher		Dabbling duck		Breeding birds [b]		Great gray owl		Ruffed grouse		Beaver	
	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC	ZI (m)	DC
roads	1000	0.50	500	0.50	1000	0.50	500	0.50	250	0.50	100	0.75	100	0.75	250	0.50	500	0.50
utility corridors	500	0.75	500	0.75	500	0.75	500	0.50	100	0.75	0	N/A	0	N/A	100	0.50	500	0.50
active mine areas, gravel pits, dumps	100	0.75	100	0.75	100	0.75	100	0.75	100	0.75	100	0.75	100	0.75	100	0.75	0	N/A
plant and camps	500	0.50	500	0.75	500	0.50	500	0.50	100	0.75	100	0.75	100	0.75	100	0.50	500	0.50

[a] Zones of influence and disturbance coefficients are not required for red-backed voles.
[b] Breeding birds includes Cape May warblers, pileated woodpeckers, and western tanagers.

- clearing vegetation and surface grading to accommodate facility construction (e.g., mine pits, storage dumps, gravel pit, service roads);mining and haul roads, drainage ditches, infrastructure);
- overburden dewatering adjacent to the mine;
- dewatering of streams and aquatic habitats;
- utility and tailings line construction; and
- air emissions.

Direct habitat loss is the most visible impact and occurs when land is allocated for other uses. Other impacts include habitat alteration, habitat alienation and habitat fragmentation. Of all possible sources of impact from facility construction, permanent habitat loss is one of the most important as it reduces the landscape's capability to support wildlife. This is discussed further under the topic of wildlife abundance and diversity. Facilities such as roads tend to be permanent, and habitat loss is a long-term event. For other types of facilities, habitat loss may be temporary, such as for construction of buried pipelines and other utilities where the terrestrial habitat is reclaimed and restored soon after construction. For extractive industries such as mining, reclamation is the first step in re-establishing a natural ecosystem following landscape alteration. On closure of a project, successful reclamation can, to some extent, reverse the effects of habitat loss.

Habitat alteration includes changes in successional stages of vegetation (i.e., changes in structure and species composition) and changes in spatial patterns of vegetation communities as may occur due to changes in hydrology or air emissions. Impacts of air emissions on vegetation communities were addressed in Section D3.2. It was concluded that air emissions from the Project will not impact the vegetation within the LSA. Therefore, impacts to wildlife habitat were also assumed to be negligible, and habitat alteration from air emissions is not an issue.

Habitat alienation refers to loss of habitat effectiveness as a result of sensory disturbances from human activities at disturbed sites. Thus, a habitat may contain suitable cover and food, however the habitat is not utilized by wildlife due to sensory disturbance (e.g., noise). This alienation effect on wildlife can be short term or long term, depending on the nature of the facilities and available mitigation techniques. Habitat alienation is discussed further under the topic of sensory disturbance.

Habitat fragmentation is another habitat-related effect that occurs when land is allocated to other uses. Fragmentation occurs when extensive, continuous tracts of habitat are reduced by habitat loss to dispersed and usually smaller patches of habitat. Habitat fragmentation reduces the total amount of available habitat and reduces remaining habitat into smaller, more isolated patches (Meffe and Carroll 1994). A major contribution to habitat fragmentation in forested habitats is the construction of roads (Reed et al.

1996). Thus, fragmentation increases the amount of edge in the habitat, decreases the amount of habitat interior, and increases the distance between habitat patches.

Forest edge differs from forest interior in both microclimatic and biotic aspects. A transition in microclimatic variables such as light intensity, temperature, wind and humidity occurs from an edge to a forest interior. Both vegetation and wildlife species respond to these microclimatic differences. The zone of influence of edges can be greater for wildlife species as they are mobile and can penetrate further into the forest. Some fragmentation changes can be positive (e.g., some habitat generalists thrive on edge conditions). However, fragmentation has a negative effect on species that require large extensive tracts of habitat (e.g., interior nesting birds and large carnivores, Weaver et al. 1996).

The impacts of roads on wildlife are well-documented (e.g., Lynch 1973, McLellan and Shackleton 1988, 1989a,b, Reed et al. 1996, Jalkotzy et al. 1997). Permanent roads represent a permanent loss of habitat for all wildlife to the extent of the width of the road surface. In addition, the effectiveness of habitat adjacent to roads may be reduced because of disturbance effects. Temporary roads represent a temporary loss of habitat, however a different habitat may evolve over time due to the loss of site productivity from road construction. Areas adjacent to roads typically possess a different vegetation community from the surrounding forest, and the width of this edge effect can vary with the size and permanency of the road. The extent of the effect of loss and alteration of habitat from roads depends on road density and pattern.

Habitat changes for the following KIRs are highlighted in this document: moose, fishers, black bears, beavers, red-backed voles, snowshoe hares, dabbling ducks, ruffed grouse, Cape May warblers, pileated woodpeckers, western tanagers, and great gray owls. Full habitat analyses are found in Golder (1998o).

Moose

Development of the Project is predicted to affect moose directly through loss of high to moderate suitability aspen-dominated habitat, key areas of preferred browse availability and winter habitat use (Golder 1998o, see also review by AXYS 1996, Mytton and Keith 1981, Westworth et al. 1989, Renecker and Hudson 1992). Removal of low suitability habitat through development of the proposed project is not considered detrimental to moose because these areas do not substantially contribute to the long-term habitat carrying capacity of the area for this species.

Impacts from loss of high to moderate habitat is not expected to result in direct mortality or to occur in direct proportion to the area of habitat removed. This is because moose have the ability to disperse ahead of construction activities. However, loss of wintering range can result in impact because moose tend to be highly traditional in their use of seasonal ranges, particularly in boreal habitats (Mytton and Keith 1981). In the boreal forest, seasonal ranges of moose tend to be relatively small (LeResche 1975). Winter ranges in northeastern and north-central Alberta vary from 2 to 54 km^2 and 3 to 111 km^2 (Mytton and Keith 1981, Hauge and Keith 1981). In west-central Alberta, home ranges of non-migratory female moose varied from 16 to 56 km^2 (Horejsi and Hornbeck 1987). Moose displaced to low suitability habitat may experience suboptimal nutrition, which can slow growth rates in ungulates (Renecker and Hudson 1993). As well, moose displaced from optimal habitat to low suitability habitat may experience reduced physical condition, which may reduce calf production and survival (Thorne et al. 1976, Ballard et al. 1988).

Furthermore, the conversion of mature habitat to early successional habitat through site clearing may restrict ungulate movements during key winter periods. Reduced canopy density of early successional forests intercepts less snowfall, resulting in increased snow depths and restricted ungulate movement. As well, disturbed sites experience greater crusting of snow, which can impair ungulate movement. Studies of cervid species such as elk (Parker et al. 1984), deer, caribou (Fancy and White 1985), mountain goats and bighorn sheep (Dailey and Hobbs 1989) have shown that increasing sinking depth relative to brisket height leads to an exponential increase in locomotion energy expenditures. Specifically for moose, a snow thickness increase of 70 cm or more (about 66% of chest height) restricts movement and influences habitat selection (Telfer 1970, Peek 1971). Increased snow thickness and crusts increase the energy costs for ungulates cratering for food (Thing 1977, Fancy and White 1985). Snow depths exceeding 90 cm may contribute substantially to mortality (Coady 1975).

In addition, displacement of moose from high to moderate suitability habitat could lead to concentrations of moose surrounding the development, depending on adjacent habitat conditions (Westworth et al. 1989). While the fate of displaced moose is highly speculative, one possibility is that moose would be exposed to increased levels of local hunting pressure. This is an important issue if hunting regulations do not compensate for the increased vulnerability. In the case of the Project, public access to the LSA will not be permitted, therefore hunting pressure should be non-existent. However, in general, survival rates of individuals displaced from optimal habitat is expected to be relatively low (Ballard et al. 1988).

At the end of the Project, restoration and reclamation should produce favourable conditions for moose to repopulate the site. This is based on the fact that moose thrive in secondary forest succession (Peterson 1955), providing other habitat components are present. Patches of more mature habitat must be associated with good browsing habitat to provide cover and decrease predation risk. The landscape can be viewed as a patchwork of different vegetation communities that represent a gradient of habitat suitability to moose and deer (i.e., prime to marginal habitat). Some habitats are more suitable for cover, while other habitats provide quality food. In areas where this habitat patchwork is disrupted by marginal or disturbed habitat, travel corridors are important for successful movement of individuals among habitats. Effective movement corridors, such as riparian areas, can also facilitate recolonization of recently disturbed areas that contain suitable ungulate habitat.

Fisher

Relative to many other mammals, reproductive rates and population density of fishers are low. Low-density populations generally recover slowly, and populations isolated by fragmentation of habitat are susceptible to extirpation (Powell and Zielinski 1994). Winter track counts indicated that fishers are relatively abundant in the LSA (Golder 1997s, Golder 1998b).

Fishers prefer high canopy closure (e.g., 80 to 100% closure) of late successional conifer-dominated forests (Powell 1993). Fishers use open areas selectively, mostly in proximity to forest cover. Habitat selection appears to be based on habitat selection of preferred prey, including snowshoe hares, carrion and a variety of small mammals (Powell 1993, Kuehn 1989, Arthur et al. 1989). Old snags and hollow trees are important habitat components for den sites. Fishers are easily trapped, and combined with habitat loss, fisher populations in many areas have been reduced to near extinction (Powell 1979).

Black Bear

The effects of habitat loss, alteration and fragmentation can be expected to displace bears from otherwise suitable habitat. The displacement of black bears from preferred habitat may have negative consequences for their long-term survival. Several mechanisms may be involved, such as:

- lower survival of bears when displaced from familiar natal home ranges through increased hunting mortality (Manville 1983);
- lower survival of bears if displaced from preferred denning sites (Horejsi et al. 1984); and
- reduced reproductive success (i.e., fewer cubs born) due to nutritional stress if access to high quality food sources is restricted (Rogers 1976, Elowe and Dodge 1989).

During the construction phase, ecological options for feeding and denning may be destroyed. In northeastern Alberta, black bears enter dens from mid-September to late October, selecting mixed stands of mature aspen and spruce, or mature spruce stands (Fuller and Keith 1980b, Tietje and Ruff 1980). The loss of abundant food supplies and home range territories for exclusive feeding areas will ultimately reduce individual bear's prospects for long-term survival and reproduction (Rogers 1976).

Beaver

Beavers, while resilient to human activities, are limited by the distribution of aspen and willow for food and suitable aquatic habitat for protection and parts of their life cycle (Nietfeld et al. 1984). Habitat loss, alteration, and fragmentation from site clearing may have a negative effect on beavers.

Red-Backed Vole

Red-backed voles are habitat generalists, inhabiting mesic habitats within mature coniferous, deciduous and mixed forests with abundant downed woody debris and dense vegetation (Golder 1998n). These small mammals have high reproductive rates (three or four litters per year), and the life expectancy is usually about one year (Banfield 1987). Red-backed voles occupy overlapping home ranges that vary from 1.5 ha in summer to 0.24 ha in winter (Stevens and Lofts 1988). Thus, habitat clearing may affect voles due to their limited mobility.

Habitat alterations, such as rights of way created along roads, will affect red-backed voles because they tend not to be abundant in regeneration sites (Millar et al. 1985). Red-backed voles avoid fields, clearings and other nonforested habitat (AXYS 1996).

Snowshoe Hare

Snowshoe hares are relatively sedentary animals that live within a limited home range (typically <10 ha, Forsyth 1985). The average home range in central Alberta is about 200 m in diameter (Keith et al. 1984). Studies suggest that habitat alteration such as forest cutting eliminates hares if suitable habitat with forest cover is not provided within 200 to 400 m (Conroy et al. 1979). Snowshoe hares avoid open habitats of all types (Pietz and Tester 1983), presumably because shelter from weather and concealment from predators is not available. Dispersal beyond established home ranges between habitat patches results in increased predation (Sievert and Keith 1985). Reduced habitat quality and availability may reduce energy balance and affect reproductive success, which can also affect predation rates. In the longer term, habitat alterations such as forest removal can rejuvenate understory vegetation with the potential of improving habitat for snowshoe hares (Litvaitis et al. 1985).

Dabbling Ducks

Dabbling ducks in the RSA include the mallard, northern pintail, northern shoveler, blue-winged teal, green-winged teal, gadwall and American wigeon (Nietfeld et al. 1984). The most current status of North American duck populations (excluding scoters, eiders, oldsquaws, mergansers and wood ducks) indicates that 1996 populations were 16% higher than the long-term average for 1955-1995 (Caithamer and Dubovsky 1996). Improved population levels are consistent with favourable habitat conditions during recent years.

Optimal habitat for dabbling ducks is represented by the interspersion of land with aquatic habitats (e.g., shallow marshes, open-water marshes and potholes). Limiting factors for dabbling ducks include lack of permanent and semi-permanent water, extensive water fluctuations and lack of nesting cover. Human activities which affect waterbodies will negatively affect dabbling ducks.

Ruffed Grouse

Ruffed grouse are non-migratory, ground-nesting birds that occupy aspen-dominated and mixedwood habitats with substantial shrub understories (Francis and Lumbis 1979). Spatial requirements of ruffed grouse are relatively small with mean daily movements during winter of <400 m (Thompson and Fritzell 1989).

The effects of habitat loss, alteration and fragmentation on ruffed grouse are difficult to predict, however, some displacement to adjacent, suitable habitat is likely to occur (Francis and Lumbis 1979). To our knowledge there are no studies documenting the survival and reproductive performance of ruffed grouse that have been displaced from preferred habitat by human developments. Food limitation and increased susceptibility to predation may reduce overall reproduction and survival of ruffed grouse displaced from familiar home ranges or displaced to suboptimal habitats. Snow roosting conditions are also believed to improve overwinter survival, and such conditions may be habitat-specific (Gullion 1970).

Cape May Warbler

The Cape May warbler is a neotropical migratory songbird. General declines have been observed in neotropical songbirds, possibly due to tropical deforestation of winter range and/or habitat loss and fragmentation of temperate forests within breeding ranges. There is evidence that both are occurring and for this species specifically, loss of neotropical wintering habitat has been noted (AEP 1996c). For breeding purposes, Cape May warblers prefer mature mixedwood forests dominated by tall white spruce (Francis and Lumbis 1979, Semenchuk 1992). The long-term trend from 1966-1988 for these warblers has been negative (Sauer and Droege 1992).

To our knowledge, species-specific research has not been done on the Cape May warbler. However, habitat loss and fragmentation effects on songbirds is an active area of research (Kuhnke 1993). In general, habitat loss and fragmentation expose migratory birds to a number of impacts, including increased competition for nest sites, predators, cowbird parasitism, avian competitors and human disturbances (Finch 1993).

Western Tanager

Similar to the Cape May warbler, declines in western tanagers are a concern due to the downward trends seen in neotropical migrant songbird populations as a whole. Generally, there is evidence that both loss of wintering habitat and loss of breeding habitat are factors (Hagan and Johnston 1992).

Western tanagers prefer mature mixedwood forests in northeastern Alberta for breeding (Francis and Lumbis 1979). However, during the winter season, they migrate to Guatemala, Mexico and Belize (Terborgh 1989). Declines during the breeding season were reported to have occurred before 1973, but since then their populations have been stable (Robbins et al. 1986). The long-term trend from 1966 to 1987 for this species has been -0.8% change per year (Droege and Sauer 1989).

To our knowledge, species-specific research in relation to disturbance has not been done on the western tanager; however, as discussed for the Cape May warbler, habitat loss and fragmentation effects on songbirds is an active area of research. In general, habitat loss and fragmentation expose migratory birds to a number of impacts, including increased competition for nest sites, predators, cowbird parasitism, avian competitors and human disturbances (Finch 1993).

Pileated Woodpecker

Pileated woodpeckers excavate nests in large dead trees, and feed on insects in large-diameter live, standing-dead or downed trees. The best habitat consists of mature mixed coniferous forest with >2 canopy layers, large live trees and dead and downed woody debris (Ball 1987).

To our knowledge, species-specific research has not been done on the pileated woodpecker. In general, site clearing will remove large blocks of habitat, including large-diameter nest and roost trees.

Great Gray Owl

Forest cover is important for nesting great gray owls (AXYS 1996), and nesting occurs in mature stands of balsam or aspen poplar, often mixed with spruce, jack pine and tamarack. In general, adults are sedentary with relatively small home ranges (1.3 to 6.5 km^2). Adults do display complex patterns of seasonal and annual movements influenced by prey availability (Duncan 1994). Human activities that reduce the abundance of nest trees will negatively affect this species.

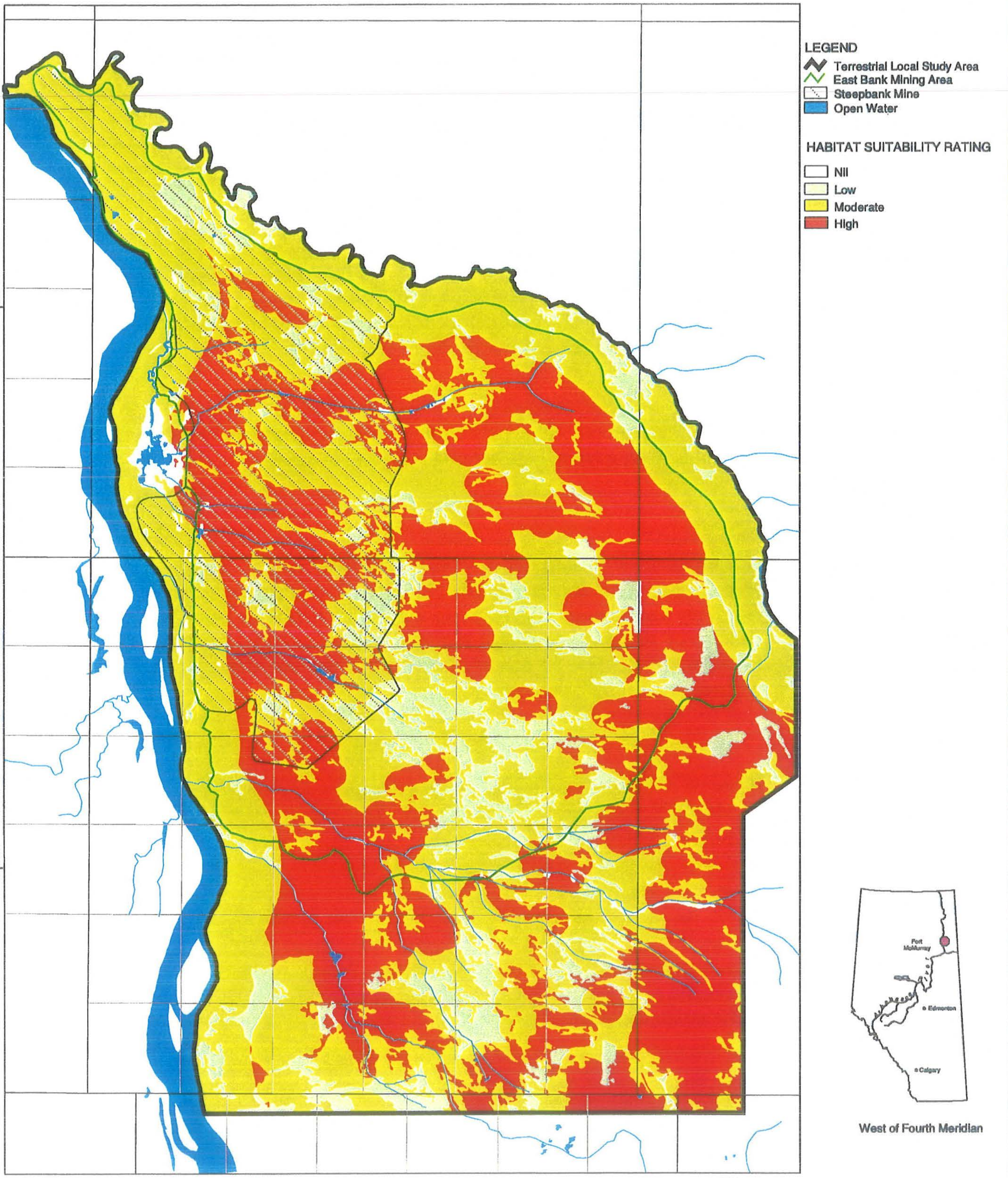
Validity of Linkage

Removal or alteration of vegetation communities will occur as part of project development. The maximum area to be disturbed through clearing for the Project is 9,420 ha, or 58% of the LSA.

While these totals are not expected to ever exist simultaneously on the LSA due to the phased approach of development, the figures represent the total amount of land that will be disturbed over time. This resulted in a conservative assessment of the impacts of the Project. Change in habitat due to removal or alteration of vegetation communities is a valid linkage for all KIRs, as discussed below.

Moose

Moose habitat within the LSA, taking into account disturbance, is currently composed of 489 HUs (5%) of low quality habitat, 3,933 HUs (41%) of moderate quality habitat and 5,193, HUs (54%) of high quality habitat (Figure D5.2-2). The overall suitability of the LSA (total number of HUs divided by total number of ha) for moose is 59%, or 9,614 HUs. Direct habitat loss is projected to affect moose habitat by removing some 59% of the HUs present (Table D5.2-3). Fifty-eight percent of low, 57% of moderate and 61% of high quality habitat will be lost due to site clearing.



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Project Millennium
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LOCAL STUDY AREA
MOOSE HABITAT SUITABILITY
BASELINE SCENARIO

07 Apr. 1998	Figure D5.2-2	PRODUCED BY: CGA REVIEWED BY:

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Table D5.2-3 Habitat Losses Associated With Project Millennium Development and the Change due to Reclamation Post Mining Within the LSA

Species or Taxa	Habitat Rating	Baseline Habitat Units	Total Loss or Gain (%)	Total Change After Reclamation (%)[a]
Moose	Low	489	-58.3	-39.4
	Medium	3,933	-56.5	-29.7
	High	5,193	-60.9	49.5
	Total	9,614	-59.0	12.6
Fisher	Low	161	-22.6	2.8
	Medium	3,583	-52.9	-18.7
	High	7,063	-65.9	-2.2
	Total	10,807	-60.9	-7.6
Black bear	Low	1,107	-46.7	-42.6
	Medium	3,915	-64.0	-31.7
	High	1,847	-49.9	193.2
	Total	6,869	-57.4	27.0
Beaver	Low	20	-0.2	-39.2
	Medium	282	-37.9	-14.3
	High	970	-31.6	-3.4
	Total	1,273	-32.5	-6.4
Red-backed vole	Low	12	-19.7	-18.9
	Medium	5,243	-65.7	-55.6
	High	6,055	-48.2	62.5
	Total	11,310	-56.3	7.6
Snowshoe hare	Low	21	-26.1	238.1
	Medium	171	-0.2	31.1
	High	14,234	-59.6	-9.3
	Total	14,426	-58.9	-8.4
Dabbling ducks	Low	509	-37.4	7.4
	Medium	338	-31.1	184.1
	High	705	-20.2	43.2
	Total	1,552	-28.2	62.1
Ruffed grouse	Low	2,357	-63.7	-57.2
	Medium	1,070	-46.1	26.8
	High	3,258	-49.4	100.7
	Total	6,685	-53.9	33.2
Cape May warbler	Low	1,269	-64.4	-12.8
	Medium	2,324	-64.4	-62.1
	High	963	-34.1	79.5
	Total	4,556	-58.0	-18.4
Western tanager	Low	715	-57.5	10.6
	Medium	435	-47.0	66.1
	High	1,779	-38.7	157.8
	Total	2,929	-44.5	108.3
Pileated woodpecker	Low	1,761	-67.3	-65.8
	Medium	693	-43.2	46.1
	High	3,820	-47.5	83.5
	Total	6,274	-52.6	37.5
Great gray owl	Low	2,608	-65.1	-47.1
	Medium	2,013	-38.5	98.2
	High	2,344	-69.5	-51.2
	Total	6,965	-58.9	-6.5
Mammal richness	Low	81	-30.8	300.8
	Medium	1,869	-53.3	-15.5
	High	11,469	-60.4	-8.2
	Total	13,441	-59.2	-7.3
Bird richness	Low	47	-42.8	-38.0
	Medium	3,347	-49.2	42.8
	High	9,602	-63.9	-32.7
	Total	12,996	-60.1	-13.3
Amphibian richness	Low	0	0.0	0.0
	Medium	2,863	-45.9	79.1
	High	10,108	-64.8	-52.9
	Total	12,971	-60.6	-23.8

[a] % change from baseline

Based on habitat modelling, the project area supports a high percentage of high-moderate habitat suitability for this species. Habitat loss, alteration and fragmentation through a variety of mechanisms are predicted to have an impact on moose. Thus, the linkage is valid for moose. The difficulty with this prediction is that, while the local population change by displacement may be measurable, depending on the scale of habitat loss, changes over the longer term in the regional population may be subtle and immeasurable.

Moose habitat within the RSA, taking into account existing disturbance, is currently composed of 32,693 HUs (2%) of low quality habitat, 541,119 HUs (35%) of moderate quality habitat, and 962,098 HUs (63%) of high quality habitat. The overall suitability of the RSA (total number of HUs divided by the total number ha) for moose is 63%, or 1,535,910 HUs. Regionally, direct habitat loss is not projected to affect moose habitat. One percent of low, 0% of moderate and 0% of high quality habitat will be lost due to site clearing (Table D5.2-4).

Fisher

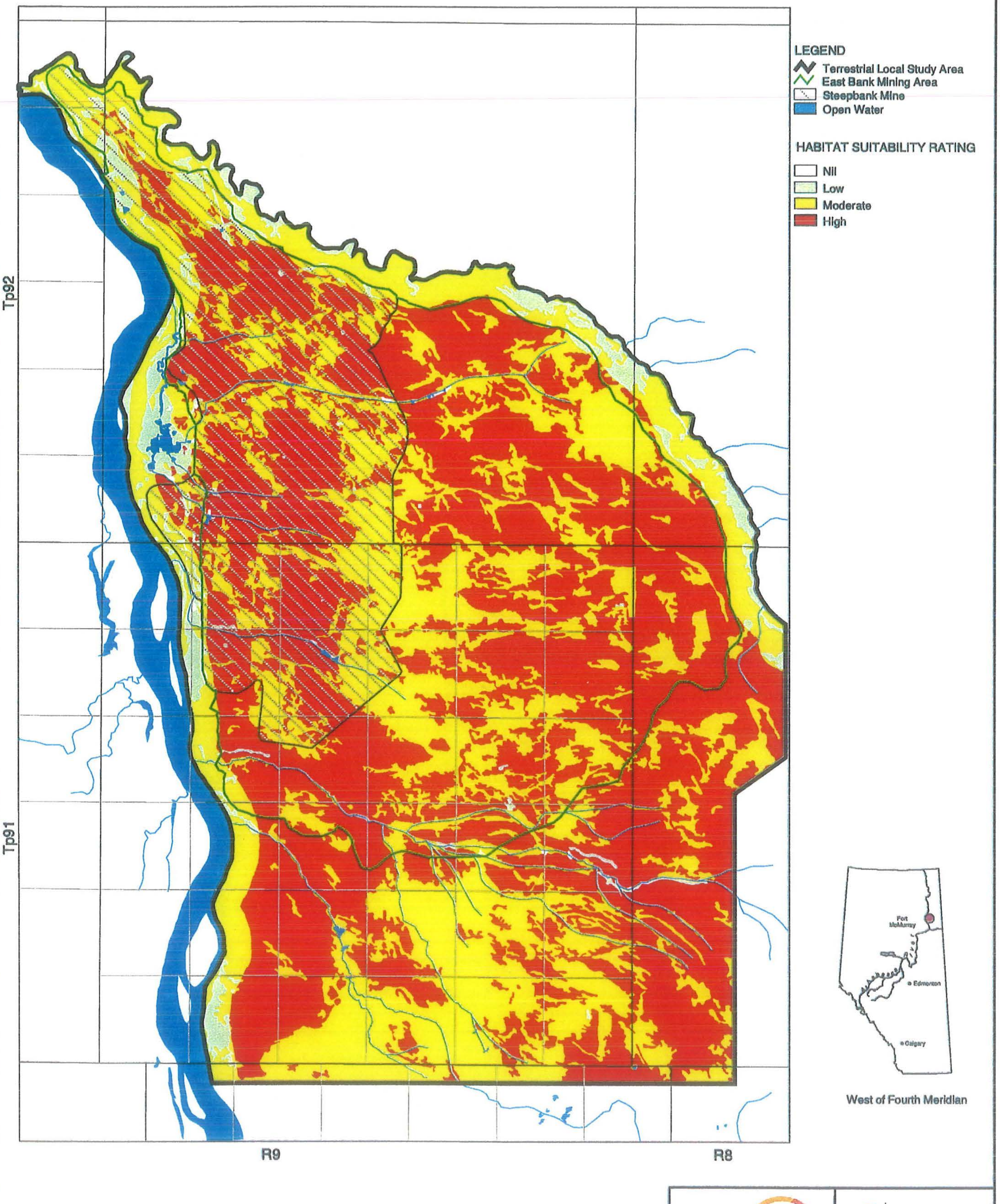
Fisher habitat within the LSA is currently composed of 161 HUs (2%) of low quality habitat, 3,583 HUs (33%) of moderate quality habitat and 7,063 HUs (65%) of high quality habitat. (Figure D5.2-3). The overall suitability of the LSA (total number of HUs divided by total number of ha) for fishers is 67%, or 10,807 HUs. Direct habitat loss is projected to affect fisher habitat by removing some 61% of the HUs present (Table D5.2-3). Twenty-three percent of low, 53% of moderate and 66% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a high percentage of high-moderate habitat suitability for this species. Fishers are sensitive to habitat loss, alteration and fragmentation, and the Project will have an initial negative impact on fisher populations in the LSA. The linkage is valid for fishers.

Fisher habitat within the RSA, taking into account existing disturbances is currently composed of 38,312 HUs (3%) of low quality habitat, 319,519 HUs (21%) of moderate quality habitat, and 1,150,654 HUs (76%) of high quality habitat. The overall suitability of the RSA for fisher is 62%, or 1,508,485 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect fisher habitat. Zero percent of low, medium and high quality habitat will be lose due to site clearing (Table D5.2-4).

Table D5.2-4 Habitat Loss Associated With Project Millennium Development Within the RSA

Species or Taxa	Habitat Class	RSA Baseline (Hus)	Project Millennium (HU Loss or Gain)	Project Millennium (% Loss or Gain)
Moose	Low	32,963	-191	-0.6
	Medium	541,119	-1,253	-0.2
	High	962,098	-1,990	-0.2
	Total	1,535,910	-3,433	-0.2
Fisher	Low	38,312	-0	-0.0
	Medium	319,519	-1,058	-0.3
	High	1,150,654	-2,987	-0.3
	Total	1,508,485	-4,045	-0.3
Black bear	Low	18,198	-333	-1.8
	Medium	643,101	-1,435	-0.2
	High	585,979	-532	-0.1
	Total	1,247,278	-2,300	-0.2
Beaver	Low	26,239	+2	+0.0
	Medium	38,927	-47	-0.1
	High	126,879	-73	-0.1
	Total	192,045	-117	-0.1
Red-backed vole	Low	18,114	-1	-0.0
	Medium	145,293	-2,310	-1.6
	High	1,516,136	-1,312	-0.1
	Total	1,679,543	-3,623	-0.2
Snowshoe hare	Low	59,535	-2	-0.0
	Medium	267,972	+24	+0.0
	High	1,311,086	-5,137	-0.4
	Total	1,638,593	-5,115	-0.3
Dabbling ducks	Low	64,410	-55	-0.1
	Medium	108,246	-25	-0.0
	High	92,395	-19	-0.0
	Total	265,051	-99	-0.0
Ruffed grouse	Low	383,674	-985	-0.3
	Medium	28,436	-243	-0.9
	High	353,435	-711	-0.2
	Total	765,545	-1,938	-0.3
Cape May warbler	Low	33,321	-544	-1.6
	Medium	551,920	-815	-0.1
	High	317,959	-186	-0.1
	Total	903,110	-1,545	-0.2
Western tanager	Low	75,118	-251	-0.3
	Medium	75,083	-71	-0.1
	High	512,049	-232	-0.0
	Total	662,250	-554	-0.1
Pileated woodpecker	Low	239,171	-779	-0.3
	Medium	81,405	-124	-0.2
	High	461,719	-855	-0.2
	Total	782,295	-1,758	-0.2
Great gray owl	Low	112,509	-1,209	-1.1
	Medium	290,562	-509	-0.2
	High	1,107,479	-319	-0.0
	Total	1,510,550	-2,037	-0.1
Mammal richness	Low	18,698	-19	-0.2
	Medium	440,769	-722	-0.7
	High	1,391,750	-3,994	-1.2
	Total	1,851,217	-4,735	-1.1
Bird richness	Low	0	+0	+0.0
	Medium	790,290	-771	-0.6
	High	896,206	-4,012	-1.5
	Total	1,686,496	-4,783	-1.1
Amphibian richness	Low	0	+0	+0.0
	Medium	471,382	-561	-1.0
	High	1,354,965	-4,303	-1.0
	Total	1,826,347	-4,864	-1.0



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LOCAL STUDY AREA
FISHER HABITAT SUITABILITY
BASELINE SCENARIO

07 Apr. 1998

Figure D5.2-3

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Black Bear

Black bear habitat within the LSA is currently composed of 1,107 HUs (16%) of low quality habitat, 3,915 HUs (57%) of moderate quality habitat and 1,847 HUs (27%) of high quality habitat (Figure D5.2-4). The overall suitability of the LSA (total number of HUs divided by total number of ha) for black bears is 42%, or 6,869 HUs. Direct habitat loss is projected to affect bear habitat by removing some 57% of the HUs present (Table D5.2-3). Forty-seven percent of low, 64% of moderate and 50% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a moderate percentage of high-moderate habitat suitability for this species. Habitat loss, habitat alteration, and habitat fragmentation as a result of this project will have an effect on bears. Bears will be displaced from moderate to high quality habitat, and this, in turn, may lower survival and reduce reproductive success. Thus, the linkage is valid for black bears.

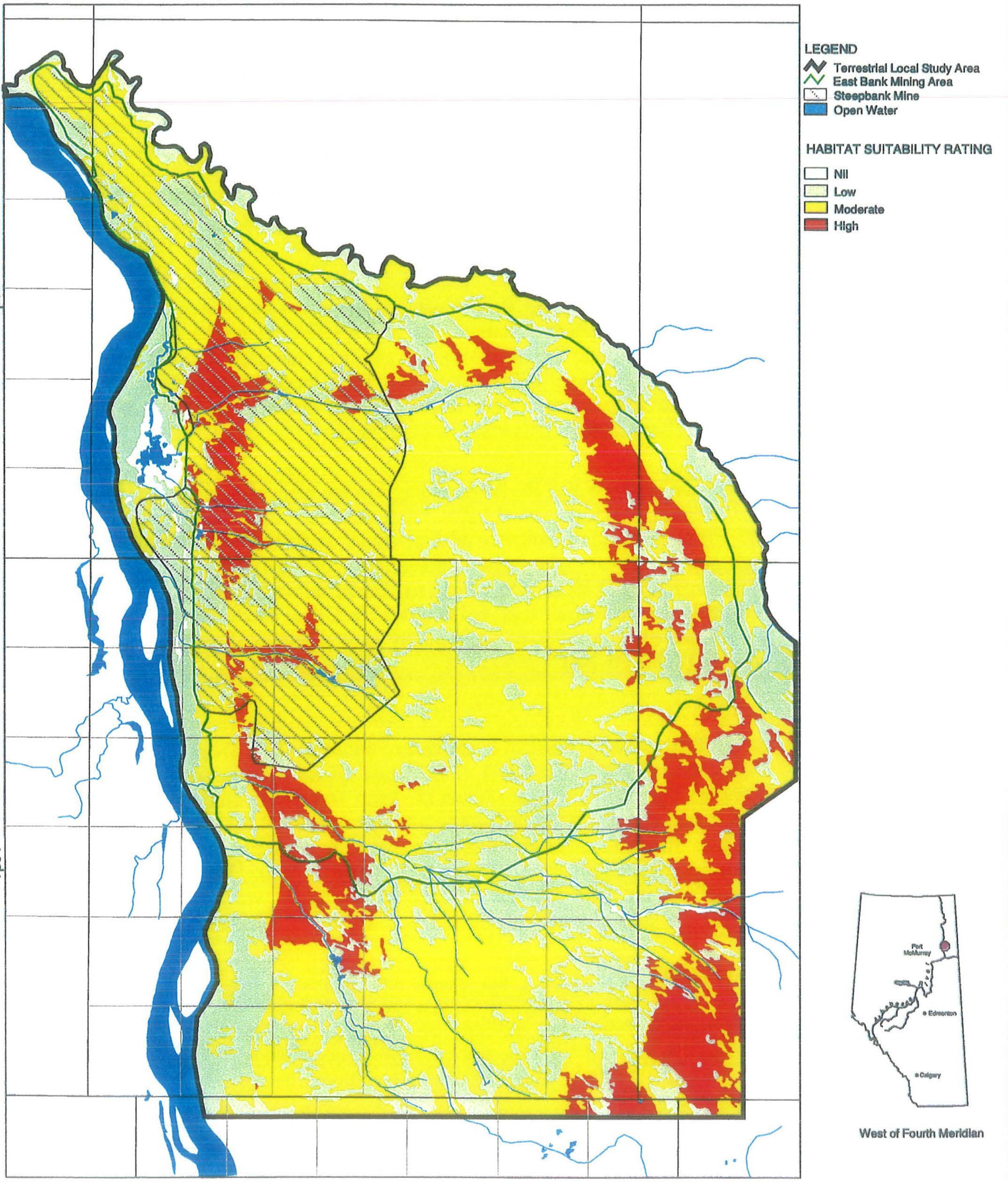
Black bear habitat within the RSA, taking into account existing disturbances is currently composed of 18,198 HUs (1%) of low quality habitat, 643,101 HUs (52%) of moderate quality habitat, and 585,979 HUs (49%) of high quality habitat. The overall suitability of the RSA for black bear is 51%, or 1,247,278 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect black bear habitat as 2% of low, 0% of moderate, and 0% of high quality habitat will be lose due to site clearing (Table D5.2-4).

Beaver

Beaver habitat within the LSA is currently composed of 20 HUs (2%) of low quality habitat, 282 HUs (22%) of moderate quality habitat and 970 HUs (76%) of high quality habitat (Figure D5.2.5). The overall suitability of the LSA (total number of HUs divided by total number of ha) for beavers is 8%, or 1,273 HUs. Direct habitat loss is projected to impact beaver habitat by removing some 33% of the HUs present (Table D5.2-3). Zero percent of low, 38% of moderate and 32% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for this species. Habitat loss, alteration and fragmentation from site grading, site drainage and stream diversions (Section C2) can all be expected to have a negative impact on beaver populations in the LSA. Thus, the linkage is valid for beavers.

Beaver habitat within the RSA, taking into account existing disturbances is currently composed of 26,239 HUs (14%) of low quality habitat, 38,927 HUs (20%) of moderate quality habitat, and 126,879 HUs (66%) of high quality habitat. The overall suitability of the RSA for beaver is 8%, or 192,045 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect beaver habitat (Table D5.2-4).



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LOCAL STUDY AREA
BLACK BEAR HABITAT SUITABILITY
BASELINE SCENARIO

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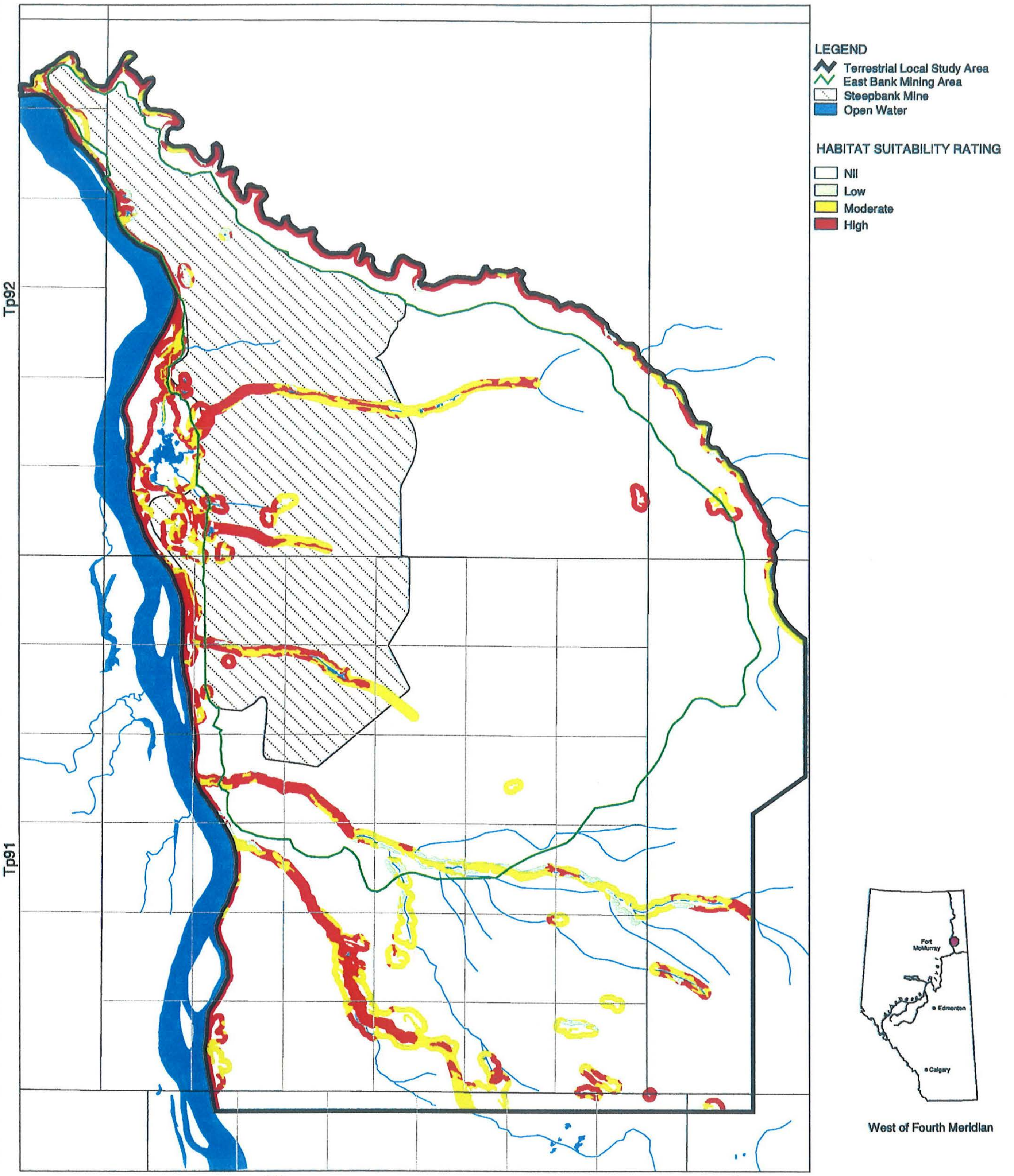

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LOCAL STUDY AREA
BEAVER HABITAT SUITABILITY
BASELINE SCENARIO

07 Apr. 1998

Figure D5.2-5

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Red-Backed Vole

Red-backed vole habitat within the LSA is currently composed of 12 HUs (0%) of low quality habitat, 5,243 HUs (46%) of moderate quality habitat and 6,055 HUs (54%) of high quality habitat (Figure D5.2-6). The overall suitability of the LSA (total number of HUs divided by total number of ha) for red-backed voles is 70%, or 11,310 HUs. Direct habitat loss is projected to affect vole habitat by removing some 56% of the HUs present (Table D5.2-3). Twenty percent of low, 66% of moderate and 48% of high quality habitat will be lost due to clearing.

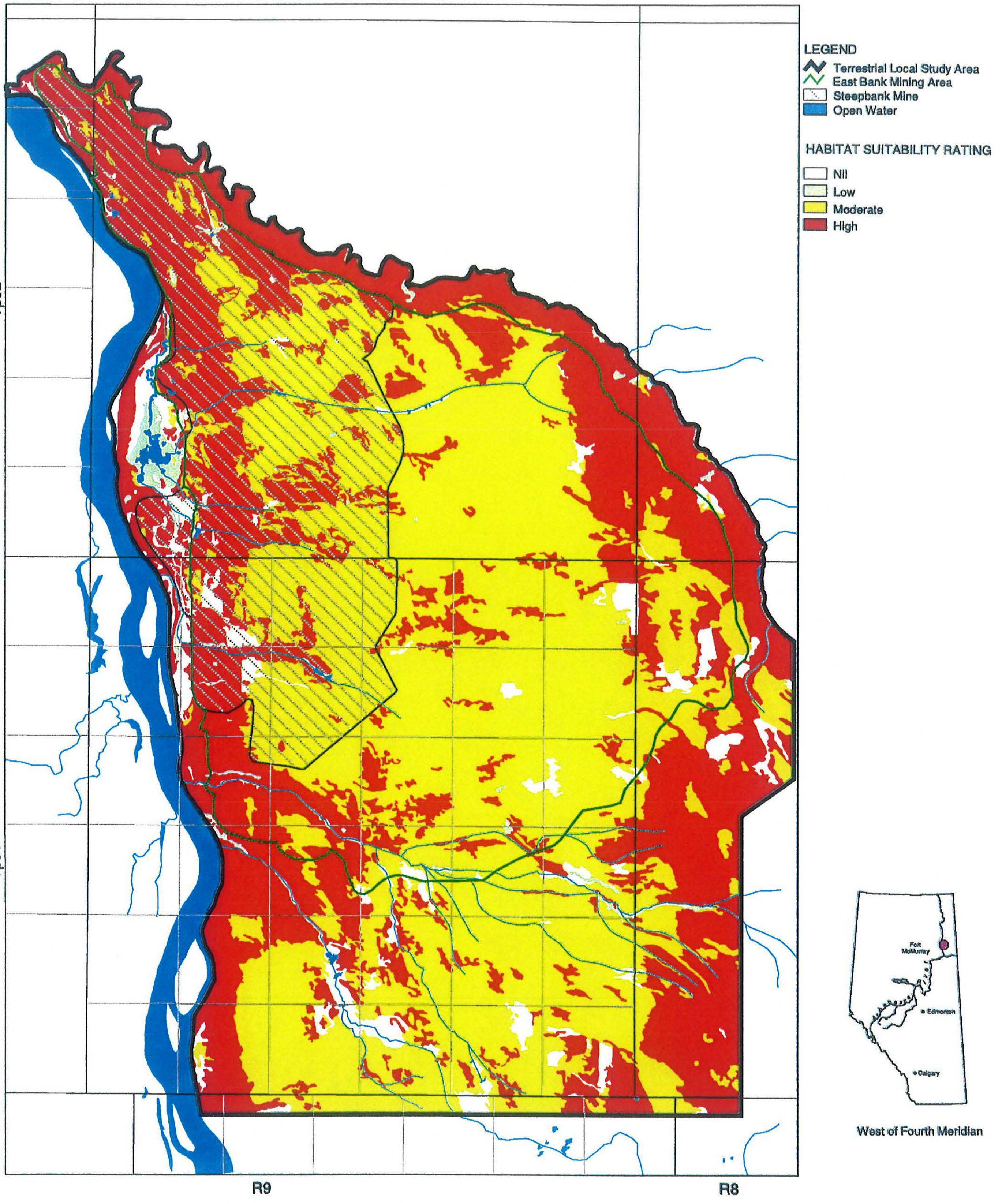
Based on habitat modelling, the project area supports a high percentage of high-moderate habitat suitability for this species. Thus, the proposed development will have an impact on red-backed voles. The impact will be approximately in proportion to the spatial extent of habitat lost because these small mammals do not have the ability to disperse ahead of construction activities. The linkage is valid for red-backed voles.

Red-backed vole habitat within the RSA, taking into account existing disturbances is currently composed of 18,114 HUs (1%) of low quality habitat, 145,293 HUs (9%) of moderate quality habitat, and 1,516,136 HUs (90%) of high quality habitat. The overall suitability of the RSA for red-backed voles is 69%, or 1,679,543 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect red-backed vole habitat, as 0% percent of low, 2% of moderate and 0% of high quality habitat will be lose due to site clearing (Table D5.2-4).

Snowshoe Hare

Snowshoe hare habitat within the LSA is currently composed of 21 HUs (0%) of low quality habitat, 171 HUs (1%) of moderate quality habitat and 14,234 HUs (99%) of high quality habitat (Figure D5.2-7). The overall suitability of the LSA (total number of HUs divided by total number of ha) for snowshoe hares is 89%, or 14,426 HUs. Direct habitat loss is projected to affect hare habitat by removing some 59% of the HUs present (Table D5.2-3). Twenty-six percent of low, 0% of moderate and 60% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a high percentage of high-moderate habitat suitability for this species. Habitat loss, alteration and fragmentation as a result of development will have an impact on snowshoe hares. Due to the limited ability of small mammals to disperse ahead of construction activities, habitat loss can be expected to affect abundance in approximate proportion to the amount of habitat lost. Prospects for individuals that can disperse ahead of land clearing are speculative, based on the uncertainty of finding suitable habitat conditions for food, shelter and security from predators. The linkage is valid for snowshoe hares.



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LOCAL STUDY AREA
RED-BACKED VOLE HABITAT SUITABILITY
BASELINE SCENARIO

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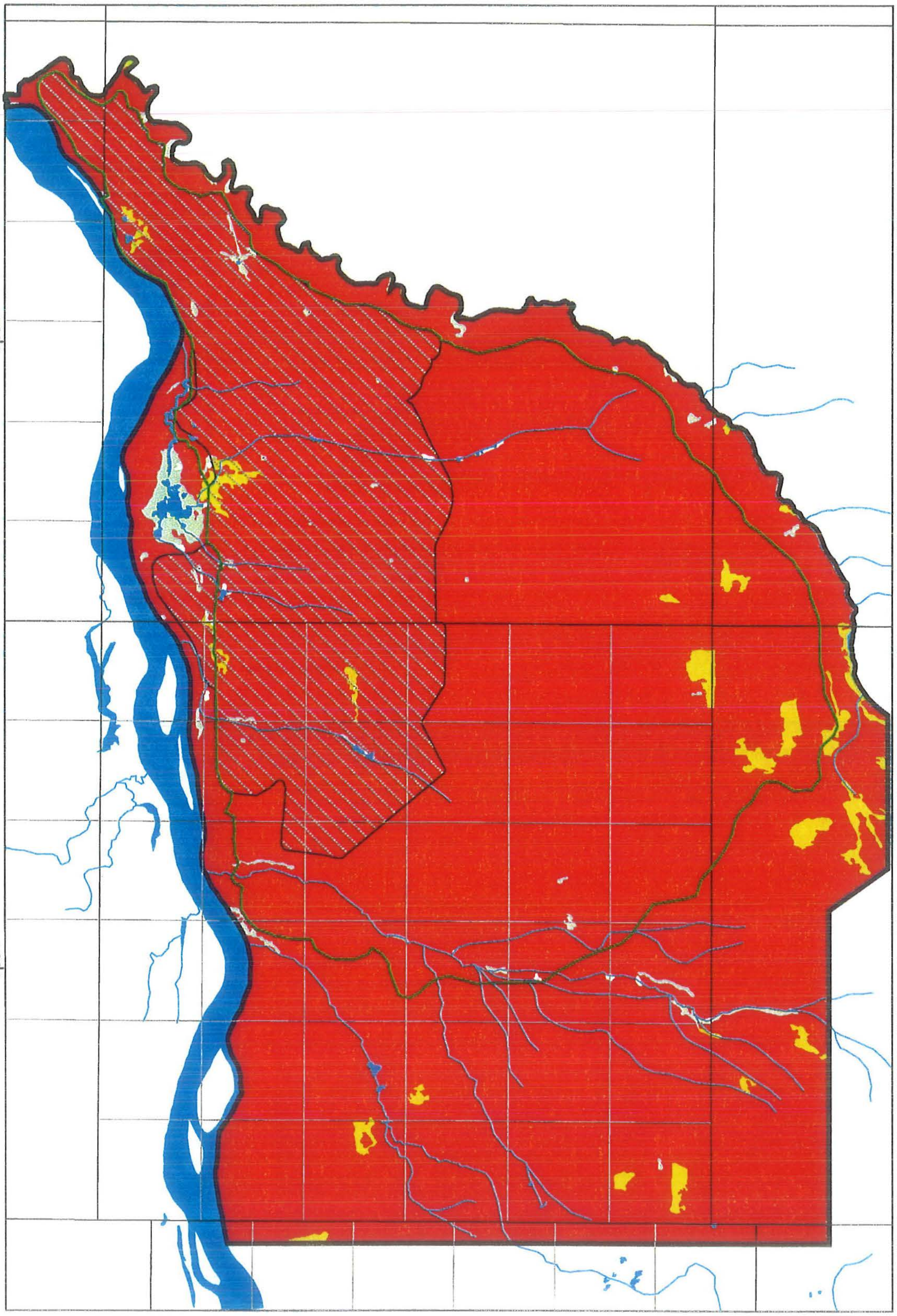

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LOCAL STUDY AREA
SNOWSHOE HARE HABITAT SUITABILITY
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Snowshoe hare habitat within the RSA, taking into account existing disturbances, is currently composed of 59,535 HUs (4%) of low quality habitat, 267,972 HUs (16%) of moderate quality habitat, and 1,311,086 HUs (80%) of high quality habitat. The overall suitability of the RSA for snowshoe hare is 67%, or 1,638,593 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect snowshoe hare habitat, as negligible amounts of suitable habitat will be lose due to site clearing (Table D5.2-4).

Dabbling Ducks

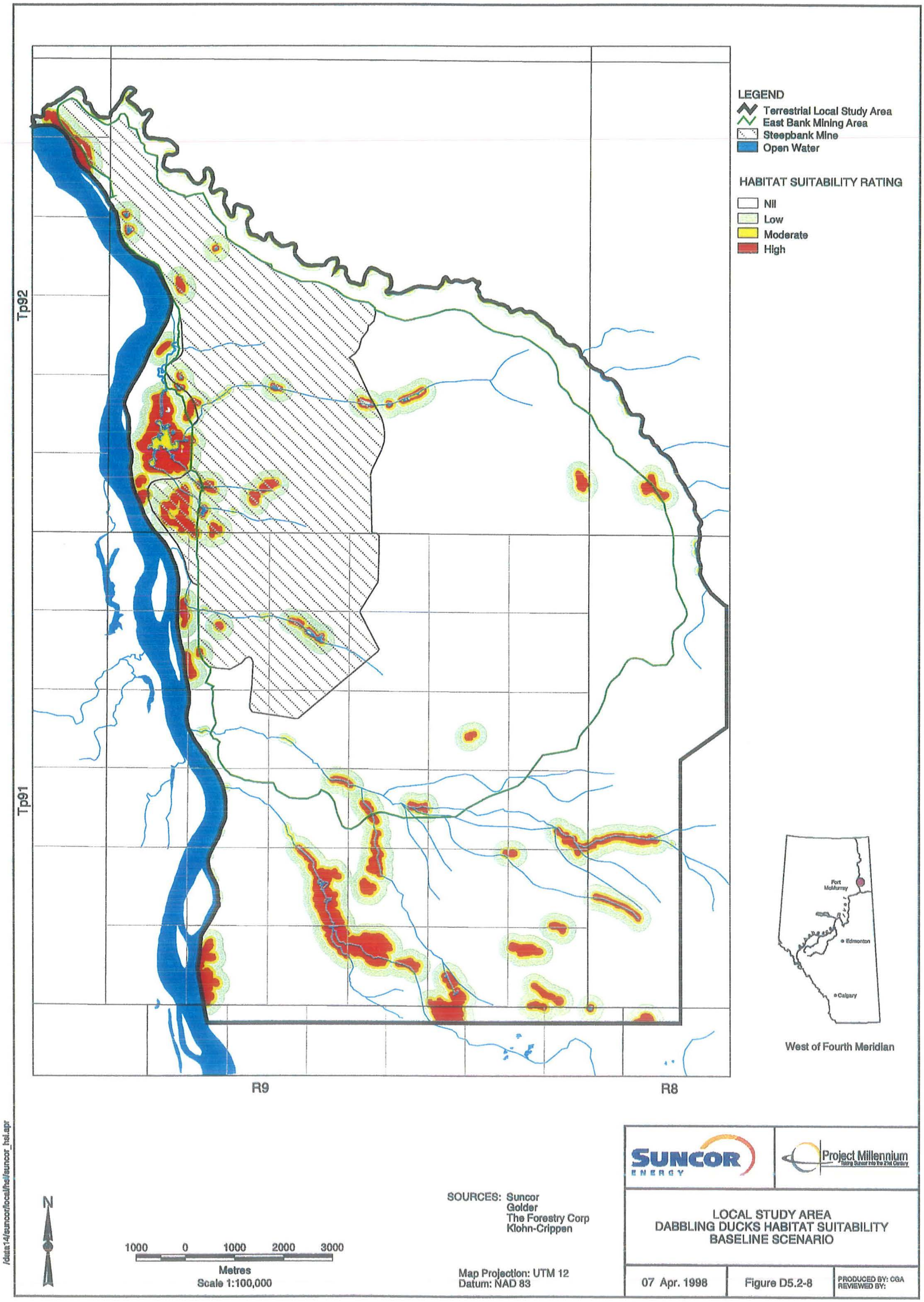
Dabbling duck habitat within the LSA is currently composed of 509 HUs (33%) of low quality habitat, 338 HUs (22%) of moderate quality habitat and 705 HUs (45%) of high quality habitat (Figure D5.2-8). The overall suitability of the LSA (total number of HUs divided by total number of ha)for dabbling ducks is 10%, or 1,552 HUs. Direct habitat loss is projected to affect duck habitat by removing some 28% of the HUs present (Table D5.2-3). Thirty-seven percent low, 31% of moderate and 20% of high quality habitat will be lost due to clearing.

Dabbling ducks are limited by suitable aquatic habitats, and high quality duck habitat is limited within the LSA. Shipyard Lake and the Athabasca River, two important water bodies for waterfowl within the LSA, will not be affected by site clearing. Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for ducks. Details on changes to habitat available for dabbling ducks within the LSA are provided in Golder (1998o). Habitat loss, alteration and fragmentation from site grading, site drainage and stream diversions will reduce the amount of aquatic habitat available for ducks. Thus, these impacts will have a negative effect on dabbling duck populations by reducing overall carrying capacity. The linkage is valid for dabbling ducks.

Dabbling duck habitat within the RSA, taking into account existing disturbances, is currently composed of 64,410 HUs (24%) of low quality habitat, 108,246 HUs (41%) of moderate quality habitat, and 92,395 HUs (35%) high quality habitat. The overall suitability of the RSA for dabbling ducks is 11%, or 265,051 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect dabbling duck habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Ruffed Grouse

Ruffed grouse habitat within the LSA is currently composed of 2,357 HUs (35%) of low quality habitat, 1070 HUs (16%) of moderate quality habitat and 3,258 HUs (49%) of high quality habitat (Figure D5.2-9). The overall suitability of the LSA (total number of HUs divided by total number of ha)



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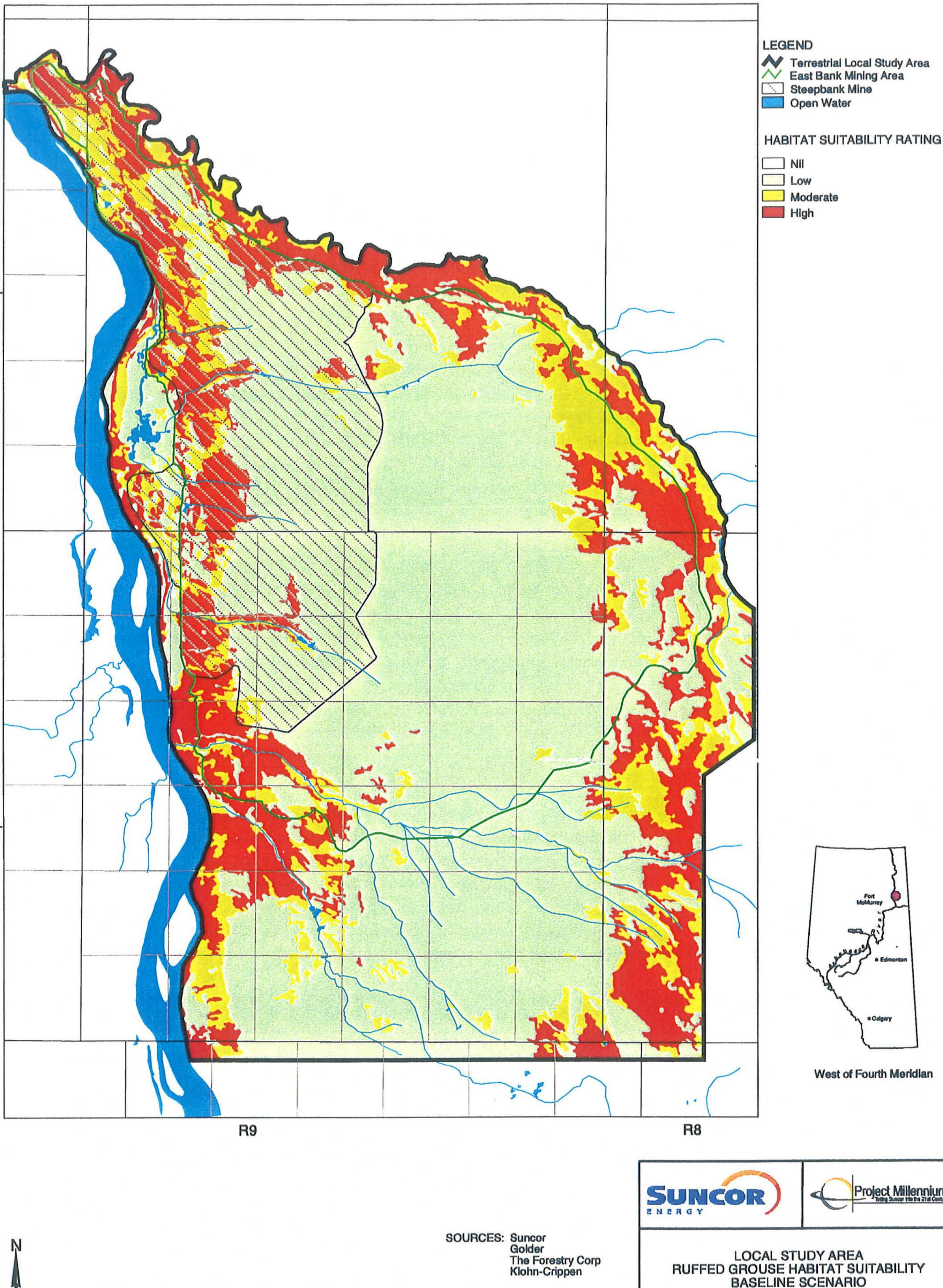

SOURCES: Suncor
Golder
The Forestry Corp
Klohn-Crippen

Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
RUFFED GROUSE HABITAT SUITABILITY
BASELINE SCENARIO

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for ruffed grouse is 41%, or 6,685 HUs. Direct habitat loss is projected to impact grouse habitat by removing some 54% of the HUs present (Table D5.2-3). Sixty-four percent of low, 46% of moderate and 49% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for this species. Loss of high to moderate habitat suitability from the LSA, and associated alteration and fragmentation accompanying the proposed development can be expected to have a negative impact on ruffed grouse by reducing the overall carrying capacity of the LSA. The linkage is valid for ruffed grouse.

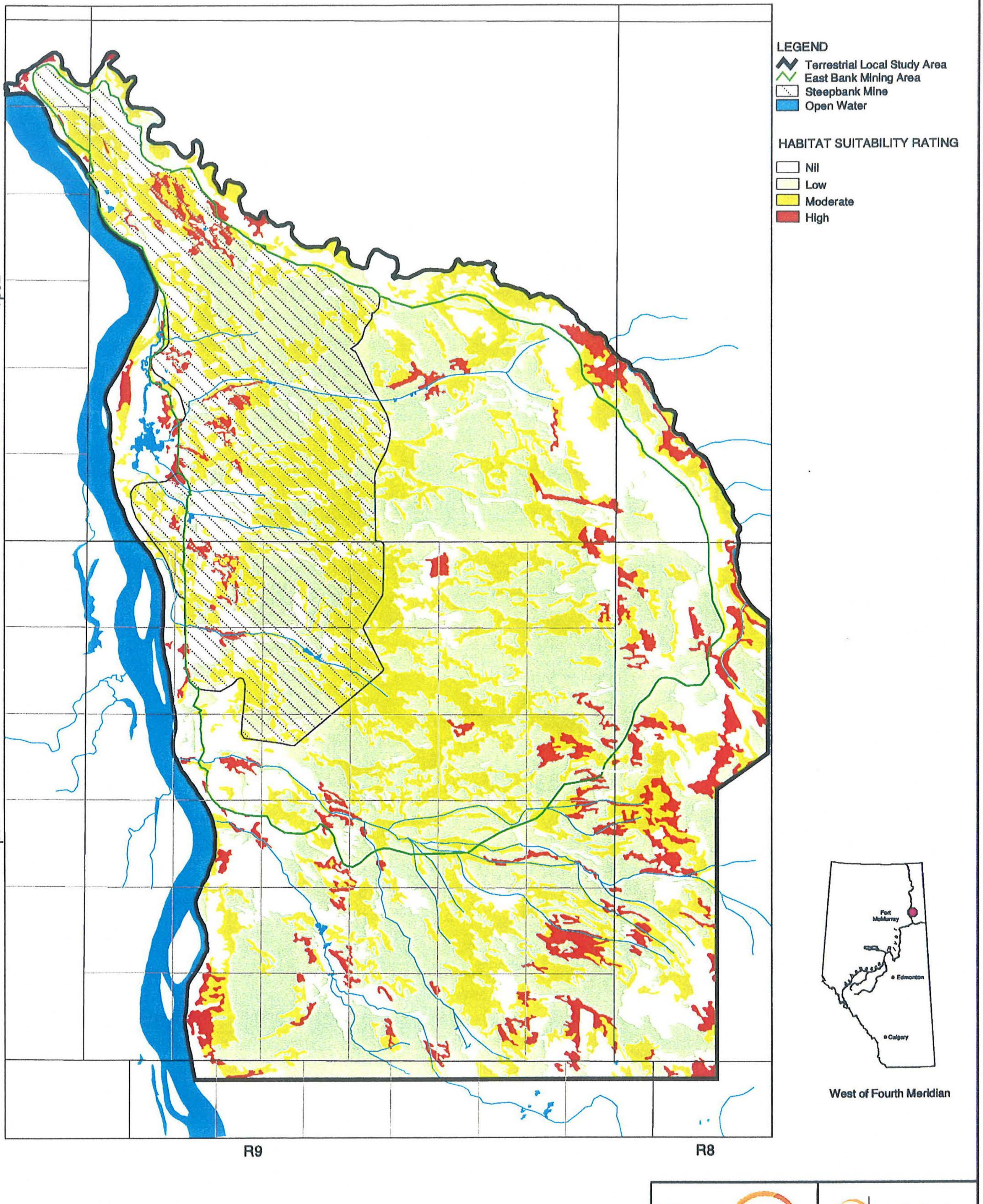
Dabbling duck habitat within the RSA, taking into account existing disturbances, is currently composed of 64,410 HUs (24%) of low quality habitat, 108,246 HUs (41%) of moderate quality habitat, and 92,395 HUs (35%) high quality habitat. The overall suitability of the RSA for dabbling ducks is 11%, or 265,051 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect dabbling duck habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Cape May Warbler

Cape May warbler habitat within the LSA is currently composed of 1,269 HUs (28%) of low quality habitat, 2,324 HUs (51%) of moderate quality habitat and 963 HUs (21%) of high quality habitat (Figure D5.2-10). The overall suitability of the LSA (total number of HUs divided by total number of ha) for Cape May warblers is 28%, or 4,556 HUs. Direct habitat loss is projected to affect warbler habitat by removing some 58% of the HUs present (Table D5.2-3). Sixty-four percent of low, 64% of moderate and 34% of high quality habitat will be lost due to clearing.

Based on habitat modelling that indicates the project area supports limited quantities of high to moderate habitat for this species, habitat loss and alterations from removal of mature coniferous forest overstory can be expected to affect Cape May warbler populations in the LSA. Since old growth white spruce forest is limited within the LSA, any loss of habitat would affect Cape May warblers. The impact will be related to the size and permanence of habitat loss. The linkage is valid for Cape May warblers.

Cape May warbler habitat within the RSA, taking into account existing disturbances, is currently composed of 33,231 HUs (4%) of low quality habitat, 904,110 HUs (61%) of moderate quality habitat, and 317,959 HUs (35%) high quality habitat. The overall suitability of the RSA for Cape May warblers 37%, or 903,110 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect Cape May warbler habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).



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LOCAL STUDY AREA
CAPE MAY WARBLER HABITAT SUITABILITY
BASELINE SCENARIO

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Western Tanager

Western tanager habitat within the LSA is currently composed of 715 HUs (24%) of low quality habitat, 435 HUs (15%) of moderate quality habitat and 1,779 HUs (61%) of high quality habitat (Figure D5.2-11). The overall suitability of the LSA (total number of HUs divided by total number of ha) for western tanagers is 18%, or 2,929 HUs. Direct habitat loss is projected to affect tanager habitat by removing some 45% of the HUs present (Table D5.2-3). Fifty-eight percent of low, 47% of moderate and 39% of high quality habitat will be lost due to clearing.

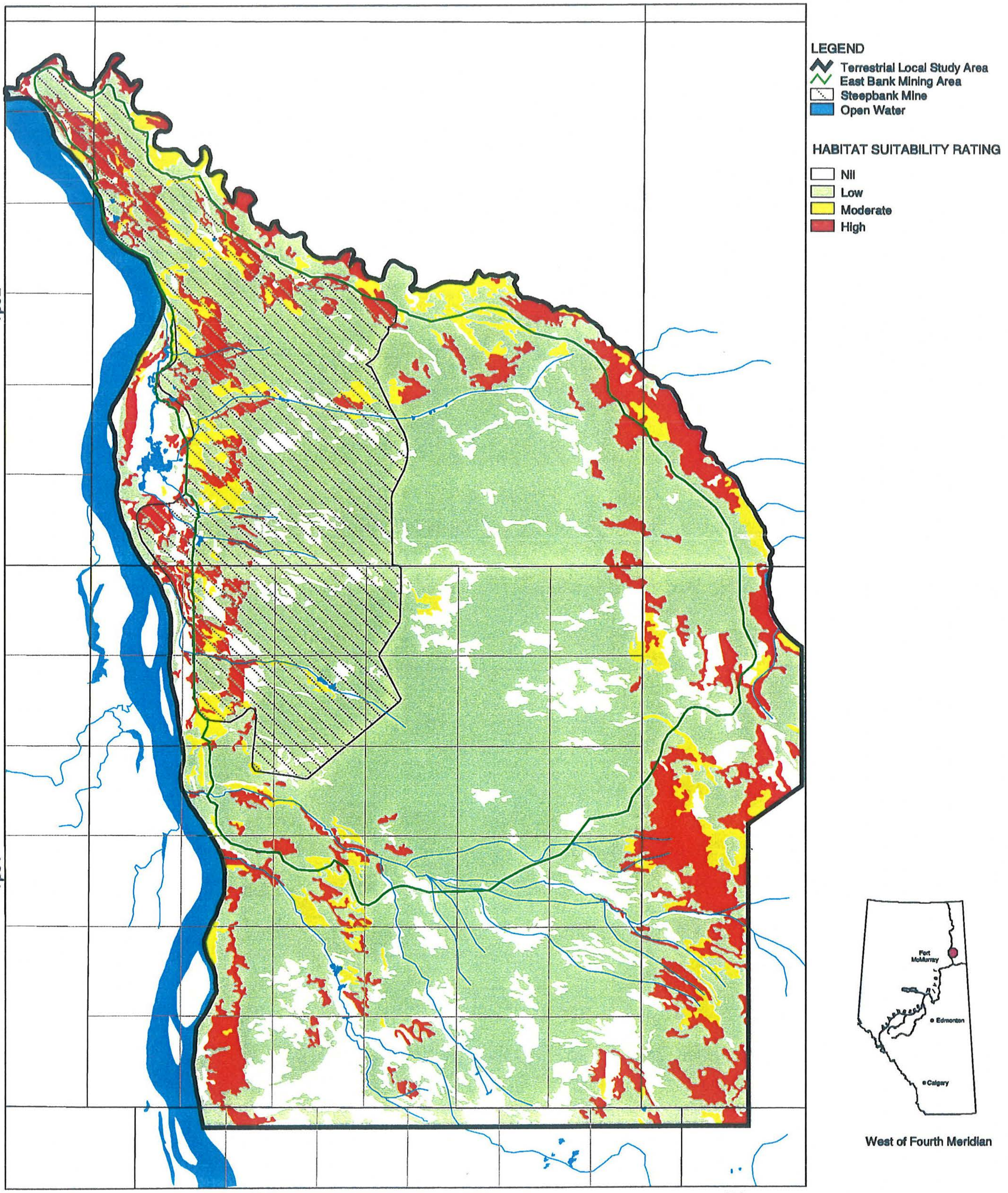
Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for this species. Habitat loss and alteration from removal of mature coniferous forest overstory accompanying the proposed development can be expected to have a negative impact on western tanager populations in the project area. The impact will be related to the size and permanence of habitat loss. The linkage is valid for western tanagers.

Western tanager habitat within the RSA, taking into account existing disturbances, is currently composed of 75,118 HUs (11%) of low quality habitat, 75,083 HUs (12%) of moderate quality habitat, and 512,049 HUs (77%) high quality habitat. The overall suitability of the RSA for western tanagers is 27%, or 662,250 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect western tanager habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Pileated Woodpecker

Pileated woodpecker habitat within the LSA is currently composed of 1,761 HUs (28%) of low quality habitat, 693 HUs (11%) of moderate quality habitat and 3,820 HUs (61%) of high quality habitat (Figure D5.2-12). The overall suitability of the LSA (total number of HUs divided by total number of ha) for pileated woodpeckers is 39%, or 6,274 HUs. Direct habitat loss is projected to impact woodpecker habitat by removing some 53% of the HUs present (Table D5.2-3). Sixty-seven percent of low, 43% of moderate and 48% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for this species. Removal of large blocks of habitat including large-diameter nest and roost trees will result in negative impact on pileated woodpecker populations in the LSA. The linkage is valid for pileated woodpeckers.



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Project Millennium

LOCAL STUDY AREA
WESTERN TANAGER HABITAT SUITABILITY
BASELINE SCENARIO

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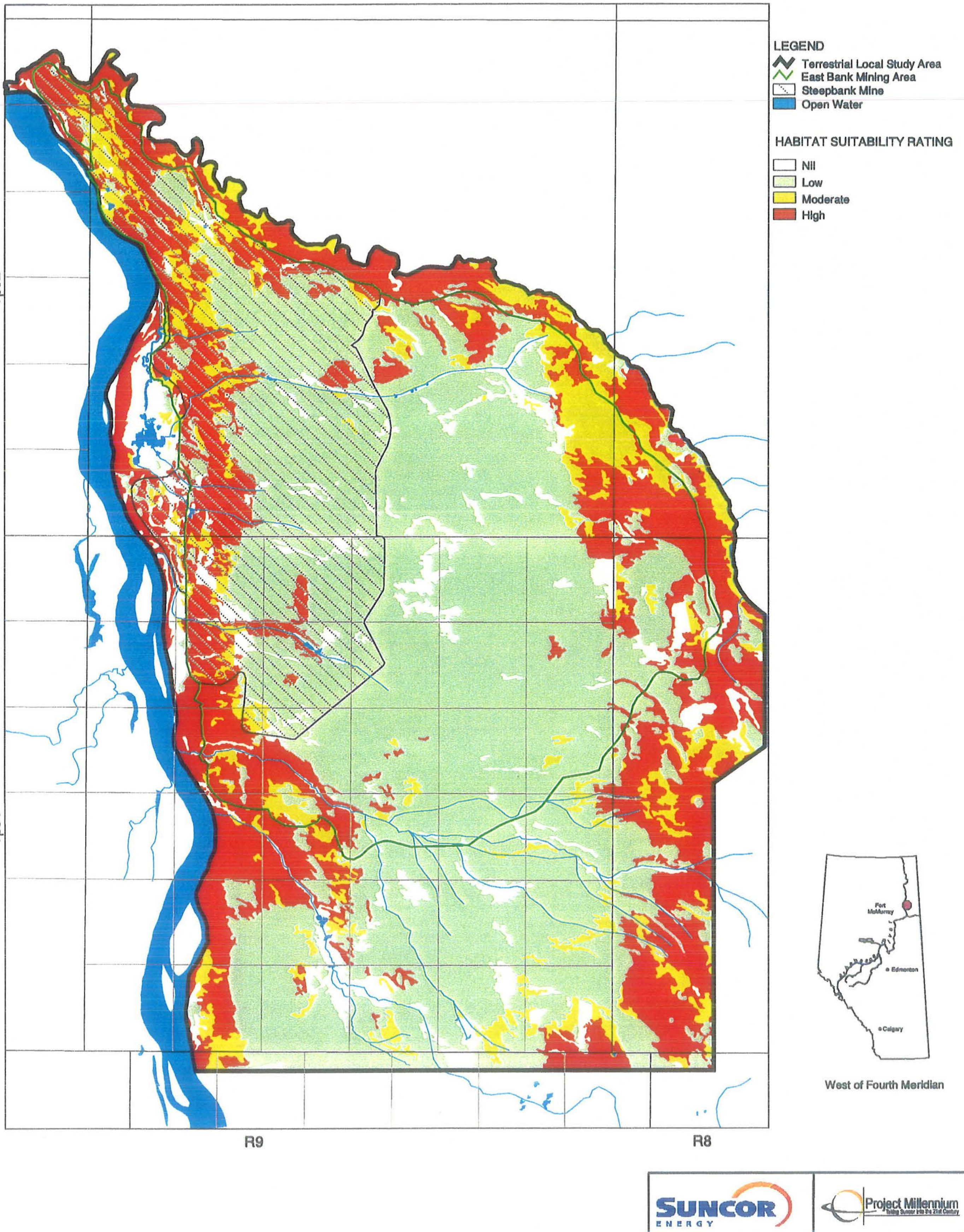

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SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
PILEATED WOODPECKER HABITAT SUITABILITY
BASELINE SCENARIO

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Pileated woodpecker habitat within the RSA, taking into account existing disturbances, is currently composed of 239,171 HUs (31%) of low quality habitat, 81,405 HUs (10%) of moderate quality habitat, and 92,395 Hus (59%) high quality habitat. The overall suitability of the RSA for pileated woodpeckers is 32%, or 782,295 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect pileated woodpecker habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Great Gray Owl

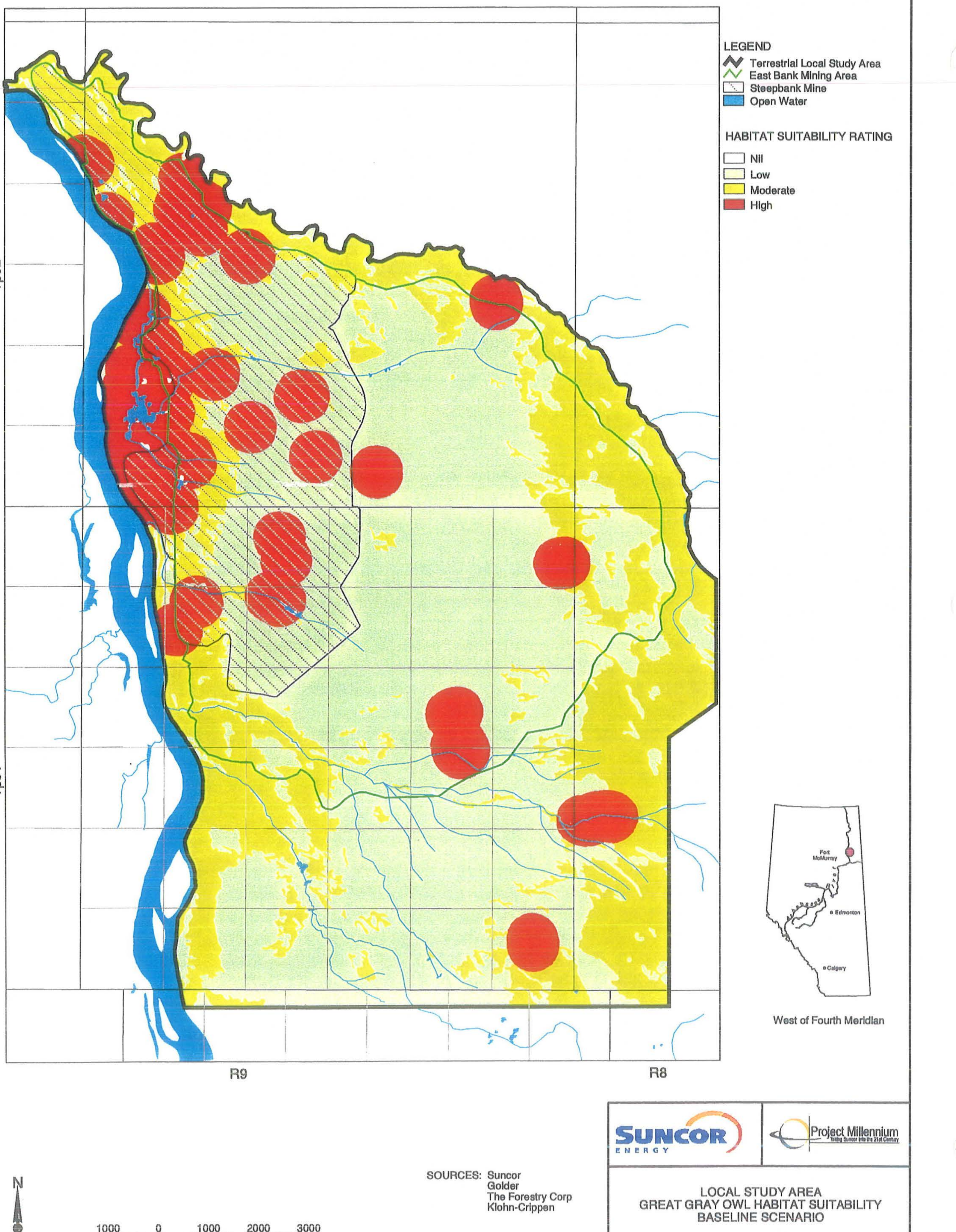
Great gray owl habitat within the LSA is currently composed of 2,608 HUs (37%) of low quality habitat, 2,013 HUs (29%) of moderate quality habitat and 2,344 HUs (34%) of high quality habitat (Figure D5.2-13). The overall suitability of the LSA (total number of HUs divided by total number of ha) for great gray owls is 43%, or 6,965 HUs. Direct habitat loss is projected to affect owl habitat by removing some 59% of the HUs present (Table D5.2-3) Sixty-five-five percent of low, 39% of moderate and 70% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports a low percentage of high-moderate habitat suitability for this species. Great gray owls are sensitive to habitat loss, alteration and fragmentation. The Project can therefore be expected to have a negative impact on great gray owl populations in the LSA. The linkage is valid for great gray owls.

Great gray owl habitat within the RSA, taking into account existing disturbances, is currently composed of 112,509 HUs (7%) of low quality habitat, 290,562 HUs (19%) of moderate quality habitat, and 1,107,479 HUs (73%) high quality habitat. The overall suitability of the RSA for great gray owls is 63%, or 1,510,550 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect great gray owl habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Diversity

Mammal richness habitat within the LSA is currently composed of 81 HUs (1%) of low quality habitat, 1,869 HUs (14%) of moderate quality habitat, and 11,491 HUs (86%) of high quality habitat. The overall suitability of the LSA (total number of HUs divided by the total number of ha) for mammal richness is 83%, or 13,441 HUs. Direct habitat loss is projected to affect habitat for mammal richness by removing some 59% of the HUs present (Table D5.2-3). Thirty-one percent of low, 53% of moderate, and 60% of high quality habitat will be lost due to clearing.



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LOCAL STUDY AREA
GREAT GRAY OWL HABITAT SUITABILITY
BASELINE SCENARIO

07 Apr. 1998	Figure D5.2-13	PRODUCED BY: CGA REVIEWED BY:

Habitat for bird richness within the LSA is currently composed of 47 HUs (0%) of low quality habitat, 3,347 HUs (26%) of moderate quality habitat, and 9,602 HUs (74%) of high quality habitat. The overall suitability of the LSA (total number of HUs divided by the total number of ha) for bird richness is 80%, or 12,996 HUs. Direct habitat loss is projected to affect habitat for bird richness by removing some 60% of the HUs present (Table D5.2-3). Forty-three percent of low, 49% of moderate, and 64% of high quality habitat will be lost due to clearing.

Habitat for amphibian richness within the LSA is currently composed of 0 HUs (0%) of low quality habitat, 2,863 HUs (22%) of moderate quality habitat, and 10,108 HUs (78%) of high quality habitat. The overall suitability of the LSA (total number of HUs divided by the total number of ha) for amphibian richness is 80%, or 12,971 HUs. Direct habitat loss is projected to affect habitat for amphibian richness by removing some 61% of the HUs present (Table D5.2-3). Zero percent of low, 46% of moderate, and 65% of high quality habitat will be lost due to clearing.

Based on habitat modelling, the project area supports high percentages of high-moderate habitat suitability for mammalian richness, avian richness, and amphibian richness. Habitat loss, alteration, fragmentation, and alienation have the potential to affect species richness within the LSA. Impacts will be minimized if site clearing and construction activities are scheduled to avoid the breeding season (e.g., late March to late July), and if various other mitigation measures are used, as described below.

Mammal richness habitat within the RSA, taking into account existing disturbances, is currently composed of 18,698 HUs (1%) of low quality habitat, 440,769 HUs (24%) of moderate quality habitat, and 1,391,750 HUs (75%) high quality habitat. The overall suitability of the RSA for mammal richness is 76%, or 1,851,217 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect mammal richness habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Bird richness habitat within the RSA, taking into account existing disturbances, is currently composed of 0 HUs (0%) of low quality habitat, 790,290 HUs (49%) of moderate quality habitat, and 896,206 HUs (53%) high quality habitat. The overall suitability of the RSA for bird richness is 69%, or 1,686,496 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect bird richness habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Amphibian richness habitat within the RSA, taking into account existing disturbances, is currently composed of 0 HUs (0%) of low quality habitat, 471,382 HUs (26%) of moderate quality habitat, and 1,354,965 HUs (74%) high quality habitat. The overall suitability of the RSA for amphibian richness is 75%, or 1,826,347 HUs. On a regional scale, direct habitat loss due to Project Millennium is not expected to affect amphibian richness habitat, as negligible amounts of suitable habitat will be lost to site clearing (Table D5.2-4).

Mitigation

Mitigation measures included in the Project design to minimize habitat loss include:

- locating the development away from important wildlife habitat (e.g., minimum of 100 m to Steepbank and Athabasca rivers);
- minimizing the footprint of the development (e.g., restricting dump size, use of common access and utility corridors);
- use of a no-disturbance buffer zone around known raptor nest sites; and
- pursuing progressive reclamation of the development area.

A proposed mitigation for impacts to wildlife relates to the timing of site clearing activities. Most site clearing will be completed in the winter. This timing avoids most wildlife breeding or nesting periods. Most area wildlife give birth, or nest and raise their young from May to July. However, two of the Project KIRs, the ruffed grouse and the great gray owl, initiate breeding in mid-March. Female black bears give birth in their dens in mid-winter. Moose calve from mid-May to early June.

Suncor will reclaim disturbed areas to equivalent pre-development habitat capability. The positive impacts of reclamation are discussed in the relevant EIA sections (e.g., Sections D2.2 and D3.2).

Change in Surface Water Hydrology

Background

Hydrological changes caused by project development can impact habitat quality and/or quantity. Mine development will include diversion of drainages and pumping runoff from the mine pits. Impacts will include drawdown of the groundwater table in the Project vicinity (Section C2.2).

Changes to wetlands as a result of changes to surficial aquifers from dewatering of the mine pits are discussed in detail in Section D3.2. A 300 m zone of influence around the mine pits was assumed for indirect impacts to wetlands. Within this zone, changes to wetland communities are likely to occur during the operation phase of the mine. It was conjectured that swamps may succeed to upland conditions, while marshes, shallow open water wetlands and fens may change to dry grassland or shrub communities. As well, there most likely will be increased growth of alder, willow, birch, aspen and balsam poplar, and reduced growth of ground vegetation, particularly species found in wetter site conditions. The alteration of vegetation communities will be most visible on the south and east ends of the LSA, as more wetlands habitats are found in these areas. The north and west sides of the LSA are bordered by riparian areas and various areas of upland habitat, neither of which will be affected.

Impacts of groundwater drawdown on vegetation communities adjacent to the Project are poorly understood. While some studies have shown that drainage or partial drainage of wetlands can enhance tree growth, the impacts of such actions on the KIRs for this project are speculative at best.

Moose

Moose are often associated with drainages and wetlands. Moose also forage in lakes and ponds for emergent and submergent vegetation (Fraser 1980). However, with the exception of Shipyard Lake, most of the wetlands affected by mine development do not appear to provide adequate foraging opportunities. Shipyard Lake will not be affected by changes in hydrology due to the Project. It is likely that the alteration of drainage patterns will result in the loss of riparian shrub communities, and may affect moose habitat to some degree.

Other KIRs

In northeastern Alberta, black bears are usually found in deciduous and mixedwood forest, and rarely in poorly-drained muskeg areas (Young 1978). Snowshoe hares are not generally associated with riparian habitat types. Ruffed grouse depend on upland areas to meet their habitat requirements (Rusch and Keith 1971). Thus, it is unlikely that loss of wetland areas will directly affect bears, snowshoe hares, and ruffed grouse.

In contrast, the loss of wetlands will have an effect on fishers, beavers, red-backed voles, waterfowl, and terrestrial songbirds. The territories of fishers are often aligned with drainages (Douglas and Strickland 1987), and Golder (1998n) reported that fisher used riparian areas as a travel corridor. Beavers are highly dependent on wetland areas for most of their food and cover needs. As well, red-backed voles, which have trouble maintaining their water balance, are often associated with streams and wetlands. Some dabbling ducks, including mallards, were observed along the various watercourses within the LSA. Loss of this habitat will have an effect on this group. As well, the alteration of habitat could affect terrestrial songbirds.

It is possible that drainage of mining areas will result in a change to the species composition of prey available to the great gray owl. However, the impact of such a change is not known.

Validity of Linkage

The alteration of drainage patterns will result in the loss of riparian shrub communities. This will have an effect on species such as moose which are often associated with drainages and wetlands. As well, fishers, beavers, red-backed voles, waterfowl, terrestrial songbirds, and great gray owls will all be affected to some degree. Thus, the linkage is valid for these species. The alteration of drainage patterns most likely will not affect black bears, snowshoe hares and ruffed grouse.

Mitigation

Mitigation for this impact will primarily be through reclamation. An end pit lake and numerous small wetlands are proposed for closure. This will have a net positive effect on wildlife. Cessation of mine dewatering at closure will also permit the groundwater table to return to its pre-development level.

Barriers to Movement

Background

Blockage of wildlife movement and dispersal corridors is an increasing concern among conservation biologists and the public. Soule (1991) defined a wildlife corridor as a "linear landscape feature that facilitates the biologically effective transport of animals between larger patches of habitat." With increasing development pressure and fragmentation of wildlife habitat, species are often confined to patches of habitat or "habitat islands". If isolated populations are not able to interact, a decrease in genetic diversity could result, leading to an overall decrease in the adaptability of the regional population. It is therefore important to maintain connectivity among habitat patches at the landscape level.

Wildlife movements can be affected by large disturbances such as the Project pits and infrastructure, as well as small disturbances such as linear corridors (e.g., roads, seismic lines, pipelines and electrical transmission lines). Generally, linear corridors have the potential to act as barriers or act as filters to wildlife movements. The topic has been discussed widely (e.g., Bromley 1985, Berger 1995, Jalkotzy et al. 1997), and literature reviews have been completed for a few individual species (e.g., Horejsi 1981; Shideler et al. 1986; Eccles et al. 1991, Jalkotzy et al. 1997). The literature on effects of barriers to movement on wildlife is disproportionate for large mammals and species otherwise managed for harvest. For many species that comprise the biodiversity of the project area, considerably less data are available. Scale (e.g., structure and dimensions of corridor relative to the wildlife species in question), particular biophysical environment and intensity of corridor use are important factors that influence corridor effects on wildlife. Some barrier effects on wildlife are relatively short term and limited to the construction period, while other effects can be long term depending on the permanence of the facility.

Recent and ongoing studies have confirmed the importance of maintaining effective corridors. The Eastern Slopes Grizzly Bear Project has shown that the Trans-Canada Highway is a barrier to the movement of adult female grizzly bears (Gibeau and Heuer 1996), and genetic analyses suggest the highway has already restricted gene flow (Gibeau 1995). Paquet and Callaghan (1996) also demonstrated that the Trans-Canada Highway acts as a barrier to wolves in the Bow Valley, and that highway deaths were one of the most important causes of wolf mortality in the Bow Valley (Paquet 1993).

The objective in planning wildlife corridors is to allow for sufficient movement between habitat islands such that a species can persist in the region. Corridors can be used by wildlife for daily, seasonal, annual and/or dispersal movements. In the context of the Project, corridors can also expedite the recolonization of reclaimed habitats following mine closure. There are little data on how to design corridors for different species. However, Beier and Loe (1992) state that corridors that act as dispersal routes for species must be able to fulfill five functions:

- permit wide-ranging animals to travel, migrate and meet mates;
- allow plants to propagate;
- allow for genetic interchange to occur;
- allow populations to move in response to natural disasters; and
- allow individuals to recolonize habitats from which populations have been locally extirpated.

If the Project does create barriers to movements, it could result in decreased gene flow between segments of a population; exclusion of movement to key habitat such as summer range, winter range and denning areas; or localized loss of populations due to restricted movement. Any of these conditions could impact the KIRs within the LSA, as discussed below. Cumulative effects of multiple developments on wildlife movements within the RSA are of particular concern and are addressed in Golder 1998o.

Moose

Within the oil sands region moose may not use well-defined corridors such as those found in mountainous habitats where animal movements are often channeled by topography. However, moose within the region do make seasonal movements, often using riparian habitats for foraging and travel during seasonal shifts in habitat use (Westworth and Associates 1980, Westworth, Brusnyk and Associates 1996a). Using radio-telemetry, Hauge and Keith (1981) found that moose made seasonal, short-range movements in response to changing snow conditions. Moose moved an average of 6 km to winter range when snow conditions became thick and soft in December-January. As well, 38% of radio-collared moose made greater movements (i.e., more than 20 km) between summer ranges in the Birch Mountains and/or the Muskeg Mountain area and winter ranges near the Fort Hills and the Athabasca River. Movements along or parallel to the Athabasca River valley were not evident. The annual home range of non-migratory moose was 97 km^2 (range 60 to 183 km^2) (Hauge and Keith 1981).

Within the LSA, moose showed seasonal movements from riparian to upland areas and travelled along riparian corridors (Golder 1997s). Thus, the Project could act as a blockage to moose movements. If key riparian and upland habitats that connect habitat patches are left undeveloped, such areas could serve to channel moose movements the way topography does in mountainous areas.

Other KIRs

Little information is available regarding movement of the KIRs within the LSA. Fishers appeared to used the riparian areas as corridors for at least some of the winter months (Golder 1997s). It has been conjectured that wolves and black bears use the Steepbank and Athabasca River valleys as travel routes (BOVAR 1996e), but no empirical data exist.

Construction of roads can act as a barrier to dispersal for certain small mammal species, possibly due to an increase in potential for predation in open spaces (Burnett 1992). Douglas (1977) found that red-backed vole activity decreased on winter roads, and Adams and Geis (1983) found that forest species such as the red-backed vole tended to avoid roadside areas. Conversely, deer mice and meadow voles, animals that prefer dry grassland habitat, showed elevated levels in the clearings provided by road construction (Douglas 1977, Adams and Geis 1983).

Birds often use riparian areas as travel corridors for dispersal and migration. Juvenile birds can be reluctant to cross open areas such as recently disturbed areas (Lens and Dhondt 1994). The combination of minimal cover and unfamiliar habitat in recently disturbed habitats increases exposure to predators and makes traversing such habitat risky.

Validity of Linkage

While specific data on wildlife movement corridors within the LSA is lacking, the Project will exclude most animals from using the development area for travel until closure. Animals that are far-ranging, such as ungulates, large carnivores and some of the smaller carnivores, will be most affected. The opportunity for beavers to disperse will also be affected. Small mammals will be less affected; but any mitigation for larger mammals should include small mammals. Thus, the linkage is valid for moose, fishers, black bears and beavers. The linkage is invalid for red-backed voles and snowshe hares.

Migratory bird species such as dabbling ducks are not likely to be affected since few waterbodies will be affected. However, the migration of migratory breeding birds such as the Cape May warbler and the western tanager could be affected, as such species are less likely to fly over large disturbed areas. However, due to the phased nature of the development, migration around the active mining areas will likely occur. The linkage is invalid for dabbling ducks, ruffed grouse, breeding birds and great gray owls.

Mitigation

Design criteria which are important for closure, are discussed below. Within Project Millennium, key habitat areas that should be left connected are the Athabasca River valley, the Steepbank River valley, the confluence of the two rivers, and upland and lowland habitats east and south of the development site. Linear strips of relatively undisturbed vegetation will be left intact to allow passage of ungulates and carnivores around the development area. Design criteria for wildlife corridors applicable to ungulates and carnivores as summarized by Soule (1991) and Harrison (1992) will be considered in closure and planning.

The KIR species of interest for the proposed corridors are moose, black bears and fishers. Since moose are considered to be affected by developments at distances of up to 500 m (AXYS 1996), large corridor widths will ensure that habitat in the centre of the corridor is relatively disturbance free. While this is the optimal minimum width, it is recognized that corridors can be narrower in places and still be effective. Thus, it is suggested that the corridors can be restricted to as narrow as 100 m in places as long as these narrow sections are fairly short.

The progressive nature of both mining and subsequent reclamation will ensure that corridors are maintained throughout the development area. The Athabasca and Steepbank river corridors will function as north-south and east-west conduits (as well as representing important habitat patches in their own right). The focus on the use of riparian areas is due to the fact that they have been found to serve as travel corridors for ungulates (Brewster 1988), fishers and Canada lynx (Golder 1997s). Black bears probably use riparian areas for travel as well.

A monitoring program should also be initiated to determine wildlife use of the corridors and to assess the impacts of variable corridor widths on wildlife.

Sensory Disturbance

Background

Sensory disturbance is a potential project-related impact to wildlife. Project-related activities that will result in sensory disturbances include:

- clearing of vegetation and surface grading for mined areas;
- truck and shovel operations during mining activities; and
- construction of infrastructure for utilities, water supply and access requirements.

Sensory disturbance results when human and mechanical activities elicit behavioral responses from wildlife. If human actions cause wildlife to change their behaviour in a way that may affect survival, disturbance has occurred (Shank 1979). While short-term evidence of disturbance is often apparent, long-term effects are difficult to observe. Several reviews of the topic in different environments and with select species have been done (Shank 1979, Prism 1982, Bromley 1985, Brusnyk and Westworth 1988, Komex 1995).

Sensory disturbance can result in reduced habitat effectiveness due to alienation of habitat and increased mortality due to changes in the energy balance of individuals. The effectivenesss of a habitat can be decreased through visual, auditory and olfactory disturbance even though the physical characteristics of the habitat may remain unchanged. Thus, although the habitat is physically suitable, wildlife do not use it.

The distance animals are displaced can vary by the amount, type and predictability of the disturbance, the local vegetation and topography, the season, the time of day or night and whether the wildlife population is hunted or not. In general, the degree of displacement is proportional to the amount of disturbance and inversely proportional to the line of sight between the disturbance source and the animals. The displacement distance is probably less in forested habitats than in open habitats.

Moose

There have been few empirical studies of the effects of disturbance on moose. The literature contains more references to the effects of disturbance on caribou, deer and elk, and the effects are numerous and varied. A study on cervid distribution in Alberta indicated that while deer and elk habitat use was influenced by human disturbances, moose were more strongly influenced by browse yield (Telfer 1978). Rolley and Keith (1980) observed that moose in central Alberta avoided agricultural clearings, roads and residences. Ferguson and Keith (1982) observed that moose moved away from areas of human activities in a study on the effects of nordic skiing on the distribution of elk and moose in Elk Island National Park, Alberta. Disturbance may be an important factor in habitat use by ungulates, and topographic barriers may be used to reduce disturbance.

Hydroelectric developments may cause behavioral displacement of moose from calving and winter habitat with resulting negative impacts (Ballard et al. 1988). A study at an open-pit copper mine in north-central British Columbia demonstrated that moose were attracted to areas of browse abundance in proximity to mining activities (Westworth et al. 1989). Moose apparently habituated to the human activities at the mine while using adjacent clearcuts that were 2 to 10 years old. The highest pellet group densities were recorded within 100 m of the open pit. Westworth et al. (1989) speculated that hunting restrictions in the vicinity of the mine and perhaps the aversion of predators such as wolves to areas of human activity may have provided a degree of security for moose, allowing habituation to occur.

Fisher

Fishers usually avoid human activity, although fishers are curious animals and are easily trapped (Powell 1993, Powell and Zielinski 1994). Fishers generally are more common where human density is low and human disturbances are reduced.

Black Bear

Black bears are highly mobile, wide-ranging animals, and they are tolerant of human activities if not hunted, as shown by their propensity to feed on human garbage. Overall, black bears are tolerant of human activity which allows them to co-exist with people (Herrero 1983, Manville 1983, Lynch 1993). However, there are consequences for black bears' tolerance of humans. Black bears readily habituate to humans and then are often subject to management actions as "problem bears". Relocation of problem bears may make them more vulnerable to hunting and illegal kills.

Tietje and Ruff (1983) studied the response of black bears to oil sands development in east-central Alberta. While they observed a general pattern of tolerance for development activities, they observed that females with cubs lessened their activity in the vicinity of oil construction activity. They concluded that secondary impacts of in situ oil extraction such as new roads, increased harvest and human habituation produce greater consequences than the primary impacts of habitat loss and alienation (Tietje and Ruff 1983). Denning behavior was also studied and, although disturbance to denning bears from oil development was not observed, there is the possibility of abandonment and overwinter weight loss (Tietje and Ruff 1980).

Beaver

Beavers are highly adaptable animals that live in close association with humans, providing minimum requirements of food and aquatic habitat are met (Nietfeld et al. 1984). This suggests that beaver are not particularly sensitive to noise and human activities.

Red-Backed Vole

The distribution of red-backed voles and many other small mammals in relation to human activities (e.g., cities, airports) suggests these wildlife are not particularly sensitive to noise and activities. This is probably because they do not have the hearing physiology, ability to learn and mobility to respond.

Snowshoe Hare

Based on the limited literature, snowshoe hares can be expected to avoid habitat within 100 to 200 m of snowmobile trails and roads (BOVAR 1996e). Lack of site-specific data means potential effects of displacement from preferred habitat are speculative. The general expectation is that displaced wildlife experience higher mortality rates.

Dabbling Ducks

Interactions that disrupt normal duck behavior, particularly during the nesting season, are subtle and are difficult to observe, but may be no less harmful than habitat loss (Dahlgren and Korschgen 1992). Possible impacts include abandonment of eggs and young, impaired habitat for molting and impaired habitat for fall staging (Nietfeld et al. 1984).

Ruffed Grouse

Ruffed grouse numbers change based on intensive forest management practices such as frequent clearcutting of relatively small tracts (e.g., 0.4 to 2.0 ha) of aspen forest (McCaffery et al. 1996). This suggests they are tolerant of human and mechanical activities such as logging, and can benefit from habitat manipulations. Certain levels of disturbance, however, can be expected to disrupt the breeding season (Francis and Lumbis 1979).

Cape May Warbler

During the breeding season in northeastern Alberta, Cape May warblers prefer mature mixedwood forests dominated by tall white spruce (Francis and Lumbis 1979, Semenchuk 1992). The Cape May warbler is susceptible to sensory disturbances during the breeding season, especially when males are vocalizing on their territories. Ambient industrial sounds may mask bird songs and could possibly disrupt breeding performance. Also, thresholds of disturbance may be reached that could cause nest abandonment and reduce reproductive success (Francis and Lumbis 1979).

Western Tanager

During the breeding season, western tanagers prefer mature mixedwood forests in northeastern Alberta (Francis and Lumbis 1979). During the breeding season, songbirds rely on vocal communication for territorial spacing and breeding performance. Sensory disturbances and chronic sounds from industrial activities can mask auditory signals and may disrupt patterns of breeding behavior.

Pileated Woodpecker

Pileated woodpeckers are considered uncommon in the LSA, but are expected to occur in areas of mature and mixed forest (Francis and Lumbis 1979). Pileated woodpeckers are primary cavity nesters that require large snags for nests (Schroeder 1983). Like other birds, they are susceptible to sensory disturbances during the breeding season. Buffer strips of 100 to 150 m are recommended around large snags and important wildlife habitat features (Backhouse 1993).

Great Gray Owl

Great gray owls are expected to occur throughout the LSA, in mixed forests and muskeg habitat (Francis and Lumbis 1979). Great gray owls hunt primarily by listening for their prey, therefore human-related noises may interfere with their ability to hunt. Like other birds, they are susceptible to sensory disturbances during the breeding season, particularly when incubating on the nest (Francis and Lumbis 1979). In Alberta, the sensitive period extends from late March to mid-May.

Validity of Linkage

Sensory disturbances and the mechanism of habitat avoidance are predicted to have an impact on moose. The difficulty with this prediction is that, while the local population change by displacement may be measurable, changes over the longer term in the regional population may be affected by other factors. The linkage is considered valid for fishers as displacement will reduce foraging efficiency and may affect long-term survival and breeding.

In areas affected by construction activities, black bears are expected to initially demonstrate an avoidance response to sensory disturbances but then habituate to the facilities, resulting in numerous indirect consequences for long-term survival. Disturbances during denning are considered problematic for survival. Rights of way along roads often have a positive impact on black bears because early successional vegetation provides food for black bears (Manville 1983). This link is considered valid for black bears.

Based on the close association of beaver and human activities in both urban and agricultural areas, this link is not considered valid for beavers. As well, red-backed voles are not expected to demonstrate an avoidance response to sensory disturbances. Therefore, this link is not considered valid for red-backed voles. A limited amount of evidence suggests this link is valid for snowshoe hares.

Human disturbance can be a factor in reproductive success of waterfowl, ruffed grouse, Cape May warblers, western tanagers, pileated woodpeckers, and great gray owls. Thus, the linkage is considered valid for bird species in the LSA.

While little information is available in the literature regarding the effects of sensory disturbance on most of the KIRs, a conservative approach to the assessment was taken. Therefore, sensory disturbance was assumed to affect the effective habitat for all KIRs except for red-backed voles and beavers. Zones of Influence and Disturbance Coefficients used in the assessment of this impact were described previously and are described in Golder (1998o).

Mitigation

The following mitigation is recommended to reduce the impacts of sensory disturbance on wildlife:

- use berms, residual and/or planted vegetation and buildings to reduce the transmission of noise to adjacent habitats;
- time activities to avoid critical seasons for wildlife (i.e., mid-March to late July);

- during the brooding and nesting season, prohibit activities within 250 m of active raptor nests if feasible;
- prohibit staff from carrying firearms or hunting on the LSA; and
- prohibit use of private vehicles and ATVs within the LSA.

Changes in Abundance and Diversity

This section details the effects of direct mortality on wildlife abundance and diversity. No attempt has been made to estimate the number of animals that may be affected by the development as such estimates are subjective and may be misleading. Rather, professional judgment was used to classify the magnitude of the impacts.

Sensory Disturbance

Background

This linkage deals with changes in abundance and diversity due to sensory disturbance, as opposed to the effects of habitat displacement due to disturbance, previously discussed. Impact resulting from sensory disturbance is not as visible as habitat loss but can be just as harmful (Dahlgren and Korschgen 1992). Similar to habitat loss, sensory disturbances can reduce the landscape's capability to support wildlife. As mentioned previously, sensory disturbances can result in habitat alienation and loss of habitat effectiveness.

Harassment can be defined as any activity that causes excitement in an animal, and causes it to prepare itself physiologically for flight (Geist 1971). This can result in increased levels of stress and energy expenditure and disruption of feeding and/or mating behaviour, and can lead to increased mortality and/or lower reproductive rates. It has been reported that changes in endocrine activity, blood pressure, glucose levels, adrenal activity, respiration and digestion may occur as the result of noise (Bommer and Bruce 1996).

Benign disturbances generally elicit subtle responses from wildlife, such as elevated heart rates but no overt reaction. Direct and persistent harassment often results in panic, flight and withdrawal from preferred habitat. Abandonment of habitat may cause reduced survival and reproductive rates (Geist 1971). The mechanism linking sensory disturbances to wildlife survival and reproduction is energy balance. For example, disturbance effects raise the cost of living by increasing home range size (Dorrance et al. 1975, Stephenson et al. 1996), disrupting social behavior and family groups (Bartelt 1987) and foraging behavior (Klein 1993), changing daily activity patterns (Vogel 1989), altering pair bonds and abandonment of young.

Noise may cause physical stress and energy loss when wildlife species flee. In many cases wildlife may habituate to sound, but this varies among individuals and species. Other activities may increase the effects of noise. For example, wildlife species that are hunted are more likely to flee because of noise (Bommer and Bruce 1996). Sensory disturbances can vary in intensity and duration, from passive and benign activities to direct and persistent harassment. Reactions to sensory disturbances vary among wildlife species, based on their ability to learn and respond, and on past experience (Geist 1971). Typically, wildlife that are highly social and live in open habitats are most susceptible. And while single-disturbance effects may be insignificant, effects can be cumulative. In general, many wildlife species have been shown to be highly adaptable, and many species habituate to disturbances that are predictable and non-threatening (Geist 1971, Stephenson et al. 1996).

In general, sensory disturbances tend to be most detrimental at critical times of the year, such as during late-winter periods of bioenergetic stress when wildlife tend to be in poor body condition, and during the spring/early summer reproductive season when wildlife are raising young-of-the-year (Kuck et al. 1985, Yarmoloy et al. 1988).

Validity of Linkage

Due to the relative lack of knowledge concerning the effects of disturbance on wildlife species, this linkage was assumed to be valid for all KIRs. Wildlife species are probably most susceptible during the breeding season.

Mitigation

Mitigations for this linkage are identical to those of sensory disturbance on habitat alienation, previously discussed.

Site Clearing

Background

Approximately 9,420 ha of land will be cleared as a result of the Project. Clearing of vegetation and removal of overburden could kill animals that are less mobile or that have small home ranges. Hibernating animals and juvenile animals, including those in nests, are particularly sensitive to mortality through site clearing. Regardless of the season, site clearing will result in major decreases in wildlife abundance and diversity due to loss of potential habitats, as previously discussed.

Validity of Linkage

This linkage is considered valid for KIRs that have small home ranges and for KIRs whose young may be susceptible in their early life stages. As well, most KIRs will be affected by loss of potential breeding habitat. A summary of the linkage validity for this component is presented in Table D5.2-5. This linkage was considered invalid only for moose, due to the mobility of both adults and calves. Potential impacts to black bears were considered moderate in the winter when females give birth to young in dens. Tietje and Ruff (1980) found that adult bears disturbed from their dens in winter were able to den in other areas and survive the winter.

Table D5.2-5 Susceptibility of Key Indicator Resources to Mortality During Site Clearing

KIR	Susceptibility to mortality		
	All year	Winter	Spring
Moose	Low	Low	Low
Fisher	Low	Low	High
Black bear	Low	Moderate	Low
Beaver	Low	Low	High
Red-backed vole	High	Low	Low
Snowshoe hare	Moderate	Low	Low
Dabbling ducks	Low	Low	High
Ruffed grouse	Low	Low	High
Cape may warbler	Low	Low	High
Western tanager	Low	Low	High
Pileated woodpecker	Low	Low	High
Great gray owl	Low	Low	High

Mitigation

Mitigation for impacts on direct mortality due to site clearing include:

- time site clearing to avoid sensitive seasons for wildlife (e.g., late March to late July for breeding birds); and
- conduct pre-development surveys for active raptor nests and establish 250 m buffers around such nests.

Hunting, Trapping and Predation

Background

Of the KIRs identified for this project, the ungulates, carnivores, furbearers, dabbling ducks and upland game birds are harvested under provincial license. KIRs hunted include moose, black bears, dabbling ducks and ruffed grouse. KIRs that are trapped for fur include beaver and fishers. While not generally listed as a furbearer, snowshoe hares are harvested by local and aboriginal people for food. The KIRs not considered to be influenced by hunting and trapping include red-backed voles, Cape May warblers, western tanagers, pileated woodpeckers and great gray owls.

An important effect of roads on wildlife populations is increased mortality from human hunters and poachers (Brody and Pelton 1989, McLellan 1988), and wolves because linear corridors provide access to previously less accessible landscapes (Horejsi 1979, Bergerud et al. 1984). There is evidence for a decline of ungulates in areas where access has been created (Shideler et al. 1986). Moose have been shown to be very susceptible to hunting pressure in logged areas (Lynch 1973, Flemming and Koski 1976, Eason et al. 1981, Timmerman and Gollat 1982, Eason 1985), probably as a result of a combination of greater visibility of the animals within cut blocks and increased access for hunters. Road mortalities may be accentuated during winter because ungulates are drawn to road salt (Fraser 1980).

Improved access after site closure may open areas previously inaccessible to hunting and trapping. Whether or not this becomes detrimental depends on the regulations in effect. Legal hunting and trapping is relatively easy to control and monitor, providing the manpower and resources are made available by regulatory authorities.

Moose, Black Bears, Dabbling Ducks, and Ruffed Grouse

In the short term, access will be limited to construction and operations personnel. As well, personnel will be prohibited from carrying firearms. Thus the potential for hunting and poaching is negligible. Improved access following closure will result in increased harvest of wildlife in the LSA. Lynch (1973) estimated that in west-central Alberta, 80% of all moose hunters and 28% or all moose kills occurred within 2 km of roads. In Alberta, moose management has become increasingly controversial, based on the perception that moose populations have declined (Todd and Lynch 1992). Specific factors in the perceived declines included native harvest, illegal hunting, habitat loss or change and excessive harvest. Brody and Pelton (1989) observed that the primary effect of roads in bear habitat was increased vulnerability to hunting.

Fishers, Beavers, and Snowshoe Hares

Because access will be controlled during the life of the project, furbearers will not be trapped within the LSA. Following closure, there may be an increase in trapping of furbearers in the project area.

Validity of Linkage

Due to restricted access, this linkage is invalid for those species normally hunted and/or trapped in the area. However, following closure, access will be controlled by the province.

Removal of Nuisance Wildlife

Background

Of the KIRs selected for this project, only beavers and black bears have the potential to become "nuisance" wildlife. Beavers can become a problem in local areas of linear corridor construction if their activities obstruct the flow of water and cause flooding and erosion at facilities. When this occurs, beavers are trapped and moved, or they are destroyed. Dewatering of the Project site will reduce the habitat suitability of the area to beavers for the life of the Project. Thus, the number of beavers expected to become nuisances is low, thus impacts will be low.

Black bears become a problem when they are attracted to food odors and have access to human sources of food. Habituated bears tend to become aggressive and can be a threat to life and property. When this occurs, black bears are usually destroyed. Bear relocation tends to be very expensive since it requires considerable manpower, and the benefits are uncertain as relocation is frequently not successful (Miller and Ballard 1982, Tietje and

Ruff 1983, Rogers 1986). Bear relocation efforts may have a role in some circumstances (Rogers 1986, Blanchard and Knight 1995).

A number of nuisance bear incidents are likely to occur in the LSA. It is difficult to predict the magnitude of this potential problem, but it should be viewed as a wildlife management issue. Suncor has had previous experience with nuisance bears. Two to three bears are trapped and moved per year from Suncor (Leo Paquin, Suncor, pers. comm., November 24, 1997). In 1997, nine bears were trapped. The higher number for 1997 may be related to the clearing of land for the Steepbank Mine. Most bear problems in the Fort McMurray area occur from June to September (Cory Craig, AEP, Fort McMurray, pers. comm., November 27, 1997).

Validity of Linkage

This linkage is considered valid for beavers and black bears. Management actions directed at "nuisance" wildlife add to natural mortality and harvest levels.

Mitigation

Mitigation for nuisance wildlife will include:

- regular monitoring and removal of beaver dams at culverts;
- management of landfill areas such that wastes (including waste food) is covered on a daily basis;
- instruction and education of Project workers to not feed wildlife; and
- implementation of a nuisance wildlife management plan in cooperation with AEP, Wildlife Management Division.

Increased Vehicle-Wildlife Collisions

Background

Virtually all wildlife species are subject to road mortality. This topic has been the subject of various literature reviews (e.g., Kelsall and Simpson 1987, Jalkotzy et al. 1997), and has been an important concern in construction of energy projects (Priddle 1996). Road mortality may cause a decline in local populations, but the effects are site-specific, depending on the species and the circumstances (e.g., type of road, volume of traffic, etc.). In most cases, the linear extent of roads within a landscape may not be sufficient to significantly affect most species. In specific cases, expensive mitigation plans are required to prevent population declines (e.g., the Trans-Canada Highway through Banff National Park).

Road mortalities are difficult to quantify, and only a fraction of the mortalities that occur are ever reported (Kelsall and Simpson 1987). One reason for low reporting is that mortality data are difficult to obtain. Mortalities are dispersed along many kilometers of complex road networks, and carcasses of small mammals and birds killed on roads are often quickly scavenged. As well, reports of wildlife road mortalities are usually only received if collisions result in human injuries, or if the collision results in expensive repair to the vehicle, as likely to occur with collisions involving large mammals. Frequencies of road mortalities are often related to specific locations, traffic volume and speed (Oxley et al. n.d., Jalkotzy et al. 1997). Thus, educating Project personnel and posting speed limits and wildlife crossing signs may alleviate some of the problem.

Ruediger (1996) analyzed the relationship between rare carnivores and highways in the United States, and hypothesized that extirpation of carnivores is partially a factor of highway densities. Carnivores are particularly vulnerable to highway habitat fragmentation due to their large home range sizes. Impacts to carnivores are positively correlated to highway grade and traffic speed.

The discussion of wildlife road mortalities is common to many different kinds of wildlife. For evaluation purposes, this discussion is divided among large mammals (e.g., moose and black bears), small mammals (e.g., red-backed voles, snowshoe hares, beavers and fishers) and avifauna.

Moose and Black Bear

Moose and black bears are vulnerable to road mortality (Jalkotzy et al. 1997), partly because they are attracted to preferred browse/forage on roadsides and/or they are attracted to salt (Fraser 1979). Moose are subject to highway mortality on the Trans-Canada highway through the Bow Corridor (Woods 1988, 1990). Other ungulates, such as elk and deer, are attracted to palatable forage on roadsides and use these areas heavily during winter (Hornbeck 1989). Moose have been known to intercept ploughed corridors and use them as travel lanes, increasing their vulnerability to this type of mortality (Child 1983). Although population effects are difficult to determine, road mortalities have been observed to threaten the persistence of black bear populations (Jalkotzy et al. 1997).

Eleven years of wildlife mortality data for roads immediately north of Fort McMurray (Table D5.2-6) indicate that 67 moose and 19 black bears were killed between 1985 and 1996. The highest number of kills was recorded in 1994/95 for moose (n=18) and 1991/92 and 1995/96 for black bears (n=4). These figures indicate that highway mortality can be substantial. Unreported kills also likely occur.

Red-Backed Vole, Snowshoe Hare, Beaver and Fisher

The literature on the impacts of road mortalities on small mammals is sparse, probably because this kind of information is extremely difficult to obtain. Small mammals killed by vehicles may be largely unnoticed and are quickly scavenged. As discussed previously, wildlife of all kinds are subject to road mortality, but the topic has not been researched widely (e.g., Oxley et al. n.d.). Adams and Geis (1983) found that small mammal mortality on highways did not appear to be detrimental to populations studied.

Table D5.2-6 Wildlife Mortality Due to Vehicle Collisions, North of Fort McMurray

Year	Wildlife Mortality	Year	Wildlife Mortality
1985-1986[a]	1 wolf - past Alsands bridge 1 deer[b] - between Fort McMurray and Suncor	1991-1992	4 bears - black 7 coyotes 1 fox - swift 2 wolves 6 deer - white-tailed 6 deer - unknown 6 moose 1 other mammal 2 other migratory birds
1986-1987	1 deer - half mile north of Suncor gate 1 deer - top of Supertest Hill 1 miscellaneous bird (raven?) - between Suncor and Syncrude site 1 bear cub - bottom of Supertest Hill 1 deer - between AOSTRA and Suncor	1992-1993	2 bears - black 12 coyotes 2 dogs 2 foxes - red 1 wolf 1 fisher 10 deer - white-tailed 9 deer - unknown 7 moose 1 other migratory bird 1 other bird
1987-1988	1 coyote - at Syncrude turnoff 1 adult bear - black - sawmill 1 adult bear - black - 1 km past Supertest Hill 1 moose - at Suncor turnoff 1 moose SE 11-92-10 W4M 1 deer - south of Suncor site 1 deer - south of Syncrude site 1 moose - sawmill	1993-1994	3 bears - black 3 foxes - red 1 weasel - short tail 14 deer - white-tailed 10 deer - unknown 10 moose 1 hawk - sharp-shinned
1988-1989	1 night hawk - between Syncrude and Suncor sites 1 horned owl - Suncor turnoff 1 raven - Suncor turnoff 2 deer - sawmill 1 deer - Suncor and AOSTRA turnoff	1994-1995	3 bears - black 3 coyotes 1 squirrel - tree 9 deer - white-tailed 4 deer - unknown 3 elk 18 moose 1 bird - other
1989-1990	1 horned owl - between Syncrude and Fort McKay 1 fox - 12-92-10-W4M 1 merlin - bottom of Supertest 1 moose - between first and second bridges, Canterra road 1 lynx - 14 km for Kearl Lake on Canterra road toward Canterra 1 coyote - on Canterra road 1 moose - 19-90-94 - Mobil's winter road by the Clearwater River 1 fox - permanent road 55 km off AOSTRA road	1995-1996	4 bears - black 1 dog 1 fox - red 3 wolves 11 deer - white-tailed 8 deer - unknown 8 moose
1990-1991[c]	2 beavers 1 muskrat 1 rabbit 5 deer - white-tailed 2 deer - unknown 13 moose		

[a] Source: J. Songhurst, Fish and Wildlife Officer, Alberta Fish and Wildlife, Fort McMurray, pers. comm.
[b] Likely white-tailed deer.
[c] After 1990 Source: Fort McMurray Fish and Wildlife District. Various locations in Fort McMurray Fish and Wildlife District.
Adapted from Shell Canada 1997.

Dabbling Ducks, Ruffed Grouse, Great Gray Owl and Forest Songbirds

Birds are frequently killed on roads (Jalkotzy et al 1997). While bird species whose habitat is bisected with roads are most vulnerable, specific levels of impact are not common in the literature. Dabbling ducks are considered more vulnerable than diving ducks because these birds make greater use of seasonal wetlands along roads (Jalkotzy et al. 1997). Raptors and owls are particularly susceptible to road kills because of their propensity for hunting small mammals within road allowances.

Validity of Linkage

Project Millennium will not involve construction of new roads in areas of otherwise undisturbed wildlife habitat. Predictions of general traffic to the Project are 6,800 vehicles per day north to Suncor during construction. This number will fall to 5,500 vehicles after construction is completed. The use of camp(s) on site will keep such trips to a minimum.

This link is considered valid for moose, black bears, snowshoe hares, beavers and fishers because of their relatively large movement and dispersal capabilities. The link is not considered valid for red-backed voles. Road mortalities to red-backed voles are not expected to have population effects because suitable habitat (forested mesic habitats) does not generally occur in close proximity to roads. This link is considered valid for ruffed grouse and great gray owls but not for Cape May warblers, western tanagers or pileated woodpeckers.

Wildlife mortality due to vehicle-wildlife collisions is most likely to occur on Highway 63 from Fort McMurray to the Suncor turn-off. Vehicle-wildlife collisions on the Project area are not of concern because of significantly fewer vehicles on the roads and much lower speed limits.

Interactions With Infrastructure

Background

Project-related infrastructure, other than linear disturbance corridors, that may be responsible for interactions with wildlife, include:

- overhead electrical power lines;
- a communication tower;
- out-of-pit tailings pond;
- mine pit water collections; and
- stacks at the extraction and upgrading facilities.

There are two main aspects of infrastructure that may affect wildlife. The physical presence of structures may lead to bird strikes to towers, poles, associated overhead power lines and other vertical towers, and tailings ponds, which may result in wildlife contacting bitumen. Potential impacts from construction activities involving infrastructure are not included in this discussion. Birds are the main concern with overhead lines, while all vertebrate groups (reptiles, amphibians, birds and mammals) may be affected by the contaminated ponds. Impacts of other infrastructure such as pipelines and roads have been considered under linkages concerning change in wildlife habitat, change in hunting, trapping and predation, and increased vehicle-wildlife collisions.

Tailings Ponds

There will be some bitumen loss to tailings ponds. The bitumen tends to float until cool, then it sinks into the pond. Before cooling, floating bitumen and bitumen that occurs along shoreline habitats of ponds presents a hazard to birds and mammals. Water birds (primarily loons, grebes, pelicans, cormorants, herons, waterfowl, shorebirds and gulls) could be affected during spring and fall migration, as they use waterbodies as stopover, staging and feeding areas. Other birds that consume carrion could also be affected by feeding on contaminated birds.

Effects on wildlife from contaminated ponds associated with oil recovery projects is not well documented in the published literature. However, the mechanism of impact for all vertebrates would be loss of insulating qualities of skin, fur and feathers from body contact by bitumen products. Ingestion and systemic poisoning of bitumen is a secondary concern, but would be a factor for wildlife attempting to groom if the body surface was contaminated. Overall, tailings ponds are considered relatively unattractive to wildlife, as observed at the existing Mildred Lake facility (BOVAR 1996e). Numbers of birds reported recovered from Suncor's Lease 86/17 tailings ponds during 1984, 1987 and 1988 are shown in Table D5.2-7.

Transmission Lines, Communication Towers and Stacks

Electrical transmission lines affect mainly bird species, particularly large raptors (hawks and eagles), but also cranes and waterfowl. Birds can also be affected by communication towers and stacks.

Wildlife may collide with transmission lines and/or become electrocuted. Electrocution is predominant in large raptors because of their size and behavior. However, electrocution is generally not a problem with high-voltage lines as the conductors are placed far apart (Kroodsma 1978). Birds are prevented from being electrocuted by not being able to touch two conductors at once. Electrocution can be a problem with low-voltage lines. However, a number of mitigation strategies can be used to lessen this impact (e.g., insulation of ground wires, perch guards to deter birds from perching and use of wooden cross braces instead of steel, APLIC 1996).

Raptors are attracted to transmission lines because they provide perches for hunting and resting and also provide nesting structures. Ravens will also use power line towers as nesting habitat. The effect is amplified in areas where nesting and perching structures are limited (i.e., disturbed areas). Birds tend to prefer towers with relatively dense lattice work. In one study, 133 pairs of birds used towers along 596 km of power line over 10 years (Steenhof et al. 1994). If transmission lines are constructed properly (i.e., do not electrocute wildlife) they can actually enhance habitat for some species.

Table D5.2-7 Birds Recovered from Suncor's Lease 86 Tailings Ponds During 1984, 1987 and 1988[a]

Species	1984	1987	1988
Waterfowl			
Common loon			1
Horned grebe		2	4
Greater white-fronted goose	1		
Green-winged teal			2
Teal spp.	1		
Mallard	6	5	2
Northern pintail	2	3	3
Northern shoveler	3	2	1
American wigeon	3	2	2
Aytha spp.	7	10	2
Lesser scaup		1	4
Common goldeneye			1
Bufflehead	1	3	1
Canvasback		1	
American coot	5	4	12
Unidentified duck		7	
Total	**29**	**42**	**35**
Shorebirds			
Killdeer	4	2	1
Lesser yellowlegs		3	3
Greater yellowlegs		1	
Lesser golden plover		6	
Caladris spp.	3	13	2
Total	**7**	**25**	**6**
Passerines			
Cliff swallow			2
Swallow spp.		2	
American crow		1	
Lapland longspur		1	
Water pipit	1		1
Unidentified Passerines	6	3	4
Total	**7**	**7**	**7**
Other			
Red-tailed hawk			1
American kestrel	1		1
Great horned owl	1		
Snowy owl			1
California gull			1
Northern flicker		1	
Total	**2**	**1**	**4**
Total All Species	**45**	**75**	**52**

[a] Source: Gulley 1985, 1987a, 1987b, 1987c, 1988.

Collisions with power lines can have an impact on waterfowl. Support structures for these facilities are not considered as hazardous although birds can be expected to strike these on occasion (Stout and Cornwell 1976). Bird strikes to wires have been well documented in the literature (Thompson 1978, Savereno et al. 1996). Bird strikes most often occur during spring and fall migration when large flocks of birds are moving, especially during inclement weather (Blokpoel and Hatch 1976). Strikes may occur to a variety of birds, including songbirds, waterbirds and raptors. In a study on migrating waterfowl, 200 to 400 waterfowl, representing 0.2 to 0.4% of total migrants, were killed during fall migration by a transmission line crossing 32 ha of water (Anderson 1978). In Manitoba, hawks and eagles accounted for 22% of mortalities on distribution lines (Berger 1995). Birds of prey injured by transmission lines are not uncommon at bird rehabilitation facilities where they are treated and released if possible. The effect of stabilizing structures like ground wires has also been studied. Ground wires can cause more collisions than conducting wires because they tend to be thinner and are more difficult to detect (Alonso et al. 1994). Ground wires primarily are expected to impact non-migratory, terrestrial birds such as ruffed grouse.

The impact of such hazards is difficult to predict, since such numbers are hard to obtain and often incomplete when available (Berger 1995). Bird strikes are largely unnoticed and hence unreported. One estimate of the number of annual bird strikes against transmission lines was approximately 1 bird/km (Berger 1995).

Validity of Linkage

Tailings Ponds

This linkage is valid for dabbling ducks, breeding birds (e.g., Cape May warbler, western tanager) and great gray owls. Impacts to beavers from tailings basins were considered to be negligible, and impact to moose and black bears extremely low for the Aurora EIA (BOVAR 1996e). The linkage, however, is also valid for animals such as coyotes and birds of prey that may scavenge on oil-contaminated birds on the shores of ponds.

Transmission Lines, Communication Towers and Stacks

Dabbling ducks and other waterfowl are affected by colliding with power lines (Anderson 1978). Songbirds and woodpeckers may also collide with power lines, although the incidence of such collisions is likely low (BOVAR 1996e). Upland game birds such as the ruffed grouse do not normally fly high enough to collide with, or be electrocuted by, transmission lines. Transmission lines may impact great gray owls and other raptors due to their predilection for using transmission lines and posts or towers as perching and/or nesting structures (APLIC 1996). Thus the linkage is valid for dabbling ducks, the Cape May warbler, the western tanager, the pileated woodpecker and the great gray owl. The linkage is invalid for ruffed grouse.

Mitigation

Mitigation regarding interactions of wildlife with Project infrastructure includes:

- use of bird deterrence devices, such as human effigies and propane-fueled cannons, particularly during the spring and fall migration periods;
- maintenance of vegetation free shoreline at the tailings pond;

- participation in the Oil Sands Bird Protection Committee to discuss mitigation results and strategies;
- use of markers such as aviation spheres to mark transmission lines; and
- use of raptor-safe construction standards for transmission lines (APLIC 1996).

Monitoring

The following monitoring programs are recommended to assess the efficacy of mitigation for impacts on wildlife mortality:

- wildlife-tailings pond interactions;
- wildlife-transmission line interactions; and
- wildlife-traffic mortalities.

Closure

Replacement of Vegetation Communities

Background

Replacement of vegetation communities due to closure is expected to result in gains in wildlife habitat. Reclamation of development sites has been shown to be an effective means of replacing vegetation communities, and hence wildlife habitat (e.g., McCallum 1989, Roe and Kennedy 1989). HSI models can be used to determine the value of reclaimed habitats (Williams 1988, BOVAR 1996e).

The Oil Sands Vegetation Reclamation Committee is currently preparing guidelines for reclamation of terrestrial vegetation in the oil sands region of Alberta. Objectives of reclamation are to return the land base to equivalent levels of pre-disturbance land use. Important land uses in the region include forestry, wildlife habitat, watershed functions, wetlands, gathering of traditional foods and medicinal plants, and recreation. An integrated approach will allow for many land uses from the same land base.

The closure planning process for Project Millennium is described in Section E. Reclamation of the Project area and replacement of vegetation communities will affect all KIRs (see discussion in analysis of Key Question, Reclaimed Habitat, below). Early successional species (e.g., red-back voles) will be immediately affected in that their habitat requirements will be met shortly after reclamation. KIRs that require late seral stages (e.g., Cape May warblers) are not expected to recolonize the reclaimed area until the vegetation matures.

Validity of Linkage

Replacement of vegetation communities during closure is expected to result in habitat gains for all of the KIR species (see Section E and discussion in

Analysis of Key Question, Reclaimed Habitat, below). Thus, the linkage is valid for all 12 KIRs.

Mitigation

The reclamation program is considered as mitigation. However, certain reclamation procedures should be followed to maximize reclamation results:

- design reclaimed landforms to include diversity and microtopographic relief;
- ensure that all slopes are not greater than 4:1;
- design reclaimed vegetation communities to provide key wildlife habitat variables for KIRs;
- use native species in reclamation wherever possible; and
- plan for vegetation community patch size, shape and juxtaposition that approximate those of pre-disturbance conditions.

Change in Hunting, Trapping and Predation Due to Closure

Background

Following successful reclamation and closure of Project Millennium, the development area may be opened to the public for those land uses deemed appropriate. It is likely that hunting and trapping will be among such land uses.

While the majority of the roads and other corridors within the development area will be reclaimed, some roads may remain. These corridors may provide access to the wildlife resources in the LSA. While increased access to an area can have impacts on wildlife populations through uncontrolled hunting and trapping, the provincial government will be responsible for managing the wildlife resource through harvest limits.

Roads can increase wolf access to prey, particularly in winter if the roads are cleared of snow. As most roads within the LSA will be reclaimed, and since remaining roads may not be ploughed in winter, impacts of increased predation by wolves on ungulates will not be a factor after closure.

Validity of Linkage

This linkage is valid for game (e.g., moose, black bears, ducks, and grouse) and furbearer (e.g., beavers, fishers and snowshoe hares) species.

Mitigation

Mitigation for the effects of access include reclamation of all roads and other linear corridors to vegetation communities that will support the desired end land uses. The provincial government will be responsible for regulating hunting and trapping on reclaimed lands.

D5.2.6.2 Analysis of Key Question

Wildlife Habitat

This section details the impacts of changes in wildlife habitat due to:

- removal or alteration of vegetation communities through site clearing;
- alteration of vegetation communities through changes in hydrology;
- alienation of vegetation communities through barriers to movement; and
- alienation of vegetation communities through sensory disturbance.

Most impacts related to change in habitat result from the removal or alteration of vegetation communities through site clearing and dewatering. Sensory disturbance is also important for most KIRs. The impacts of barriers to movement on wildlife are difficult to predict, however larger, more mobile species (e.g., moose, bear and fisher) will most likely be affected. Impact descriptions for habitat loss are summarized in Table D5.2 -8.

Habitat loss resulting from site clearing is predicted to affect all of the KIR species. For most of the KIR species the magnitude of impact is expected to be high. However, for beaver and dabbling ducks, which are fairly common in the RSA and which have limited habitat within the LSA, the magnitude of impact is expected to be low. The geographic extent of impact is local, the duration is long-term, and the frequency is low. Habitat loss resulting from site clearing is reversible through progressive reclamation activities. Habitat loss resulting from changes in hydrology is expected to affect KIR species which are associated with drainages and wetlands. These species are the moose, fisher, beaver, red-backed vole, dabbling ducks, Cape May warbler, western tanager, pileated woodpecker, and great gray owl. The magnitude of impact is predicted to be low. This is based on the fact that most of the habitat will be removed through site clearing. The geographic extent of the impact is local, the duration is long-term, and the frequency is low. Habitat loss resulting from changes in hydrology is reversible through cessation of mine dewatering and various reclamation activities.

Habitat loss resulting from barriers to movement is expected to affect larger, more mobile KIR species such as the moose, fisher, black bear, and beaver. The magnitude of impact is high, geographic extent is local to regional, the duration is long-term, and the frequency is low. Loss of movement corridors is reversible, mainly through progressive reclamation activities.

Table D5.2-8 Summary of Wildlife Residual Impacts and Degrees of Concern

KIR:	Direction	Magnitude	Geograpic Extent	Duration	Reversibility	Frequency	Environmental Consequence
HABITAT LOSS							
SITE CLEARING:							
Moose	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Fisher	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Black bear	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Beaver	Negative	Low	Local	Long-Term	Reversible	Low	Negligible
Red-backed vole	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Snowhoe hare	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Dabbling ducks	Negative	Low	Local	Long-Term	Reversible	Low	Negligible
Ruffed grouse	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Cape May warbler	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Western tanager	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Great gray owl	Negative	High	Local	Long-Term	Reversible	Low	Moderate
HYDROLOGY CHANGES:							
Moose	Negative	Low	Local	Long-Term	Reversible	High	Low
Fisher	Negative	Low	Local	Long-Term	Reversible	High	Low
Black bear	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Beaver	Negative	Low	Local	Long-Term	Reversible	High	Low
Red-backed vole	Negative	Low	Local	Long-Term	Reversible	High	Low
Snowhoe hare	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Dabbling ducks	Negative	Low	Local	Long-Term	Reversible	High	Low
Ruffed grouse	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Cape May warbler	Negative	Low	Local	Long-Term	Reversible	High	Low
Western tanager	Negative	Low	Local	Long-Term	Reversible	High	Low
Pileated woodpecker	Negative	Low	Local	Long-Term	Reversible	High	Low
Great gray owl	Negative	Low	Local	Long-Term	Reversible	High	Low
BARRIERS TO MOVEMENT:							
Moose	Negative	High	Regional	Long-Term	Reversible	Low	Moderate
Fisher	Negative	High	Regional	Long-Term	Reversible	Low	Moderate
Black bear	Negative	High	Regional	Long-Term	Reversible	Low	Moderate
Beaver	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Red-backed vole	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Snowhoe hare	N/A	N/A	N/A	N/A	N/A	N/A	Negligible

KIR:	Direction	Magnitude	Geograpic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Dabbling ducks	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Ruffed grouse	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Cape May warbler	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Western tanager	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Pileated woodpecker	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Great gray owl	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
SENSORY DISTURBANCE:							
Moose	Negative	Moderate	Local	Long-Term	Reversible	Medium-High	Low
Fisher	Negative	High	Local	Long-Term	Reversible	Medium-High	High
Black bear	Negative	Low	Local	Long-Term	Reversible	Medium-High	Low
Beaver	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Red-backed vole	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Snowhoe hare	Negative	Moderate	Local	Long-Term	Reversible	Medium-High	Low
Dabbling ducks	Negative	High	Local	Long-Term	Reversible	Medium-High	High
Ruffed grouse	Negative	Low	Local	Long-Term	Reversible	Medium-High	Low
Cape May warbler	Negative	High	Local	Long-Term	Reversible	Medium-High	High
Western tanager	Negative	High	Local	Long-Term	Reversible	Medium-High	High
Pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Medium-High	High
Great gray owl	Negative	High	Local	Long-Term	Reversible	Medium-High	High
ABUNDANCE AND DIVERSITY:							
SENSORY DISTURBANCE:							
Moose	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Fisher	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Black bear	Negative	Moderate	Local	Long-Term	Reversible	Medium-High	Low
Beaver	Negative	Low	Local	Long-Term	Reversible	Medium-High	Low
Red-backed vole	Negative	Low	Local	Long-Term	Reversible	Medium-High	Low
Snowhoe hare	Negative	Moderate	Local	Long-Term	Reversible	Medium-High	Low
Dabbling ducks	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Ruffed grouse	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Cape May warbler	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Western tanager	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
Great gray owl	Negative	High	Local	Long-Term	Reversible	Medium-High	Moderate
SITE CLEARING:							
Moose	N/A	N/A	N/A	N/A	N/A	N/A	Negligible

KIR:	Direction	Magnitude	Geograpic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Fisher	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Black bear	Negative	Moderate	Local	Long-Term	Reversible	Low	Low
Beaver	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Red-backed vole	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Snowhoe hare	Negative	Moderate	Local	Long-Term	Reversible	Low	Low
Dabbling ducks	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Ruffed grouse	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Cape May warbler	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Western tanager	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Low	Moderate
Great gray owl	Negative	High	Local	Long-Term	Reversible	Low	Moderate
REMOVAL OF PROBLEM WILDLIFE							
Moose	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Fisher	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Black bear	Negative	Low	Local	Long-Term	Irreversible	Medium	Moderate
Beaver	Negative	Low	Local	Medium-Term	Irreversible	Medium	Low
Red-backed vole	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Snowhoe hare	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Dabbling ducks	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Ruffed grouse	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Cape May warbler	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Western tanager	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Pileated woodpecker	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Great gray owl	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
INCREASED WILDLIFE VEHICLE COLLISIONS							
Moose	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
Fisher	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
Black bear	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
Beaver	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
Red-backed vole	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Snowhoe hare	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
Dabbling ducks	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Ruffed grouse	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Cape May warbler	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Western tanager	N/A	N/A	N/A	N/A	N/A	N/A	Negligible

KIR:	Direction	Magnitude	Geograpic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Pileated woodpecker	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Great gray owl	Negative	Low	Regional	Long-Term	Reversible	Medium	Low
INTERACTIONS WITH INFRASTRUCTURE							
Moose	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Fisher	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Black bear	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Beaver	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Red-backed vole	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Snowhoe hare	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Dabbling ducks	Negative	Low	Local	Long-Term	Reversible	Medium	Low
Ruffed grouse	N/A	N/A	N/A	N/A	N/A	N/A	Negligible
Cape May warbler	Negative	Low	Local	Long-Term	Reversible	Medium	Low
Western tanager	Negative	Low	Local	Long-Term	Reversible	Medium	Low
Pileated woodpecker	Negative	Low	Local	Long-Term	Reversible	Medium	Low
Great gray owl	Negative	Low	Local	Long-Term	Reversible	Medium	Low
CHANGES IN HABITAT DUE TO RECLAMATION							
Moose	Positive	Moderate	Local	Long-Term	Reversible	Low	Moderate
Fisher	Negative	Low	Local	Long-Term	Reversible	Low	Moderate
Black bear	Positive	High	Local	Long-Term	Reversible	Low	Moderate
Beaver	Negative	Low	Local	Long-Term	Reversible	Low	Moderate
Red-backed vole	Positive	Low	Local	Long-Term	Reversible	Low	Moderate
Snowhoe hare	Negative	Low	Local	Long-Term	Reversible	Low	Moderate
Dabbling ducks	Positive	High	Local	Long-Term	Reversible	Low	Moderate
Ruffed grouse	Positive	High	Local	Long-Term	Reversible	Low	Moderate
Cape May warbler	Negative	Moderate	Local	Long-Term	Reversible	Low	Moderate
Western tanager	Positive	High	Local	Long-Term	Reversible	Low	Moderate
Pileated woodpecker	Positive	High	Local	Long-Term	Reversible	Low	Moderate
Great gray owl	Negative	Low	Local	Long-Term	Reversible	Low	Moderate

Habitat loss resulting from sensory disturbance is expected to affect all KIRs, except for beavers and red-backed voles. The magnitude of impact ranges from low for species such as black bears which habituate to human activities to high for more sensitive species such as Cape May warblers and great gray owls. The geographic extent is local, the duration is long-term, and the frequency is medium to high. Habitat loss resulting from sensory disturbance is reversible.

Wildlife Abundance and Diversity

Wildlife Abundance and Diversity

This section details the impacts of changes in wildlife abundance and diversity due to:

- sensory disturbance;
- site clearing;
- removal of problem wildlife;
- vehicle-wildlife collisions; and
- interactions with infrastructure.

Most impacts related to change in wildlife abundance and diversity result from site clearing or the direct removal of vegetation communities. Wildlife species with small home ranges or limited mobility, or wildlife species with young are more susceptible to site clearing. Moose were the only KIR species determined not to be affected. Moose and moose calves are highly mobile. The magnitude of impact ranges from moderate in species such as black bears and snowshoe hares to high for the remaining KIRs. The geographic extent is local, the duration is long-term, and the frequency is low. Seasonality is factor as most KIRs will be affected during reproduction. Black bears, which give birth to their cubs in their dens, may be affected during the winter. Red-backed voles, which have 3 or 4 litters per year, will be affected year round. Most other species will be affected in the spring and summer months. This impact is reversible. Impact descriptions for habitat loss are summarized in Table D5.2-8.

Sensory disturbance may affect all of the KIR species, especially during reproductive periods or periods of energetic stress (i.e., overwintering). Sensory disturbances, such as noise, may interfere with reproductive activities (e.g., territory selection, mate attraction) and may interfere with hunting activities in species that hunt by listening for their prey (e.g., great gray owls). The magnitude of impact was predicted to range from low for beavers and red-backed voles to high for most of the breeding birds. The geographic extent is local, the duration is medium to long-term, and the frequency is medium to high. Sensory disturbance will result in higher degree of impact during the spring/summer breeding seasons and possibly during the winter when wildlife can become energetically stressed. Sensory disturbance affecting wildlife abundance and diversity is reversible.

Removal of problem or nuisance wildlife will be concern for beavers and black bears. However, it is difficult to predict the magnitude of this impact with any certainty. It is expected that site clearing will result in the removal of beavers. As habitat is lost, beavers will not be attracted to the area, and the potential for problem situations will decrease. Bears, on the other hand, may be attracted to human food waste. The magnitude of impact was predicted to be low for both beavers and black bears. The geographic extent is local, the duration is medium to long-term, and the frequency is medium. Removal of nuisance wildlife is considered to be irreversible.

Vehicle-wildlife collisions are expected to occur to some extent on Highway 63 from Fort McMurray to the Suncor turn-off, as a result of increased traffic levels. Vehicle-wildlife collisions on-site will be reduced through site clearing, resulting in habitat loss, and reduced speed limits. Few mortalities are expected to occur on-site. Thus, the magnitude of impact is expected to be low. The geographic extent is regional due to the potential for collisions on Highway 63. The duration is long-term and the frequency is medium. This impact is reversible.

Wildlife interactions with infrastructure are expected to occur, as well. However, it is difficult to predict the magnitude of this impact. Suncor will employ various wildlife deterrent systems to prevent wildlife from becoming contaminated by the tailings pond. In addition, Suncor will consider various mitigation measures during infrastructure construction. These measures should reduce the effect of these structures. The magnitude of impact is low, the geographic extent is local, the duration is long-term, and the frequency is medium. More wildlife interactions with infrastructure are expected in the spring and fall during seasonal migration. This impact is reversible.

Reclaimed Wildlife Habitat

Full details of all of the habitat changes resulting from reclamation is provided in Golder (1998n). A summary of the impacts resulting from reclamation are presented in Table D5.2-7. Moose habitat is expected to increase by 12.6% over baseline conditions following closure. This is in part due to the creation of upland habitats preferred by moose. Impacts to moose resulting from reclamation of habitat are positive in direction, moderate in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Fisher habitat is expected to decrease by 7.6% over baseline conditions following closure. This is in part due to the loss of 19% of moderate suitability habitat. Impacts to fisher resulting from reclamation of habitat are negative in direction, low in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Black bear habitat is expected to increase by 27% over baseline conditions following closure. This is in part due to the creation of high suitability habitats preferred by black bears. Impacts to black bears resulting from reclamation of habitat are positive in direction, high in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Beaver habitat is expected to decrease by 6.4% over baseline conditions following closure. This is in part due to the loss of low and moderate suitability habitats for beaver. Impacts to beaver resulting from reclamation of habitat are negative in direction, low in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Red-backed vole habitat is expected to increase by 7.6% over baseline conditions following closure. This is in part due to the creation of high suitability habitats preferred by red-backed voles. Impacts to red-backed voles resulting from reclamation of habitat are positive in direction, low in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Snowshoe hare habitat is expected to decrease by 8.4% over baseline conditions following closure. This is in part due to the loss of high suitability habitats preferred by snowshoe hares. Impacts to snowshoe hares resulting from reclamation of habitat are negative in direction, low in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Dabbling duck habitat is expected to increase by 62.1% over baseline conditions following closure. This is in part due to the creation of low, moderate and high suitability habitats preferred by dabbling ducks. Impacts to dabbling ducks resulting from reclamation of habitat are positive in direction, high in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Ruffed grouse habitat is expected to increase by 33.2% over baseline conditions following closure. This is in part due to the creation of moderate and high suitability habitats preferred by ruffed grouse. Impacts to fisher resulting from reclamation of habitat are positive in direction, high in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Cape May warbler habitat is expected to decrease by 18.4% over baseline conditions following closure. This is in part due to the loss of low and moderate suitability habitats preferred by warblers. Impacts to warblers resulting from reclamation of habitat are negative in direction, moderate in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Western tanager habitat is expected to increase by 108.3% over baseline conditions following closure. This is in part due to the creation of low, moderate and high suitability habitats preferred by western tanagers. Impacts to tanager resulting from reclamation of habitat are positive in direction, high in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Pileated woodpecker habitat is expected to increase by 37.5% over baseline conditions following closure. This is in part due to the creation of moderate and high suitability habitats preferred by woodpeckers. Impacts to woodpeckers resulting from reclamation of habitat are positive in direction, high in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Great gray owl habitat is expected to decrease by 6.5% over baseline conditions following closure. This is in part due to the loss of high suitability habitats preferred by great gray owls. Impacts to owls resulting from reclamation of habitat are negative in direction, low in magnitude, local in geographic extent, of medium-term duration, and of high frequency.

Environmental Consequence

The environmental consequence for impacts on wildlife habitat, movement corridors, abundance, and diversity was determined to be not significant for the various KIRs. Habitat loss resulting from site clearing was determined to have the greatest effect on the KIRs. However, habitat loss from site clearing was determined to be not significant for two reasons. When habitat loss is considered on a regional scale, the amount of habitat lost is actually quite small. As well, the site will be reclaimed to productive forest, including suitable vegetation types for all of the KIRs, as discussed above.

Changes in hydrology resulting in habitat alteration or loss was also determined to be not significant. Most habitat loss will result from site clearing. Some remaining habitat will be affected by changes in hydrology, however, this impact was determined to be quite small. Likewise, barriers to movement was determined to be not significant. The mine plan will not affect the Athabasca and Steepbank River movement corridors, the two main travel corridors in the LSA. Site clearing will affect east-west travel in the LSA, however the extent such movements are not known.

Most impacts relating to change in wildlife abundance and diversity result from site clearing. Since site clearing will be conducted during the winter seasons, most of the bird species will not be affected. As well, larger, more mobile species should not be affected. Thus, the environmental consequence of site clearing on wildlife abundance and diversity is expected to be low to moderate, depending on the KIR species.

Sensory disturbance, removal of nuisance wildlife, increased wildlife-vehicle collisions, and interactions with infrastructure may also affect wildlife abundance and diversity. The environmental consequence of all of these factors was determined to be negligible to low for most KIR species.

Changes in wildlife habitat resulting from reclamation is expected to be positive for most species. Habitat for most of the KIR species is expected to return to equivalent capability. For some species (e.g., moose), habitat is expected to increase over baseline conditions following closure. The environmental consequence of this impact is moderate.

D5.2.6.3 Monitoring

Monitoring is required to assess the effects of habitat change on wildlife including the evaluation of the use of designed wildlife corridors by wildlife. Monitoring of vegetation (and hence wildlife habitat) will also be required, and is discussed in Section D3.2. All monitoring programs should have a sound scientific design such that effects of the Project are clearly separated from those of natural variation and other effects. Results of the monitoring should be used to improve the mitigation programs as appropriate.

Monitoring of wildlife numbers will be required on reclaimed lands. As many KIRs depend on mid to late forest seral stages, monitoring of these species numbers will not be useful, at least not in the short-term. Rather, monitoring for these KIRs in the short-term should be based on whether the reclaimed area has been successfully set on a successional pathway that will eventually result in good habitat for the KIR of concern. Certification should be achieved once it has been demonstrated that early successional wildlife species have recolonized the development site and that the vegetation has been set on its desired successional pathway.

Monitoring of KIR habitat will be required to determine the success of establishment of early successional communities; and to determine that the communities are established on a successional pathway that will result in the desired late successional communities. Monitoring includes measurement of HSI variables for KIRs.

Monitoring will also be required to ensure that the bird deterrent systems on the tailings pond are effective. As well, Suncor should encourage personnel to report interactions with nuisance wildlife and to report traffic and infrastructure mortalities.

D5.2.7 Key Question W-2: What Impacts Will Chemicals in Operational Air and Water Releases From Project Millennium Have on Wildlife Health?

D5.2.7.1 Analysis of Potential Linkages

Linkage Between Changes in Water Quality and Wildlife Health

The linkage between Project activities and water quality has been previously addressed in Section C3.2. Since the Project is not yet in operation, measured data specific to the Project could not be evaluated. However, surrogate data from existing operations (e.g., Syncrude and Suncor) were used to provide an estimate of the chemistry of release waters during operation, at closure and in the far future. These data were then used to predict water quality in receiving waters of McLean Creek, Shipyard Lake and the Athabasca River (refer to Section C3 for further details). This section addresses the potential linkage between water quality changes and wildlife health during the operation phase. Predicted water concentrations at closure and in the far future are evaluated in Key Question W-3, Section D5.2.8.

A Problem Formulation was conducted including chemical, receptor and exposure pathway screenings, as described in Section D5.1.7 and Appendix VI.1 to VI.3. Potential receptors include wildlife that feed in aquatic environments (e.g., water shrew, river otter, killdeer, great blue heron) and those that feed in terrestrial environments (e.g., moose, snowshoe hare, black bear, beaver and deer mouse). These animals may be exposed through ingestion of water from the Athabasca River, McLean Creek or Shipyard Lake. Chemical screening was conducted based on predicted future water concentrations in these waterbodies during operation. Screening tables are presented in Appendix VI.1.2. The predicted low level, long term chemical concentrations in these waterbodies suggested no hazardous conditions would exist. Consequently, no chemicals of potential concern were identified in all waterbodies and for all species evaluated, based on predicted concentrations during the operation phase. However, no screening criteria were available for naphthenic acids, and therefore this group of chemicals was retained for further evaluation.

Since naphthenic acids, receptors and exposure pathways have been identified, a potential linkage exists between water quality changes and wildlife health.

Linkage Between Changes in Fish Tissue Quality and Wildlife Health

To determine whether changes in fish tissue quality may affect wildlife health, a Problem Formulation was conducted including chemical, receptor and exposure pathway screenings, as described in Section D5.1.7 and Appendix VI.1 to VI.3. Aquatic wildlife species, such as the river otter and great blue heron, consume large quantities of fish daily (up to 100% of their diet). For this reason, the river otter and great blue heron were selected as representative receptors for evaluation of this key question.

A combined field and laboratory study was completed to address the potential for accumulation of chemicals in fish tissue. These data are summarized in Section C4 and briefly described in this section. Walleye, goldeye and longnose sucker were collected in 1995 as part of a baseline aquatics study in the oil sands region (Golder 1996c). Walleye and goldeye were captured in the Athabasca River near Suncor and longnose sucker were captured as they moved up the Muskeg River to spawn. All three species spend part of the open water season in the vicinity of existing oil sands operations. Composite samples of fish fillets were analyzed for organic chemicals and metals (data presented in Section C4.2). Samples from longnose sucker contained trace concentrations of naphthalene (0.02 to 0.04 μg/g) and methylnaphthalene (<0.02 to 0.03 μg/g); however, other polycyclic aromatic hydrocarbons (PAHs) were not detected. No PAHs were detected in walleye and goldeye samples. Levels of trace metals in fish tissue were generally low or less than detection limits.

Uptake of oil sands related chemicals into fish tissue was also investigated during two laboratory fish health studies where juvenile walleye and rainbow trout were exposed to a variety of waters, including a dilution series of water collected from Suncor's Tar Island Dyke (TID) drainage system (0.1 to 10% strength), Suncor wastewater treatment system effluent (0.01 to 10% strength), laboratory control water and Athabasca River water collected upstream of existing oil sands operations (i.e., background controls). The fish were exposed to these waters in a flow-through system for 28 days, sacrificed and their tissues analyzed for PAHs and trace metals (HydroQual 1996a,b). PAH concentrations in juvenile walleye and rainbow trout were generally below detection following exposure to TID water; naphthalene and methyl naphthalene levels in rainbow trout were at or just above the detection level in both control and treatment samples (0.02 to 0.03 μg/g; Section C4). PAHs were not detected in fish exposed to refinery effluent water. Concentrations of most metals were generally low or less than detection limits in both treatment and control samples. The only notable exceptions were arsenic and mercury where concentrations of <0.1 - 2.3 μg/g and 0.02 - 0.45 μg/g, respectively, were measured. However, the highest concentrations were associated with the background control fish exposed to the Athabasca River water. Thus, no significant accumulation of PAHs or metals (relative to detection limits or levels in background control fish) is indicated by either laboratory exposure of fish to Tar Island Dyke water and wastewater treatment system effluent, or from fish captured in the Athabasca River.

Notwithstanding the lack of evidence of accumulation of chemicals in fish tissue, a chemical screening was conducted to determine whether ingestion of fish from the Athabasca River might potentially pose a hazard to river otters or great blue herons. The chemical screening process followed the same screening protocol as for drinking water. No chemicals of concern in fish tissue were identified. Chemical screening tables are presented in Appendix VI.1.2.

It should be noted that levels of mercury in fish tissues are elevated and may increase exposure for wildlife eating fish from this region of the river. Elevated levels of mercury in fish tissues have also been noted by the Northern River Basin Study (NRBS), and have been attributed to natural sources (NRBS 1996a). Water quality modelling suggests the Project will not significantly change the waterborne mercury levels. For these reasons, mercury was not evaluated further in the risk assessment.

In summary, based on the data and results of the Problem Formulation, release waters do not appear to contribute to increases in chemical concentrations in fish within the RSA to concentrations that would be associated with adverse health effects in wildlife. Hence, a linkage between changes in fish tissue quality associated with the Project and wildlife health does not exist.

Linkage Between Changes in Aquatic Invertebrate Tissue Quality and Wildlife Health

A Problem Formulation was conducted including chemical, receptor and exposure pathway screenings as described in Section D5.1.7 and Appendix VI.1 to VI.3. The diet of aquatic wildlife species, such as the water shrew and killdeer, is largely composed of aquatic invertebrates. Therefore, in addition to direct exposure to water, these species may also be exposed through ingestion of aquatic invertebrate prey. For this reason, the validity of the linkage between aquatic invertebrate tissue quality and wildlife health was evaluated.

Data for evaluation of this pathway were limited, consisting of a few samples of benthic invertebrates collected in 1995 from potentially impacted areas of the Athabasca River near existing oil sands facilities (Golder 1996c). No data were available for water column invertebrates (such as insects), which would be more typical of the diet of water shrew and killdeer. Benthic invertebrates receive the majority of their exposure from sediments, whereas water column invertebrates are exposed primarily to chemicals in the water column. Since sediment concentrations of metals are usually higher than water column concentrations, benthic invertebrates may accumulate higher concentrations in their tissues, relative to water column invertebrates. As such, use of benthic invertebrate tissue data as a surrogate for potential tissue concentrations in water column invertebrates will likely overestimate risk estimates. Chemical screening tables are presented in Appendix VI.1.2.

Chemical screening of these data identified the following seven chemicals of potential concern to water shrew and killdeer:

- barium (water shrew, killdeer)
- chromium (killdeer)
- cobalt (water shrew, killdeer)
- copper (water shrew, killdeer)
- manganese (water shrew)
- molybdenum (water shrew)
- zinc (water shrew, killdeer)

Since chemicals, receptors and exposure pathways have been identified, a potential linkage exists between aquatic invertebrate quality and wildlife health.

Linkage Between Changes in Air Quality and Wildlife Health

Although wildlife may be exposed to chemicals in air by direct inhalation, this route of exposure is typically considered to be minor for wildlife compared to that obtained through the food chain. Airborne chemicals may deposit directly onto plant surfaces, and/or plants may take up chemicals that have deposited onto soils. Subsequent ingestion of these plants by herbivorous animals is an important exposure route. The results of an animal tissue sampling program conducted in 1994 also suggest that ingestion is the primary exposure pathway for animals in the oil sands area (Conor Pacific Environmental Technologies 1998a Draft; refer to Section F1.2.5 for further details of the study).

There is also considerable uncertainty associated with risk predictions for wildlife based on inhalation exposure due to:

- the limited amount of inhalation toxicity studies conducted with wildlife; and
- the uncertainty in extrapolating from laboratory animals to wildlife to determine the dose deposited and retained in the respiratory tract of various wildlife species (i.e., requires detailed knowledge of the respiratory anatomy/physiology of each species).

Therefore, while a linkage between changes in air quality and wildlife health is valid, direct effects of air inhalation will not be considered for wildlife. Rather, indirect exposure via ingestion of plants will address this issue, as described in the following section.

Linkage Between Changes in Vegetation Quality and Wildlife Health

The linkage between oil sands activities and plant tissue quality was evaluated previously in the baseline assessment, Section D5.1.8. This linkage was neither validated nor invalidated because there was no consistent subset of chemicals that were elevated within areas subject to oil sands air emissions. Nevertheless, a baseline risk assessment was conducted and results indicated no unacceptable health risks to wildlife that consume plants containing the maximum measured chemical concentrations. Although the data from the vegetation program did not show a definite linkage between oil sands activities and plant tissue concentrations, there is some uncertainty associated with the small sample size and in choosing test areas on the basis of modelled air deposition predictions. Due to this uncertainty, potential linkages between activities of Project Millennium, changes in plant tissue quality and wildlife health were considered valid for further evaluation.

D5.2.7.2 Analysis of Key Question

The analysis of this key question is divided into three steps:

- wildlife health risks associated with water releases;
- wildlife health risks associated with air emissions/vegetation; and
- wildlife health risks associated with combined exposure to all media.

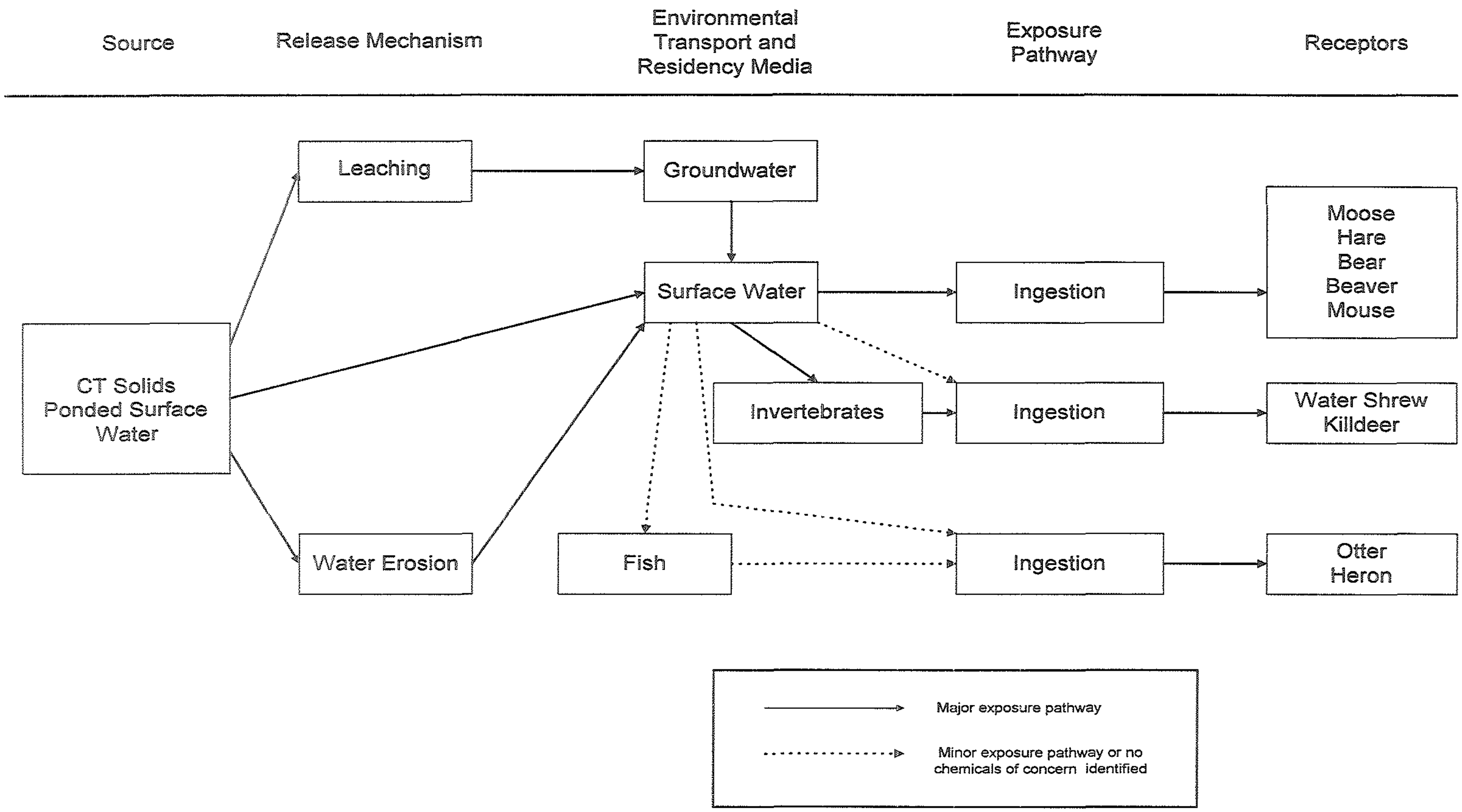
Step 1: Water Releases

Valid linkages associated with water releases include changes in water quality, as a result of naphthenic acids, and aquatic invertebrate tissue quality. To further investigate these linkages, a quantitative wildlife health risk assessment was conducted for conceptual model W-2a (Figure D5. 2-14), according to the method described in Section D5.1.7.

Wildlife Health Risks From Water Quality (Naphthenic Acids)

To date, there are insufficient mammalian toxicological data to calculate a defensible reference dose (RfD) for naphthenic acids, and therefore to assess the potential for chronic adverse health effects in wildlife. RfDs are normally calculated based on chronic or subchronic studies in laboratory animals. Currently, there are only acute lethal toxicity mammalian data available for naphthenic acids. The acute toxicity data suggest that naphthenic acids have a relatively low potency for lethality under acute exposure conditions. Predicted concentrations in the Athabasca River, Shipyard Lake and McLean Creek are much less than concentrations that would be associated with acute lethality.

Figure D5.2-14 W-2a: Conceptual Model for the Water Releases Scenario



Further study has been and will be initiated by Suncor to determine the potential for chronic mammalian toxicity of naphthenic acids and CT water. Recently, Suncor completed preliminary studies to determine the potential for mutagenicity of CT water (both fresh and aged). Preliminary results of this study were equivocal, and therefore further studies are currently being conducted. In addition, an industry-sponsored three-year study of the mammalian toxicity of naphthenic acids in laboratory animals is in the planning stages at the University of Saskatchewan. Refer to Section F1.1.4.3, Toxicity Assessment, for further details.

Wildlife Health Risks From Aquatic Invertebrate Quality

Exposures to water shrew and killdeer from ingestion of aquatic invertebrates, were estimated based on measured tissue concentrations in benthic invertebrates collected from potentially impacted areas of the Athabasca River (Golder 1996c). It was conservatively assumed that water shrews and killdeer consumed 100% of their diet of aquatic invertebrates from the Athabasca River, every day of the year for their entire lifespan. ERs for water shrew and killdeer are presented in Table D5.2-9.

ERs for consumption of aquatic invertebrates were less than or marginally greater than 1. Based on the conservative assumptions used in the assessment (i.e., 100% of the diet from impacted areas; benthic invertebrate tissue concentrations used as surrogates for water column invertebrate tissue concentrations), the marginal exceedance of 1 for aquatic invertebrate consumption indicates a *de minimis* risk to individual animals. Thus, risks to water shrew and killdeer populations are considered to be *de minimis*. Therefore, no adverse impact to wildlife health is predicted to occur as a result of exposure to chemicals in aquatic invertebrates by water shrew and killdeer.

Table D5.2-9 Exposure Ratio Values for Water Shrew and Killdeer

Receptor/Chemical	ER for Invertebrate Diet
Water Shrew	
Barium	2.26
Cobalt	0.44
Copper	1.24
Manganese	1.49
Molybdenum	2.67
Zinc	0.35
Killdeer	
Barium	0.22
Chromium	1.63
Cobalt	0.31
Copper	0.15
Manganese	0.05
Zinc	1.43

Step 2: Air Emissions and Vegetation

The linkage between airborne chemical deposition and plant ingestion by wildlife is shown in conceptual model W-2b (Figure D5.2-15).

In response to the uncertainties and concerns articulated by stakeholders respecting air deposition of airborne chemicals onto vegetation, Suncor undertook a stack survey to collect information respecting particulate matter, organic chemicals and metals. Information from this study will be used to model the deposition of air contaminants onto vegetation and then interpret this in the context of potential exposure for wildlife consuming plants from this area. However, the results of the stack survey were not received in time to be incorporated into this section at the time of submission. The results of the stack survey and ramifications to wildlife health will be available after the analysis is complete.

In the interim, the available information regarding plant consumption and relevance to wildlife health is discussed in the context of baseline conditions (Section 5.1.8). That analysis indicated no unacceptable health risks to wildlife which consume plants having the maximum chemical concentrations measured in the baseline vegetation sampling program.

Step 3: Combined Exposure to all Media

To calculate risk estimates for the combined exposure to all media, incremental risk estimates (ERs) for each media were summed, resulting in a total ER for each chemical. Consideration ws also given to the additivity of chemicals having similar effects on reproduction. For each receptor, chemical screening for each media identified different chemicals. However, for the purposes of this linkage analysis, any chemical that was retained for one media was evaluated in all media, where data were available, to ensure a conservative assessment of combined exposure. The same values used in the previous linkage analyses for behavioural exposure parameters also apply in the present case.

ER values for wildlife are presented in Table D5.2-10 for each pathway separately and for the total combined exposure to all media. The health risks to wildlife populations from exposure through the food chain have been determined in the previous sections to be *de minimis*. The water ingestion pathway is a minor component of the exposure received by wildlife populations, compared to food chain exposure, and does not contribute to a significant increase in health risks. Therefore, on the basis of individual chemicals, no adverse impact to wildlife health is predicted to occur as a result of exposure to chemicals in water, plants and/or aquatic invertebrates.

Figure D5.2-15 W-2b: Conceptual Model for the Air Emissions/Vegetation Scenario

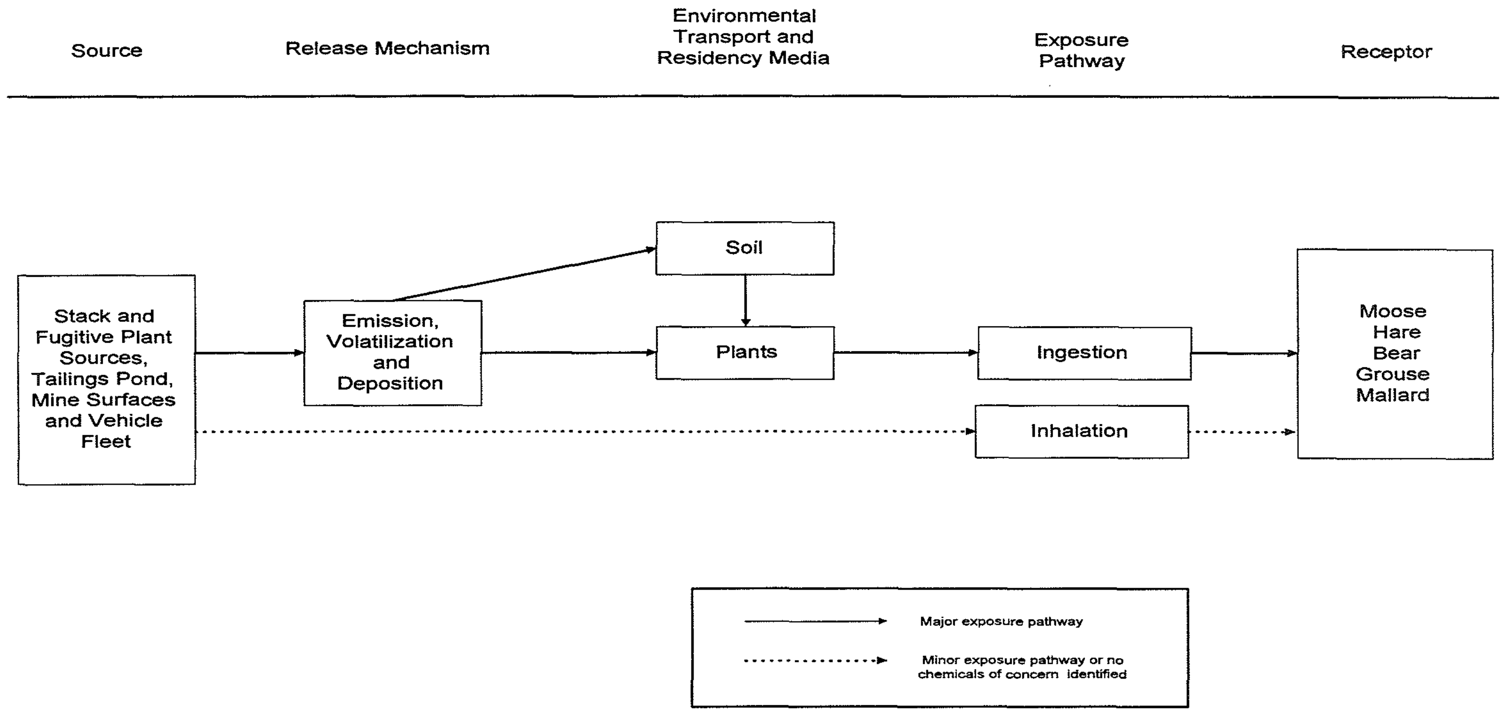


Table D5.2-10 Combined Exposure Ratio Values for Wildlife Based on Exposure to all Media during the Operation Phase

Receptor/ Chemical	ER for Water Exposure[a]	ER for Aquatic Invertebrate Exposure	ER for Exposure to Plants[b]	Total ER for Exposure to All Media
Water Shrew				
Barium	0.001	2.26	n/a[d]	2.26
Cobalt	no data[c]	0.44	n/a[d]	0.44
Copper	0.00002	1.24	n/a[d]	1.24
Manganese	0.0003	1.49	n/a[d]	1.49
Molybdenum	0.02	2.67	n/a[d]	2.69
Zinc	0.00002	0.35	n/a[d]	0.35
Killdeer				
Barium	0.0008	0.22	n/a[d]	0.22
Chromium	0.0009	1.63	n/a[d]	1.63
Cobalt	no data[c]	0.31	n/a[d]	0.31
Copper	0.00002	0.15	n/a[d]	0.15
Manganese	0.00009	0.05	n/a[d]	0.05
Zinc	0.0006	1.43	n/a[d]	1.43
River Otter[e]				
Molybdenum	0.05	n/a[d]	n/a[d]	0.05
Moose				
Antimony	0.0002	n/a[d]	0.33	0.33
Barium	0.005	n/a[d]	1.13	1.13
Boron	0.004	n/a[d]	0.07	0.074
Cadmium	0.0008	n/a[d]	0.01	0.01
Cobalt	no data[c]	n/a[d]	0.14	0.14
Copper	0.00008	n/a[d]	0.20	0.20
Manganese	0.001	n/a[d]	0.83	0.83
Molybdenum	0.08	n/a[d]	0.46	0.54
Selenium	0.002	n/a[d]	0.12	0.12
Vanadium	0.011	n/a[d]	1.24	1.25
Snowshoe Hare				
Antimony	0.00009	n/a[d]	0.57	0.57
Barium	0.002	n/a[d]	1.44	1.44
Copper	0.00004	n/a[d]	0.29	0.29
Manganese	0.0006	n/a[d]	1.06	1.06
Molybdenum	0.03	n/a[d]	0.09	0.12
Black Bear				
Antimony	0.0002	n/a[d]	0.39	0.39
Barium	0.004	n/a[d]	0.98	0.98
Copper	0.00007	n/a[d]	0.20	0.20
Manganese	0.001	n/a[d]	0.72	0.72
Molybdenum	0.07	n/a[d]	0.07	0.14
Ruffed Grouse				
Barium	0.0005	n/a[d]	0.24	0.24
Copper	0.00001	n/a[d]	0.06	0.06

(a) ER values for water are the maximum predicted for wildlife species during operation (2000 to 2025).
(b) ER values for plants are based on the results of the 1997 vegetation sampling program (refer to Section D5.1.8 for further details).
(c) future predictions of cobalt were not available, but evidence suggests ER values would be similar to those predicted for other metals.
(d) this is not a relevant exposure pathway for the receptor indicated.
(e) ingestion of fish by river otter was not evaluated for combined exposures since molybdenum was not detected in fish tissue samples

When chemicals having marginal risk estimates based on reproductive endpoints are considered collectively (i.e., additive effect) for a given species, the total ER values remain less than 10. Therefore, even if additive interactions among chemicals are considered, risks to wildlife are *de minimis*.

D5.2.7.3 Residual Impact Classification and Environmental Consequence

Based on the results of the risk assessment, impacts to wildlife health are negligible during operation of the Project for the chemicals evaluated. However, due to the uncertainty regarding the potential effects of chronic low level exposure to naphthenic acids present in water releases, the magnitude of impact is low. The geographic extent is regional since exposures may occur beyond the LSA. The duration is long-term, since exposures may occur for greater than 30 years. The impact is reversible, since further study of naphthenic acids toxicity is being conducted to resolve the uncertainty and mitigation options will be considered as necessary to reduce exposures. The frequency is high, since exposures occur continuously. The resulting environmental consequence is low.

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-Term	Reversible	High	Low

Certainty

The assessment of potential impacts to local wildlife was based on a number of highly conservative assumptions, with the intent to overestimate rather than underestimate risk. The conservative assumptions related to chemical screening are discussed in Section D5.1.7. These assumptions provide assurances that no chemicals were excluded from the screening step except those that clearly pose no incremental risk to wildlife health. Risk estimates were calculated deterministically to provide single value estimates of ERs; however, a significant degree of uncertainty is associated with most ER values. In light of this uncertainty, to ensure that this assessment errs on the side of safety, protective input values were used throughout. Hence, the actual risks to wildlife health will likely be even lower than those suggested by ER estimates because of the multiple protective assumptions as outlined below:

- reasonable worst case exposure point concentrations in the Athabasca River, McLean Creek and Shipyard Lake were used, assuming no decay or degradation of chemicals;
- exposure locations were set within the mixing zone of the rivers, downstream of all potential water emissions;

- animals were assumed to drink 100% of their water requirements from McLean Creek, Shipyard Lake or the Athabasca River, whichever had the highest concentration;
- measured tissue concentrations in benthic invertebrates (i.e., animals subject to sediment contaminant accumulation) were used as surrogates for invertebrates which inhabit the water column;
- exposure parameter values for wildlife receptors represent reasonable maximum exposure values;
- maximum baseline concentrations measured in plant tissue were used and animals were assumed to fulfill daily vegetation requirements with plants of the same chemical concentrations as those measured in the vegetation sampling program; (i.e., no proportion of their plant diet was assumed to be less contaminated);
- receptor-specific toxicity reference values were developed to be protective of wildlife under chronic exposure conditions; and
- wildlife were assumed to be exposed to maximum measured or predicted chemical concentrations in all relevant media at the same time.

Due to the conservatism involved in the risk assessment, there is a high degree of confidence in the results of the assessment. However, some uncertainty exists with respect to the following:

- future vegetation concentrations as a result of air deposition;
- lack of a toxicity reference value for naphthenic acids and CT water and corresponding health risks; and
- uncertainties inherent to predictive water quality modelling (refer to Section C3).

With respect to chronic mammalian toxicity of naphthenic acids and CT water, several efforts are underway to further resolve this issue. As discussed previously, Suncor has recently completed preliminary studies on the mutagenic potential of CT water. These results were equivocal and further studies are currently being conducted. Additionally, an industry-sponsored 3 year study of the mammalian toxicity of naphthenic acids in laboratory animals is in the planning stages at the University of Saskatchewan. Refer to Section F1.1.4.3, Toxicity Assessment, for further details.

D5.2.7.4 Monitoring

A suite of chemical substances, including the chemicals of concern discussed here will continue to be monitored annually in surface water at predetermined locations in the Athabasca, Muskeg and Steepbank rivers and Shipyard Lake as part of the RAMP program. In addition to water quality monitoring, periodic sampling of benthic invertebrate and fish tissues for chemical analysis should be included in the RAMP program to provide a more comprehensive dataset for validating the exposure and risk assessments. Refer to Section C4.2.8.5 and Golder (1998h) for further details of the RAMP program.

Further study will be initiated by Suncor to determine the potential for chronic mammalian toxicity of naphthenic acids and/or CT water. Consideration will also be given to resolve these data gaps as part of CONRAD. Refer to Section F1.1.4.3, Toxicity Assessment, for more details.

Suncor is a member of the Wood Buffalo Environmental Association (WBEM). The Environmental Effect Monitoring (EEM) Committee is currently planning a study to be implemented in 1998 that will involve sampling of plant tissue for analysis and interpretation respecting wildlife health.

D5.2.8 Key Question W-3: What Impacts Will the Release of Chemicals in Soil, Plants and Waters of the Project Millennium Reclaimed Landscape Have on Wildlife Health?

Key question W-3 is evaluated in two parts. Part A evaluates the potential for adverse effects to wildlife health as a result of exposure to chemical concentrations predicted for Shipyard Lake, McLean Creek, Athabasca River and the EPL at closure and in the far future. The approach used for Part A mirrors that used for key question W-2. Part B involves evaluation of the potential for adverse wildlife health effects as a result of exposures to chemicals on the reclaimed landscape, including exposure to ponded surface waters/streams, soils and vegetation. The approach used for Part B involves consideration of wildlife foraging within the LSA in the far future.

D5.2.8.1 Part A: Effects of Water Quality at Closure and in the Far Future on Wildlife Health

Analysis of Linkages

Predicted water concentrations in McLean Creek, Shipyard Lake, Athabasca River and the EPL at closure and in the far future were evaluated with respect to wildlife health. The results of chemical screening identified only molybdenum as a potential chemical of concern in McLean Creek in the far future for moose and black bear, in the EPL at closure, and in the far future for water shrew, river otter, deer mouse, moose, beaver, snowshoe hare and black bear. In addition, no screening criteria were available for naphthenic acids and therefore this group of chemicals was retained as chemicals of potential concern. Screening tables are presented in Appendix VI.1.2 (data for operation, closure and far future were screened on the same tables). No other chemicals were identified as being of potential concern for any other waterbodies.

Since chemicals, receptors and exposure pathways have been identified, a potential linkage exists between water quality changes and wildlife health.

Analysis of Key Question (Part A)

The approach for Part A mirrors that used for assessment of water quality during operation in key question W-2, Section D5.2.7 (refer to conceptual model in Figure D5.2-1). In the exposure assessment, it was conservatively assumed that wildlife would ingest their total daily water requirements from either McLean Creek or the EPL, every day of the year for their entire lifespan. ER values for wildlife exposed to molybdenum at closure are presented in Table D5.2-11.

ER values are less than 1 for McLean Creek. In light of this, and the absence of other chemicals of concern, predicted maximum exposures of molybdenum in McLean Creek, Shipyard Lake and the Athabasca River at closure and in far future are within acceptable limits for protection of wildlife health.

Table D5.2-11 Exposure Ratios Predicted for Maximum Molybdenum Exposure in Drinking Water during Operation and in Far Future

Receptor	McLean Creek (Far Future)	End Pit Lake (2044)	End Pit Lake (Far Future)
Water Shrew	0.03	0.34	0.05
River Otter	0.08	0.95	0.13
Deer Mouse	0.03	0.37	0.05
Beaver	0.09	1.0	0.14
Snowshoe Hare	0.06	0.68	0.09
Moose	0.14	1.6	0.22
Black Bear	0.13	1.4	0.19

With respect to the EPL, ER values for beaver, moose and black bear are marginally greater than 1 in 2044 (prior to discharge), but are less than 1 in the far future. Due to the uncertainty associated with predictions of EPL water quality, the conservativism of the assessment, the marginal nature of the ER exceedence, and the fact that there is only one chemical of potential concern (molybdenum) to wildlife in EPL water, the magnitude of the problem is not considered to be high at this time. Further monitoring of EPL water quality at closure will enable informed decisions about this potential issue.

D5.2.8.2 Part B: Effects of Chemical Releases From the Reclaimed Landscape on Wildlife Health

Analysis of Linkages

Following closure of Project Millennium and reclamation of the site, it is intended that the reclaimed landscape will attract wildlife into the area. This key question addresses the potential for impacts to the health of wildlife that forage within the LSA following closure of the Project under far future equilibrium conditions. The wildlife receptors selected for evaluation of this key question include: deer mouse, snowshoe hare, moose, ruffed grouse, beaver and mallard, species which collectively provide good representation of terrestrial and aquatic dependencies.

Linkage Between Changes in Water Quality and Wildlife Health

Potential sources of drinking water associated with the reclaimed landscape include ponded surface water, streams, wetlands, ponds and rivers. The linkage between water quality and wildlife health in the far future has been validated in Part A of this key question for larger waterbodies. However, wildlife foraging on the reclaimed landscape may also drink water from other sources (i.e., ponded surface water, streams, wetlands, salt licks). This linkage evaluates the potential for adverse health effects in wildlife as a result of consumption of water from these types of seepage waters. Seepage waters will contain the chemicals which naturally leach from the reclamation soils and ultimately discharge to surface waterbodies. In some instances, seepages may surface and provide a water source to wildlife. Seepage waters in reclaimed areas of the site in the far future will contain low levels of CT water, since CT flux will have become minimal by this time. The water quality of ponded water sources on the reclaimed landscape will be determined primarily be precipitation, run-off and sand seepage. For this assessment, on-site seepage water quality was assumed to consist of 15% CT seepage water and 85% sand seepage water. The resulting on-site seepage water estimates were screened against one-tenth of the RBCs for wildlife. Screening tables are presented in Appendix VI.1.2. The following chemicals were identified for further evaluation in the risk assessment for the species identified in parentheses:

- cadmium (grouse, hare)
- molybdenum (moose, hare)

Since chemicals of concern, receptors and exposure pathways may co-exist, a potential linkage exists between water quality changes and wildlife health following closure.

Linkage Between Changes in Air Quality and Wildlife Health

Following closure of Project Millennium, there will be no air emissions from extraction, utilities or vehicles. In addition, disturbed areas of the site will be capped with a layer of reconstructed soils, reducing the potential for volatile air releases. CT deposits will be capped with lean CT and sand to a depth of 5 to 10 m, followed by a surface layer of reconstructed soils. Although there is some potential for release of volatile chemicals through the capping layer and into the air above CT deposits, these releases are likely to be minimal and will decrease over time as the CT consolidates. In the far future, when wildlife are likely to frequent the reclaimed landscape, volatilization is expected to be negligible. To examine this issue further Suncor has undertaken a multi year demonstration project known as the CT Reclamation Demonstration, which will aid in confirming, in the short term, that the long term strategy for capping will minimize or virtually eliminate release of CT-derived soil gas.

Therefore, this linkage is considered to be invalid for the reclaimed landscape in the far future.

Linkage Between Changes in Soil Quality and Wildlife Health

It is unlikely that wildlife will be directly exposed to CT, because these deposits will be buried below a capping layer of sand, muskeg and vegetation. Soil concentrations that wildlife may be exposed to will be comparable to natural background levels within muskeg; hence incidental ingestion of soils will not be a significant source of Project-related chemicals. For this reason, a linkage between soil quality and wildlife health was considered invalid.

Linkage Between Changes in Terrestrial Invertebrate Quality and Wildlife Health

Some of the wildlife species selected as receptors for this assessment (i.e., deer mouse, ruffed grouse), feed on terrestrial invertebrates. On reclaimed areas of the site, a minimum 20 cm layer of muskeg will be applied to all areas. Most terrestrial invertebrates would live within this layer, which is considered to be equivalent in chemistry to the muskeg soils in natural areas of the LSA. Since terrestrial invertebrate exposures in the capping layer of reclaimed areas of the site would be similar to exposures in undisturbed areas of the site, a linkage between terrestrial invertebrates and wildlife health was considered to be invalid.

Linkage Between Changes in Terrestrial Plant Quality and Wildlife Health

Wildlife may be exposed to chemicals from the reclaimed landscape via ingestion of plants. Some of these plants may be growing on top of capped

CT deposits. At equilibrium, the CT will be consolidated below 5 to 10 m of lean CT and sand and a surface layer (i.e., 20 cm) of muskeg. Therefore, plant roots may extend into the sand layer overlying the CT deposit, but would be unlikely to extend into the CT deposit itself.

Xu (1997) measured uptake of metals into the leaves, stems and roots of poplar, willow and reed canary grass from reclamation materials of various composition. For the purpose of this key question, metal concentrations in plants growing on CT, capped with 20 cm of tailings sand and 5 cm of muskeg, were used as conservative estimates of the potential concentrations of plants on the Project Millennium reclaimed landscape. The geometric mean of these data was used for chemical screening and exposure modelling involving plants growing on capped CT deposits. Since no measured data were available for PAHs in plants growing on reclaimed landscapes, plant tissue concentrations were estimated based on the chemistry of tailings sand and bioconcentration factors (BCF) for plant uptake (Travis and Arms 1988), according to the following equation:

plant concentration = BCF * tailing sand concentration

A chemical screening process was conducted to determine whether the measured and/or predicted plant concentrations may exceed RBCs for plant consumption by wildlife. Screening tables are presented in Appendix VI.1.2. The following chemicals were identified for further evaluation in the risk assessment for the species identified in parentheses:

- barium (moose, hare, mouse)
- boron (moose, grouse)
- cobalt (moose, hare, grouse)
- mercury (mouse)
- molybdenum (moose, mouse)
- nickel (mouse)
- selenium (mouse, moose, grouse)
- strontium (mouse)
- vanadium (mouse, hare, moose)
- zinc (mouse, grouse)

Since elevated chemical concentrations, receptors and exposure pathways may co-exist, a potential linkage exists between plant quality changes and human health following closure.

Linkage Between Changes in Aquatic Plant Quality and Wildlife Health

Some of the wildlife species selected as receptors for this assessment (i.e., moose, mallard and beaver), feed on aquatic plants. For these receptors, a chemical screening process was conducted to determine whether there is a potential for adverse health effects in these wildlife species from ingestion of aquatic plants growing in wetlands and open water areas of the reclaimed landscape. Several studies have been conducted to determine metal and organic chemical uptake into aquatic plants growing in constructed wetlands and natural wetlands in the oil sands area. Chemical concentrations measured in aquatic plants harvested from the Suncor dyke drainage water constructed wetland, Pond 1A, Syncrude Pit 7, Suncor Pond 5 and Suncor hummock wetlands, were used for chemical screening and in exposure modelling (Nix 1995, Golder 1997g). Screening tables are presented in Appendix VI.1.2. No chemicals of concern were identified for mallards. The following chemicals were identified for further evaluation in the risk assessment for the species identified in parentheses:

- barium (moose)
- boron (moose)
- vanadium (beaver, moose)

Since elevated chemical concentrations, receptors and exposure pathways may co-exist, a potential linkage exists between potential changes in aquatic plant quality and wildlife health following closure.

Linkage Between Changes in Aquatic Invertebrate Quality and Wildlife Health

A certain portion of the diet of mallards and other waterfowl consists of aquatic invertebrates. Therefore, a chemical screening process was conducted to determine whether there is a potential for adverse health effects to mallards from ingestion of aquatic invertebrates from wetlands and open water areas of the reclaimed landscape. Data from a study in which aquatic invertebrates were living in constructed wetlands on a reclaimed landscape were used for chemical screening (Nix 1995). Screening tables are presented in Appendix VI.1.2. The following chemicals were identified for further evaluation in the risk assessment for the species identified in parentheses:

- barium (mallard)
- zinc (mallard)

Since elevated chemical concentrations, receptors and exposure pathways may co-exist, a potential linkage exists between potential changes in aquatic invertebrate quality and wildlife health following closure.

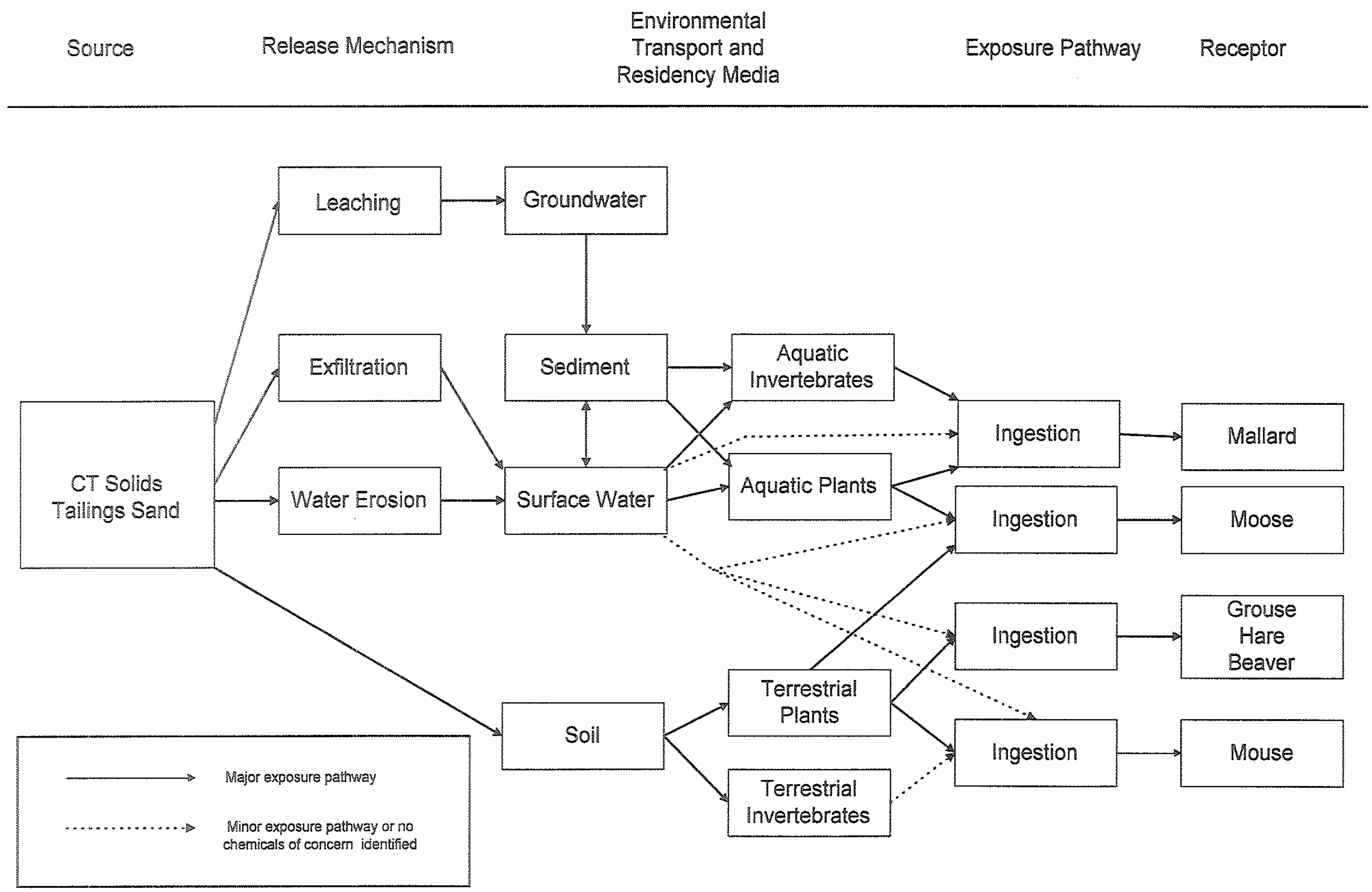
Analysis of Key Question (Part B)

Several chemicals were identified for further evaluation in the risk assessment for conceptual model W-3 (Figure D5.2-16), based on chemical screening of measured or predicted concentrations in water, terrestrial plants, aquatic plants and aquatic invertebrates. For the purposes of this analysis, any chemical that was retained for one media was evaluated in all media (i.e., water, terrestrial plants, terrestrial invertebrates, aquatic plants and aquatic invertebrates), where data were available, to ensure a conservative assessment of combined exposure on the reclaimed landscape. Although the linkage between terrestrial invertebrates and wildlife health was considered invalid, to ensure that the complete diet of all wildlife receptors was evaluated in the exposure model, exposures to terrestrial invertebrates were considered for animals that consume this food source.

As discussed previously, the assessment endpoint for wildlife health impacts is the protection of wildlife populations. Therefore, an exposure model was developed to assess the potential for population level effects to terrestrial wildlife exposed to chemicals associated with the reclaimed landscape. The model incorporates information on the spatial distribution of chemicals within the landscape, as well as foraging and movement of the wildlife species. For this assessment, a wildlife species population was defined as a hypothetical population foraging within the boundaries of the LSA following closure under far future equilibrium conditions. This area includes both reclaimed areas and natural areas. Although the foraging ranges for some wildlife species are likely to extend beyond the LSA boundaries, it was assumed that all foraging would take place within this area, to maximize the exposure and risk estimates. This assumption introduces a significant degree of conservatism into the risk assessment process.

The wildlife exposure model was developed to compute chemical intake for wildlife populations, taking into account spatial differences in chemical concentrations and use of the reclaimed landscape. Chemical residues in food consumed by wildlife (e.g., plants, invertebrates) were assumed to vary in accordance with the environmental media (e.g., soil, sediment, water) in which the food item resided. Variation in environmental media was related primarily to the materials comprising the basic landform (e.g., overburden, tailings sand, CT). At equilibrium, the CT deposits will be consolidated below 5 to 10 m of lean CT and sand. Other areas of the reclaimed landscape will consist of overburden or tailings sand. The final cap for the whole reclamation area is the muskeg soil amendment layer (15-20 cm in depth). Undisturbed areas of the LSA will consist of natural soils (i.e., muskeg).

Figure D5.2-16 W-3: Conceptual Model for the Reclaimed Landscape Scenario



A chemical fate model was used to predict chemical concentrations in environmental media and biota when measured concentrations were not available. Predicted or measured concentrations were then used as input concentrations for the wildlife exposure model. The model employs distributions of exposure concentrations for surface water, plant and invertebrate tissues. Intake rates for individuals within the LSA were then estimated as follows:

1. Chemical concentration distributions for water, soil, plants and invertebrates within the reclaimed and natural areas of the LSA were predicted.
2. Each species was assumed to forage randomly within the LSA based on preferences for habitat, as defined by Ecological Land Classification (ELC) type.
3. The movement of an individual within the LSA boundaries was simulated according to its foraging habitat.
4. Chemical intake rates were calculated as a result of foraging uptake (refer to Appendix VI.3 for equations).
5. If the species foraging area requirement was greater than the area of the first selected ELC, steps (3) and (4) were repeated to add more ELC areas to the forage range for the individual until its foraging requirements were met.
6. Steps (2) to (5) were repeated for many individual animals. On each loop, a new set of input parameters were selected based on random sampling of the input data distributions.

Results of the exposure modelling therefore provide probabilistic distributions of the intake rates expected for all individuals of a hypothetical population for a given species foraging within the LSA boundaries following closure of Project Millennium. For further details of the model, refer to Appendix VI.4.1.

ER values (median and 90th percentile) for the hypothetical wildlife populations are presented in Table D5.2-12. Further details of daily intake rates and probability distributions of ER values for each animal are provided in Appendix VI.6.1.

For ruffed grouse, mallard, deer mouse and snowshoe hare, median and 90th percentile ER values were less than or marginally greater than 1, suggesting a *de minimis* risk to populations of these species foraging within the LSA in the far future. Therefore, no adverse impact to wildlife health is predicted to occur to these species.

Table D5.2-12 Exposure Ratio Values for the Reclaimed Landscape Scenario

Chemical	Median ER	90th Percentile ER
Ruffed Grouse		
Boron	0.011	0.42
Cadmium	0.01	0.07
Cobalt	0.0007	0.22
Selenium	0.007	0.04
Zinc	0.15	0.58
Mallard		
Barium	0.051	0.14
Zinc	0.21	0.3
Deer Mouse		
Barium	1.16	1.44
Mercury	0.0014	0.002
Molybdenum	0.51	1.0
Nickel	0.0017	0.0071
Selenium	0.023	0.068
Strontium	0.0001	0.008
Vanadium	2.9	3.5
Zinc	0.011	0.081
Snowshoe Hare		
Barium	0.35	0.81
Cadmium	0.001	0.075
Cobalt	0.0007	0.25
Molybdenum	0.23	2.26
Vanadium	0.29	0.97
Moose		
Barium	0.36	0.72
Boron	0.12	1.0
Cobalt	0.003	0.43
Molybdenum	1.3	10
Selenium	0.001	0.043
Vanadium	0.57	7.0
Beaver		
Vanadium	0.76	6.6

For the moose and beaver, median ER values for all chemicals evaluated are less than or marginally greater than 1, suggesting a *de minimis* risk to the majority of the population. However, 90th percentile ER values range from 6.6 to 10 for molybdenum and vanadium exposures to moose, and vanadium exposures to beaver, suggesting that a small proportion of the population could receive higher than average exposures, resulting in potential risks to these animals. Ninety-five to ninety-nine per cent of the dose received by these animals for vanadium and molybdenum was derived from ingestion of plants, with the remainder from ingestion of water. The majority of the plant exposures were derived from aquatic plants, and thus, the large difference between the median and 90th percentile ERs for these chemicals is likely a result of the large range of measured concentrations used as input concentrations for aquatic plants. Chemical concentrations measured in aquatic plants harvested from the Suncor dyke drainage water constructed wetland, Pond 1A, Syncrude Pit 7, Suncor Pond 5 and Suncor hummock wetlands, were used to estimate wildlife exposures in open water areas of the reclaimed landscape (Nix et al. 1995, Golder 1997g). Since this data is based on a small number of samples, and the measured concentrations vary widely, there is some uncertainty associated with these predictions. Further monitoring of aquatic plants will be conducted to verify the ranges of chemical concentrations used in this assessment.

It should also be noted that the home range of a moose is larger than the area of the LSA and would extend into undisturbed habitat outside the LSA. However, these risk estimates have been conservatively derived assuming the home range of a moose is confined to the LSA. If the modelling exercise allowed moose to forage outside the LSA in undisturbed areas, the risk estimates would likely be lower.

When chemicals having marginal risk estimates based on reproductive endpoints are considered collectively (i.e., additive effect) for a given species, the population model predicts that a small proportion of the moose population may experience a reproductive effect, with an ER of approximately 19. This is virtually entirely due to molybdenum and vanadium. In light of the conservative assumptions employed, as noted above, and the small proportion of the population potentially affected, this is not considered to be significantly affecting the health of individuals or the stability of moose populations. Nevertheless, a potential impact has been identified and is classified below.

D5.2.8.3 Residual Impact Classification and Environmental Consequence

Based on the results of the risk assessment, two classifications are provided. For ruffed grouse, mallards, deer mice, beaver and snowshoe hares, the magnitude of impact and resulting environmental consequence is negligible, since ER values were less than or marginally greater than 1 (i.e., ER<10). For the moose, since a small proportion of the population may experience ER values as high as 10 for molybdenum or 19 based on additive effects of chemicals, the magnitude of the impact is classified as low, rather than negligible. The geographic extent is local, since impacts are confined to the LSA. The duration is long-term, since exposures may occur for greater than 30 years. The impact is reversible, since exposures should decrease over time. The frequency is high, since the exposure occurs continuously for those animals foraging on the reclaimed landscape. The resulting environmental consequence is low, as follows:

Species	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Moose	Negative	Low	Local	Long-Term	Reversible	High	Low

Certainty

The assessment of potential impacts to wildlife foraging within the LSA following closure was based on a number of conservative assumptions, including the following:

- it was assumed that the foraging areas of all wildlife species would be confined to the LSA;
- uniform distributions of measured or conservatively predicted concentrations in water, plants and invertebrates were used, such that exposures to low or high concentrations could occur with equal probability;
- daily ingestion estimates for water, plants and prey represent reasonable maximum exposure values for the wildlife evaluated;
- combined exposure to water, terrestrial plants, aquatic plants, terrestrial invertebrates and aquatic invertebrates was considered, according to the dietary requirements of each wildlife species evaluated; and
- toxicity reference values were developed to be protective of wildlife populations under chronic exposure conditions.

Due to the conservatism involved in the risk assessment for wildlife foraging within the LSA following closure of the Project, it is very unlikely that potential risks have been underestimated. However, it is likely that maximum exposures and risk estimates have been overestimated due to the uncertainty and consequent conservatism applied to the large range of metal concentrations measured in aquatic plants growing in reclamation waters.

D5.2.8.4 Monitoring

There remains some uncertainty associated with uptake of chemicals by plants growing in reclamation materials and the distribution of chemical concentrations in reclamation soils. Suncor is currently conducting a CT landscape reclamation study to alleviate some of this uncertainty. Refer to Section E of Volume 1 for more details.

Suncor is a very active member of the Environmental Effects Monitoring (EEM) Subcommittee of the Wood Buffalo Environmental Association (WBEA). The EEM Subcommittee is presently planning a plant and animal tissue study in 1998.

As discussed previously, further study has been initiated by Suncor to address the chronic toxicity of naphthenic acids. Refer to Section F1.1.4.3, Toxicity Assessment, for further details. Finally, monitoring of EPL water quality is recommended, to verify predicted water concentrations.

D5.3 WILDLIFE CONCLUSION

D5.3.1 Introduction

Project Millennium has been designed to mitigate impacts to wildlife habitat, movement corridors, abundance and diversity by the measures described below:

- locating the development away from important habitat (e.g., minimum of 100 m from the Steepbank and Athabasca rivers);
- minimizing the footprint of development (e.g., restricting dump size, use of common access and utility corridors);
- completion of most clearing activities during the winter when wildlife are typically not in breeding season;
- progressively reclaiming the development area;
- managing landfill areas such that wastes (including food wastes) are covered on a frequent basis;
- ensure awareness by employees on nuisance wildlife;
- use of bird deterrence devices, such as human effigies and propane-fueled cannons, particularly during spring and fall migration periods; and
- maintaining vegetation free shoreline in tailings pond areas.

Mitigation for habitat lost due to changes in surface hydrology will primarily be through reclamation. Mine dewatering will cease at closure. This will allow the groundwater table to return to pre-development levels. As well, an end pit lake and numerous small wetlands are proposed for closure. This will have a net positive effect on wildlife.

The wildlife impact assessment predicted the incremental effects of the Project on top of existing and approved oil sands operations. The assessment considered the issues, as addressed through the key question approach in Section D5.2 of the EIA. The issues and environmental consequences are summarized in Table D5.3-1.

Table D5.3-1 Wildlife Issues and Environmental Consequences

Issue	Environmental Consequence
Wildlife habitats and movement	Low
Wildlife abundance and diversity	Low
Wildlife health during operations	Low
Wildlife health for closure	Low

D5.3.2 Impact Assessment

The wildlife habitat, wildlife abundance, wildlife diversity and wildlife health impact assessments predicted the incremental effects of the Project on top of existing and approved oil sands developments. This was done quantitatively for changes in habitat and changes in potential wildlife diversity using Habitat Suitability Index (HSI) modelling and qualitatively for wildlife abundance using professional judgment. Wildlife health was assessed quantitatively using risk assessment techniques.

Changes in wildlife habitat and movement were addressed by examining the effects of site clearing, changes in hydrology, barriers to movement, sensory disturbances and reclamation practices. Changes in wildlife abundance and diversity were addressed by examining site clearing, sensory disturbance, changes in access leading to increases in hunting and poaching, removal of nuisance wildlife, increased vehicle-wildlife collisions and interactions of wildlife with infrastructure.

Habitat Changes

Habitat loss due to site clearing was predicted to have the greatest impact on wildlife. The magnitude of this impact is high for most of the KIR species. However, this impact is reversible, and it is expected that wildlife habitat will be progressively reclaimed during closure. Habitat loss due to changes in hydrology, barriers to movement and sensory disturbance were also predicted to have an effect on wildlife. Changes in hydrology were determined to be low in magnitude because most wildlife habitat will be lost through site clearing. Barriers to movement will have the greatest impact on the larger, more mobile wildlife species (e.g., moose, bear, and fisher). Sensory disturbance affecting habitat use will affect some wildlife species, particularly during the breeding seasons or when species are overwintering and may be energetically stressed.

Progressive reclamation practices will result in gains in wildlife habitat. This impact is expected to be positive for most of the KIR species. The magnitude of this impact is expected to range from low to high depending on the amount and types of habitat reclaimed.

The residual impact of the Project on wildlife habitat and movement was rated as low in environmental consequence. This is based on the predicted effectiveness of the reclamation and closure plans in replacing ecosystems. The preliminary indications of the effectiveness of the reclamation activities shows that wildlife species readily use the areas. Some uncertainty exists because some of the selected KIRs for wildlife frequent mature ecosystems, which have not had time to develop on oil sands reclamation areas.

Wildlife Abundance and Diversity

Abundance and diversity of wildlife species will be affected to some degree by site clearing, sensory disturbance, removal of problem or nuisance wildlife, wildlife-vehicle collisions and interactions with infrastructure. Site clearing will result in a loss of wildlife abundance, particularly of smaller, less mobile species (e.g., red-backed voles, snowshoe hares). Site clearing will also reduce wildlife diversity and the potential for diversity. Sensory disturbance may affect all of the KIR species, especially during reproductive periods or periods of energetic stress. Removal of problem wildlife will be a concern for beavers and black bears, however the magnitude of this impact will probably be low. Wildlife-vehicle collisions are expected to occur to some extent on Highway 63 from Fort McMurray to the Suncor turn-off, as a result of increased traffic levels. The magnitude of this impact is expected to be low on the highway and negligible on-site where reduced habitat and reduced speed limits will reduce the probability of collisions. Interactions with infrastructure (e.g., tailings pond, power lines, towers) will mainly affect bird species. The magnitude of this impact is expected to be low.

Most impacts related to change in wildlife abundance and diversity will result from site clearing or direct removal of vegetation communities. Wildlife species with small home ranges or limited mobility, or wildlife species with young will be most affected. As clearing is anticipated to take place during the winter months, most of the bird species will not be affected. As well, some of the larger, more mobile species (e.g., moose, bear, fisher) will most likely move out of the area. This impact was determined to be of low environmental consequence.

Changes in wildlife abundance and diversity attributed to sensory disturbance, removal of nuisance wildlife, increased wildlife-vehicle collisions and interactions with infrastructure were all determined to be of negligible to low environmental consequence.

Wildlife Health - Operations

Chemical concentrations in the water of the Athabasca River, McLean Creek and Shipyard Lake as a result of the Project are predicted to be safe for consumption by wildlife during the operational phase of the Project. The levels of Project-related chemicals in fish and aquatic invertebrates are also predicted to be safe for ingestion by wildlife during the operational phase. Direct inhalation of chemicals by wildlife is considered to be a minor exposure pathway in comparison to exposures through the food chain, and therefore was not evaluated. Rather, this pathway was indirectly evaluated via deposition of airborne chemicals onto plants and soils, followed by ingestion of these plants by wildlife. Based on the available data, chemical concentrations in vegetation are predicted to be safe for consumption by wildlife during the operational phase. Thus, impacts to wildlife health were predicted to be negligible for the chemicals evaluated during the operational phase. However, there is some uncertainty associated with the toxicity of naphthenic acids to wildlife, and therefore the environmental consequence of the residual impact is classified as low. Further studies are being conducted by Suncor to help resolve the uncertainty associated with naphthenic acids.

Wildlife Health - Closure

The potential for impacts to wildlife health as a result of exposure to chemical concentrations was predicted for Shipyard Lake, McLean Creek, Athabasca River and EPL at closure and in the far future. The levels of substances in these waterbodies, with the exception of the EPL, at closure and in the far future were not predicted to result in impacts to wildlife health. The risk assessment predicted marginal and inconsequential wildlife health risks for use of EPL water at closure. Monitoring of the EPL will be conducted to establish if access to this waterbody by wildlife should be restricted, and whether mitigation will be needed to reduce exposures.

The potential for impacts to wildlife health as a result of exposures to chemicals on the reclaimed landscape, including exposure to ponded surface water/streams, soils and vegetation, was evaluated. Animals were assumed to forage within the LSA (including reclaimed areas and natural areas) in the far future, ingesting water, terrestrial plants, aquatic plants, terrestrial invertebrates and/or aquatic invertebrates, as determined by their foraging preferences. For ruffed grouse, mallards, deer mice, beavers and snowshoe hare, the magnitude of impact and resulting environmental consequence was determined to be negligible. For the moose, although average exposures on the reclaimed landscape were determined to result in negligible impacts to moose populations, maximum exposures to aquatic plants on the reclaimed landscape may lead to potential health risks for a small proportion of the population. Therefore, the environmental consequence was classified as low, rather than negligible. It should be noted that these risk estimates have been conservatively modelled assuming the home range of a moose is confined to the LSA, despite the fact that the home range of a moose would extend beyond this range. If the modelling procedures allowed moose to forage outside the LSA in undisturbed areas, the risk estimates would be lower. There is some scientific uncertainty associated with this prediction, based on the limited available data for chemical concentrations in aquatic plants growing on reclaimed landscapes.

D5.3.3 Monitoring

Monitoring of wildlife numbers will be undertaken on reclaimed lands. As many wildlife species depend on mid to late forest seral stages, monitoring of these species numbers will not be useful, at least not in the short-term. Rather, monitoring for wildlife in the short-term should be based on whether the reclaimed area has been successfully set on a successional pathway that will eventually result in good habitat for the wildlife species of interest.

Monitoring of the success of mitigation for wildlife impacts will also include:

- continued assessments of wildlife interactions with tailings ponds; and
- further research to determine the potential for toxicity of naphthenic acids to wildlife.

D6 TERRESTRIAL CUMULATIVE EFFECTS ASSESSMENT

D6.1 INTRODUCTION

D6.1.1 Introduction

This section of the Project Millennium (the Project) EIA provides a cumulative effects assessment (CEA) of terrestrial resources. This review considers the potential effects from the Project plus existing, approved and planned developments.

D6.1.2 Methods

The methodologies used to assess potential effects related to the CEA are described in Section A2 and the preceding Sections of D of this EIA. If additional methodologies were employed for a specific terrestrial component, they are defined in this section. Each section compares the effects of Project Millennium and combined projects to the baseline conditions in table format. A description of the contents in the tables is presented below.

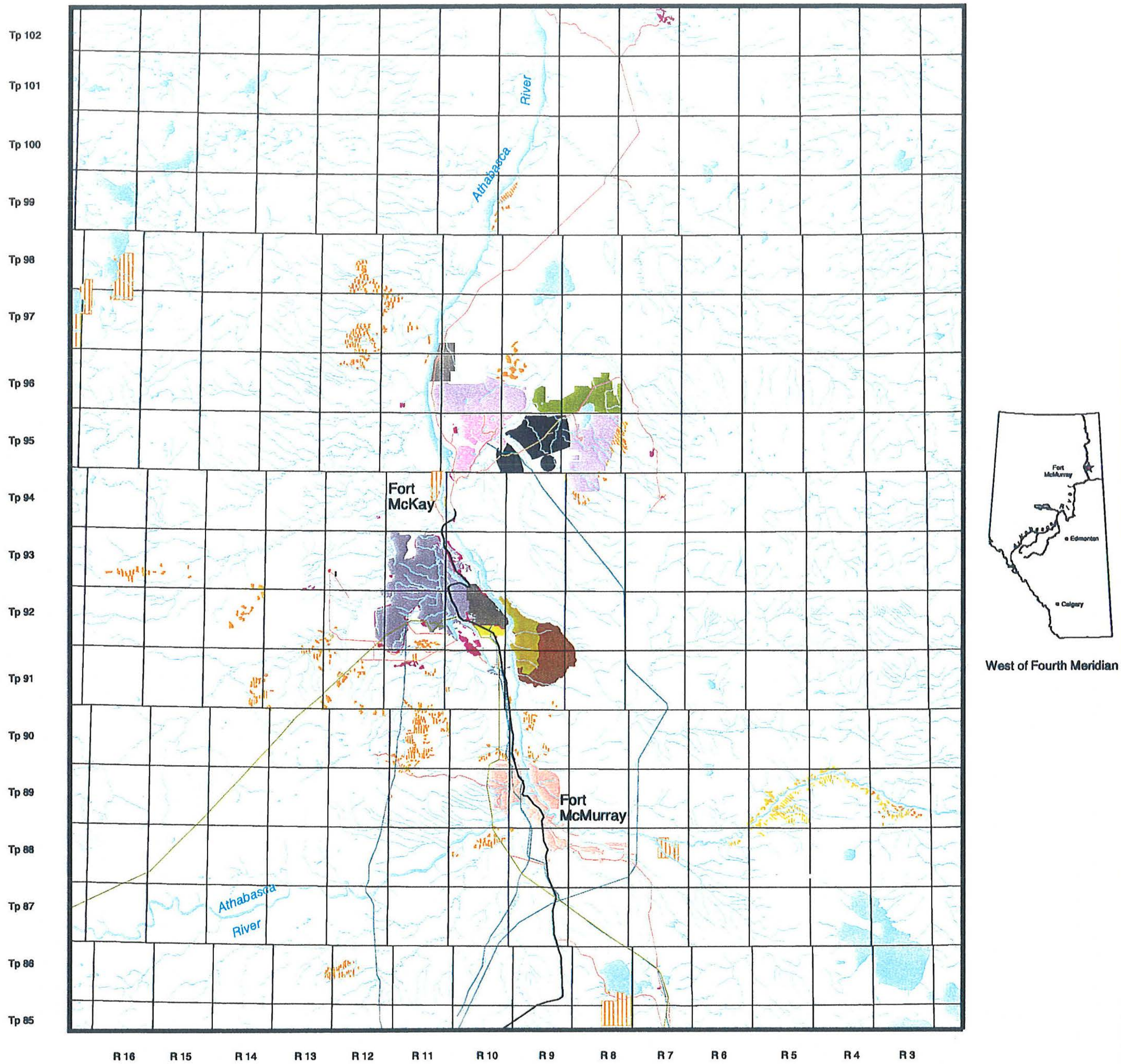
	Impacts	Far Future
Project Millennium Area (ha)	The total area of each (soil, terrain, vetetation, ELC) unit within the Project Millennium footprint prior to reclamation and site closure.	The total area of each terrestrial unit within the Project Millennium footprint after reclamation and site closure.
percent (%)	The incremental increase in cumulative effects due to Project Millennium prior to reclamation and closure. Expressed as a percentage of each RSA unit. (Project Millennium Impacts divided by RSA Baseline)	The incremental increase in cumulative effects due to Project Millennium after reclamation and closure. Expressed as a percentage of each RSA unit. (Project Millennium Far Future divided by RSA Baseline)
CEA Area (ha)	The total area of terrestrial units in the combined development footprints within the RSA (including Project Millennium) prior to reclamation.	The total area of terrestrial units in the combined development footprints in the RSA, including Project Millennium, after reclamation.
percent (%)	The impact of combined developments (including Project Millennium) prior to reclamation and closure. Expressed as a percent of each terrestrial unit area within the RSA. (CEA Impacts divided by RSA Baseline)	The impact of combined developments, including Project Millennium prior to After ? reclamation and closure. Expressed as a percent of each terrestrial unit area within the RSA. (CEA Far Future divided by RSA Baseline)

D6.1.3 Planned Developments

In addition to the existing and approved developments, it is recognized that other oil sands developments have been publicly disclosed or are planned for the region. Although all of these developments have not been the subject of formal approval applications, if they were to proceed they may result in additional environmental impacts in the RSA. The planned developments included in the CEA, as well as existing and approved developments, are shown in Figure A2-8 and detailed in Table A2-11. Table A2-14 reviews the Athabasca Oil Sands production for the CEA.

This CEA predicts the effects of Project Millennium plus existing, approved and planned developments (Table D6-1) on the terrestrial resources including soils, terrain, vegetation, wetlands and wildlife, in the Regional Study Area (RSA). The following developments, as shown in Figure D6-1 are included in the CEA:

- Suncor Lease 86/17
- Syncrude Aurora Mine
- Suncor Steepbank Mine
- Syncrude Mildred Lake
- Suncor Steepbank Mine and Fixed Plant Expansion
- Syncrude Mildred Lake Upgrader Expansion
- Suncor Project Millennium
- Syncrude Mildred Lake Debottlenecking Phase 1/2
- Shell Muskeg River Mine Project
- SOLV-EX
- Shell Lease 13 East
- Mobil Kearl Mine and Upgrader
- Petro-Canada MacKay River
- Gulf Surmont
- JACOS Hangingstone
- Northstar Energy
- Suncor Fee Lot 2 Development, including Novagas Natural Gas Liquids Plant
- Municipalities and Municipal Growth
- Pipelines, utility corridors and roadways
- Forestry



SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

LEGEND

- Regional Study Area
- Highway
- Secondary Roads
- Pipelines
- Power Lines
- Open Water
- Municipalities
- Suncor Lease 86/17
- Suncor Steepbank Mine
- Suncor Project Millennium
- Suncor Fee Lot 2
- Syncrude Mildred Lake
- Aurora Mines
- SOLV-EX
- Northstar Energy
- Muskeg River Mine Project
- Mobil Kearl Oil Sands Mine
- Petro-Canada MacKay River
- Shell Lease 13 East
- Cutblocks (recent)
- Cutblocks (reforested)
- Other Disturbances
- Indian Reserves

N

SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA
REGIONAL DEVELOPMENTS FOR
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998 | Figure D6-1 | PRODUCED BY: K.K.Q. REVIEWED BY:

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Table D6-1 Regional Developments Included in the Cumulative Effects Assessment

Developments	Area (ha)
Baseline (existing and approved)	
Suncor Lease 86/17	2,877
Syncrude Mildred Lake	18,782
Suncor Steepbank	3,776
Suncor Fee Lot 2	522
Northstar Energy	22
SOLV-EX	2,088
municipalities	4,002
pipelines/roadways/others	2,904
Syncrude Aurora Mine	15,171
Sub-total	**50,144**
Project Millennium	**5,644**
Planned Projects	
Muskeg River Mine Project	4,343
Shell Lease 13 East	7,215
Syncrude Upgrader (at Mildred Lake)	0
Mobil Kearl Oil Sands Mine	5,350
Petro-Canada MacKay River	33
JACOS Hangingstone	0[a]
Gulf Surmont	0[a]
Fort McMurray Expansion	5,902
Sub Total	**22,843**
Total Developed Area	**78,631**
Regional Study Area	**2,428,645**

[a] These developments fall outside the Regional Study Area. However, they are considered in the cumulative effects assessment for air emissions.

Details on the basis of assumptions for each development in the CEA are provided in Section A2. The CEA discussion for terrestrial resources is presented as follows:

- soil and terrain
- terrestrial vegetation and wetlands
- ecological land units
- wildlife

D6.2 SOIL AND TERRAIN

The soil and terrain CEA included consideration of the following points of clarification, which must be made to place the analyses in context.

- Forestry development was assumed to have a negligible impact on soils and terrain. Unlike open pit mining, the disturbances resulting from forestry are largely superficial and transitory in nature. Therefore, this variable was not considered in the analysis.
- The Syncrude Upgrader is to be located within the Mildred Lake development footprint and does not require additional area. It is incorporated here because it will increase the level of potentially acidifying emissions within the RSA. The same reasoning holds for the Mobil Upgrader at the Kearl Mine.
- Although JACOS Hangingstone and Gulf Surmont fall outside the spatial boundaries of the RSA, they are considered here because their emission plumes may impact soil within the RSA.

Data from Syncrude's Aurora Mine and Suncor's Steepbank Mine Applications were used to determine the vegetation communities, land capabilities for forest ecosystems, soils and terrain units which would be found in the respective mines. Suncor's Steepbank Mine Application provided similar information for Suncor's Lease 86/17. Data for Syncrude's Mildred Lake facility were extrapolated from the Aurora Mine Application.

The following section addresses the soil and terrain portion of key question CTER-1: What impacts will result from changes to ecological land units (soils, terrain, vegetation and wetlands) associated with Project Millennium and the combined developments?

D6.2.1 Soil and Terrain Units, Quantity and Distribution

D6.2.1.1 Analysis and Results

Analysis of soil and terrain units at the RSA level was conducted in the following manner:

- preliminary digital files of soil maps for the region (Turchenek and Lindsay 1982) were acquired and additional information required to encompass the eastern portion of the RSA incorporated; and
- following completion of soil mapping, terrain units were derived by combining all soil types having similar genetic characteristics into common groups (e.g., all soil series with eolian parent materials became eolian terrain units).

Table D6-2 outlines the distribution of RSA soil units, which are illustrated in Figure D6-2 for baseline conditions. Table D6-3 shows the extent of the terrain units in the RSA, while Figure D6-3 illustrates the distribution for the CEA scenario. Both tables provide details of the baseline conditions, the Project and the full CEA impacts, and are organized as follows:

Naturally occurring soil and terrain features will be removed during development and construction. However, phased reclamation over the life spans of the various developments will produce a closure landscape wherein these have been replaced with reclamation substitutes. Examination of the data indicate that 78,631 ha (3.2% of the RSA) will be affected by the developments considered in the CEA scenario. The majority of this area, approximately 16,000 ha, are bog or fen terrain units (primarily Kenzie soils) which will be converted to either reclaimed terrestrial or wetland areas in the closure landscape. At closure, approximately 80% of the disturbed areas will be reclaimed for regrowth of terrestrial vegetation while the remaining 20% will be either reclaimed wetlands or open water areas.

D6.2.1.2 Residual Impact Classification

The areas disturbed by development will be reclaimed as similar but not identical landscapes. Evaluated in a strictly objective sense, this would be seen as a loss of soil and terrain when in fact it is more accurately a change in the types and distribution of the units.

The Environmental Consequence of residual impacts has been assessed according to the classification system described in Section A2 and is presented in Table D6-4. The low magnitude (<10% change) and the positive influence of reclaimed soils are primarily responsible for a low Environmental Consequence.

At closure, the residual impacts would be close to off-setting in a quantitative sense. This is a function of the relatively small percentage of the total RSA area that will be disturbed at maximum CEA impact. It may be possible to question the assertion that the positive aspects of reclamation will off-set the losses due to development and thus have a low Environmental Consequence. Reclamation objectives set out in the Terms of Reference for the Project state precisely what the end land use objectives are and, since these are fulfilled by the C & R Plan (Section E of Volume 1 of the Application), the objective measurement criteria are met.

Table D6-2 Soil Units of the Project Millennium RSA, CEA Scenario

Soils Series/Map Unit	Baseline RSA[a]		Project Millennium Impact[b]		Project Millennium Far Future		CEA[c] Impact[b]		Far Future	
	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%
Algar	47,879	2.0	0	0	0	0	157	0.3	47,722	99. 7
Bitumount	11,087	0.5	47	0.4	1	<0.1	177	1.6	10,910	98.4
Buckton	32,571	1.3	0	0	0	0	0	0	32,571	100.0
Dover	83,169	3.4	0	0	0	0	1,619	2.0	81,550	98.0
Eaglesham (Mc)[e]	148,031	6.1	1,885	1.3	14	<0.1	2,803	1.9	145,228	98.1
Firebag	128,206	5.3	0	0	0	0	2,409	1.9	125,797	98.1
Horse River	26,076	1.1	0	0	0	0	0	0	26,076	100.0
Heart	87,154	3.6	0	0	0	0	769	0.9	86,385	99.1
Joslyn	86,797	3.6	0	0	0	0	18	0	86,779	100.0
Kearl	1,167	<0.1	0	0	0	0	0	0	1,167	100.0
Kinosis	73,757	3.0	803	1.0	44	<0.1	803	1.1	72,954	98.9
Kenzie (Mus)	803,804	33.1	1,797	0.2	23	<0.1	12,943	1.6	790,861	98.4
Legend	105,507	4.3	0	0	0	0	0	0	105,507	100.0
Livock	47,198	2.0	0	0	0	0	1,874	4.0	45,324	96.0
Mildred	205,128	8.4	35	<0.1	0	0	1,004	0	204,124	99.5
Mikkwa	112,834	4.6	0	0	0	0	0	0	112,834	100.0
McMurray	71,247	2.9	6	<0.1	1	<0.1	140	0.2	71,107	99.8
Namur	55,302	2.3	0	0	0	0	0	0	55,302	100.0
Rock	19,329	0.8	0	0	0	0	0	0	19,329	100.0
Rough Broken	66,792	2.8	247	0.4	24	<0.1	1,186	1.8	65,606	98.2
Ruth Lake	22,709	0.9	0	0	0	0	1,309	5.8	21,400	94.2
Surmont	18,808	0.8	0	0	0	0	0	0	18,808	100.0
Steepbank	40,717	1.7	818	2.0	30	<0.1	1,601	3.9	39,116	96.1
Reclaimed Soils Terrestrial	3,600	0.1	0	0	4,873	135	0	0	57,900	0
Reclaimed Wetlands and Open-water	0	0	0	0	634	-	0	0	14,556	0
Total, Soil Units	**2,298,869**	**94.8**	**5,638**	**0.2**	**5,644**	**0.2**	**28,812**	**1.3**	**2,338,913**	**101.7**
AIM[f]	49,814	2.1	1	0	0	0	49,814	100	9,904	19.9
NWL[f]	72,763	3.0	5	<0.1	0	0	5	<0.1	72,629	99.8
IR[g]	7199	<0.1	0	0	**0**	**0**		**0**	**7,199**	**100.0**
Total, Non-soil	**129,776**	**5.2**	**7**	**<0.1**	**0**	**0**	**0**	**0**	**89,732**	**69.1**
Total	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**78,631**	**3.2**	**2,428,645**	**100**

(a) Current situation in RSA, with consideration of existing and approved developments.
(b) Incremental increase because of Project.
(c) Total impacts from Project, Approved Projects and planned developments does not include forestry as operations do not impact soils.
(d) McLelland in the LSA.
(e) AIM = Undeveloped, developed and reclaimed areas; NWL = Open water, rivers streams and lakes.
(f) IR - Indian Reserves, no classification for these areas.

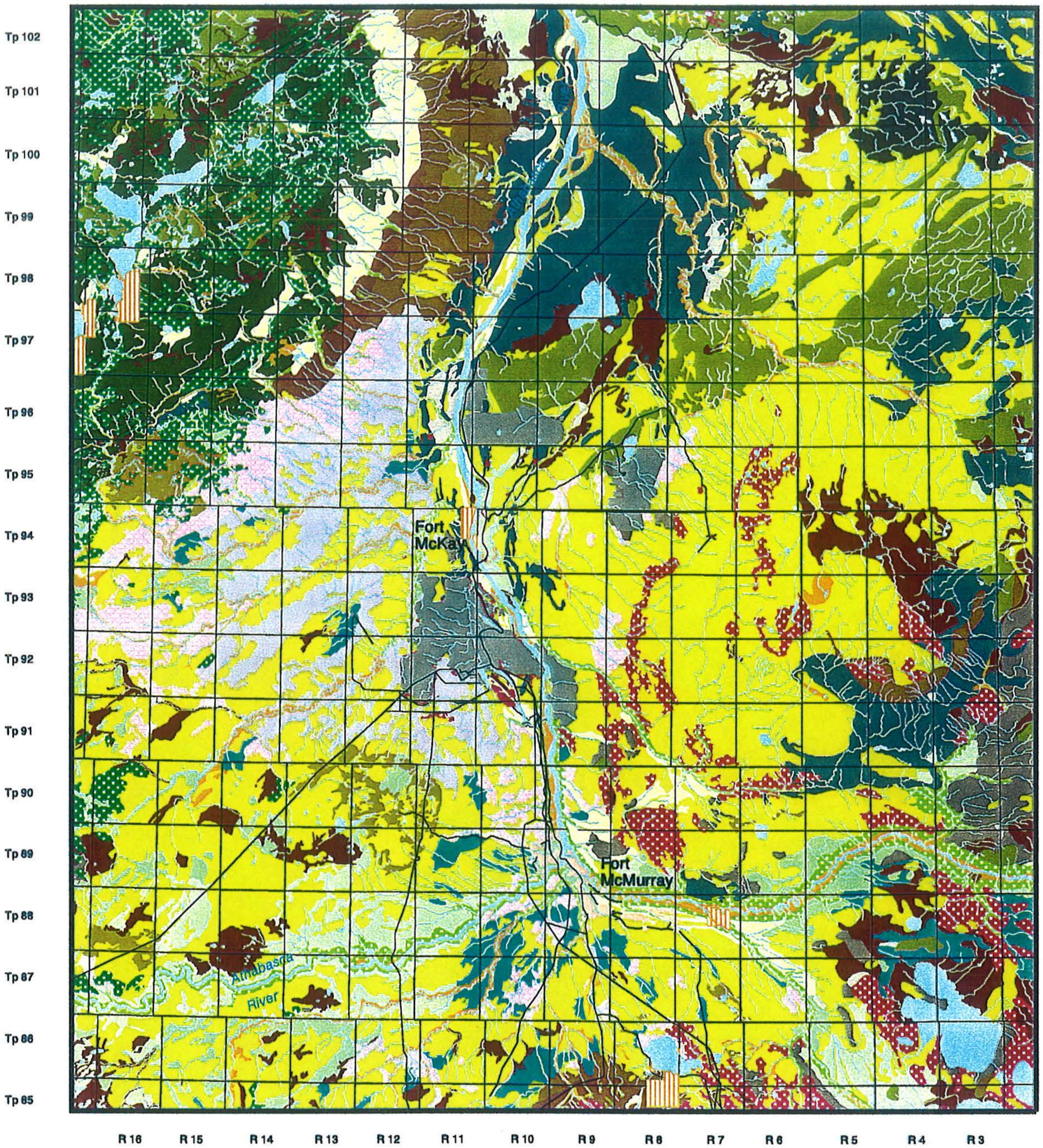
Table D6-3 Terrain Units of the Project Millennium RSA, CEA Scenario

Terrain	Baseline RSA[a]		Project Millennium				CEA[c]			
			Impact[b]		Far Future		Impact[b]		Far Future	
	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%
Bog	458,289	19.0	223	<0.1	12	<0.1	4,442	0.9	453,847	99.0
Shallow Bog	457,069	18.9	1,573	0.3	124	<0.1	8,256	1.8	448,813	98.2
Eolian	87,154	3.6	0	0	0	0	769	0.9	86,385	99.1
Fluvial	126,549	5.2	6	<0.1	6	<0.1	135	0.1	126,414	99.9
Glaciofluvial	367,130	15.1	900	<0.1	224	<0.1	5,324	1.5	361,806	98.5
Glaciofluvial and Glaciolacustrine, medium, over Morainal Till	47,198	1.9	0	0	0	0	1,874	4.0	45,324	96.0
Glaciolacustrine over Morainal/Till	258,562	10.6	0	0	0	0	2,577	1.0	255,985	99.0
Glaciolacustrine	1,167	<1	0	0	0	0	0	0	1,167	100.0
Morainal/Till, fine	184,242	7.6	803	0.4	266	0.1	537	0.3	183,705	99.7
Morainal/Till, coarse	73,757	3.0	0	0	0	0	1,047	1.4	72,710	98.6
Fen	148,031	6.0	1,885	1.3	105	<0.1	2,698	1.8	145,333	98.2
Rough Broken	66,792	2.8	248	0.4	34	<0.1	1,153	1.7	65,639	98.3
Rock	19,329	0.8	0	0	0	0	0	0	19,329	100.0
Reclaimed Terrestrial	3,600	<1	0	0	4,357	121	0	0	57,905	
Reclaimed Wetland and open water	0	0	0	0	516	-	0	0	14,556	
Total, Terrain Units	2,298,869	94.8	5,638	0.2	5,644	0.2	28,812	15.0	**2,338,918**	
AIM [d]	49,814	2.1	1	<0.1	0	0	49,814	100.0	9,904	19.9
NWL [d]	72,763	3.0	5	<0.1	0	0	5	0	72,629	99.8
IR [e]	7199	<0.1	0	0	0	0	0	0	**7,199**	**100.0**
Total, Non-terrain	129,776	5.2	6	<0.1	0	0	0	**100**	**89,732**	**69.1**
TOTAL	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**78,631**	**115**	**2,428,650**	**100**

(a) Current situation in RSA, with consideration of existing and approved developments.
(b) Incremental increase because of Projects.
(c) Total impacts from Project, Approved Projects and planned developments does not include forestry as operations do not impact soils.
(d) McLelland in the LSA.
(e) AIM = Undeveloped, developed and reclaimed areas; NWL = Open water, rivers streams and lakes.
(f) IR - Indian Reserves, no classification for these areas.

Table D6-4 Residual Impacts for Soils and Terrain of the RSA, CEA Scenario

	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Natural Units	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Reclaimed Units	Positive	Low	Regional	Long-term	Irreversible	Low	Low



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

/data14/suncor/regional[illegible]/9740/arcview/soil2.apr

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

SOIL CLASSIFICATION

Algar	Joslyn	McMurray	
Buckton	Kearl	Namur	
Bitumont	Kinosis	Rock	
Dover	Kenzie	Rough Broken	
Eaglesham	Legend	Ruth Lake	
Firebag	Livock (Fort)	Surmont	
Horse River	Mildred	Steepbank	
Heart	Mikkwa		

N

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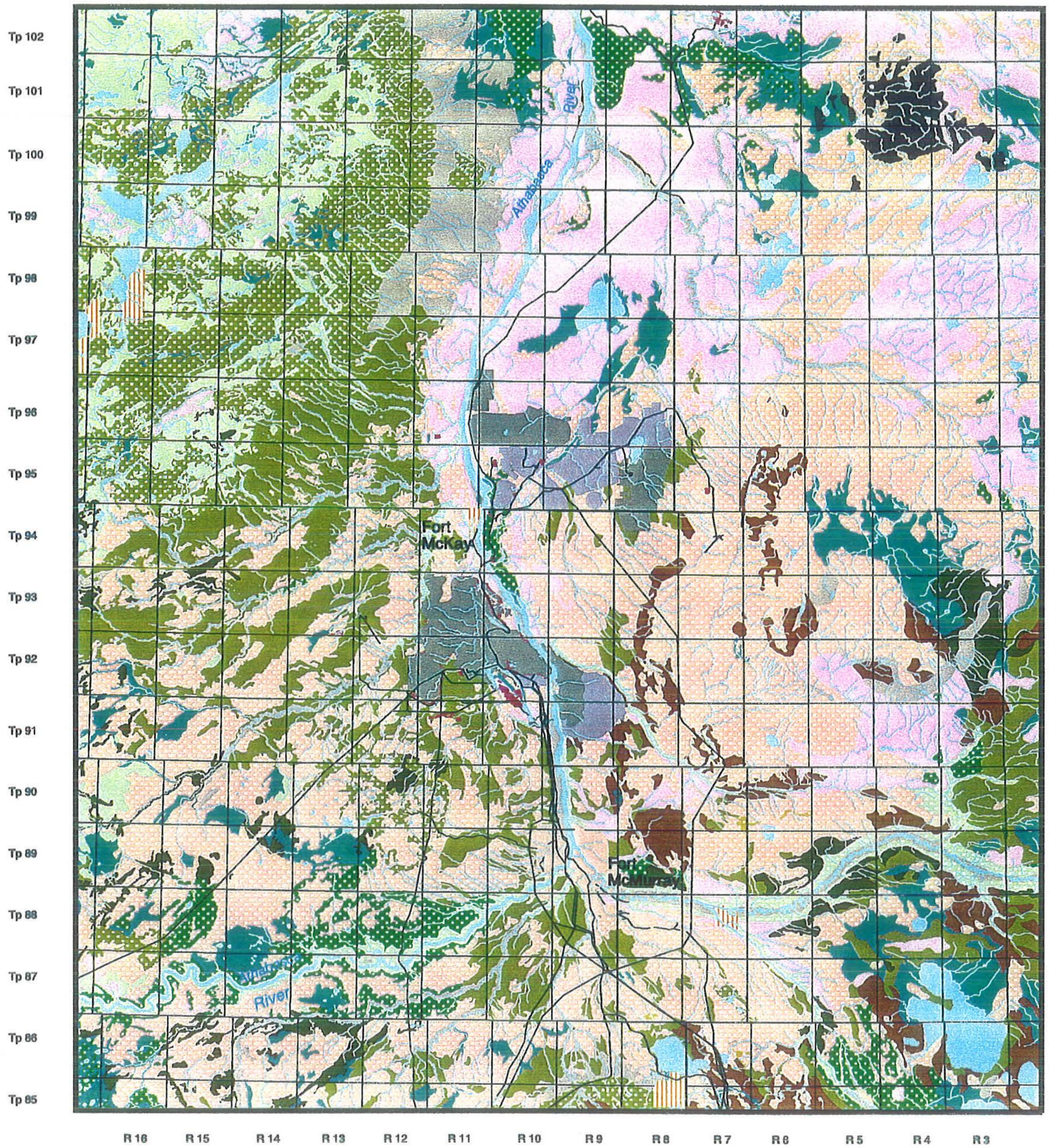
**REGIONAL STUDY AREA
SOIL CLASSIFICATION
IMPACT ASSESSMENT BASELINE**

16 Apr. 1998	Figure D6-2	PRODUCED BY: K.K.Q. REVIEWED BY:



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

TERRAIN CLASSIFICATION

- Bog
- Shallow Bog
- Eolian
- Fluvial
- Glaciofluvial
- Glaciolacustrine/Morainal
- Glaciolacustrine
- Glaciolacustrine, Glaciofluvial
- Moraine / Till, fine
- Morainal / Till, coarse
- Fen
- Rock
- Rough Broken

N

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REGIONAL STUDY AREA
TERRAIN CLASSIFICATION
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-3	PRODUCED BY: K.K.O. REVIEWED BY:

D6.2.2 Land Capability for Forest Ecosystems

This facet of the CEA addresses land capability which is defined herein as the potential to support forest ecosystems. Soil capability for the RSA was evaluated in the same manner as for the LSA. A detailed description of this method may be found in Section D2.2.7. Note that because of the differences in the resolution of the available data, a small area of the LSA was rated as Class 1 - this does not appear in the RSA inventory. To account for this anomaly, 465 ha was subtracted from Class 2 and placed in Class 1.

D6.2.2.1 Analysis and Results

The distribution of land capabilities for forest ecosystems is shown in Table D6-5 and Figures D6-4 and D6-5 for baseline and CEA conditions, respectively. As shown in Table D6-6 there is a significant change in the proportions of the various capability classes between the baseline and CEA closure landscapes. The major difference is the conversion of approximately 50,000 ha (2% of the RSA) from either existing disturbed or non-productive class 5 lands to a low forest capability class 3 rating. This enhancement in overall forest capability potential is the result of the reclamation soil mixture applied over the reconfigured terrain units in the closure landscape

Table D6-5 Land Capability Classification for Forest Ecosystems in the RSA

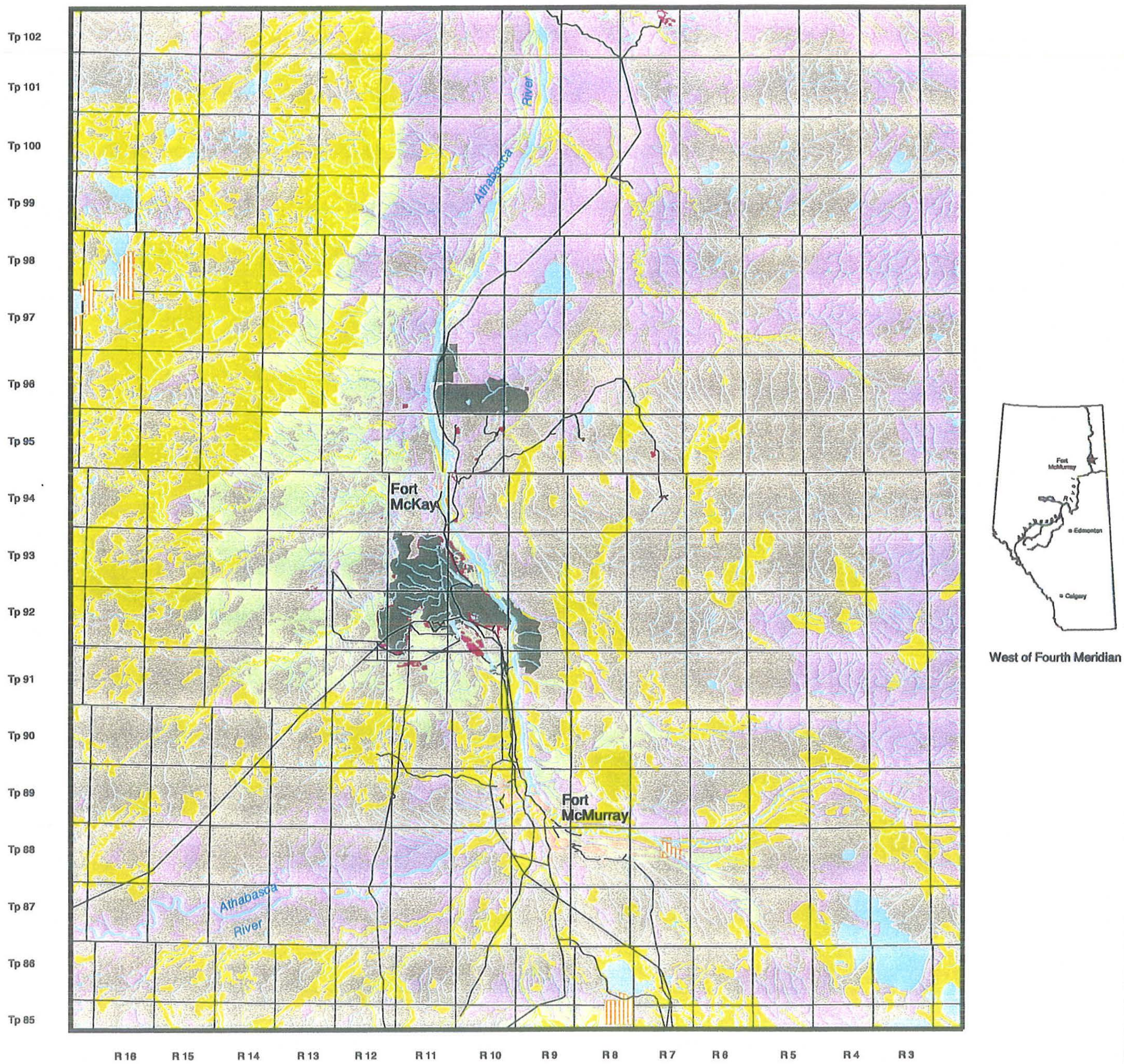
Capability Class	Area, ha	Area, % of RSA
Class 1[(a)]	465	<0.1
Class 2	439,060	18.1
Class 3	332,722	13.7
Class 4	438,304	18.0
Class 5[(b)]	1,210,895	49.9
Unclassified[(c)]	7,199	<0.1
Total	2,428,645	100.0

(a) Class 1 - no Class 1 capabilities were assigned in the broad scheme used for the RSA; however, the finer resolution within the LSA resulted in 465 ha fitting the criteria. For consistency this value was subtracted from the Class 2 values and used in this analysis.

(b) Previously disturbed lands and water were assumed to be non-productive for forestry.

(c) Indian Reserves were not classified.

As shown in Table D6-5 there are 7,199 ha of existing disturbed lands which cannot be placed in a capability class; however, they must be considered herein. The impact of the Project will be on 3646 ha of class 5 (4.5% of CEA impact) lands currently rated as non-productive which will be reclaimed to low productivity class 3 land.



SOURCES: Suncor, Syncrude, Petro-Canada, CAN-AG, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

LAND CAPABILITY
- High (1)
- Moderate (2)
- Low (3)
- Conditionally Productive (4)
- Non-Productive (5)

N

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REGIONAL STUDY AREA
LAND CAPABILITY CLASSIFICATION
FOR FOREST ECOSYSTEMS
IMPACT ASSESSMENT BASELINE

16 Apr. 1998 | Figure D6-4 | PRODUCED BY: K.K.Q. REVIEWED BY:

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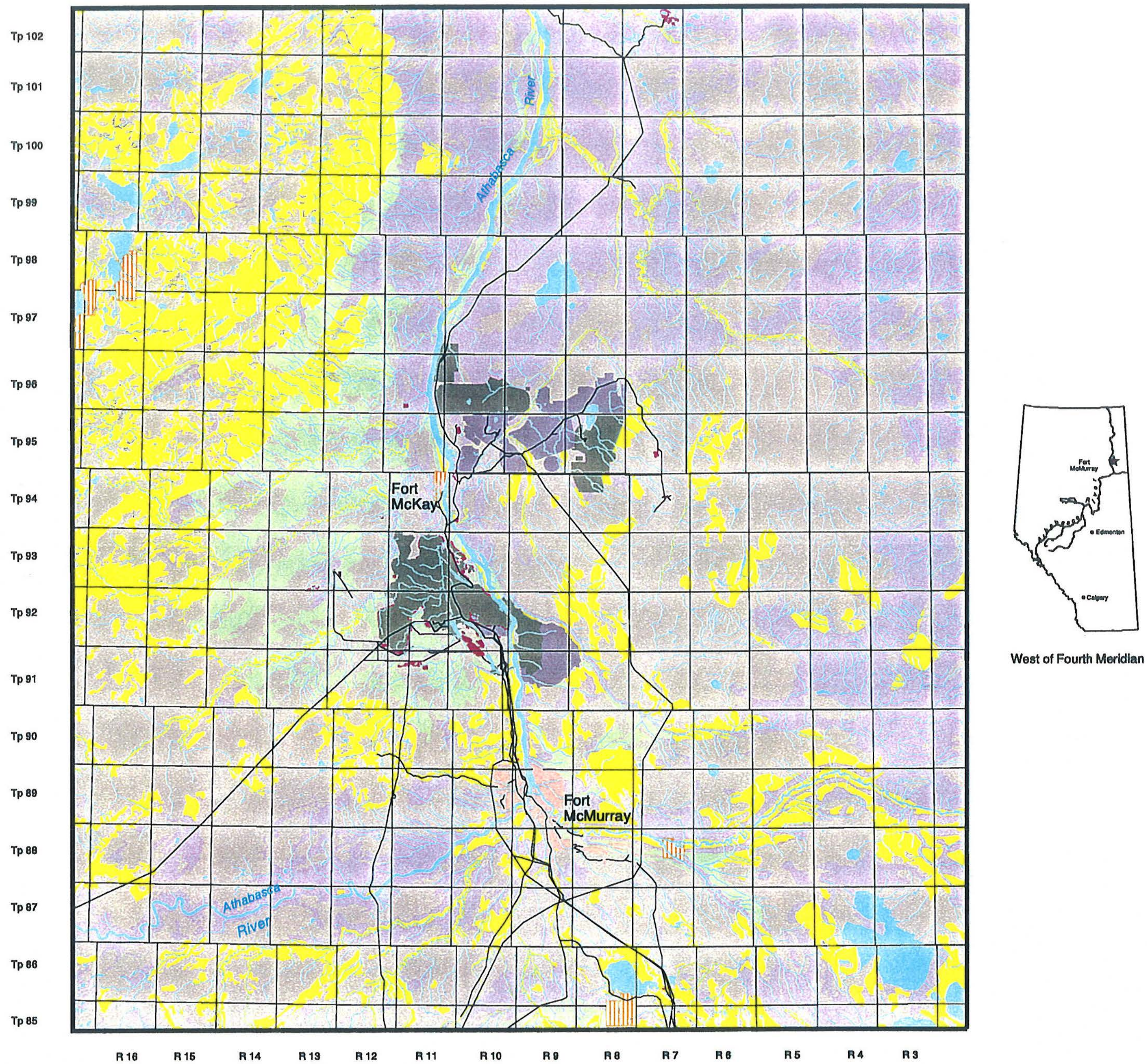

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, CAN-AG, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

LAND CAPABILITY

- High (1)
- Moderate (2)
- Low (3)
- Conditionally Productive (4)
- Non-Productive (5)

N

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REGIONAL STUDY AREA
LAND CAPABILITY CLASSIFICATION
FOR FOREST ECOSYSTEMS
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-5	PRODUCED BY: K.K.Q. REVIEWED BY:

D6.2.2.2 Residual Impacts Classification

Land capability for forest ecosystems is a function of the combined interactions of terrain and soil, hence alterations in these components will alter the capabilities. Evaluation of the data in Table D6-6 allows the assignment of the residual impacts provided in Table D6-7. Existing disturbed soils and those in currently non-productive class 5 will be reclaimed to low productivity class 3. This should be interpreted as a positive, qualitative alteration to land capability for forest ecosystems in the RSA.

Table D6-6 Land Capability for Forest Ecosystems in the RSA, CEA Scenario

			Project Millennium				CEA[c]			
	Baseline RSA[a]		Change[b]		Far Future		Impact		Final Landscape	
CLASS	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA
1	465	<0.1	106	22.8	8	1.7	106	22.8	359	77.2
2	439,060	18.1	672	0.1	39	<0.1	4,680	1.1	434,380	98.9
3	332,722	13.7	476	0.1	4,074	1.2	2,772	0.8	392,855	118.1
4	438,304	18.0	584	0.1	626	0.1	5,771	1.3	432,533	98.7
5 [d]	1,210,895	49.9	3,646	0.3	264	<0.1	65,302	5.4	1,161,320	95.9
IR [e]	7,199	<0.1	0	0	0	0	0	0	7199	100
TOTAL	**2,428,645**	**100.0**	**5,484[g]**	**0.2**	**5,644**	**0.2**	**78,631**	**3.2**	**2,428,645**	**100**

[a] Undeveloped plus revegetated land (not classified).
[b] Incremental change.
[c] Effects of projects approved and planned developments on baseline conditions, excludes forestry.
[d] All disturbed lands and water were assumed to be non-productive for forestry.
[e] IR - Indian Reserves were not classified.
[f] 5484 - development of the Project calls for some small areas to be "unmined development" areas, these account for 160 ha of terrain units.

Table D6-7 Residual Impacts and Environmental Consequence on Land Capabilities for Forest Ecosystems Due to Regional Development

Capability Class	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
1	negative	high	local	long-term	irreversible	low	high
2	negative	negligible	regional	long-term	irreversible	low	negligible
3	positive	low	regional	long-term	irreversible	low	low
4	negative	negligible	regional	long-term	irreversible	low	low
5	positive	low	regional	long-term	irreversible	low	low
Disturbed	positive	low	regional	long-term	irreversible	low	low

A number of points in Table D6-7 require further elaboration. The high Environmental Consequence assigned to the losses in class 1 may be artificial since identification of class 1 soils was only possibleat the LSA level of analysis. As discussed previously this is more a function of a lack of data than a true estimate of potential class 1 soil in the RSA. The second item is to reiterate that much of the class 5 land disturbed by CEA development, both existing and planned, will be reclaimed to class 3. The land capability potential will be upgraded for a significant portion of the disturbed areas.

D6.2.3 Soil Sensitivity to Acidifying Emissions

Soil sensitivity is evaluated in the context of the capacity of the soils in the RSA to resist the acidifying effects of anthropogenic inputs (i.e., emissions from industrial sources). The potentially acidifying emissions in studies of this nature are oxides of sulfur (SO_x) and oxides of nitrogen (NO_x). The present approach is to combine these and other atmospheric variables to produce Potential Acid Input (PAI) values.

An extensive background discussion on the limitations and uncertainties involved in assessing acidifying emissions and their potential impacts on soils may be found in Section D2.2 of this EIA. A conceptual approach to assigning relative sensitivities to both mineral and organic soils is outlined and appropriate values assigned to each soil series in the RSA. This allows a degree of quantification with respect to acidifying impact potentials.

The World Health Organization has proposed critical PAI loading factors for highly sensitive ecosystems of 0.25 keq/ha/a and 0.50 keq/ha/a for moderately sensitive ecosystems (WHO 1994). These values have been adopted for an interim 5 year period in Alberta on the recommendation of the CASA Target Loading Subgroup so they are the benchmarks used in the evaluations for all three specified emission scenarios. As described in Section B3 - Air Quality, PAI values in the immediate vicinity of the existing and approved developments either do at present or will, once the facilities are in operation, exceed the critical loading benchmarks. It follows, therefore, that potential soil acidification would have the greatest likelihood of occurring in these same areas. However, it must be emphasized that the PAI values are for operational maxima, whereas in reality they will be phased in as the various developments come on-stream, then cease at the end of development.

Table D6-8 provides data on the areas of the three soil sensitivity classes estimated to be affected by PAI for baseline, Project Millennium and full CEA emissions scenarios. These numbers are further analyzed in Table D6-9 to show the incremental impacts associated with Project Millennium on the soils in the RSA. A brief discussion of the incremental increases in area attributable to Project Millennium for sensitive ecosystems, defined as those receiving a critical load of 0.25 keq/ha/a, is warranted. As shown in Table D6-9, Project Millennium is predicted to have the following effects:

a) For highly sensitive soils, the additional area potentially impacted by Project emissions is estimated to be 33,024 ha or 19% of the total CEA affected area.

b) For moderately sensitive soils, the additional area potentially affected by Project Millennium is estimated to be 28,755 ha or 18% of the total CEA impact.

c) For low sensitivity soils, the additional area potentially affected by Project emissions is predicted to be 115,713 ha or 34% of the total CEA impact area.

Comparable data for the 0.50 keq/ha/a area are also shown in Tables D6-8 and D6-9 from which it may be seen that the Project is estimated to contribute relatively little in the way of additional PAI affected area. Figures D6-6 and D6-7 illustrate the PAI isopleths for baseline and CEA emission levels, respectively, superimposed on the soil sensitivity maps.

Table D6-8 Areas Within Specified Critical Load Isopleths for Baseline, Impact and CEA Scenarios in the RSA

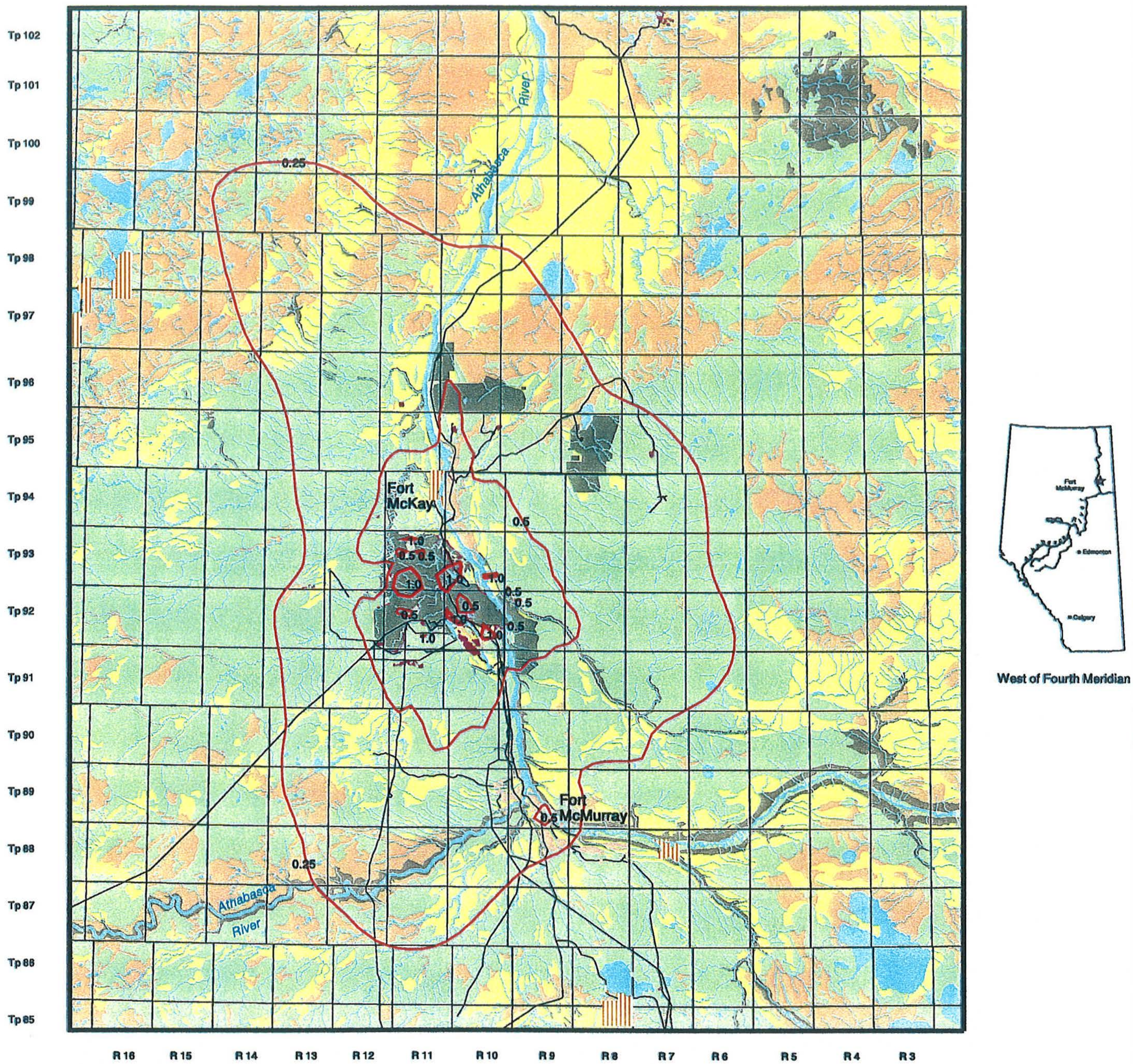
PAI Critical Load Value	Soil Sensitivity Rating	Baseline		Project Millennium Impact		CEA Scenario	
		ha	% RSA	ha	% RSA	ha	% RSA
>0.25 keq/ha/a	Low	391,660	16	507,373	21	734,983	30
	Moderate	102,706	4	131,461	5	266,279	11
	High	88,778	4	121,802	5	266,883	11
	Variable[(a)]	26,104	1	28,846	1	39,852	2
	Not Applicable[(b)]	61,261	3	71,677	3	107,885	4
>0.50 keq/ha/a	Low	62,763	3	126,324	5	229,889	9
	Moderate	12,105	<1	18,494	<1	57,923	2
	High	4,443	<1	5,007	<1	40,163	2
	Variable[(a)]	5,230	<1	8,454	<1	12,781	<1
	Not Applicable[(b)]	31,157	1	37,359	2	79,332	3

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings

Table D6-9 Contribution of Project Millennium to Areas Affected by Acidifying Emissions in the RSA

PAI Critical Load Value	Soil Sensitivity Rating	CEA Baseline		Project Millennium - Baseline		Incremental Impact of Project Millennium,
		ha	% RSA	ha	% RSA	% of CEA Impact
>0.25 keq/ha/a	Low	343,323	14	115,713	5	34
	Moderate	163,573	7	28,755	1	18
	High	178,573	7	33,024	1	19
	Variable[(a)]	13,748	<1	2,742	1	20
	Not Applicable[(b)]	46,624	2	10,416	<1	22
>0.50 keq/ha/a	Low	167,126	7	63,561	3	38
	Moderate	45,818	2	6,389	<1	14
	High	35,720	1	564	<1	2
	Variable[(a)]	7,551	<1	3,224	<1	43
	Not Applicable[(b)]	48,175	2	6,202	<1	13

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings



SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- PAI Isopleths (keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

SOIL SENSITIVITY

- Low
- Moderate
- High
- Variable

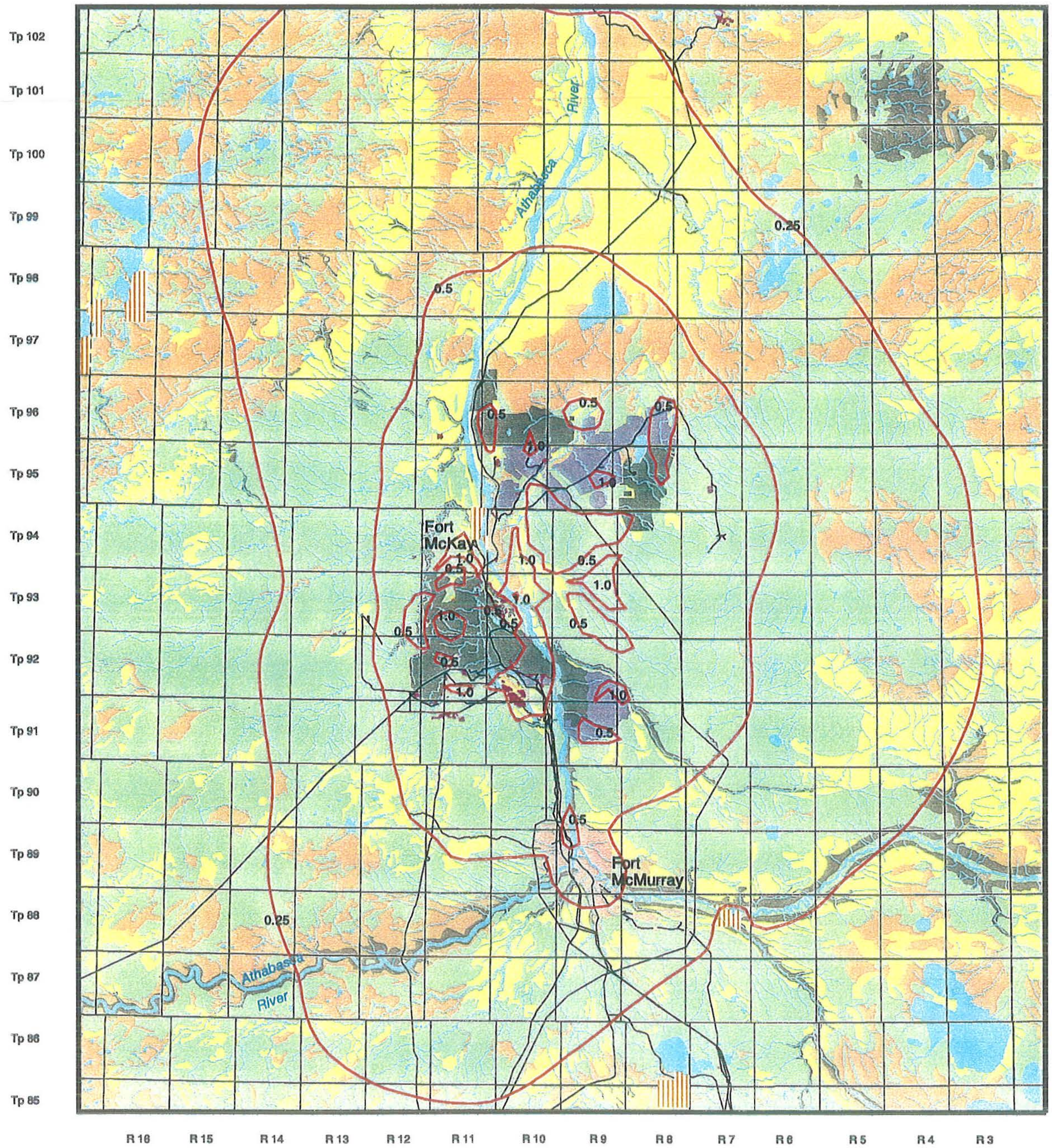
N

SUNCOR ENERGY | Project Millennium

REGIONAL STUDY AREA RELATIVE SOIL SENSITIVITIES TO ACIDIFYING EMISSIONS PAI BASELINE

16 Apr. 1998	Figure D6-6	PRODUCED BY: K.K.Q. REVIEWED BY:

/data14/suncor/regional/9700/8740/arcview/air.apr



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- PAI Isopleths ((keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

SOIL SENSITIVITY

- Low
- Moderate
- High
- Variable

N

SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA RELATIVE SOIL SENSITIVITIES TO ACIDIFYING EMISSIONS PAI CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-7	PRODUCED BY: K.K.Q. REVIEWED BY:

/data14/suncor/regional/9700/f9740/arcview/air.apr

D6.2.3.1 Residual Impacts Classification

It is difficult to quantify either the residual impacts or environmental consequence with anything less than a high level of scientific uncertainty due to the ill-defined nature of the emissions-soil acidification relationship and the relationship of deposition to effect (as discussed at length in Section D2.2 of this EIA). The most definitive statement that may be made with any degree of confidence is that soils classified as highly sensitive and falling within the area defined by the 0.25 keq/ha/a isopleth are the most logical candidates to experience adverse impacts associated with the Project. Monitoring recommendations to address the scientific uncertainty are discussed in Section D2.2.11.

It is estimated that the environmental consequence associated with potential soil acidification resulting from the CEA be rated as low but emphasis must be placed on the high level of scientific uncertainty in the analysis.

D6.2.4 Conclusion/Summary

Table D6-10 summarizes the residual impacts for Soils and Terrain under the CEA. This summary addresses Key Question CTER-1 regarding the potential impacts of combined developments on soil and the terrain resources.

Table D6-10 Summary of Residual Impacts

Key Question	CEA Results
Quantity and Distribution of Soil and Terrain Units	During the construction and operation phases, the combined developments will cause a loss of 3.2% of the natural soil and terrain units in the RSA, the impacts associated with this are estimated to be: negative in direction, low in magnitude, regional in extent, of long-term duration, irreversible, low in frequency with a low level of scientific uncertainty. This will generate a low Environmental Consequence. This is a worst case perspective as it is unlikely that all sites will be developed to their maximum extent concurrently. The phased nature of development and reclamation will mediate the Environmental Consequence. Reclamation of the developed areas and existing disturbed areas with reconfigured terrain units covered by a reclamation soil mixture will produce very Positive impacts by increasing the diversity of terrain units.
Land Capability for Forest Ecosystems and Soil Sensitivity to Acidifying Emissions	As a result of alterations in the quantity and distribution of soil and terrain units between the baseline and closure landscapes, changes in land capability will be produced. These are estimated to be: positive in direction, low in magnitude, regional in extent, of long-term in duration, irreversible, low in frequency, of a low level of scientific uncertainty and generate a low Environmental Consequence. The positive direction of change is the result of significant areas of non-productive class 5 land being reclaimed to low capability class 3. Operational activities of the developments will increase the levels of potentially acidifying emissions released into the RSA air shed. The potential impacts are estimated to be: negative in direction, variable in magnitude, regional in extent, lasting for an undetermined period, potentially reversible, continuous in frequency (for the duration of production) with a moderate to low Environmental Consequence. Associated with this is a high level of scientific uncertainty as the PAI-soil acidification linkage is ill-defined and the precise nature of the impacts are highly site specific.

D6.3 TERRESTRIAL VEGETATION AND WETLANDS

D6.3.1 Approach and Methods

The approach used to assess terrestrial vegetation and wetlands for the CEA is consistent with Section D3. This vegetation assessment includes all developments described in Section D6.1.3 (Planned Developments) as well as Forestry developments, which were not included in Sections D6.2 (Soil and Terrain). There are three main CEA vegetation issues in the RSA: direct losses of vegetation from Project developments, subsequent changes in vegetation diversity, and indirect losses to vegetation as a result of air emissions. For the purpose of cumulative effects assessment, the terrestrial vegetation effects are divided into three sections as follows:

- vegetation community quantity and distribution;
- vegetation diversity; and
- vegetation sensitivity to acidifying emissions.

D6.3.1.1 Classification Scheme

Vegetation communities were classified according to dominant overstorey species and site conditions using Landsat Imagery. Due to the coarser mapping scale, vegetation could not be classified to one specific ecosite site phase or wetland class (AWI) but rather each vegetation class reflects a complex of ecosite phases. Table D6-11 provides a summary of the vegetation classification developed for the RSA. There are 17 vegetation classes and three disturbance classes, which include forestry cutblocks and natural non-vegetated (i.e., sand dunes) and anthropogenic disturbances (i.e., gravel pits) in the RSA. The corresponding ecosite phases for each of the three Ecological Areas represented in the RSA are also presented in Table D6-11. A detailed description of each vegetation class is provided in the Baseline Terrestrial Vegetation Report (1998l).

D6.3.1.2 Mapping

Landsat Thematic Mapper Satellite imagery was collected for two areas ("scenes") in July 1994 and July 1996 respectively to classify and map vegetation classes in the RSA. The majority of the RSA was covered with the more recent 1996 imagery; however, due to cloud cover constraints, small portions were covered by the 1994 imagery. A supervised classification of the imagery was undertaken, including the selection of a number of "training" or test areas determined from information collected from aerial photographs, Alberta Phase 3 Forest Inventory Maps, Alberta Vegetation Inventory Maps (AVI), Vegetation Maps produced for oil sands projects, Soil Inventory Maps of the Alberta Oil Sands Environmental

D6.2.3.1 Residual Impacts Classification

There is a high level of scientific uncertainty in the assessment of environmental consequence of soil acidification due to the ill-defined nature of the emissions-soil acidification relationship and the relationship of deposition to effect (as discussed at length in Section D2.2 of this EIA). The most definitive statement that may be made with any degree of confidence is that soils classified as highly sensitive and falling within the area defined by the 0.25 keq/ha/a isopleth are the most logical candidates to experience adverse impacts associated with the Project. Monitoring recommendations to address the scientific uncertainty are discussed in Section D2.2.11.

It is estimated that the environmental consequence associated with potential soil acidification resulting from the CEA be rated as low but emphasis must be placed on the high level of scientific uncertainty in the analysis.

D6.2.4 Conclusion/Summary

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Land Capability for Forest Ecosystems and Soil Sensitivity to Acidifying Emissions	As a result of alterations in the quantity and distribution of soil and terrain units between the baseline and closure landscapes, changes in land capability will be produced. These are estimated to be: positive in direction, low in magnitude, regional in extent, of long-term in duration, irreversible, low in frequency and generate a low Environmental Consequence. The positive direction of change is the result of significant areas of non-productive class 5 land being reclaimed to low capability class 3. Operational activities of the developments will increase the levels of potentially acidifying emissions released into the RSA air shed. The potential impacts are estimated to be: negative in direction, variable in magnitude, regional in extent, lasting for an undetermined period, potentially reversible, continuous in frequency (for the duration of production) with a moderate to low Environmental Consequence. Associated with this is a high level of scientific uncertainty as the PAI-soil acidification linkage is ill-defined and the precise nature of the impacts are highly site specific.

Research Program (AOSERP) and a 1997 field investigation. An accuracy assessment of the classified imagery based on field data collected in July 1997 indicated a final overall accuracy of 80% (Golder 1997o: Terrestrial Vegetation Baseline Report).

Vegetation Classes from the Landsat imagery were transferred to a geographical information system (GIS) to allow the relative abundance of vegetation classes to be compared within the RSA. By superimposing baseline, Project Millennium and planned developments over the existing vegetation "polygons", the distribution and amounts of each class affected can be quantified and an assessment of significance made using the criteria previously described. Similarly, by superimposing the successive reclamation activities onto the combined development area, the progression of revegetation can be quantified and monitored.

This classification is at a coarser scale than completed for the local study area. This is reflected in slight differences in area calculations for baseline and impact values for the Project.

D6.3.1.3 Biodiversity Measurements

Biodiversity was assessed for vegetation communities in the RSA by quantifying community richness and patch size. Richness was determined by counting the number of different classified units within the RSA for pre and post-development scenarios. Patch size assessment is described in detail in Section D6.3.3.1.

D6.3.1.4 Potential Linkages: Construction and Operation

The first vegetation resources linkage pertains to the potential impacts of Project construction and operation on the terrestrial vegetation and wetlands communities in the RSA. Project activities that may affect the vegetation resource include, but are not limited to: site clearing, soil and overburden stripping and storage, changes in soil properties, development of Project facilities and infrastructure, changes to hydrology and emissions and releases to the air, ground and water. The impacts from these activities are expected to include direct losses or alteration of terrestrial vegetation and wetlands as a result of site clearing and the physical removal of terrestrial vegetation and wetlands, while the indirect losses may result from air emissions and/or water releases.

Effects on terrestrial vegetation and wetlands may include changes in vegetation community diversity. Linkage may also be drawn to other related resources, as a result of potential impacts to terrestrial vegetation and wetlands, including changes in resource use, wildlife habitat and human health.

D6.3.1.5 Potential Linkages: Closure

A second linkage identifies the potential impacts on the vegetation and wetlands resource at (and beyond) closure of developments. Development activities that affect vegetation communities and species at closure include, but are not limited to: reclamation activities, such as grading and replacement of overburden and topsoil materials, development of end pit lakes and alterations to surface drainage patterns. These activities will result in a variety of reclamation surfaces which will be revegetated to meet end land use objectives. Revegetation efforts will eventually replace plant communities displaced during development constructions and operation.

Reclaimed vegetation, however, will initially result in changes in vegetation successional stage within and among the reclaimed communities. This change has the potential to affect resource use and wildlife habitat while succession proceeds.

D6.3.2 Vegetation Community Quantity and Distribution

D6.3.2.1 Analysis and Results

Direct Losses/Alterations

The combined developments will result in direct losses and alteration to terrestrial vegetation (Table D6-12). A discussion detailing activities associated with these developments is presented in Section A2. Baseline regional vegetation is shown in Figure D3a-d.

Table D6-12 Direct Losses/Alteration of Existing Terrestrial Vegetation, Wetlands, Lakes, Rivers and Other Areas in the RSA

General Community Types	Baseline		Project Millennium		CEA[a]		
	(ha)	(% of RSA)	(ha)	(% of RSA)	(ha)	(% of RSA)	(% of Total RSA)
Uplands	970,774	40	1,116	0.1	93,219	9.6	3.8
Wetlands	1,235,595	51	4,448	0.4	89,581	7.2	3.7
Water	64,429	3	1	<0.1	896	<1	<1
Forestry Activity	13,867	<1	0	0	157,230	n/a	n/a
Developed, Nonvegetated, or Unclassified	144,085	6	79	<0.1	119,157	n/a	n/a
TOTAL	**2,428,750**	**100**	**5,644**	**0.2**	**n/a**	**n/a**	**8**

[a] includes forestry activities at 50% of total FMA area

There are approximately 75,665 ha which could not be classified through Landsat Imagery in the RSA. Existing forestry disturbances occupy 13,872 ha or less than 1% of the RSA. The total baseline disturbance to vegetation due to developments is 69,629 ha or 3% of the RSA.

Construction of the Project will result in the clearing of 5,644 ha (less than 1% of the RSA). Other approved and existing developments (including forestry) will contribute an additional 250,674 ha, therefore, the combined cumulative impact is approximately 256,318 ha or 10% of the RSA.

Disturbance Summary for the RSA

Baseline terrestrial vegetation accounts for 970,774 ha or 40% in the RSA. The Project will clear 1,116 ha or <1 of upland vegetation within the RSA. While combined developments will clear 93,219 ha or 11% of the RSA. The Project, therefore, contributes only a small proportion (1.2%) of this loss. Commercial logging contributes the most to this disturbance in the RSA.

Within upland (terrestrial) plant communities (Table D6-13), the greatest impacts occur within the mixed coniferous (11% Sw dominant), mixed deciduous (11% Aw dominant) and mixedwood (13% Sw-Aw dominant). The lowest impacts will occur within the open pine-lichen, where 6,080 ha or less than 5% of the community will be cleared.

Overall, terrestrial vegetation will increase by 39,251 ha due to reclamation from 970,774 ha at baseline to 1,010,025 ha in the RSA.

Effect on wetlands from the Project is estimated to be 4,448 ha or 2% of all wetlands in the RSA. Combined developments, including Forestry, will result in either permanent or temporary losses to 89,581 ha or 7%. It is expected that in the Far Future wetlands disturbed by forestry will return to baseline conditions. Oilsands developments, however, will reclaim fens and bogs to other upland vegetation communities, marsh wetlands, or lakes.

Impacts from the Project will result in a loss of 2,953 ha or 1% of wet closed coniferous (Sb dominant) and 159 ha or <1% of wet open coniferous (Sb dominant). Shrubby and graminoid fens will be reduced by 1% as a result of the Project. Combined developments will affect 48,664 ha or 10% of wet closed coniferous (Sb dominant); 10,749 ha or 8% wet open coniferous (Sb dominant). In addition, combined developments will affect a total of 12% of fens in the RSA.

Table D6-13 Baseline, CEA and Closure Terrestrial Vegetation and Other Land Cover Types in the RSA

Vegetation Types	Baseline RSA		Project Millennium		CEA[a]		Far Future	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	%
Open Pine-Lichen	130,819	5	1	<0.1	6,080	4.6	130,819	100
Mixed Deciduous (Aspen dominant)	177,541	7	357	0.2	20,189	11.4	180,758	102
Mixedwood (White Spruce - Aspen dominant)	318,772	13	437	0.1	40,154	12.6	344,546	108
Mixed Coniferous (White Spruce dominant)	112,186	5	321	0.3	12,654	11.3	122,446	109
Mixed Coniferous (White Spruce - Pine dominant)	18,778	1	0	0	1,130	6.0	18,778	100
Mixed Coniferous (Pine dominant)	15,075	1	0	0	3,085	20.5	15,075	100
Mixed Coniferous (Black Spruce - Tamarack)	93,444	4	951	1.0	7,361	7.9	93,444	100
Pine Recolonization (Pine <2m)	87,474	4	0	0	2,566	2.9	87,474	100
Shrubland (low shrub recolonization, no pine)	16,685	1	0	0	0	0	16,685	100
Wet Closed Coniferous (Black Spruce)	511,785	21	2,953	0.6	48,664	9.5	499,546	98
Wet Open Coniferous (Black Spruce)	135,784	6	159	0.1	10,749	7.9	133,415	98
Bog (Sphagnum around edges of graminoid fens)	3,333	<1	0	0	1	<0.1	3,333	100
Low Shrub Wetland (bog)	64,798	3	0	0	1,229	1.9	64,798	100
Shrubby Fen	289,689	12	232	<0.1	17,678	6.1	289,445	100
Graminoid Fen	224,531	9	153	<0.1	9,682	4.3	224,531	100
Marsh Emergent	5,675	0	0	0	420	7.4	9,267	163
Water	64,429	3	1	0	1,158	1.8	73,772	115
Barren Ground/Exposed Bedrock	12,660	1	4	0	896	7.1	12,660	100
Unclassified	75,665	3	76	0.1	6,107	8.1	75,665	100
Disturbances								
Forestry Activity	13,867	1	0	n/a	157,230	n/a	13,867	100
Municipalities	4,002	0	0	n/a	5,902	n/a	9,904	247
Open Pit Mines	43,238	2	5,644	n/a	22,552	n/a	n/a	n/a
Other Disturbances	5,618	<1	0	n/a	1,602	n/a	5,618	100
In-Situ	0	0	0	n/a	33	n/a	0	0
Additional Linear Disturbances	2,904	<1	0	n/a	3,838	n/a	2,904	100
Sub-Total Disturbances in RSA	***69,629***	***3***	***5,644***	***<1***	***191,157***	***8***	***75,531***	***n/a***
TOTAL	**2,428,750**	**100**	**5,644**	**<1**			**2,428,750**	**100**

[a] includes Forestry

In the Far Future scenario, wetlands will decrease from 1,235,595 ha to 1,224,335 ha. A total of 11,260 ha of fens will be converted to upland vegetation types or lakes (i.e., end pit lakes).

Old-Growth Forests

The RSA supports very few forest communities classified as "old-growth". This conclusion is based on field inventory results and a search of forest age records maintained by Alberta Environmental Protection (AEP). Tree age criteria for old-growth forests has been defined for this area as outlined in Section D3.

The two forest communities most likely to support old-growth forests included open pine lichen, mixed coniferous (Sw dominant) and mixed deciduous (Aw dominant) forests. These are described in Section D3. A description of commercial forestry under the CEA is provided in Section F3.6 - Resource Use.

Rare or Endangered Terrestrial Plant Species or Communities

Rare plants often require unique habitat types, a number of which were observed in the RSA including the Project. Rare plants are found to a limited extent in upland locations depending upon the species requirements.

Traditional Plants (Food, Medicinal and Spiritual)

A description of traditional plants is provided in Section F3. Due to the generalized vegetation classification of the RSA and the widespread habitat requirements, traditional plants identified may be found in multiple ecosite phases within the RSA. Accordingly, many of the plants can potentially be found over large areas within the RSA.

As most of the traditional plants are widespread in the RSA, particularly in wetlands, losses associated with the Project Millennium and combined developments are equally distributed across all species. Many wetlands, such as wooded fens, are lost because of oil sands developments. Combined development will decrease wetlands by 5,062 ha or 15% within the RSA.

Indirect Losses/Alterations

The combined developments will result in indirect losses/alterations to vegetation resources within the RSA. Such impacts are difficult to quantify and are largely due to the effects of acidifying emissions and changes in surface water hydrology. These issues are addressed within the LSA in Sections C2.2 and C3.2 (respectively). Changes in surface water hydrology affecting soil mixture conditions and vegetation resources have been quantified for those areas affected by groundwater drawdown; however other indirect impacts such as those areas adjacent to roads and drainages are not quantified within the RSA.

Other indirect impacts to vegetation within the RSA include, for example, the accidental introduction of exotic species on temporarily disturbed surfaces and changes in stand structure as a result of soil disturbance. These changes will be monitored within the LSA and extrapolated within the regional context.

D6.3.2.2 Residual Impact Classification and Environmental Consequence

A total of 16,129 ha or 2% of terrestrial vegetation in the RSA will be removed from combined developments. This represents a low magnitude, high in frequency and a low Environmental Consequence.

Open and closed coniferous (black spruce) in the RSA represent approximately 26% of the wetlands. The loss of wetlands from combined developments is 33,661 ha or 3% of wetlands within the RSA. The impacts to wetlands therefore are negative in direction, low in magnitude and of a low Environmental Consequence. Table D6-14 summarizes the impacts to vegetation communities in the RSA.

Table D6-14 Residual Impact Classification on Terrestrial Vegetation and Wetlands in the RSA and Environmental Consequence

Vegetation Community Type	Impact Assessment Criteria						
Ecosite Phases	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Open Pine-Lichen	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixed Coniferous (Sw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixed Deciduous (Aw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixedwood (Sw-Aw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Wet Closed Coniferous (Sb)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Wet Open Coniferous (Sb)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Graminoid Fen	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Low Shrub Wetland (bog)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Bog (Sphagnum around edges of graminoid fens)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Marsh Emergent	Positive	Low	Regional	Long-term	Irreversible	Low	Low

The primary residual impacts include:

- a change in dominant vegetation type from wetlands to upland communities;
- a decrease in areas of wetlands;
- an increase in deciduous shrub communities; and
- an increase in areas of ponds/wetlands and lakes.

In general, the direct and indirect impacts to the vegetation resources do not represent a significant reduction. Some vegetation types such as fens and bogs will represent a permanent loss of that resource, however several upland ecosite phases will be replaced during reclamation. In addition, loss/alteration to vegetation will be phased over the construction and operation phases of development. Substantial increases in community types, for example, open pine-lichen and mixed coniferous (Sw dominant) are foreseen following mine closures based on reclamation plans.

The CEA is presented as the worst case scenario. Developments may not occur simultaneously and reclamation will be phased over time.

D6.3.3 Vegetation Diversity

D6.3.3.1 Richness (Patch Types)

Richness of patch types is determined by counting the number of different classified units within a given landscape or community unit. These values can be determined for baseline, impact and reclaimed areas.

Patch dynamics examines vegetation communities as mosaics of different areas in which disturbances and biological interactions proceed. A patch habitat is an environment within which there are significant variations in size and quality of habitat available for particular species. The variability (range) in patch size will prove some indication of diversity at the landscape and community level. The number and size of vegetation patches (polygon) with the RSA are quantified in hectares. Polygons are assessed by comparing the number of polygons (patches) within the RSA before and after impacts by the combined developments. The assessment of polygons was determined by vegetation types, for example, mixed coniferous (Sw dominant).

Patch size was assessed to determine impacts from combined developments in the RSA. The Project alone does not affect patch size in the RSA. Average patch size for mixed deciduous (Sw dominant) is reduced from approximate 108,457 ha to 106,200 ha. Average patch size for mixedwood (Sw-Aw) will decrease approximately 4,459 ha from 911,118 ha to 86,659 ha. Average patch size for mixed coniferous (Sw-Pj/Pl) will increase 1,218 ha.

D6.3.3.2 Species Diversity

Species diversity has been a central theme of much research in community ecology in the last score of years. General discussions of species diversity are presented in Whittaker (1972), Pielou (1975), Ricklys (1979), Pianka (1983), and Krebs (1989).

Species diversity is composed of two components: 1) the number of species that coexist in an area; and 2) the relative number of individuals belonging to each species.

D6.3.3.3 Residual Classification and Environmental Consequence

The residual impact classification of changes in diversity of terrestrial vegetation communities for the combined developments is positive in direction, low in magnitude, regional in extent and of long-term duration. The Environmental Consequence is moderate.

Table D6-15 outlines patch size impacts to each ecosite phase. The largest impact will occur to the low shrub wetland (bog) ecosite phase with an increase in average patch size from 14 to 16 ha. Average patch size will decrease by 1 ha in the mixed coniferous ecosite phase (Pj/Pl dominant) and will increase by 1 ha in open pine lichen, pine recolonization and graminoid fen ecosite phases. The remainder do not change significantly due to the combined developments. The impact to diversity is Low magnitude, with a Low environmental consequence.

Table D6-15 Patch Size for Baseline and CEA Vegetation Communities

Ecosite Phase	Baseline Patch Size (ha)			CEA Patch Size (ha)			Change in Patch Size (ha)			
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg[a]	% of Baseline
Open pine lichen	0.25	19,245	16	0.25	30,255	17	0	-11,010	0.34	2.0
Mixed coniferous (Sw dominant)	0.25	4,130	5	0.25	4,130	5	0	0	-0.03	-0.3
Mixed deciduous (Sw dominant)	0.25	12,422	11	0.25	12,422	11	0	0	-0.23	-2.1
Mixedwood (Sw/Aw dominant)	0.25	20,987	9	0.25	10,359	9	0	10,629	-0.44	-4.9
Mixed coniferous (Pj/Pl dominant)	0.25	24,523	6	0.25	821	5	0	2	-1.77	-27.8
Mixed coniferous (Sb--Lt dominant)	0.25	4,722	4	0.25	4,722	4	0	0	-0.02	-0.4
Mixed coniferous (Sw-Pj/Pl dominant)	0.25	853	5	0.25	589	5	0	265	0.12	2.5
Pine recolonization	0.25	32,628	11	0.25	32,628	12	0	0	5.80	5.1
Shrubland (low shrub recolonization)	0.75	15,167	232	0.75	15,167	232	0	0	0	0
Marsh emergent	0.25	209	2	0.25	209	2	0	0	-0.004	-0.2
Wet closed coniferous (Sb dominant)	0.25	98,640	20	0.25	98,645	20	0	-4	0.57	-2.8
Wet open coniferous (Sb dominant)	0.25	5,594	4	0.25	5,594	4	0	0	0.21	5.5
Shrubby fen	0.25	22,299	7	0.25	20,053	7	0	2,246	0.30	4.5
Graminoid fen	0.25	17,351	7	0.25	22,870	8	0	-5,518	0.40	5.6
Bog (shagnum dominant)	0.25	301	4	0.25	301	4	0	0	0.01	0.3
Low shrub wetland (bog)	0.25	41,414	14	0.25	41,414	16	0	0	1.66	11.8

[a] A negative sign indicates a reduction in patch size.

D6.3.4 Vegetation Sensitivity to Acidifying Emissions

Potential Acid Input (PAI) from combined developments, including fully disclosed, is predicted to centered around oil sands development areas. The World Health Organization (1994) has proposed a PAI critical loading factor of 0.25 keq/ha/a for sensitive ecosystems and 0.5 keq/ha/a for moderately sensitive ecosystems. The only dominant vegetation community not occurring within isopleths of 0.25 keq/ha/a is shrubland. Within the 0.25 keg/ha/a isopleth, the combined developments will have the highest impacts on open pine-lichen and mixed coniferous (Sw-Pj/Pl dominant) vegetation types. The lowest impacts will occur within the mixed coniferous (Pj/Pl dominant) vegetation type. PAI impacts are described in detail in Section D3.2.

D6.3.4.1 Residual Classification and Environmental Consequence

The residual impact classification of acid emissions and vegetation health for the combined developments is Negative in direction, Undetermined in magnitude, Regional in extent and of Long-Term duration. These impacts are of High frequency and are Reversible. The Environmental Consequence is Undetermined.

D6.3.5 Conclusion and Summary

Table D6-16 summarizes the residual impacts to terrestrial vegetation under the CEA.

Table D6-16 Summary of Residual Impacts to Terrestrial Vegetation

Issue	CEA Results
Vegetation Community Quantity and Distribution	For the CEA, loss of vegetation communities (16,129 ha or >1%) is predicted in the RSA. The Project contributes 5,644 ha or >1% of this impact. The CEA impact on loss or alteration of vegetation communities as Positive in direction, Low in magnitude, Regional in geographic extent, Long-term in duration and reversible. The Environmental Consequence is Low. The CEA reclamation will increase terrestrial vegetation by 306% to 49,444 ha or 2% of the RSA. This impact is Positive in direction, Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Moderate. The total loss to wetlands from the combined developments is 33,661 ha or 1% of the RSA. The Project's contribution to this loss is >1% under the CEA. This impact is Negative in direction, Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Moderate. Reclamation activities and reforestation will result in changes to the distribution of wetland types in the RSA. Overall, wet open coniferous will be reduced by 24% but (Sb dominant) marshes will increase by 595% in the RSA.
Vegetation Diversity	The CEA impact on diversity to vegetation communities is Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Low. The CEA impact on diversity to wetlands is Positive in direction, Low in magnitude, Regional in geographic extent, Long-Term in duration, and the Environmental Consequence is Moderate.
Vegetation Sensitivity to Acidifying Emissions	The CEA impact on air emission to vegetation health is Negative in direction, Undetermined in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Undetermined.

D6.4 ECOLOGICAL LAND CLASSIFICATION

D6.4.1 Approach and Methods

An ecological land classification (ELC) was utilized within the RSA to identify relatively homogeneous, spatially distinct areas, referred to as ELC units. These units fundamentally classify the landscape in a three dimensional sense, composed of a "terrain layer" (geology and surface geology), overlain by a "soil layer", in turn overlain by a "vegetation layer". The inter-relationships between these "layers", combined with physical and biological modifying processes, allows the landscapes to be classified and analyzed at a variety of scales and levels of complexity. The first level of classification was to identify landforms or macroterrain units, which represent permanent features in the landscape. Boundaries of macroterrain units were based on terrain units described in the Soils and Terrain Section of this EIA. Macroterrain will be assessed to determine the cumulative effects of developments in the RSA. Macroterrain or landforms are permanent features of the landscape. Oil Sands development will occur in only a few macroterrain units. As such, utilizing macroterrain as a broad geographical unit assists in focusing the assessment on a few key landform features.

The approach used to assess potential cumulative effects on the ecological land classification component was consistent with the approach described for the ELC Impact Assessment in Section D4.2.

D6.4.2 Potential Linkages and Key Questions

Figure D4.2-1 shows the linkage diagram for Project activities and potential changes in the ELC component. The same linkage diagrams apply to the CEA.

The overall impacts to ELC units falls under two distinct categories which are discussed in this section - macroterrain quantity and distribution and macroterrain diversity.

D6.4.3 Macroterrain Quantity and Distribution

D6.4.3.1 Analysis and Results

The analysis of potential linkages indicates that the valid linkage necessary for determining cumulative losses or alteration of ELC units at the macroterrain level involves site clearing during development. For oil sands developments, site clearing involves the direct removal of landforms, and associated soils and vegetation communities. Forestry disturbances will not affect macroterrain units.

There are fifteen macroterrain units in the RSA. A detailed description of each macroterrain type is found in the Baseline Ecological Land Classification Document (Golder 1998c). Figure D6-8 shows baseline regional macroterrain units and Figure D6-9 shows macroterrain units within the combined developments.

Project Millennium will impact two macroterrain units; namely the Athabasca-Clearwater River Valley (492 ha or <1% loss) and the Steepbank Organic Plain (5,152 ha or 1% loss). Within the RSA, open pit mine will increase by 5,644 ha or 13% due to Project Millennium. As such, the relative contribution of Project Millennium to these macroterrain units is low.

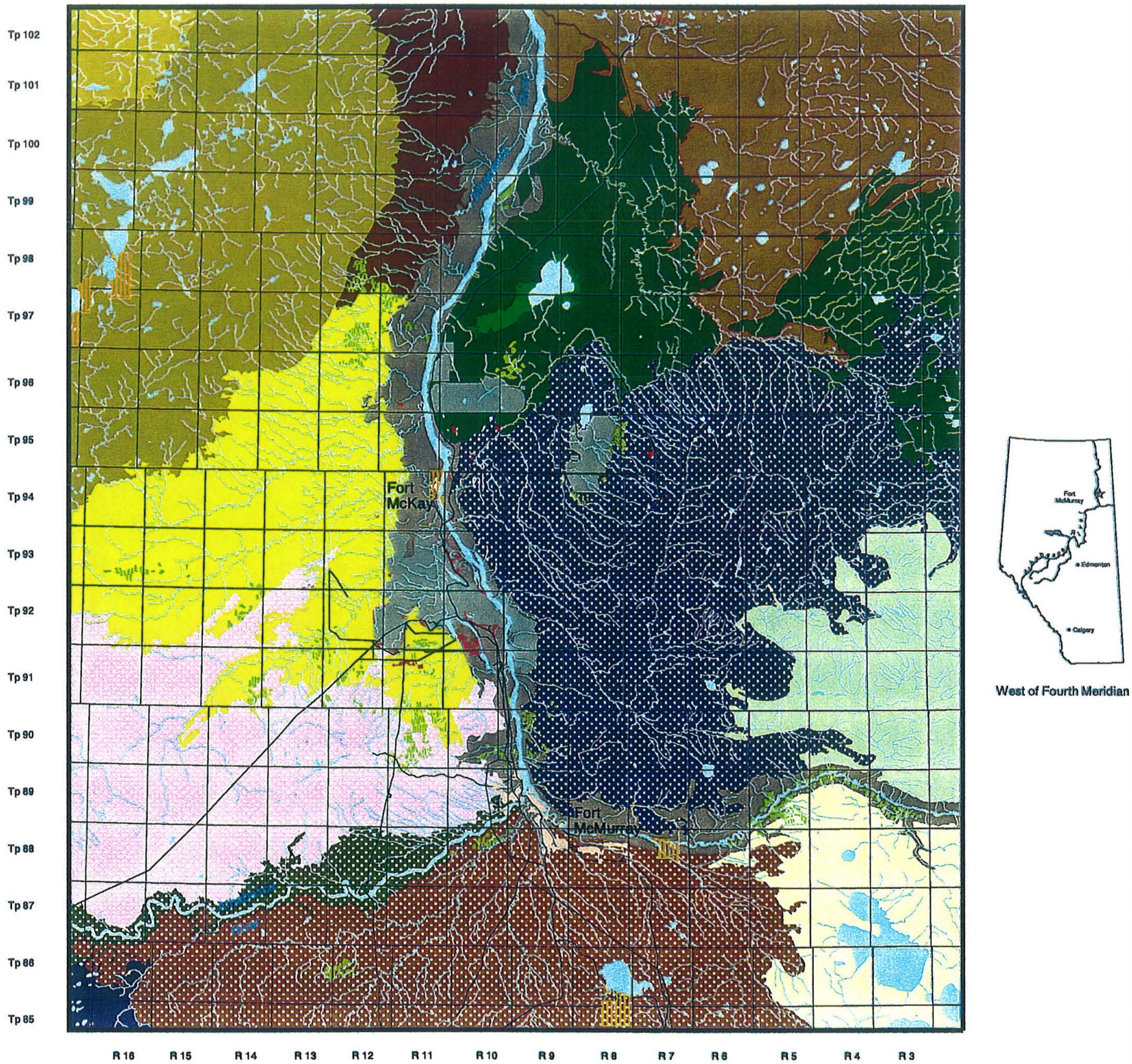
Combined developments, which include such developments as Syncrude Aurora Mine and Shell's Muskeg River Mine will impact a total of seven macroterrain units within the RSA; namely Athabasca-Clearwater River Valley, Thickwood Plain, Dover Lacustrine Plain, McKay Organic-Morainal Complex, East Athabasca River, Steepbank Organic Plain and McLelland Lake Glaciofluvial Plain (Table D6-17). Combined developments will affect 4,418 ha (3%) of the Athabasca-Clearwater River Valley macroterrain unit within the RSA (singly). The Steepbank Organic Plain is the macroterrain unit most affected by cumulative developments in the RSA. The total loss is 25,789 ha or 5% of the RSA; Project Millennium will reduce the unit's area by 5,152 ha, while the approved developments will impact 20,637 ha. The Project Millennium will remove a total area of 5,644 ha of macroterrain units and the approved developments will remove 58,015 ha in total. The total area disturbed including baseline, Project and Combined developments is 63,659 ha or 2% of RSA. This area will be reclaimed to new macroterrain units.

As a result of increased development in the RSA, municipalities are expected to increase by 5,902 ha or 60%; open pit mines will increase by 35%; and other disturbances are expected to increase by approximately 6%.

This CEA scenario represents the worst case scenario, as all developments do not occur simultaneously. Additionally, phased reclamation will also occur for each development scenario. Thereby reducing the total area under development at any one time.

D6.4.4 ELC Diversity

A discussion of biodiversity and how it was assessed for the Project EIA was provided in Section D3.2. The CEA assessment showed that no macroterrain units will be completely removed by the combined developments. Therefore, the overall biodiversity at the macroterrain level will not be significantly be altered by developments in the RSA. Moreover, within macroterrain units, the vegetation diversity, does not change substantially as a result of the combined developments or reclamation activities.



SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

MACROTERRAIN

- High Hill Glaciofluvail Plain
- Athabasca - Clearwater River
- Clearwater Upland
- Thickwood Plain
- Schultz's Bog Diversity Area
- Birch Mountains Organic Plain
- Birch Mountains Upland
- Dover Lacustrine Plain
- MacKay Organic - Morainal Complex
- East Athabasca River
- Steepbank Organic Plain
- McClelland Lake Glaciofluvial Plain
- Athabasca Shield
- Birch Mountain Fluvial Terrace

N

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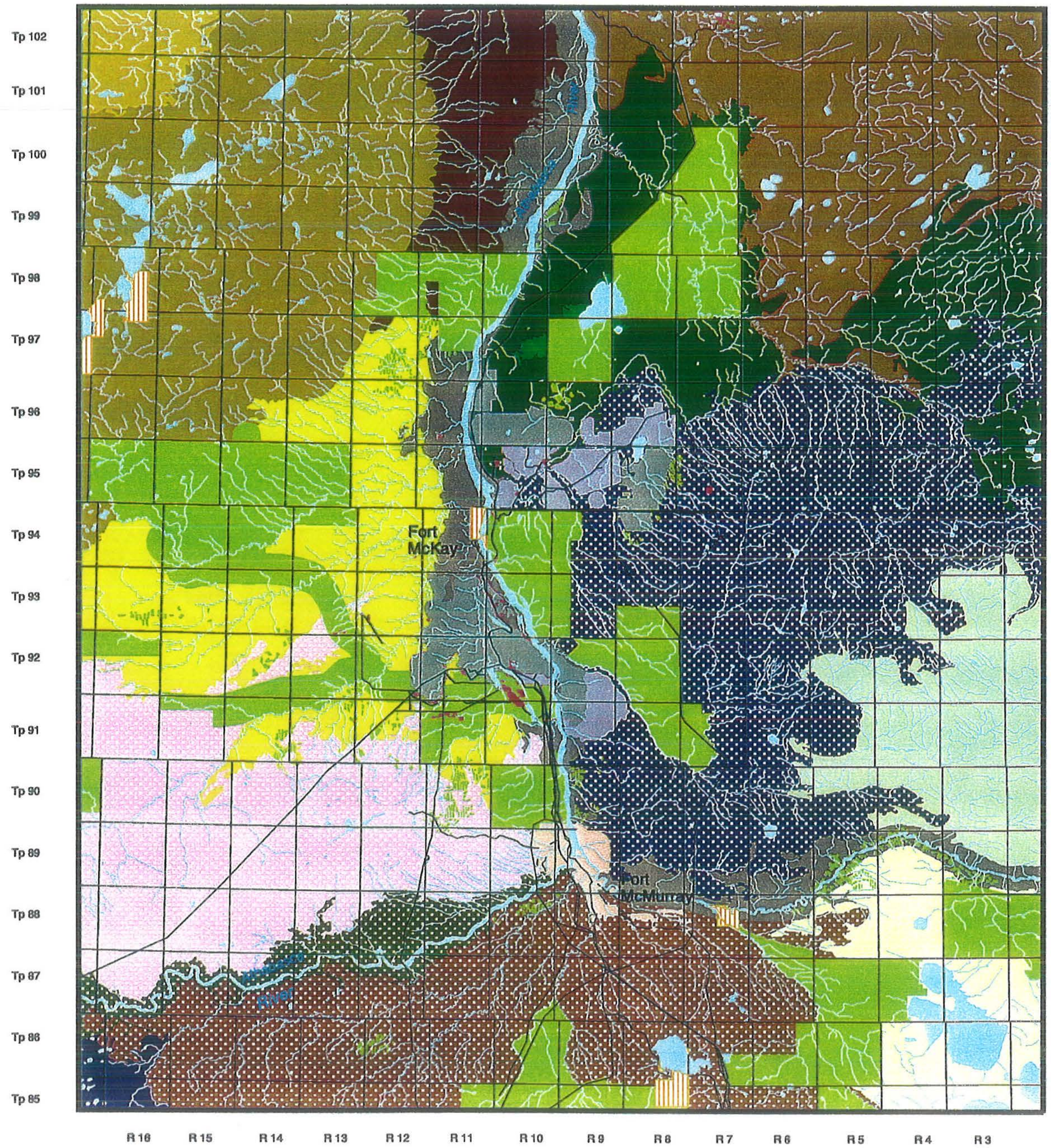
REGIONAL STUDY AREA MACROTERRAIN IMPACT ASSESSMENT BASELINE

16 Apr. 1998	Figure D8-6	PRODUCED BY: K.K.Q. REVIEWED BY:

/data14/suncor/regional/.../03/8740/arcview/macro2.apr



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

MACROTERRAIN

- High Hill Glaciofluvail Plain
- Athabasca - Clearwater River
- Clearwater Upland
- Thickwood Plain
- Schultz's Bog Diversity Area
- Birch Mountains Organic Plain
- Birch Mountains Upland
- Dover Lacustrine Plain
- MacKay Organic - Morainal Complex
- East Athabasca River
- Steepbank Organic Plain
- McClelland Lake Glaciofluvial Plain
- Athabasca Shield
- Birch Mountain Fluvial Terrace

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REGIONAL STUDY AREA MACROTERRAIN CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-9	PRODUCED BY: K.K.Q. REVIEWED BY:

Table D6-17 Direct Losses/Alteration of Existing Macroterrain in the RSA

Macroterrain	Baseline RSA[a]		Project Millennium Change[b]		Project Millennium Far Future		Approved Developments Change[c]		Approved Developments Far Future	
	Total (ha)	% RSA	Total (ha)	% Resource	Total (ha)	% Resource	Total (ha)	% Resource	Total (ha)	% Resource
High Hill Glaciofluvial	101,534	4	0	0	0	0	0	0	101,534	100
Athabasca-Clearwater River Valley	142,637	6	492	0.3	0	0	4,418	3	137,727	97
Clearwater	106,555	4	0	0	0	0	0	0	106,555	100
Thickwood Plain	269,274	11	0	0	0	0	2	0	269,272	100
Schutzes Bog Diversity Area	11,159	0	0	0	0	0	2	0	11,159	100
Birch Mountains Organic Plain	26,845	1	0	0	0	0	2	0	26,845	100
Birch Mountains	304,894	13	0	0	0	0	33	0	304,894	100
Dover Lacustrine Plain	231,191	10	0	0	0	0	314	0	231,158	100
McKay Organic-Morainal Complex	225,340	9	0	0	0	0	487	1	225,026	100
East Athabasca River	45,576	2	0	0	0	0	20,637	5	45,089	99
Steepbank Organic Plain	408,876	17	5,152	1.3	0	0	2,926	1	383,087	94
McLelland Lake Glaciofluvial Plain	217,420	9	0	0	0	0	0	0	214,494	99
Athabasca Shield	209,497	9	0	0	0	0	0	0	209,497	100
McLelland Lake Glaciofluvial Plain	7,338	0	0	0	0	0	0	0	7,338	100
Birch Mountain Fluvial Terrace	70,695	3	0	0	0	0	5,902	n/a	70,695	100
Municipalities	4,002	0	0	0	0	0	23,073	n/a	-1,900	n/a
Open Pit Mines	42,717	2	-5,644	13.0	0	0	191	n/a	25,288	n/a
Other Disturbances	3,095	0	0	0	0	0	33	n/a	2,904	n/a
In-Situ	0	0	0	n/a	0	0	0		-33	n/a
Total	**2,428,645**	**100**	**0**	**0**	**0**	**0**	**58,015**	**2**	**2,370,630**	**98**
Existing Developments					5,644	100				
Reclamation Units [d]									58,015	2
Total	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**58,015**	**2**	**2,428,645**	**100**

[a] Undeveloped macroterrain units plus existing developed area.
[b] Incremental changes to undeveloped terrain units.
[c] Cumulative effect of Project and Approved Developments on Baseline conditions.
[d] Newly created macroterrain units (revegetated tailings sand, overburden storage areas).

D6.4.4.1 Residual Impact Classification and Environmental Consequence

Table D6-18 details the residual impact classification and Environmental Consequence for macroterrain units. In summary, the direction is negative, the magnitude is negligible to low, regional in geographic extent and the Environmental Consequence is low.

Table D6-18 Residual Cumulative Impact Summary for Macroterrain Units

Macroterrain Types	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
High Hill Glaciofluvial	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Athabasca-Clearwater River Valley	Negative	Low	Regional	Long-term	No	Low	Low
Clearwater	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Thickwood Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
Schutzes Bog Diversity Area	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountains Organic Plain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountains	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dover Lacustrine Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
McKay Organic-Morainal Complex	Negative	Negligible	Regional	Long-term	No	Low	Low
East Athabasca River	Negative	Negligible	Regional	Long-term	No	Low	Low
Steepbank Organic Plain	Negative	Low	Regional	Long-term	No	Low	Low
McLelland Lake Glaciofluvial Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
Athabasca Shield	n/a	n/a	n/a	n/a	n/a	n/a	n/a
McLelland Lake Glaciofluvial Plain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountain Fluvial Terrace	n/a	n/a	n/a	n/a	n/a	n/a	n/a

D6.4.5 Summary of Impacts

Table D6-19 summarizes the impacts of the CEA results on Ecological Land Classification.

Table D6-19 Summary of Impacts on Ecological Land Classification

Key Question	CEA Results
ELC Quantity and Distribution	In this CEA, the total losses are 63,659 ha or 3% of the RSA. The Project will contribute 5,644 ha or <1 % of the loss in the RSA
ELC Diversity	The CEA impact on diversity to vegetation communities is negative in direction, negligible to low in magnitude, regional in geographic extent, long-term in duration and the Environmental Consequence is low.

D6.5 WILDLIFE

Discussion on the wildlife baseline for the Project was provided in Section D5.1, while the potential impacts of the Project on wildlife were detailed in Section D5.2 and summarized in Section D5.3 of this EIA.

D6.5.1 Approach and Methods

The approach used to assess wildlife resources for the CEA is consistent with Section D5. This approach consisted of a quantitative analysis of changes to wildlife habitat abundance and diversity. Habitat Suitability Index (HSI) models were used as a tool to quantitatively assess changes in habitat.

D6.5.2 Potential Linkages and Key Questions

Figure D5.2-1 (Section D5.2) shows the linkage diagram for project activities and potential changes in wildlife associated with the Project. Generally the same linkages and key questions apply to the CEA.

The key question for the wildlife CEA was:

CTER-2: What impacts will result from changes to wildlife habitat, abundance, or diversity associated with Project Millennium and the combined developments?

This key question is addressed in four sections below.

- Wildlife Habitat
- Wildlife Abundance
- Wildlife Diversity
- Wildlife Health

A summary of the cumulative effects as they relate to wildlife is presented in Section D6.5.6.

D6.5.3 Wildlife Habitat

Wildlife can be directly or indirectly affected by project developments. Direct habitat change occurs through the removal or alteration of vegetation communities during construction of project facilities (e.g., site clearing). Indirect habitat change can occur through changes in hydrology, creation of barriers to movement, and sensory disturbance. Potential changes to wildlife habitat were discussed in detail in Section D5.2.

D6.5.3.1 Analysis and Results

Direct incremental changes to wildlife habitat due to the Project and combined developments are shown in Table D6-20.

Table D6-20 Cumulative Effects of Habitat Loss for KIRs in the RSA

KIR	Baseline HUs [a]	Habitat Units (HUs) Lost				
		Project Millennium	% Change from Baseline	Total Developments	% Change from Baseline	% Change Attributed to Project Millennium [b]
Moose	1,535,910	-3,433	-0.2	-20,205	-1.3	17
Fisher	1,508,485	-4,045	-0.3	-21,591	-1.4	19
Black Bear	1,247,278	-2,300	-0.2	-13,150	-1.1	18
Beaver	192,045	-117	-0.1	-1,896	-1.0	6
Red-backed Vole	1,679,543	-3,623	-0.2	-20,566	-1.2	18
Snowshoe Hare	1,638,593	-5,115	-0.3	-25,705	-1.6	20
Dabbling Ducks	243,130	-99	-0.0	-1,564	-0.6	6
Ruffed Grouse	765,545	-1,938	-0.3	-7,133	-0.9	27
Cape May Warbler	903,110	-1,545	-0.2	-11,682	-1.3	13
Western Tanager	662,250	-554	-0.1	-8,430	-1.3	7
Pileated Woodpecker	782,295	-1,758	-0.2	-6,469	-0.8	27
Great Gray Owl	1,510,550	-2,037	-0.1	-31,076	-2.1	7

(a) Number of HUs for Existing and Approved Developments within the RSA.
(b) The percent change resulting from Project Millennium divided by the percent change of all of the developments.

Over baseline conditions, the Project will result in a loss of 0.0 to 0.3% of the baseline HUs within the RSA. In total, disturbances for the CEA will range from 0.6 to 2.1% of baseline conditions. Changes attributed to the Project represent from 6 to 27% of the total disturbances. The project will have the greatest effect on ruffed grouse habitat, pileated woodpecker habitat and snowshoe hare habitat. The Project will have the least effect on dabbling duck habitat, beaver habitat, western tanager habitat, and great gray owl habitat.

D6.5.3.2 Residual Impact Classification

Cumulative, residual losses of wildlife habitat were considered to be low to moderate in magnitude, because no KIR will experience losses of more than 27% of baseline HUs within the RSA. The impacts are negative in direction (Table D6-21). However, eventual reclamation of the sites is expected to return wildlife habitats to equivalent capability. The geographic extent of the impacts is regional, the duration is long-term, and the frequency is generally low. The scientific uncertainty is moderate.

The Environmental Consequence for all KIRs was considered to be low for the total impact scenario due to the low magnitude of the impacts (Table D6-21).

Table D6-21 Residual Impact Classification on Wildlife Habitat

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Scientific Uncertainty	Environmental Consequence
Negative	Low - Moderate	Regional	Long-term	Reversible	Low	Moderate	Low

D6.5.4 Wildlife Abundance

Wildlife abundance can be affected either directly or indirectly. The removal or alteration of vegetation communities, creation of barriers to movement, sensory disturbance, and the release of air or water emissions (see Section D6.5.5) can result in indirect impacts on wildlife abundance. Site clearing may also result in direct loss of a variety of wildlife species. Direct mortality impacts also can include the effects of increased hunting and trapping due to increased access, removal of problem or nuisance wildlife (e.g., beavers and black bears), increased traffic-caused mortality of wildlife, and interactions of wildlife with project infrastructure (e.g., tailings ponds, transmission lines, towers). Potential changes in wildlife abundance were discussed in detail in Section D5.2.

Within a CEA context, it is very difficult to assess changes in wildlife abundance as it is extremely difficult to estimate the numbers of animals that may be affected by various developments. Such estimates are often subjective and may be misleading. Rather, in this CEA, professional judgement is used to classify the impacts on wildlife abundance.

D6.5.4.1 Analysis and Results

Site clearing will have the greatest effect on wildlife abundance. While larger, more mobile species may be able to move away from disturbances, site clearing for the various projects may result in direct mortality for animals that have small home ranges, limited mobility or who are susceptible in their early life stages. It is anticipated that the indirect effects of barriers to movement, changes in hydrology, and sensory disturbance will be minor compared to the effects from site clearing. However, when examined within a regional context, the amount of area lost to site clearing is quite small (10%). Thus, the potential loss in wildlife abundance is low.

As a result of Project Millennium, increased hunting and trapping will result in a cumulative effect on wildlife abundance. Increased hunting and trapping is not an issue for Project Millennium as access is controlled during the life of the Project. Changes in wildlife abundance due to removal of problem or nuisance wildlife, increased traffic-caused mortality, and interactions of wildlife with project infrastructure are expected to be low to negligible.

D6.5.4.2 Residual Impact Classification

Changes in wildlife abundance due to the combination of Project Millennium and the various other existing, approved and planned barriers to movement, and sensory disturbance. Potential changes to wildlife habitat were discussed in detail in Section D5.2.

D6.5.3.1 Analysis and Results

Direct incremental changes to wildlife habitat due to the Project and combined developments are shown in Table D6-20.

Table D6-20 Cumulative Effects of Habitat Loss for KIRs in the RSA

KIR	Baseline HUs [a]	Habitat Units (HUs) Lost				
		Project Millennium	% Change from Baseline	Total Developments	% Change from Baseline	% Change Attributed to Project Millennium [b]
Moose	1,535,910	-3,433	-0.2	-20,205	-1.3	17
Fisher	1,508,485	-4,045	-0.3	-21,591	-1.4	19
Black Bear	1,247,278	-2,300	-0.2	-13,150	-1.1	18
Beaver	192,045	-117	-0.1	-1,896	-1.0	6
Red-backed Vole	1,679,543	-3,623	-0.2	-20,566	-1.2	18
Snowshoe Hare	1,638,593	-5,115	-0.3	-25,705	-1.6	20
Dabbling Ducks	243,130	-99	-0.0	-1,564	-0.6	6
Ruffed Grouse	765,545	-1,938	-0.3	-7,133	-0.9	27
Cape May Warbler	903,110	-1,545	-0.2	-11,682	-1.3	13
Western Tanager	662,250	-554	-0.1	-8,430	-1.3	7
Pileated Woodpecker	782,295	-1,758	-0.2	-6,469	-0.8	27
Great Gray Owl	1,510,550	-2,037	-0.1	-31,076	-2.1	7

(a) Number of HUs for Existing and Approved Developments within the RSA.
(b) The percent change resulting from Project Millennium divided by the percent change of all of the developments.

Over baseline conditions, the Project will result in a loss of 0.0 to 0.3% of the baseline HUs within the RSA. In total, disturbances for the CEA will range from 0.6 to 2.1% of baseline conditions. Changes attributed to the Project represent from 6 to 27% of the total disturbances. The project will have the greatest effect on ruffed grouse habitat, pileated woodpecker habitat and snowshoe hare habitat. The Project will have the least effect on dabbling duck habitat, beaver habitat, western tanager habitat, and great gray owl habitat.

D6.5.3.2 Residual Impact Classification

Cumulative, residual losses of wildlife habitat were considered to be low to moderate in magnitude, because no KIR will experience losses of more than 27% of baseline HUs within the RSA. The impacts are negative in direction (Table D6-21). However, eventual reclamation of the sites is expected to return wildlife habitats to equivalent capability. The geographic extent of the impacts is regional, the duration is long-term, and the frequency is generally low.

The Environmental Consequence for all KIRs was considered to be low for the total impact scenario due to the low magnitude of the impacts (Table D6-21).

Table D6-21 Residual Impact Classification on Wildlife Habitat

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low - Moderate	Regional	Long-term	Reversible	Low	Low

D6.5.4 Wildlife Abundance

Wildlife abundance can be affected either directly or indirectly. The removal or alteration of vegetation communities, creation of barriers to movement, sensory disturbance, and the release of air or water emissions (see Section D6.5.5) can result in indirect impacts on wildlife abundance. Site clearing may also result in direct loss of a variety of wildlife species. Direct mortality impacts also can include the effects of increased hunting and trapping due to increased access, removal of problem or nuisance wildlife (e.g., beavers and black bears), increased traffic-caused mortality of wildlife, and interactions of wildlife with project infrastructure (e.g., tailings ponds, transmission lines, towers). Potential changes in wildlife abundance were discussed in detail in Section D5.2.

Within a CEA context, it is very difficult to assess changes in wildlife abundance as it is extremely difficult to estimate the numbers of animals that may be affected by various developments. Such estimates are often subjective and may be misleading. Rather, in this CEA, professional judgement is used to classify the impacts on wildlife abundance.

D6.5.4.1 Analysis and Results

Site clearing will have the greatest effect on wildlife abundance. While larger, more mobile species may be able to move away from disturbances, site clearing for the various projects may result in direct mortality for animals that have small home ranges, limited mobility or who are susceptible in their early life stages. It is anticipated that the indirect effects of barriers to movement, changes in hydrology, and sensory disturbance will be minor compared to the effects from site clearing. However, when examined within a regional context, the amount of area lost to site clearing is quite small (10%). Thus, the potential loss in wildlife abundance is low.

As a result of Project Millennium, increased hunting and trapping will result in a cumulative effect on wildlife abundance. Increased hunting and trapping is not an issue for Project Millennium as access is controlled during the life of the Project. Changes in wildlife abundance due to removal of problem or nuisance wildlife, increased traffic-caused mortality, and interactions of wildlife with project infrastructure are expected to be low to negligible.

D6.5.4.2 Residual Impact Classification

Changes in wildlife abundance due to the combination of Project Millennium and the various other existing, approved and planned developments are negative in direction, low in magnitude, regional in geographic extent, long-term in duration, reversible and of varying frequencies. Although there is considerable scientific uncertainty due to all the unknown variables associated with wildlife abundance, the overall environmental consequence is considered to be low (Table D6-22).

Table D6-22 Residual Impact Classification on Wildlife Abundance

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Low to High	Low

D6.5.5 Wildlife Diversity

Similar to wildlife abundance, wildlife diversity can be affected either directly or indirectly. Within a CEA context, it is difficult to assess changes in wildlife diversity as there are numerous factors which can affect wildlife species, (e.g., seasonality of disturbance, individual sensitivity, proximity to human activity, intensity of human activity, and various natural factors, such as forest fires). For this CEA, we estimated the change in wildlife diversity potential using HSI modelling as a tool (Section D5.2). We estimated potential diversity by predicting all of the species that might be found within a particular vegetation type. This number was then multiplied by the area of that particular vegetation type (ha) within the RSA, resulting in the number of habitat units (HUs) available. The number of diversity HUs for each taxa (e.g., mammals, birds, and amphibians/reptiles), or baseline conditions, are presented in Table D6-23. While such an estimate is subjective and may be misleading, it does provide a means of comparing the potential of each project to affect diversity. Thus, the number of HUs lost for each taxa are presented in Table D6-23. Professional judgement was used to further classify the magnitude of impacts on wildlife diversity.

Table D6-23 Cumulative Effects of Loss of Potential Diversity in the RSA

		Habitat Units (HUs) Lost				
Taxa	Baseline [a]	Project Millennium	% Change	Total Developments	% Change	Change Attributed to Project Millennium [b]
Mammals	1,851,217	-4,735	-0.3	-25,275	-1.4	19
Birds	1,686,496	-4,783	-0.3	-22,888	-1.4	21
Amphibians and Reptiles	1,826,347	-4,864	-0.3	-23,040	-1.3	21

[a] Number of HUs for the Existing and Approved Developments.
[b] The percent change resulting from east bank mining area divided by the percent change of all of the developments.

The Project will result in a loss of diversity of 0.3% of the baseline HUs within the RSA for each taxa. In total, disturbances for the CEA will range from 1.3 to 1.4% of baseline conditions. Changes attributed to the Project represent 19 to 21% of the total disturbances.

D6.5.5.1 Residual Impact Classification

Changes in wildlife diversity due to the combination of Project Millennium and the various other existing, approved, and planned developments are negative in direction, low in magnitude, regional in geographic extent, long-term in duration, reversible, and of varying frequencies. The overall environmental consequence is low (Table D6-24).

Table D6-24 Residual Impact Classification on Wildlife Diversity

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Low to High	Low

D6.5.6 Wildlife Health

The CEA for wildlife health evaluated the potential for adverse effects to wildlife health due to the release of chemicals in air and water emissions from Project Millennium and the combined developments. Quantitative risk assessment methods, as presented in Section D5.1.7, were used where data were available (i.e., water quality). However, due to uncertainty surrounding future developments, assessment of other cumulative effects were more qualitative in nature. This section addresses the potential wildlife health impacts associated with cumulative releases of water and air to the extent that the current database allows. The CEA considered four exposure scenarios as described in Table D6-25.

Table D6-25 Exposure Scenarios Evaluated in CEA for Wildlife Health

Exposure Scenario	Operation	Closure	Far Future
Water Ingestion	✓	✓	✓
Fish/Invertebrate Ingestion	✓		
Air Inhalation and Vegetation Ingestion	✓		
Chemical Exposures From Reclaimed Landscape			✓

D6.5.6.1 Analysis and Results

Effects of Water Quality on Wildlife Health

To evaluate the potential linkage between cumulative changes to water quality and wildlife health, a quantitative wildlife health risk assessment was conducted using methods described in Section D5.1.7. The following exposure scenarios evaluated for the reclaimed landscapes of the Steepbank Mine and the Muskeg River Mine Project indicated a similarly low probability of potential impacts to wildlife health (Golder 1996r, Shell 1998).

Thus, chemical releases from multiple reclaimed landscapes within the region are unlikely to result in increased exposures on reclaimed areas. Rather, due to the larger area of reclaimed landscapes in the Athabasca oil sands region, there is a greater likelihood for wildlife to forage in a reclaimed area. Therefore, this exposure pathway becomes more likely, but the health risks are not significantly enhanced.

D6.5.6.2 Residual Impact Classification

For exposures to water during the operation phases of combined developments, no wildlife health impacts were identified. However, due to the uncertainty regarding the potential chronic effects of naphthenic acids, the magnitude of impact is rated as Low, rather than negligible. This finding is the same as that predicted for the Project.

For exposures on reclaimed landscapes, while the magnitude of the impact is considered to remain unchanged and low, it is recognized that there is an increased likelihood on a regional basis for this exposure pathway to be realized. Therefore, the scope of the residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project (Section D5.2.8). The predicted enhancement is based on a greater likelihood of animals being exposed to chemicals on reclaimed landscapes. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased in the CEA, relative to the Project. Further data are necessary to substantiate this prediction. The impact is shown in Table D6-26.

Table D6-26 Residual Impact Classification for Wildlife Health

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Scientific Uncertainty	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Moderate-High	Moderate	Low

Certainty

The assessment of potential impacts to local wildlife health from exposure to Athabasca River water was based on a number of highly conservative assumptions as outlined in Sections D5.2.7 and D5.2.8. Hence, the actual risks to wildlife health will likely be even lower than those suggested by ER estimates because of the multiple protective assumptions. However, there is some uncertainty associated with fish and aquatic invertebrate quality, plant quality and exposures on reclaimed landscapes, as a result of cumulative chemical releases. Ongoing monitoring is required to address these uncertainties.

D6.5.7 Summary of Impacts

Table D6-27 summarizes the predicted impacts and corresponding concern levels identified in the CEA assessment for wildlife. This summary addresses the Key Question CTER-2 regarding the impacts which will result from changes to wildlife habitat abundance or diversity associated with Project Millennium and combined developments.

Table D6-27 Summary of CEA for Wildlife for the Existing, Approved, Planned and Project Millennium Developments

Key Question	CEA Results
CTER-2: What impacts will result from changes to wildlife habitat, abundance or diversity associated with Project Millennium and the combined developments?	During the construction phase of the oil sands developments, the combined developments will cause relatively small losses of wildlife habitat due to site clearing. These impacts are predicted to be negative in direction, low in magnitude, regional in geographic extent, long-term in duration, and of varying frequency. The Environmental Consequence for the cumulative effects is low. As well, minor changes in wildlife abundance and diversity are expected to occur as a result of site clearing, sensory disturbance, removal of nuisance wildlife, wildlife-traffic mortalities, and wildlife interactions with infrastructure. These impacts represent a worst case scenario, as it is unlikely that all sites will be cleared to their maximum extent at the same time. The phased nature of site clearing and progressive reclamation will mitigate the cumulative effects of habitat loss. Eventual reclamation of all sites should result in equivalent habitat capability for wildlife within the region. During operation of combined developments, no significant health impacts were identified for wildlife from exposures to water from the Athabasca River; however there is some uncertainty regarding the chronic toxicity of naphthenic acids. In the far future when equilibrium conditions have been established for all combined developments, a potential impact has been identified in CEA. The scope of the residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project, since there is a greater likelihood on a regional basis for this exposure pathway to be realized. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased in the CEA. The cumulative effects on wildlife health are predicted to be Negative in direction, Low in magnitude, Regional in geographic extent, Long -Term in duration, Reversible and of Moderate-High frequency. The Scientific Uncertainty is moderate. The Environmental Consequence is Low, reflecting the regional extent and degree of uncertainty associated with impact predictions.

the Project boundaries, despite the fact that the foraging ranges of many species will extend beyond the Project boundaries into undisturbed areas. Nevertheless, this conservative exposure scenario did not result in significant adverse effects to wildlife populations.

The results of the impact analysis for wildlife living for extended periods of time on the reclaimed Project site would be applicable to reclaimed landscapes for other regional developments. This assumes that chemical releases from the reclaimed landscapes of other regional developments are not significantly greater than those predicted for the Project. Similar exposure scenarios evaluated for the reclaimed landscapes of the Steepbank Mine and the Muskeg River Mine Project indicated a similarly low probability of potential impacts to wildlife health (Golder 1996r, Shell 1998).

Thus, chemical releases from multiple reclaimed landscapes within the region are unlikely to result in increased exposures on reclaimed areas. Rather, due to the larger area of reclaimed landscapes in the Athabasca oil sands region, there is a greater likelihood for wildlife to forage in a reclaimed area. Therefore, this exposure pathway becomes more likely, but the health risks are not significantly enhanced.

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Table D6-26 Residual Impact Classification for Wildlife Health

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Certainty

The assessment of potential impacts to local wildlife health from exposure to Athabasca River water was based on a number of highly conservative assumptions as outlined in Sections D5.2.7 and D5.2.8. Hence, the actual risks to wildlife health will likely be even lower than those suggested by ER estimates because of the multiple protective assumptions. However, there is some uncertainty associated with fish and aquatic invertebrate quality, plant quality and exposures on reclaimed landscapes, as a result of cumulative chemical releases. Ongoing monitoring is required to address these uncertainties.

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In the far future when equilibrium conditions have been established for all combined developments, a potential impact has been identified. The residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project, since there is a greater likelihood on a regional basis for this exposure pathway to be realized. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased. The cumulative effects on wildlife health are predicted to be low in magnitude, regional in geographic extent, long-term in duration, reversible and of moderate to high

The residual impact on loss or alteration of terrestrial vegetation communities as low in magnitude, regional in geographic extent, long-term in duration and reversible. The environmental consequence is rated as low.

The total loss to wetlands from the combined developments is 33,661 ha or 1% of the RSA. The Project's contribution to this loss is 6,501 ha. Reclamation activities and reforestation will result in changes to the distribution of wetlands types in the RSA. Overall, wet open swamp will be reduced by 24%, but (blackspruce) marshes will increase by 595% in the RSA.

The residual impact to wetlands is low in magnitude, regional in geographic extent, and long-term in duration. Some impacts, such as those to bogs and fens, are not reversible, therefore the environmental consequence has been rated as low.

The impact of air emissions on vegetation health is undetermined. Additional data is required to assign an environmental consequence.

D6.6.3 Ecological Land Classification Units

The CEA showed that 63,659 ha or 3% of ELC units in the RSA will be impacted by the combined developments. The Project contributes 5,644 or <1% of the loss in the RSA.

The impact on diversity to ELC units is negligible to low in magnitude, regional in geographic extent and long-term in duration. The environmental consequence in the RSA is rated as low.

D6.6.4 Wildlife

During the construction phase of the oil sands developments, the combined developments will cause relatively small losses of wildlife habitat due to site clearing. These impacts are predicted to be negative in direction, low in magnitude, regional in geographic extent, long-term in duration and of varying frequency. The environmental consequence for the cumulative effects is low.

As well, minor changes in wildlife abundance and diversity are expected to occur as a result of site clearing, sensory disturbance, removal of nuisance wildlife, wildlife-traffic mortalities and wildlife interactions with infrastructure. These impacts represent a worst case scenario, as it is unlikely that all sites will be cleared to their maximum extent at the same time. The phased nature of site clearing and progressive reclamation will mitigate the cumulative effects of habitat loss. Eventual reclamation of all sites should result in equivalent habitat capability for wildlife within the region.

With the expectation of equivalent habitat capability, the residual impact to wildlife abundance and diversity is rated as being of low environmental consequence.

In the far future when equilibrium conditions have been established for all combined developments, a potential impact has been identified. The residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project, since there is a greater likelihood on a regional basis for this exposure pathway to be realized. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased. The cumulative effects on wildlife health are predicted to be low in magnitude, regional in geographic extent, long-term in duration, reversible and of moderate to high

E CLOSURE PLAN ASSESSMENT

E1 INTRODUCTION

This section describes the conceptual Closure Plan Assessment for Project Millennium. The Closure Plan presents a final "snapshot" of the landscape after completion of reclamation activities. It includes an initial assessment of the final landform structures for their geotechnical, environmental, and end use performance in terms of final end use objectives and regulatory guidelines. Neither the Closure Plan nor the Closure Plan Assessment is intended to be a final document, but rather they constitute a process that provides a framework for ongoing evaluation of closure options. The closure landscape may evolve due to changing stakeholder requirements for specific end uses, revised standards for regulatory certification, as well as the introduction of new oil sands operational and reclamation technologies.

This Closure Plan is described in detail in Section E of Volume 1 of the Application. That plan utilizes much of the expertise and methodology obtained from related projects undertaken for existing oil sands operations and, in particular, expertise gained on Suncor Lease 86/17. Previous research and analysis of ongoing reclamation practices have been used as a basis for the predictive modelling of the closure landscape. The majority of the analyses pertinent to the Closure Plan Assessment are also described in the impact assessments for aquatics, terrestrial resources, human health and land use. This assessment provides a framework for examining the results of these analyses but refers back to the appropriate EIA section for the details.

The Closure Plan Assessment focuses on an initial prediction of post development landforms and a methodology for the continuing assessment of these landforms in terms of the feedback received from reclamation practices and evolving land use expectations. The initial performance assessment provides a screening level review of engineering, environmental and land use issues. This assessment is used to document data gaps and provide recommendations for ongoing monitoring that will be required to achieve the Suncor end use objectives.

This Closure Plan Assessment focuses on the east bank mining area. Closure of the area within Lease 86/17 has been discussed in the Steepbank Mine application and there have been only minor changes to that closure landscape. These changes include pond elevations, the timing of the closure sequences and some vegetative unit changes to reflect enhanced feedback from the ongoing reclamation and monitoring program. In addition, the majority of the issues discussed as part of the east bank mining area assessment are directly applicable to Lease 86/17 closure.

E1.1 Terms of Reference

Section 5.0 of the Final Terms of Reference for the Project Millennium reclamation/mine closure tasks include requirements for determination of baseline conditions, conservation and reclamation activities, closure design, and closure plan assessment. Consideration of pre-development information is provided in the key reference reports and EIA environmental setting sections for the appropriate components. Conservation and reclamation (C&R) activities and closure design are addressed in Section E of Volume 1 of this application. The specific clauses in the Terms of Reference as related to Closure Plan Assessment include:

- re-establishment of self-sustaining topography, drainage, and surface watercourses;
- post-development forest productivity;
- water management;
- hydrological analysis of the post-reclamation landscape;
- contrast of the pre-disturbed aquatic ecosystem to the post-reclamation system;
- end pit lakes, wetlands, or other alternatives to reclaim the land;
- return of the land to pre-disturbed capability having regard for regulatory requirements and stakeholder end land use preferences;
- incorporation of the resources and values identified in the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan (IRP) into the reclamation plan;
- promotion of biodiversity;
- species selection based on the need for development of a self-sustaining, biologically diverse ecosystem;
- monitoring of the reclaimed terrestrial and aquatic ecosystems; and
- further reclamation and research programs.

E1.2 Approach

The purpose of the Closure Plan Assessment is to provide a description and systematic evaluation of the predicted performance of the final reclaimed landscape compared with the Project's environmental and final land use goals and policies. Specifically, this section of the EIA provides:

- a summary of key issues which are most significant to the success of the Closure Plan;

- a description of the final reclamation units and the landforms/reclamation practices that are being assessed;
- an analysis of landform and vegetation performance, including geotechnical, geomorphic, terrestrial and aquatic considerations;
- identification of areas of uncertainty; and
- recommendations for monitoring and research to address the uncertainty and assure the success of the closure process.

It is important to recognize that the performance evaluations conducted as part of this process are made on different levels of knowledge. Some issues can be addressed with a reasonable degree of certainty based on our current knowledge base. An example of this is the surface water runoff quantity. Some are based on accepted criteria and analysis methodology but for which final design information will be required for a quantitative analysis. Geotechnical design falls into this category. Still other issues can only be fully addressed with the results of further research such as the end pit lake.

E2 CLOSURE OBJECTIVES AND KEY ISSUES

E2.1 Closure Objectives

This section outlines the general objectives and issues that have been used to guide the assessment of the Closure Plan. These goals have been developed based on current oil sands standards and practices, regulatory requirements, recommendations from oil sands technical committees, and other stakeholder consultation forums. Objectives for the reclamation and closure of Project Millennium include:

- Structures will be geotechnically stable. Catastrophic discharges of earth materials (coarse and fine tailings, overburden storage piles), particularly to the Athabasca and Steepbank Rivers, must be controlled to achieve an extremely-low probability of occurrence.
- Earth materials discharges through surface erosion processes will be controlled to rates which are typical of the region.
- Surface and seepage water discharge will be managed to ensure an acceptable level of input to the Athabasca and Steepbank Rivers, Shipyard Lake, and other fish habitats.
- Ecosystems re-established on disturbed lands will be self-sustaining and capable of maturing naturally, to present suitable opportunities for the needs of resident and migratory wildlife species.
- Reclaimed lands will be maintenance-free, thereby qualifying for reclamation certification. Various end uses will be possible for the reclaimed landscape, with end-use decisions made based on input from

both regional communities and recommendations in the report of the Oil Sands Mining End Land Use Committee.

E2.2 Key Issues

The assessment of the objectives described above is made in terms of specific key issues. These key issues are based on issues raised in the Terms of Reference, recommendations in the End Land Use Committee Draft Report of December, 1997, the Integrated Resource Plan guidelines for the Fort McMurray-Athabasca Oil Sands Subregion (AEP 1996a), and the collection of input from stakeholder consultation. The key issues provide end points in the assessment process which can be compared to evaluation criteria or targets to predict the success of the final closure landscape. An example of the evaluation criteria is the re-establishment of land capability for forestry to be equal to or greater than that for pre-development.

The Oil Sands Mining End Land Use Committee (in which Suncor participated) has published a second draft recommendations for closure planning goals (Oil Sands Mining End Land Use Committee 1997). The draft recommendations pertinent to this assessment process include:

- compatibility with the surrounding developments and natural ecosystems.

- re-establishing diversity and abundance of wildlife habitat (e.g., habitats for moose, black bear, deer, bird game and furbearers.

- Consideration of traditional aboriginal land uses, recreational uses, and general community hunting, trapping, fishing and gathering of plants should also be considered.

- reclaimed land achieving a productivity equal to or better than pre-development lands, with an appropriate land area available for forestry. Other forestry goals include the use of a similar species mix as occurred at pre-development to maintain biodiversity, and contiguous blocks of forest as appropriate for efficient harvesting operations; and

- assessing the impact of the loss of productive forest lands on the annual allowable cut (AAC) and determining which mitigation measures can be taken to reduce the impact on the forest industry.

Recent guidelines contained in the IRP for the Fort McMurray-Athabasca Oil Sands Subregion have been incorporated into this Closure Plan Assessment. The overall intent of the IRP is to achieve development in a manner compatible with environmental and social considerations and to conserve land and natural resources.

Objectives pertinent to this assessment that are set out for the Mildred-Kearl RMA include:

- restoration of post-developed lands to a state that will allow sustained levels of use equivalent to that which existed before development, including forest growth. Revegetation to a mixedwood boreal forest, using native species, will be the primary means by which the lands base is reclaimed;
- maintain moose habitat and to rebuild the wintering moose population to levels greater than the present population; and
- assure that future uses of reclaimed land are compatible with existing and planned uses for adjacent lands.

The IRP indicates reclamation should achieve the replacement of the commercial conifer and deciduous forest land base and moose habitat to pre-disturbed levels. Moose are identified as the most important wildlife species within the Local Study Area (LSA) from an economic and social viewpoint. They are the focal point of aboriginal subsistence hunting and the most sought after game species by sports hunters. In addition, moose have a very high social value as a wildlife viewing resource, contributing to recreation and tourism. The IRP places a strong emphasis on moose management and calls for an increased moose population and the restoration of moose habitat to be an objective of reclamation for oils sands mines

E2.2.1 Other Regulatory Guidelines

AEP guidelines (Conservation and Reclamation Regulation of AEPEA, AEP 1996d) require that post-development lands be reclaimed to a capability equivalent to that existing before development. Where commercial forest is the reclamation objective, the capability will be measured in terms of meeting reforestation standards. Revegetation to a mixedwood boreal forest, using native species, will be the primary means by which the land base is reclaimed. An important aspect of this process is a commitment to continuing research by oil sands operators in land reclamation technology.

E2.3 Summary of Closure Plan Objectives and Issues

Based on the Terms of Reference, Suncor's corporate objectives, the End Land Use Committee goals, the IRP guidelines, other regulatory input, and stakeholder consultation, the closure objectives and issues related to Closure Plan Assessment can be summarized as follows:

Objective: *Geotechnical stability and landform conformance*

- geotechnical stability; and
- landform conformance.

Objective: *Surface erosion processes controlled to rates typical of the region*

- erosion and sedimentation performance; and
- physical viability of constructed wetlands.

Objective: *Acceptable discharge water quality to the Athabasca and Steepbank Rivers, Shipyard Lake and other fish habitats*

- hydrologic assessment of the closure landscape;
- drainage on CT landforms;
- treatment in CT wetlands associated with backfilled mine cells;
- groundwater and seepage water quality;
- effects on McLean Creek, Shipyard Lake and the Athabasca River;
- fish habitat; and
- end pit lake issues.

Objective: *Ecosystems re-establishment*

- Ecological Land Units;
- rare plants;
- wildlife and habitat use with particular emphasis on species identified in regulatory guidelines; and
- diversity of final landscape.

Objective: *Maintenance free end land use*

- forest productivity of reclaimed landscape;
- compatibility with traditional land use (e.g., hunting, trapping);
- minimization of impact on forest industry (AAC);
- maintenance or increase in moose habitat;
- compatibility with nearby developments;
- engineered structures; and

- on-site public health and safety.

It is assumed as part of this assessment that the goal of a maintenance-free landscape qualifying for reclamation certification will be achieved if the other goals described above are met. The process recognizes that there will be a continuing consultation on end land use goals as the project progresses over its 35 year operational period and subsequent ten year final reclamation time period.

In summary, the goal of the closure process is to re-establish self-sustaining landscapes and ecosystems that are compatible with the closure goals and final end land use. The assessment recognizes the goal of having a closure landscape will have the capability of supporting various desired end uses including forestry, wildlife habitat, and traditional land use although these land uses will not be identical to those prior to development.

E3 CLOSURE PLAN

E3.1 Mine Schedule

The Closure Plan is based on the most recent mine plan and on the following schedule:

- Year 1997 - Initial clearing and infrastructure work for Pit 1 as part of the Steepbank Mine approval
- Year 1999 - Construction of Millennium infrastructure components
- Year 2001 - Initiation of mining of Pit 2
- Year 2005 - Completion of mining in Pit 1
- Year 2012 - Ponds 8 filled to capacity
- Year 2018 - Pond 9 filled to capacity
- Year 2023 - Pond 10 filled to capacity
- Year 2027 - Backfilling of Pond 8a
- Year 2031 - Pond 11 filled to capacity
- Year 2033 - End of Mining Operations
  - Ponds 7 and 12 filled to capacity
  - Start of Final Reclamation Period
- Year 2043 - End of Final Reclamation Period; Start of Closure Period
- Far Future - Equilibrium closure conditions

For the purposes of project closure planning, the year 2043 is taken as the beginning of the closure period. The closure period implies that the final landscape will have achieved a self-sustaining state with maintenance restricted to a limited number of issues (e.g., end pit lake water quality).

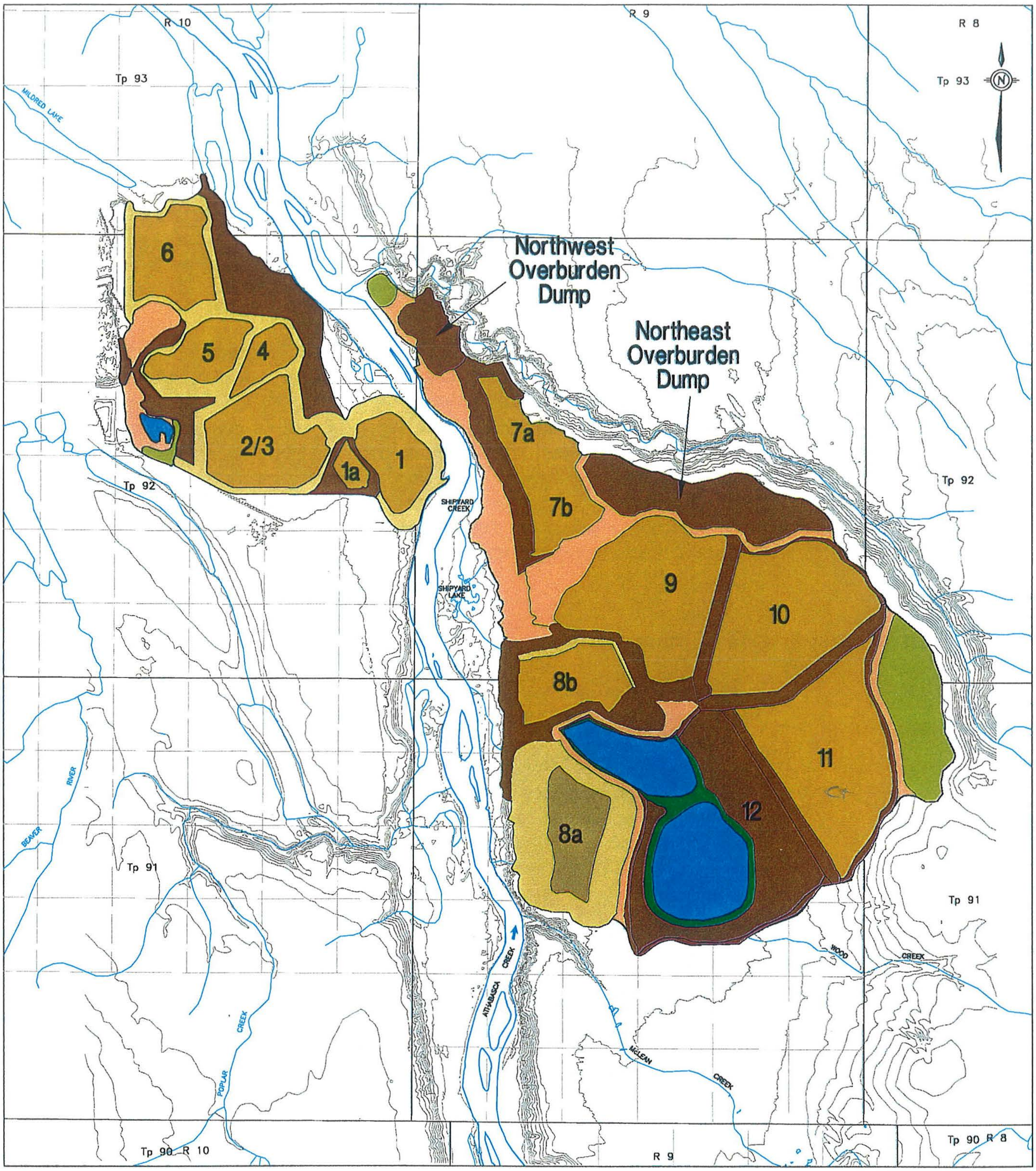
The final reclamation period comprises a ten year time frame after the end of mine operations. However, significant reclamation activities will also have been commenced during the operation period.

E3.2 Reclamation Units

The east bank mining area has an area of 9281 ha. The major post-development landscape features include:

- 274 ha for the reclaimed tailings settling pond (Pond 8a);
- 520 ha in tailings sand dykes;
- 3,278 ha for CT backfilled mine cells;
- 573 ha for above ground overburden disposal areas;
- 2,117 ha for other overburden areas including dykes and backfill for Pond 12;
- 437 ha in the reclamation material storage (RMS) areas;
- 883 ha in the end pit lake and (including the lake, littoral zone, and the intralake wetlands area); and
- 943 ha for unmined development areas which include extraction plants, pipelines, roads, and other ancillary facilities as well as some undeveloped areas.

In addition to the above-noted reclamation units, the development area also includes a 50m buffer around the outside of the mining, dyke and dump areas. This buffer area has an area of 256 ha and is not considered to be a reclamation unit per se although reclamation will be conducted as appropriate in this zone. For the purposes of this plan, these features have been broken down into reclamation units which are shown on Figure E-1.



LEGEND
- OVERBURDEN
- TAILINGS SAND
- OVERBURDEN SAND MIX
- CONSOLIDATED TAILINGS
- END PIT LAKE
- LITTORAL ZONE
- UNMINED DEVELOPMENT AREA
- RECLAMATION MATERIALS STORAGE
- **7a** POND NUMBER

REFERENCE
DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 2.5 5km
SCALE 1:125,000

SUNCOR ENERGY
Project Millennium
Taking Suncor into the 21st Century

CLOSURE LANDFORMS

09 Apr. 1998	Figure E-1	DRAWN BY: RFM

E3.2.1 Tailings Pond

There are two potential ponds which are scheduled to receive non-CT tailings and the associated process water. Initially, tailings will be placed in Pond 8a. After about year 2027, this pond will be emptied by pumping to the south end of the end pit lake which will have been constructed in Pond 12. The southern portion of the end pit lake, then, will consist of a water capped facility storing treated tailings material. The details of this is described in the end pit lake section below.

The tailings settling pond (Pond 8a) will be constructed to a maximum elevation of 355 metres above sea level (masl). Pond 8a includes both the overburden/sand mix and tailings sand dyke reclamation areas. The external slopes of the tailings settling pond are currently planned to be constructed at an angle of 8H:1V on the west (Athabasca River side) and 12.5H:1V on the pit (east) side. Further detailed geotechnical studies will be used to finalize designs for the slope angle. The toes of the slopes will be set back a minimum 100 m from the Athabasca River and McLean Creek. Seepage control will be provided by an external perimeter ditch around the pond.

E3.2.2 CT Backfilled Mine Cells

The backfilled pits are designated as "Ponds" with the ponds within a specific pit separated by an overburden dyke. Pit 1 will be backfilled in two units designated as Ponds 7a and 7b (collectively designated as Pond 7). Pit 2 will be backfilled in six units which include Ponds 8, 9, 10, 11a, and 11b (collectively designated as Pond 11). A portion of Pond 8 will be over natural ground outside the mined area. Pond 12 will be backfilled primarily with overburden although some CT will be placed in the south end of the end pit lake at the end of the project.

Ponds 7 through 11 be backfilled with a combination of overburden and CT. The percentage of overburden in the ponds ranges from 19% (Pond 8) to 54% (Pond 10). Overburden will be placed during the initial portions of pond backfilling with the majority of the material in the later stages being CT. For this reason, the reclaimed pond landscapes have been assumed to be CT reclamation units. It is possible, however, that there will be some areas where reclamation within the ponds will be on overburden soils.

The CT backfilled mine cells will be a dominant landform after Project closure. Therefore the characteristics of its surface environment are crucial to accomplish many reclamation and closure goals (e.g., commercial forestry, wildlife habitat, aesthetics, traditional end land uses). Since the majority of this reclamation unit will be impacted by CT release water during the first few years, adequate drainage is a prerequisite for reclamation.

After filling of CT has been completed, the final contours for the ponds will be sculpted and the CT capped. This capping will include a minimum of 1m of tailings sand or overburden with significantly greater thicknesses (typically 3 to 5m) in the hummock areas between the drainage channels. On average the slopes of the capped CT ponds will be approximately 1% with a constructed dendritic drainage pattern as shown on Figure E-2.

All pond areas will have constructed wetlands which will be integrated with the surface drainage system. A description of the constructed wetlands are provided below.

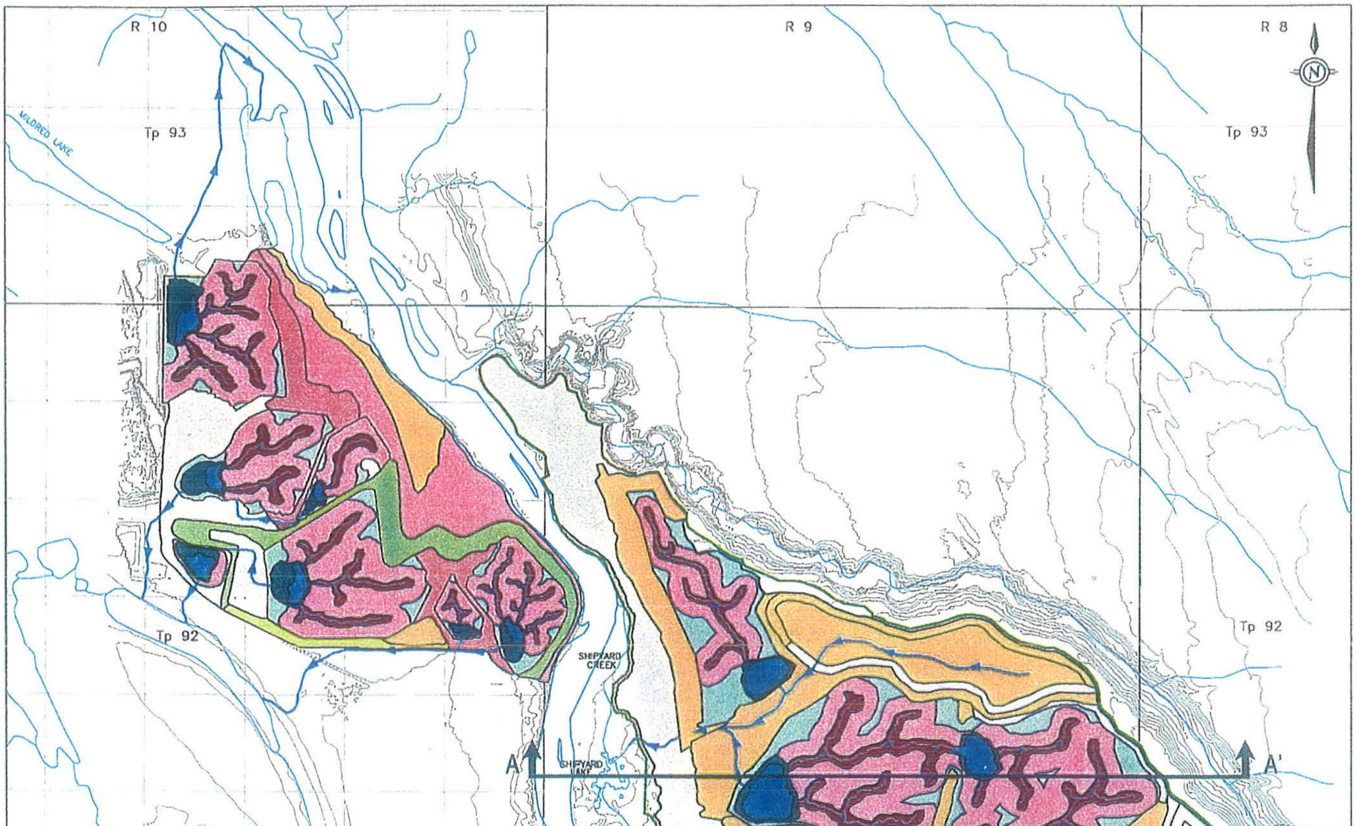
E3.2.3 Overburden Dumps

A total of about 6 billion m^3 of overburden will be generated during mine development. The majority of this material will be disposed in the overburden dykes or the ponds. However, the a certain amount of material will be placed in specifically designated overburden disposal areas.

The two areas that have been identified for the above ground overburden disposal are the Northwest and Northeast Overburden Dumps. These overburden areas are shown on Figure E-1. The Northwest dump is currently being filled as part of the approved Steepbank Mine project. In addition to the overburden, some of the excess muskeg will also be placed in these overburden disposal areas. The muskeg so disposed will be contained by overburden shells.

Above ground overburden dumps will be engineered and constructed to ensure long-term geotechnical stability. Overburden dumps will be constructed in a controlled manner. Although the detailed design of these dumps will be made taking into account site-specific ground conditions, it is currently anticipated that the final slopes will be in the range of 4H:1V. To ensure stability, the disposal areas will be monitored.

Some Clearwater formation materials are likely to have chemical properties which are not conducive to revegetation. Material with a sodium adsorption ratio (SAR) of greater than 12 will be placed preferentially towards the center of the overburden dumps. Soils more conducive to reclamation will be preferentially placed on the external slopes of the disposal areas to a minimum depth of 1 m. This handling practice may be reviewed once more information on the quality and variation of the Clearwater material is obtained.



LEGEND

- B1–BLUEBERRY PJ–AW
- B2–BLUEBERRY AW(BW)
- B3–BLUEBERRY AW–SW
- D1–LOW–BUSH CRANBERRY AW
- D2–LOW–BUSH CRANBERRY AW–SW
- D3–LOW–BUSH CRANBERRY SW
- E1–DOGWOOD PB–AW
- E2–DOGWOOD PB–SW
- E3–DOGWOOD SW
- SH(SONS)–DECIDUOUS SWAMPS
- OPEN WATER
- CONSTRUCTED WETLANDS
- SHRUBLAND
- INTERMITTENT DRAINAGE

FOR CROSS–SECTIONS A–A' AND B–B' SEE FIGURES E–4 AND E–5 RESPECTIVELY

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 2.5 5km

SCALE 1:125,000

SUNCOR ENERGY

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DRAINAGE PLAN AND VEGETATION CLASSIFICATION

09 Apr. 1998	Figure E–2	DRAWN BY: RFM

E3.2.4 Overburden Dykes

Overburden dykes are shown on Figure E-1 as overburden units. These dykes will be along the Athabasca River side of the mine (Ponds 7a, 7b, and 8) and around Pond 8. Overburden will also be expressed on the final surface in the intercell berms and in Pond 12 around the end pit lake. The overburden dykes facing the Athabasca River will have steeper slopes than the sand tailings structure (Pond 8a) and are currently anticipated to be approximately 3H:1V. The configuration of these dykes will be reviewed during final design. Consistent with overburden dump design, Clearwater material will be confined to the central portion of the dykes (minimum 1m burial depth) to promote reclamation.

E3.2.5 Reclamation Materials Storage Areas

Muskeg will be removed during the winter and will be either directly placed in a reclamation area, stored for future use, or discarded in one of the overburden dumps. As described in Section E of Volume 1 of this application, sufficient reclamation materials are available for reclamation to allow discarding of some materials. Muskeg to be discarded will be co-disposed with the overburden.

Muskeg salvaged for future use as a soil amendment will be preferentially directed into the reclamation materials storage area on the west side of the site for future use. The main reclamation materials storage area is to the east side of the development as shown on Figure E-1. In addition, muskeg storage is currently occurring to the northwest of Pit 1 as part of the approved Steepbank Mine project.

As the reclamation progresses (and particularly after muskeg stripping has finished), muskeg will be hauled from the storage areas to areas undergoing reclamation. After the muskeg has been removed from the storage area, the overburden shells will be graded out and soil amendment will be placed over the area if necessary.

E3.2.6 End Pit Lake

The end pit lake consists of two water bodies interconnected by a constructed wetlands. For the purposes of this closure plan, these two water bodies are designated as the north and south ends of the lake. A schematic section through the end pit lake is shown on Figure E-3.

The north end will be formed in the northwest corner of Pit 12 after completion of mining. This section of the lake will be typically 100m deep and will have a capacity of approximately 180 million m^3. There will be no mining and/or extraction waste materials deposited in this lake.

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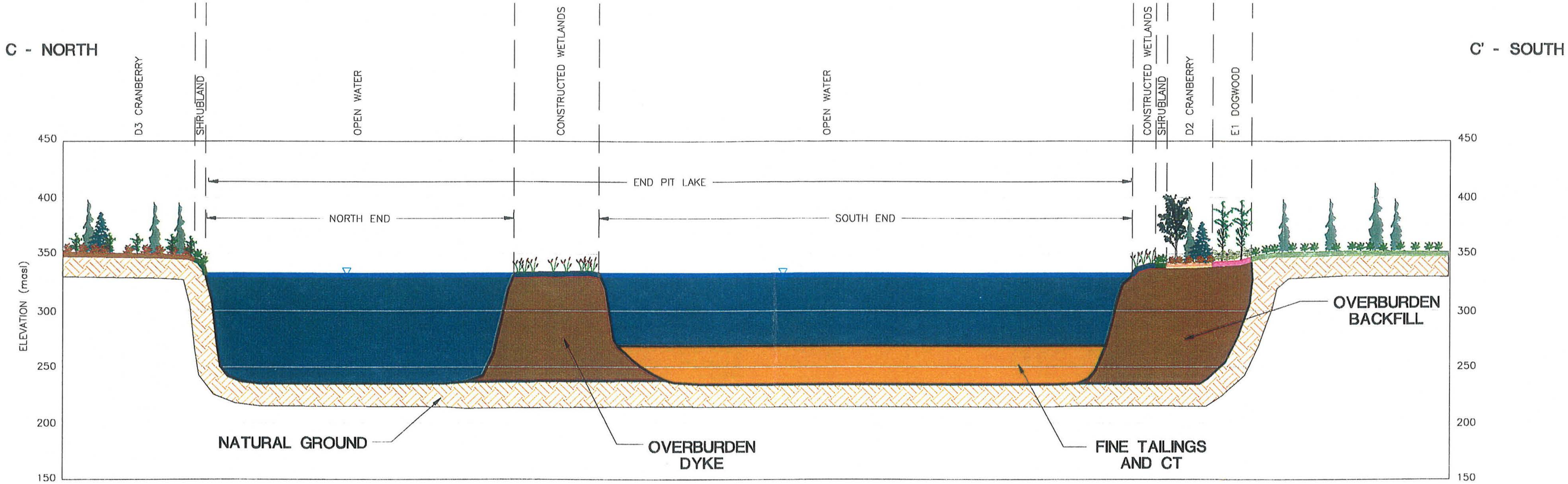
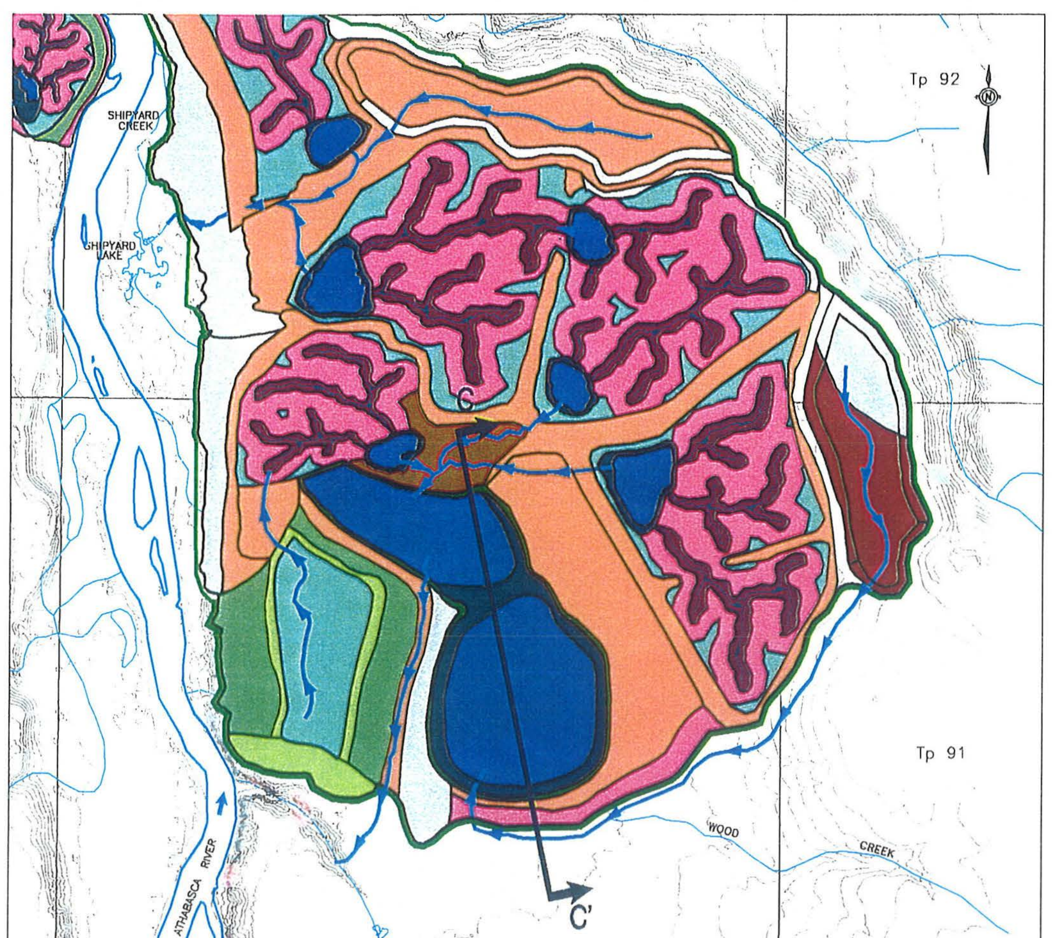


PROPOSED CROSS-SECTION AFTER CLOSURE



PLAN VIEW SHOWING LOCATION OF CROSS-SECTION

LEGEND

- B1–BLUEBERRY PJ–AW
- B2–BLUEBERRY AW(BW)
- B3–BLUEBERRY AW–SW
- D1–LOW–BUSH CRANBERRY AW
- D2–LOW–BUSH CRANBERRY AW–SW
- D3–LOW–BUSH CRANBERRY SW
- E1–DOGWOOD PB–AW
- E2–DOGWOOD PB–SW
- E3–DOGWOOD SW
- SH(SONS)–DECIDUOUS SWAMPS
- OPEN WATER
- CONSTRUCTED WETLANDS
- SHRUBLAND
- INTERMITTENT DRAINAGE

0 1 2 3 4 5km
SCALE 1:100,000

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

NOTES

VERTICAL EXAGERATION = 5.0
SCHEMATIC ONLY – NOT TO SCALE

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END PIT LAKE SCHEMATIC CROSS-SECTION
PROFILE C-C'

09 Apr. 1998	Figure E-3	DRAWN BY: RFM

The south end will start to form at about year 2027. At that time, the pit area around this end of the lake will have been backfilled with overburden to allow for the formation of the lake. This overburden backfill will include a dyke separating the northern and southern ends. Based on the current material balances for the end of mining, it is anticipated that this lake will have approximately a 35 m thickness of fine tailings and CT at the bottom with a 65 m deep water cover.

The end pit lake and the associated wetlands will have a total surface area of about 883 ha and will store about 285 million m^3 of water. The shoreline area for the lake will be sculptured to allow for a littoral zone area which, with the intralake wetlands, will comprise about 20% of the lake volume to enhance its biological productivity. This littoral zone will consist of gently sloping topography resulting in a water depth of between 0 and 1.5 m. The other parts of the lake will be provided with erosion protection where necessary.

Initial filling of the south end of the end pit lake will commence near the end of the operation period. At the end of operations, continued filling of the lake will occur from the following sources:

- operational water and reclamation materials(south end);
- seepage inflow;
- on-site drainage from reclamation units;
- inflow from Wood Creek; and
- supplemental inflow as required from the Athabasca River.

Based on the current information and modelling of the seepage, on-site drainage, and off-site inflow, it is currently considered likely that Athabasca River water will be required as a supplement to assure that the lake is filled by the desired date. This use of Athabasca River water will tend to increase overall end pit lake water quality.

The end pit lake will provide remediation of CT reclamation water, sand porewater seepage and porewater release from reclamation materials deposited in the bottom of the south end of the end pit lake during consolidation. The lake will also reduce flood flows by providing storage for flow attenuation. The lake has been designed to include the following functional goals:

- it will provide a buffer for water flow effects on either the Athabasca River or McLean Creek;
- its littoral area will enhance its capability to treat CT release water; and

- it will increase the potential for enhanced wildlife diversity due to the large littoral and riparian areas.

E3.2.7 Unmined Development Areas

At the end of the east bank mining area operations, the buildings and other man-made structures will be demolished and the area regraded to a topography that will support timely revegetation. Some muskeg amended soil may be used for this purpose if necessary.

The undeveloped areas will be used as refugia for native plants. These refugia will be maintained to enhance the recolonization of the reclamation areas with native species.

E3.2.8 Constructed Ponds/Wetlands

Wetlands will be constructed by reducing the ground slope and providing natural material outlet structures to retain water. They will be located within the drainage areas of all the CT filled ponds within the development area. The function of these wetlands include surface water retention, CT release water treatment, and provision of a diverse and productive wildlife habitat. Wetlands will be constructed in three areas as part of the closure landscape:

- on the surface of backfilled mine cells;
- as littoral area around the end pit lake; and
- as linear features around the perimeter of the development as the drainage ditches evolve into wetlands. This evolution will result in drainage which is similar to the existing wetlands drainage in the area.

Wetlands on the backfilled mine ponds are sized to be approximately 10% of the total CT landform area. Current planning is to design the wetlands to have approximately 70% open water and 30% intermittently flooded marshland (littoral wetlands). In addition, the drainage runs to the wetlands areas are anticipated to have high water tables for the majority of the year and have been designated as deciduous swamps. These drainage areas typically comprise an additional 20% of the total CT landform area.

The littoral zone around the end pit lake will be approximately 20% of the total lake area. This littoral zone will be less than 1.5 m in water depth and will provide an environment conducive to biodegradation (e.g., plant surfaces for microbes, nutrient recycling).

The linear ditches around the perimeter will be allowed to evolve naturally into linear wetlands. On the southern part of the site, this evolution will allow the final landscape to be in harmony with the surrounding natural ecosystem.

Table E-1 presents the size of the reclamation surface area, open water and littoral wetlands for the various reclamation units that has been assumed as part of this assessment.

Since these ponds and wetlands will be constructed after the CT has become trafficable (i.e., mostly dewatered), the ponded water will consist mostly of precipitation. However, CT release water will flow through these ponds, in diminishing quantities as the CT finishes the consolidation process.

Table E-1 Areas of Constructed Ponds and Wetlands

Location	CT Surface Area (ha)	Open Water (ha)	Littoral Wetlands (ha)
Pond 7	434	31	12
Pond 8	303	21	11
Pond 9	818	55	27
Pond 10	835	56	28
Pond 11	888	62	26
End Pit Lake		692	191

E3.2.9 Closure Drainage

The schematic drainage system for the closure landscape is shown on Figure E-2. The majority of the reclamation landforms drain to either Shipyard Lake or the end pit lake. The details of the closure drainage system are described in Section C2.2.

The design for the reclaimed CT landform will provide a well-drained surface in comparison with a generally poorly drained pre-development landscape. However, both abiotic (e.g., siltation, consolidation and settling of CT deposits) as well as biotic (e.g., beaver dams, tree falls, dying vegetation) factors may alter drainage patterns such that a portion of the landscape may revert to a poorly drained condition. If this were to happen, an increase in soil salinity might result along with rising groundwater levels and a consequent decrease in forest production. For this reason, the degree of slope on CT landforms is designed to be relatively high (typically 1%) so that processes creating poorly drained areas are localized to restrict their effects to as small an area as possible. The hummock areas on the reclaimed surface of a CT landform will also be elevated (e.g., > 3 m) relative to the wetlands surface to provide a better draining soil to enhance vegetation efforts.

Ponds 7, 9, the northern half of Pond 10, and the northwest overburden dump drain to Shipyard Lake. Drainage on the CT deposits will be via designated wetlands channels to constructed wetlands near the exit point from the CT area. The current planning is to channel this drainage down the Athabasca embankment using a permanent man-made structure and then into Shipyard Lake. However, an alternative is to move the southern end of Pit 1 to the north and use the existing gully for Unnamed Creek for drainage down the Athabasca escarpment. These options will be further evaluated as the detailed planning for Pit 1 is completed. Other structures or landform contouring will also be required for the flow of water off the overburden waste dumps.

Ponds 8, 8a, 11, the southern half of Pond 10, and a small part of Pond 12 drain to the north end of the end pit lake. The rest of Pond 12 and the reclamation materials storage area drain to the south end of the end pit lake which drains into the end pit lake through the intralake wetlands. Ultimately, water from the end pit lake will flow in a drainage channel on the eastern side of Pond 8a to McLean Lake and then to the Athabasca River. This routing takes advantage of the existing gully in the Athabasca embankment to provide a sustainable form of natural drainage. Water flow from the lake, however, may be routed during the reclamation and early closure period directly to the Athabasca River. This temporary routing will be necessary if the water quality exiting the end pit lake is not of sufficient quality to maintain suitable water quality and fish habitat in McLean Creek.

Water collected in the ditch system around the sand dykes of Pond 8a will initially be discharged to the Athabasca River directly down the remnants of Wood and Leggett Creeks.

The outside of the dykes which form the west boundary of Ponds 7 and 8 will drain by sheet flow to the Athabasca River floodplain and ultimately the river. This flow will consist primarily of runoff with a minimal amount of seepage through the dykes.

E4 PERFORMANCE ASSESSMENT

E4.1 Framework for Assessment

The performance assessment is an evaluation of the conceptual snapshot for the proposed final landscape design as described in Section E3 of this assessment. The assessment described herein is based on data generated prior to and during this EIA process. Further refinement will be required with time. Where possible, quantitative predictions of anticipated performance has been made to demonstrate that the closure goals can be achieved with the proposed final landscape. Examples of these quantitative predictions include hydrological and water quality modelling results and pre and post development soil/forestry capability. In other instances, the closure design is not fully developed to the point of conducting detailed analysis. An example of this is the geotechnical assessment of the major dykes which require site specific foundation soils information, design of the dykes (including internal drainage, as required), and the final slopes. In these cases, it is assumed that the geotechnical design will have an appropriate factor of safety which is consistent with the consequence of failure and dam safety guidelines.

A discussion of the performance assessment is broken down by the closure plan goals and associated key issues described in Section E2-3.

E4.2 Landform Stability and Conformance

E4.2.1 Geotechnical Stability

The closure landscape is relatively flat with the only significant slopes being the dykes along the Athabasca River, overburden dumps, and in the area of Ponds 8a and 8b. It is recognized that there will have to be a considerable level of detailed geotechnical design related to many of these slopes, particularly in areas where Clearwater formation soils have been identified. The dykes along the Athabasca River represent a reconstruction of the existing embankment at angles that are typically less than or equal to the current slope. As a result, it is likely that a stable configuration can be achieved.

The factors causing uncertainty in the geotechnical stability are primarily related to the occurrence, geotechnical properties, and use of Clearwater soils. These materials can have a significant bearing on the foundation stability and internal stability (when used as backfill) for all earth structures. Detailed site investigations and analyses of material behaviour will be included in the final design stage for all significant earth structures.

The current closure plan recognizes that different structures must be sloped at different angles depending on the anticipated ground conditions and the materials in the structure. For example, the feasibility level designs for sand dykes around Pond 8a show slope angles ranging from 8V:1H to 12.5V:1H.

All of the major external geotechnical structures external to the mine pits will be completed by the year 2008. These external structures include the overburden dumps, the overburden dykes along the Athabasca River, and the sand dyke for Pond 8a. This results in a 35 year observation period for geotechnical stability, erosion, and drainage prior to the start of the closure phase of the project in 2043. This observation period will provide information concerning the stability of the slopes in these areas which will have been designed in accordance with proper geotechnical practice in the first place. As such, the probability of deep-seated geotechnical failures is considered to be relatively low.

The walls of the south end of the end pit lake will be designed to an appropriate slope using overburden. The angles of these overburden slopes will be determined based on site specific conditions with respect to the basal materials and the overburden source. Slope angles around the upper portion of the lake (i.e., near the water surface) will allow for construction of a littoral zone.

The end pit lake will have slopes on the north and southwest sides that will be made during the mining operation. Of particular concern is the slope where the end pit lake abuts Pond 8 where a permanent earth structure and an overburden plug will be required to separate the CT pond from the end pit lake. The CT deposits within Pond 8 and the dyke on the east side of the Athabasca River will provide a barrier a minimum of 1 km wide between the end pit lake and the dyke forming the reconstruction of the Athabasca River embankment.

The design of all end pit lake slopes will have to take into account the permanent nature of the end pit lake as opposed to the short term stability requirement for other pit wall slopes.

It is possible, however, that some shallow skin failures will be observed on the slopes of the dyke areas or the disposal areas. These types of earth movements typically have a low consequence of failure are often self-healing. If necessary, repairs can be made as part of regular maintenance during the operations and final reclamation period. For this plan, it is assumed that an observational approach will be appropriate and that specific design issues can be addressed as they arise.

Other geotechnical issues such as quick conditions and internal drainage are assumed to be addressed in the design of specific areas and thus are not considered to be significant issues as related to this assessment.

E4.2.2 Landforms

Comparisons of the predevelopment and closure landforms are shown on Figures E-4 and E-5. The cross-sections on these figures provide a schematic representation of landforms and vegetation.

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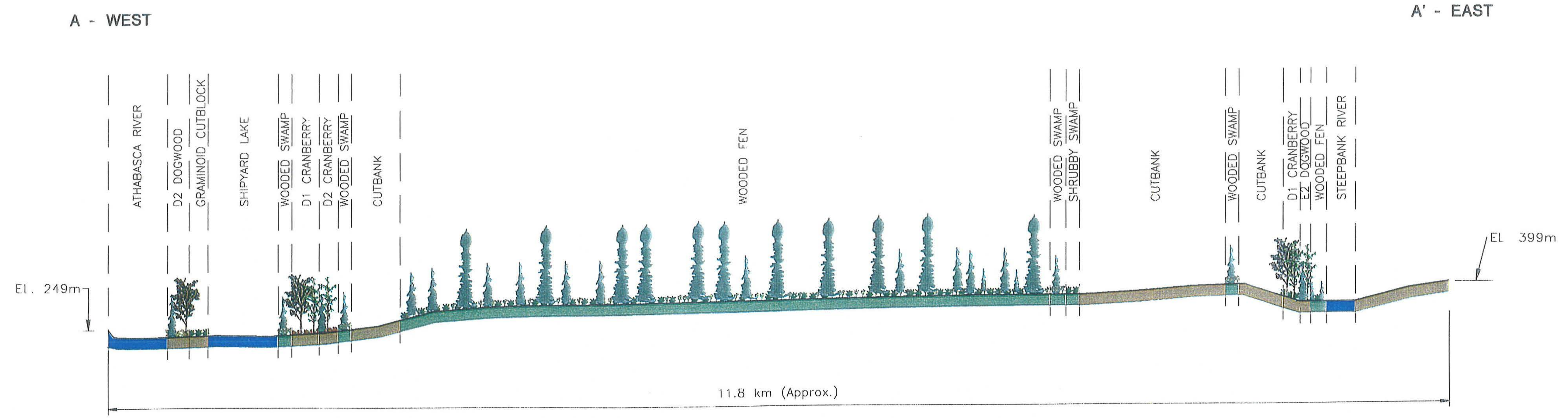
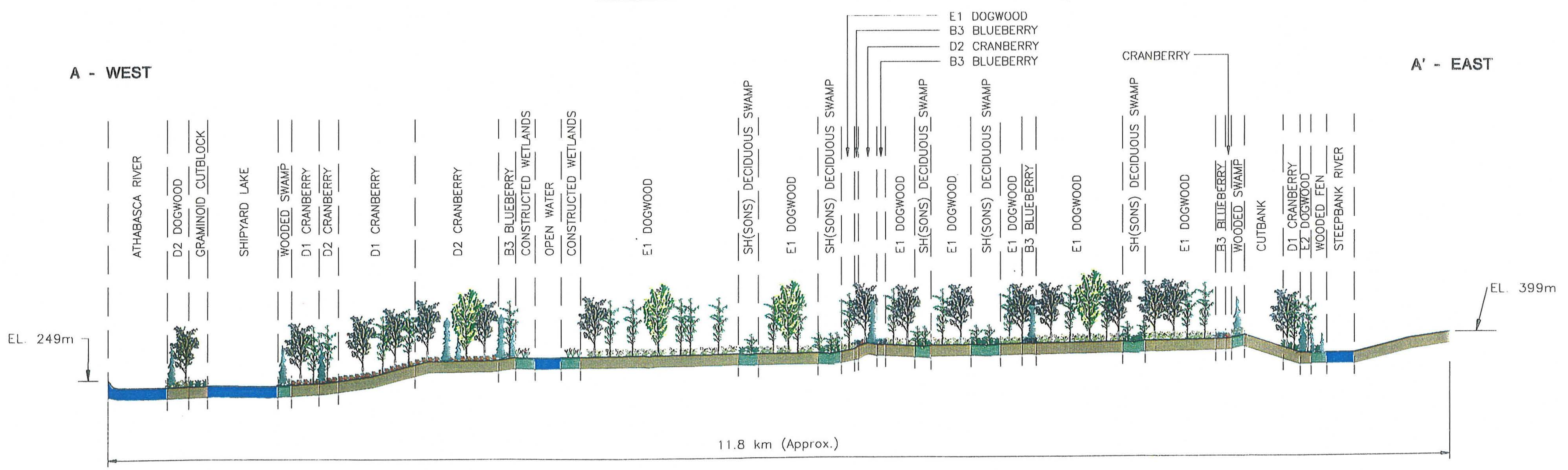


PROPOSED CROSS-SECTION PRE-DEVELOPMENT



PROPOSED CROSS-SECTION AFTER CLOSURE

NOTES:

FOR LOCATION OF CROSS-SECTION A-A'
SEE FIGURE E-2

VERTICAL EXAGERATION = 2.5
SCHEMATIC ONLY - NOT TO SCALE

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VEGETATION CLASSIFICATION
PROFILE A-A'

09 Apr. 1998	Figure E-4	DRAWN BY: RFM

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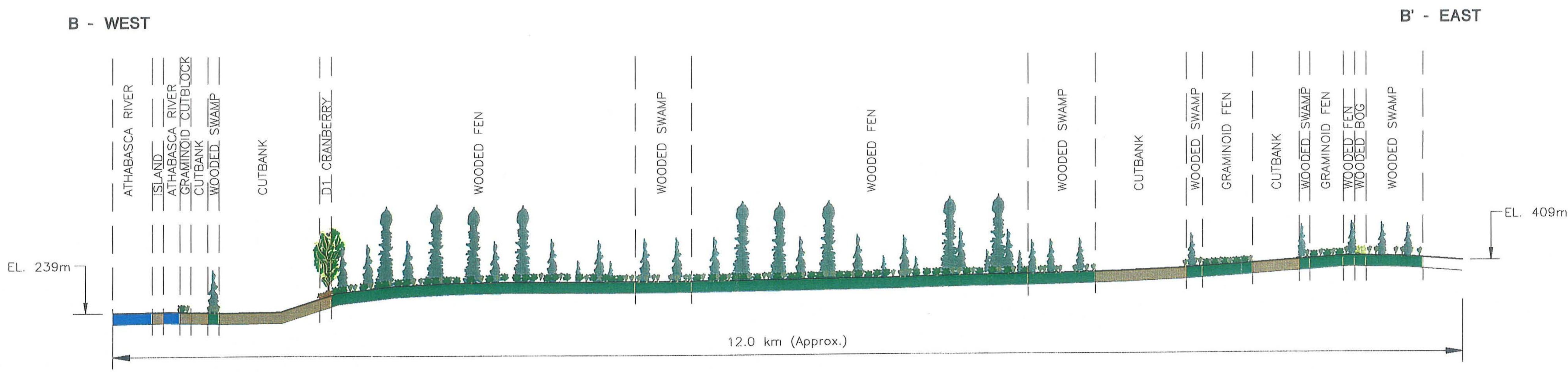
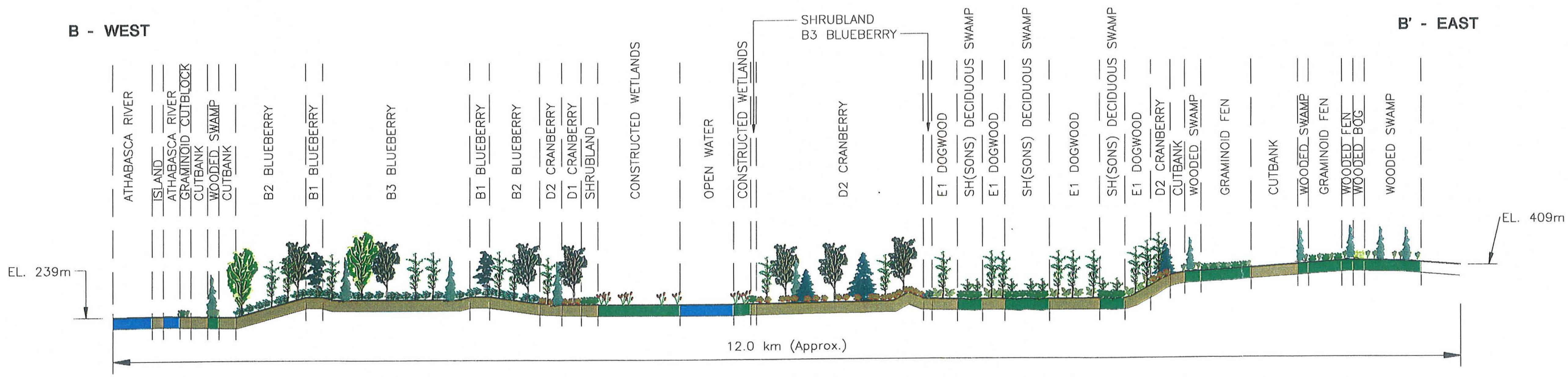


PROPOSED CROSS-SECTION PRE-DEVELOPMENT



PROPOSED CROSS-SECTION AFTER CLOSURE

NOTES:

FOR LOCATION OF CROSS-SECTION B-B' SEE FIGURE E-2

VERTICAL EXAGERATION = 2.5
SCHEMATIC ONLY – NOT TO SCALE

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VEGETATION CLASSIFICATION PROFILE B-B'

09 Apr. 1998	Figure E-5	DRAWN BY: RFM

The Project Millennium pre-development terrestrial LSA is dominated by two principal terrain units - fens and glaciofluvial deposits. To a lesser extent, recent fluvial, glaciolacustrine, morainal, bog and eolian features are present. Except for the Athabasca and Steepbank River valleys, relief in the terrestrial LSA is quite subdued, the topography best described as gently undulating. In comparison, the post-development reclaimed landscape will have a number of topographic features that generally will provide for a better drained landscape with a variety of slopes and aspects. In general, the loss of fens will be offset by greater terrain diversity and improved habitat for some wildlife species.

The closure landforms will also include a much greater area of open water than is currently existing. When combined with the littoral zones around these open water areas, the final landscape should be a substantial benefit to many types of waterfowl, other waterbirds and aquatic mammals.

The closure landforms are bounded by the Athabasca and Steepbank Rivers on all but the south end of the project. The Athabasca escarpment will be rebuilt using primarily overburden materials to be compatible with the underlying floodplain. The tailings sand around Pond 8a will be set back a minimum of 100 m from the Athabasca River escarpment and the McLean Creek gully to avoid encroachment on these landforms. There will be transition both in elevation and vegetation type at the south end of the site but the drainage system will be restored to be self-sustaining by routing Wood Creek through the end pit lake system.

E4.3 Surface Erosion

E4.3.1 Erosion and Sedimentation

Since the slope of the closure landscape on the CT reclamation units is relatively modest by erosion standards, it is not anticipated that there will be significant erosion of these surfaces or sedimentation in the wetlands in these areas after vegetation has become well established. Erosion calculations, based on mean annual flows and basin sizes, indicate that typical erosion rates will be 15 to 25 m^3 (See Section C2.2). This erosion rate corresponds to a deposition rate of less than 1 mm per year.

Erosion on the more steeply sloping landforms will be mitigated by an aggressive revegetation program on dyke and overburden dump slopes. Since these slopes will be reclaimed early during the reclamation period, an extended reclamation and maintenance period will be available to allow re-establishment of low erosion surfaces. In addition, local changes in topography will be made to decrease erosion potential.

Erosion and sedimentation on the CT landforms is not considered to be a significant factor after re-vegetation has been established. Erosion on steeper slopes will addressed through measures as described in Section E of Volume 1 of this application. Monitoring of erosion performance is currently being conducted by Suncor and will be continued in the ongoing reclamation program.

E4.3.2 Physical Viability of Constructed Wetlands

The design of self-sustaining marsh-type wetlands on the surface of CT landforms requires further research and development. Typically, these types of wetlands ultimately evolve into meadows, grasslands, and eventually forest ecosystems. On the CT landforms, this evolution is complicated by settlement of CT areas which could impact (both positively and negatively) overall drainage and wetlands effectiveness. Therefore, there will be a dynamic (but unknown) relationship between the time required for treatment and the sustainability of these wetlands. The duration, rate and quantity of discharge of CT release waters into these wetlands is currently uncertain at this time. The design of the wetlands system will have to evolve as more information becomes available on issues such as CT water release (i.e., ongoing water quality monitoring) and wetlands evolution.

Although the wetlands evolution and settlement phenomena tend to be offsetting, there is no confidence that they can be said to balance each other off. The prediction of differential settlement will be based on the site specific factors such as the thickness of CT, the sand:fines ratio, and the amount of time allowed between completion of CT filling and wetlands construction. As the settlement rate of the CT deposit diminishes with time, the wetlands will be on a more stable platform. It is recognized that periodic monitoring of overall CT settlement and wetlands performance during the reclamation period will be necessary to determine the time when the wetlands platform will tend to stabilize.

As described in Section E4.3.1, there is anticipated to be a very low sedimentation rate in the CT wetlands which indicates that sedimentation will not cause loss of wetlands performance in the closure period. Natural organic buildup processes are likely to be a more limiting factor in wetlands life and this site-specific phenomenon is difficult to predict at this time. It is recognized, however, that the reduction in wetlands volume and hence retention time will be balanced by the improvement of the quality of the surface water inflow into the wetlands as the CT flow diminishes. Again, this is a dynamic situation and the assessment of whether an appropriate balance is achieved will be based on actual field observations during the operational and reclamation phases of the project.

Finally, there is the potential of scouring and channelization in the reconstructed wetlands during periods of high flow such as during the spring freshet. This effect would reduce their size over time and hence further inhibit their ability to treat chemicals in CT release water. The potential for scouring and channelization will be addressed as part of the detailed hydraulic design of the wetlands and overall drainage system.

In conclusion, the initial analysis of physical viability of constructed wetlands has uncertainties concerning the long term performance of these units. This uncertainty can only be mitigated through long term performance monitoring and design adjustments of active constructed wetlands.

E4.4 Acceptable Discharge Water Quality

The assessment of the impact of the closure landscape on the surface water regimes in the LSA can be discussed in terms of the following issues:

- hydrologic assessment of closure landscape;
- drainage from CT landforms;
- treatment in CT wetlands associated with backfilled mine cells;
- groundwater and seepage quality;
- effects on McLean Creek, Shipyard Lake, and the Athabasca and Steepbank Rivers; and
- end pit lake issues.

A description of the existing hydrological conditions is contained in Section C2.1 of this EIA. Detailed impact analyses of the proposed development both during operations and after final reclamation are contained in Section C2.2.

E4.4.1 Hydrologic Assessment of Closure Landscape

The drainage and vegetation plan shown on Figure E-2 indicates two primary discharge points - one to Shipyard Lake and one to McLean Creek. In addition, it is likely that there will be discharge of tailings sand seepage water to the remnants of Wood and McLean Creek. A temporary discharge of end pit lake water directly to the Athabasca River may also be required if the water quality during the reclamation and early closure period is not acceptable for McLean Creek.

Based on the proposed closure landscape design, the mean annual surface water flow to Shipyard Lake is calculated to be 150 L/s which is very close to the existing inflow. The sources of this flow are the CT reclamation landscapes on Pond 9 and the north half of Pond 10, the northeast overburden dump, and the CT reclamation surface for Pond 7.

Flow from the end pit lake to McLean Creek will increase the volume of water in the lower reach of McLean Creek from the current 154 to 340 L/s. The drainage system from Wood Creek to the end pit lake will be designed to accommodate the one in fifty year flood. The drainage channel from the end pit lake to McLean Creek will be sized such that there will be only a 10% increase in the flood flow in McLean Creek due to discharges from the end pit lake. The channel in McLean Creek downstream from this confluence will be reconstructed as required with natural hydraulic structures to accommodate the increase in average annual and flood flows without excessive erosion.

Hydraulic calculations predict that the reclaimed landscape will have a slightly greater amount of surface runoff than the pre-development conditions due to the presence of slopes and the replacement of fens/bogs with better drained reclamation structures. The loss of pre-development wetlands will result in a net decrease the retention of water on the closure landscape. Consequently, spring runoff may not be stored to the same extent and the CT landform will be better drained than pre-development landforms. Additional storage will be available, however in both the end pit lake and Shipyard Lake. Hence, spring freshet flows to the Athabasca River will not be substantially different than those for the pre-development landscape.

The changes of the total annual water yield to the Athabasca River is described in Section C2.2. The annual water yield is predicted to increase by 33 L/s which represents less than 0.01% of the average annual Athabasca River flow (655,000 L/s) and will have a negligible environmental consequence on that river.

The hydrologic analysis has a relatively high degree of certainty in terms of total flows. The principal factor causing some uncertainty is the quantity and duration of reclamation material flows from consolidating CT deposits. Sufficient flow quantities will be maintained to Shipyard Lake. Increased flow in McLean Creek will be addressed through appropriate enhancement of the channel. Streamflow monitoring in the closure period can be used to verify the design.

E4.4.2 Drainage on CT Landforms

The design drainage system from CT landforms is shown on Figure E-2. This system has an overall ground slope of 1% and a drainage system that emulates a natural system. The CT landforms for all ponds have approximately 10% of the surface area being wetlands of which 7% is open water and 3% consists of periodically flooded littoral zone.

The wetlands are designed to attenuate high runoff events and to provide for natural treatment of water running off the site. The impact of the wetlands on runoff flows are described in Section C2.2. This attenuation of high runoff events is further enhanced by the end pit lake for the portion of the drainage that flows to McLean Creek.

The principal design concern with respect to the drainage from CT landforms is related to the outlets for drainage from the different ponds. The outlets will be on relatively stable platforms (natural ground or overburden dykes) whereas the CT deposit is anticipated to settle for a period of typically 20 years and perhaps longer. The outlets for Ponds 8, 9, and 10 can be adjusted during the operational and reclamation period and are likely to be relatively stable after closure. Some monitoring of the outlets to Ponds 7 and 11 may be required to maintain the desired CT landscape in the post-closure period.

The drainage system for the reclaimed CT deposits has been designed to be robust and self healing. There is, however, some uncertainty, in the settlement of CT deposits and the impact on drainage. Although a certain degree of settlement is anticipated and is incorporated into the overall design, the duration is not known at this time. There will be further research of CT properties as the technology progresses. In addition, monitoring of the settlement of CT deposits will be conducted as they are constructed.

E4.4.3 Treatment Capability of CT Wetlands Associated with Backfilled Mine Cells

Suncor has been conducting wetlands research with emphasis on CT treatment since 1995. The current information indicates that wetlands have a positive effect on CT reclamation water quality and that a minimum 30 day retention time is required to mitigate acute toxicity to rainbow trout for undiluted CT water (EVS 1996). Acute toxicity to other organisms was reduced but not totally mitigated. Considerably longer retention times are currently indicated to be required for chronic toxicity. The recommended retention time for actual reclamation water and runoff mixtures will be reviewed as further research is conducted and monitoring of the performance of large scale constructed wetlands becomes advanced.

The design of wetlands calls for an open water and littoral zone having a total area of 10% of the CT deposit, an average open water depth of 1.5m and outlet control to maintain the open water. Hydraulic analyses reported in Section C2.2 indicate that the typical retention times are 200 days for base flow conditions. The retention time for the for peak flow conditions is a function of the outlet control design since there will likely be sufficient storage in the system for this level of flow. It is possible, then, to have peak flow retention for at least 30 days in the CT wetlands. The average flow condition is considered to be a more representative indicator of the available treatment time and, thus, there is an excellent good opportunity for water quality improvement for flow from the CT reclamation units.

The retention time during peak flow would be too short to allow adequate treatment for undiluted CT release water. However, this retention time may be adequate when dilution is taken into account. There is a concern, however, that peak flows after closure may have adverse impacts due to surface runoff flushing effects of chemicals from CT deposits and/or from overlying sand/overburden material which may accumulate CT-related compounds (e.g., salts, metals, naphthenic acids) during the initial consolidation and dewatering period. In that event, this retention time may be inadequate for treatment of this water. Flushes of untreated CT water, perhaps containing ammonia and naphthenic acids, may limit the productivity and capability of the aquatic ecosystem within these wetlands and drainage channels. However, more significant impact to the environment should be averted by dilution and residency within the end pit lake.

The final design of the constructed wetlands will evolve as an increasing knowledge is attained on the quantity of the CT reclamation water, the required water quality leaving the wetlands, and the effectiveness and viability of different wetlands ecosystems. Suncor is committed to continuing research on constructed wetlands through the Oil Sands Wetlands Working Group.

E4.4.4 Groundwater and Seepage Water Quality

As demonstrated in Section C2.2 , seepage water flow from both the tailings sand and the CT reclamation units are anticipated to have a negligible environmental consequence on the Athabasca and Steepbank Rivers and also on McLean Creek. At the end of the consolidation period, seepage from the CT reclamation units will be naturally directed to the basal aquifer which has similar water quality characteristics to the reclamation water.

The only groundwater that is anticipated to become a surface seepage is the sand seepage from the Pond 8 area. The estimated seepage rates are 10 L/s to the remnants of Wood and Leggett Creek and 10 L/s to the end pit lake. The environmental consequences of these seepage rates are anticipated to be negligible.

E4.4.5 Effects on McLean Creek, Shipyard Lake and the Athabasca River

The principal water quality discharge issues during the closure period will relate to the impact of CT reclamation water and water quality issues related to the end pit lake. The discharge end points for this water include McLean Creek, Shipyard Lake, and the Athabasca River. Detailed discussions of the predicted impacts related to these issues are contained in Section C3.2 .

The water quality modelling for the end pit lake is based on a number of assumptions including the time over which CT reclamation drainage occurs (primarily from Pond 11), the amount of drainage, the quality of the CT water, the change in water quality due to retention in wetlands, and the use of Athabasca River water during initial filling of the end pit lake. Based on the current conservative assumptions, the analyses predict that there may be unacceptable water quality for discharge into McLean Creek for up to 10 years after closure. As a result, contingency planning will be made to transport the end pit lake outflow directly to the Athabasca River. The options for this include pipelines down the McLean Creek gully or down the escarpment at the southwest corner of the Pond 8a sand dyke or direct release down the remnant of the Wood Creek gully. At the same time, a spillway will be maintained to McLean Creek to allow for peak flow events to be transmitted safely off site. This spillway will be converted to the primary discharge point once the water quality from the end pit lake is deemed acceptable.

A monitoring program will be undertaken to provide information related whether the water quality at closure is acceptable (in terms of AEP water quality guidelines) for discharge into McLean Creek. This approach will include:

- monitoring of the time-rate of settlement of CT deposits to determine the total amount of settlement subsequent to final filling and hence CT water discharge and the relationship between the discharge volume and time;
- monitoring of the quality of the water being released by the CT deposits during consolidation after final filling;
- monitoring of the effectiveness of the wetlands for improving water quality; and
- monitoring of the effectiveness of the end pit lakes for improving water quality.

The anticipated end pit lake performance will be reassessed as further monitoring information becomes available. Adjustments to the design or the approach to water management will be made as appropriate.

Water into Shipyard Lake will originate from Ponds 7, 9 and the north half of 10, the northeast overburden dump, and some non-mined areas. Since Ponds 9 and 10 are scheduled to have completed CT deposition in 2012 and 2018 respectively, there is anticipated to be little CT consolidation water coming from these areas during the latter part of the reclamation period and during the closure period. Similarly, the water quality from the overburden dump is anticipated to be of acceptable quality assuming that it is not detrimentally impacted by Clearwater materials.

The water quality analyses for the closure drainage basin that will flow into Shipyard Lake indicates that there will be limited potential to accept CT reclamation drainage to achieve the objective of acceptable water quality after closure in Shipyard Lake. It is anticipated that relatively little CT reclamation water will be produced in Ponds 8 and 9 since they will have had over 20 years of reclamation time prior to the start of closure in 2043. However, there is greater uncertainty whether there will be CT reclamation water flow from Pond 7 which will be "topped off" with CT very near the end of the operational period. Monitoring of water from this source will be particularly important to determine whether it will be necessary to divert water from Pond 7 to the end pit lake during the final reclamation and initial period after closure.

Sheet flow from overburden dykes is not anticipated to have a detrimental impact on Shipyard Lake in the closure period, particularly since these dykes will have been built for almost 40 years and should be reclaimed and stable in terms of sediment discharge.

The impact of closure drainage on the site is shown in Section E4.4.1 and E4.4.2 to have a negligible impact on the Athabasca River quality. A similar negligible impact on fish habitat is shown in Section E4.5.3.

In summary, there is still some uncertainty about the water quality of the inflows to the end pit lake and Shipyard Lake. This uncertainty is related to reclamation drainage which has been discussed earlier in this assessment. Mitigative measures can be invoked in the event that water quality discharges at either location are unacceptable.

E4.4.6 Fish Habitat

Initial fish habitat loss due to the cutoff of flow to Wood and Leggett Creeks will be mitigated during the operation period. On closure, there will be no additional habitat loss and it is likely that the end pit lake and some of the associated open water areas and connecting streams may form fish habitat. The viability of the end pit lake aquatic system, however, will have to be demonstrated prior to the introduction of fish.

As described in Section C4.2, the increased flow in McLean Creek is not anticipated to have a detrimental impact on fish habitat. The water flow to Shipyard lake will be the same as the pre-development values, thereby maintaining fish habitat. Water quality issues related to McLean Creek and Shipyard Lake are discussed in Section E4.4.4 above.

E4.4.7 End Pit Lake

The principal end pit lake closure issues relate to biological viability and discharge water quality. Since there are many unknowns about the biological viability, this issue has been addressed as a water quality issue - it is assumed that acceptable water quality will result in a self-sustaining, biologically active ecosystem. Hence, the overall assessment of the end pit lake for both issues is made in terms of water quality. Research will be undertaken to address many of the end pit lake issues as described in Section E of Volume 1 of this application.

Water quality of the end pit lake will be a function of several variables as described in Section 3.2. Some of these variables can be optimized to ensure that water quality conditions in the lake will be suitable for its intended end use.

The south end of the lake will have a fine tailings or CT bottom. This type of lake has been evaluated and approved as a reclamation feature for Syncrude's Mildred Lake facility (Base Mine Lake) although the water cap on the Project Millennium end pit lake will be considerably thicker. While this increased thickness reduces wave action churning up the bottom, it can create the potential for a thermocline with different concentrations of chemicals in the top and bottom of the lake. As the lake turns over with colder surface temperatures, these chemicals (and potentially gases) from the bottom of the lake can be brought up to the surface.

There are still some issues to be resolved to assure that the end pit lake is sustainable and safe for users. These issues include:

- stratification potential;
- nutrient status;
- dissolved oxygen;
- solids resuspension;
- hydrogen sulphide generation; and
- time frame over which lake water quality will improve so that it would be acceptable for discharge into McLean Creek.

In the event that the performance of the lake is not as expected, a number of mitigative measures can be considered. These measures are described in Section 3.2. The impact and strategy for discharges to McLean Creek have been discussed in Section E4.4.4 of this closure plan assessment.

In summary, there is a level of uncertainty concerning the performance of the end pit lake. Given the nature of the final reclamation landform and the reduction in CT reclamation flows with time, the principal uncertainty is the length of time that it will take to have a self-sustaining productive body of water. However, issues such as insufficient nutrient loading may have a long term negative impact. This overall uncertainty will be addressed through long term research. There are also potential mitigative measures to address potential issues in the final reclamation and immediate post-closure period.

E4.5 Self Sustaining Ecosystems

One of the primary goals of reclamation is to establish self-sustaining ecosystems similar to pre- development ecosystems. Following surface development, the land should be reclaimed in a manner that re-establishes a watershed that resembles and functions as a natural system. The restructured soil profile shall be capable of supporting native vegetation. The ability of the land to support various end uses must be similar to what it was before surface development, but specific land uses will not necessarily be identical (i.e., the return of equivalent land capability), an approach that maintains future land use options.

E4.5.1 Ecological Land Units

The ecological land classification (ELC) of macroterrain and component ELC units within the LSA provides an integrated planning tool in the design of reclamation landscapes and an understanding of how such landscapes may function and develop over time. Natural landscapes, composed of particular combinations of terrain, soil and vegetation types, can be used as analogues in this process to help in the design of appropriate reclamation and revegetation of specific reclaimed landscape types. The ELC concept can also be used in the assessment and monitoring of diversity given its incorporation as a principle in reclamation design. Further details are discussed in Section E4.5.4 on diversity.

Impacts to macroterrain and ELC units as a result of Project Millennium will primarily affect the Steepbank Organic Plain and specifically the component wetlands, fen and bog ELC units. The ten wetlands, fen and bog ELC units that will be removed will account for 67% of the disturbance within the east bank mining area. Each of these units, however, comprise less than 1% of the Steepbank Organic Plain and they are typically very widespread, extending well beyond the LSA.

The loss of fen-type wetlands will be permanent since it likely will not be possible to recreate that exact environment (e.g., deep peat layers, inflows of groundwater, nutrient-poor regimes). Indeed, it would not be desirable to recreate the same extent of poorly-drained conditions given the goal of a creating an equal or better land capability for commercial forestry.

In general, the closure plan will result in the replacement of fen and bog ELC units by better drained uplands with treed and shrub reclamation types. Overall, land capability for end uses such as forestry will be enhanced through better drainage and improved reclaimed soils. Of the total development area of 9,281 ha, 7,247 ha of upland ELC units will be reclaimed as compared to 2,780 ha which existed prior to development. The closure landscape includes 918 ha of open water, 276 ha of littoral zone, and 715 ha of drainage areas that are designated as deciduous swamps. These three units will increase the diversity of ELC types in the final landscape.

E4.5.2 Rare Plants

Two rare plants have been identified as being directly impacted by development. Turned sedge was identified in a dogwood ecosite (e1). This community will be used over much of the CT backfilled mine cell reclamation unit as shown on Figure E-2 and thus there will be an increase in habitat for this plant after closure. The area of this ecosite increases from 402 ha (pre-development) to 1,992 ha (closure) within the LSA.

Wool grass was identified in a wooded fen (Ftnn) and in a low-bush cranberry ecosite (d1). Although the wooded fen will not be replaced as part of reclamation, low-bush cranberry is anticipated to be the dominant community along the Athabasca River dykes and in other parts of the site. The area of low-bush cranberry increases from 4,877 ha (pre-development) to 5,656 ha (closure) within the LSA.

Based on the above assessment, closure of the site is considered to have a low environmental consequence on rare plant occurrence within the development area. It is recognized, however, that, it is not possible to conduct a complete listing of all indigenous species present. Therefore, it is likely that some loss of fen-related species will occur. As a result, monitoring of these biological communities in adjacent, non-developed areas is important.

E4.5.3 Wildlife and Habitat Use

During the construction and operational life of the Project, land development will result in a change of the Ecological Land Classification (ELCs) on the Project area. As a result of this development, wildlife displacement will occur. Sensory disturbance will compound this displacement for some wildlife species.

Following mine closure, new ELC units will be replacing those lost. Upland vegetation communities will predominate the new landscape replacing the previously existing wetlands. These vegetation communities were selected based on:

- landforms, soil, drainage, slope and aspect using following the methodologies recommended in the Draft Guidelines for Reclamation of Terrestrial Vegetation in the Alberta Oil Sands Region (Oil Sands Vegetation Reclamation Committee 1997);

- a blending of reclamation communities with those in adjacent non-disturbed communities; and
- diversity of wildlife habitat.

Details of the changes in habitat for the key indicator resources (KIRs) is provided in Section E5.2. These analyses indicate that seven KIR species will have increased habitat while the amount of habitat will be reduced for five species. Habitat will be increased for black bear, moose, and red backed vole. The addition of littoral zones and adjacent open water will provide greater habitat for waterfowl as evidenced by the increase in dabbling duck habitat by 67%. The increased upland area will provide greater habitat for pileated woodpecker, ruffed grouse, and western tanager.

Habitat decreases were relatively modest (less than 10%) for species such as beaver, fisher, owl, and hare. An 18% decrease is calculated for Cape May warbler.

In summary, there will be an overall net increase in habitat for the KIRs on the closure landscape. This is consistent with the objective of achieving a sustainable, productive ecosystem as the landscape matures after closure.

E4.5.4 Diversity of Final Landscape

Although diversity of the closure landscape can be addressed qualitatively on a species level, certain analyses can be made on a community level based on the pre-development conditions and the designed closure landscape. The community level analyses include:

- comparison of the Shannon index for the pre-development and closure landscape based on community types and distribution (Section D4.2); and
- assessment of species richness as part of the HSI modelling (Section D5.2).

The Shannon Index is a measure of comparability (H) calculated to incorporate the sum of the proportional contributions of an individual species or community to the total population. Minimal values occur when one species or community has a disproportionate dominance whereas maximum values occur when all species or communities share equally in the dominance of the community or population. Pre-development there was a relatively equal distribution in the number of ecosite phases throughout the LSA. Post-development there will be a few large ecosite phases (reclaimed ecosite phases) with some smaller undisturbed ecosite phase patches. As succession proceeds over the reclaimed landscape it is possible that the proportion of ecosite phases may become more evenly distributed throughout the LSA.

The quantification of species richness has been based on habitat parameters developed as part of the HSI modelling. These indicators provide a quantification of the relative numbers and abundance of different groups of species in the pre-development and post-closure landscapes. Details of the methodologies used to determine species richness and the results are contained in Section D5.2 as well as the key reference report entitled Wildlife Habitat Suitability Index Modelling for Project Millennium (Golder 1998p).

Species richness for reptiles and amphibians is calculated to decrease 23% for the closure landscape when compared to the predevelopment conditions. A decrease of 13% is calculated for bird species richness. This is reflective principally due to the decrease in fen and other wetlands areas. The species richness decrease for mammals (7%) is due partially to the increase in open water which will form 10% of the closure landscape.

On a qualitative basis, there are anticipated to be some losses and gains in species diversity associated with the closure landscape. The replacement of wetlands with upland vegetation typically creates a greater diversity of animals and a less diversity of plant species. It has been demonstrated, however, that the impact of development on rare plants is expected to be low since only one rare plant was identified in a fen environment which will not exist on the closure landscape. Increased terrain diversity and transitional areas is anticipated to translate greater diversity of animal species. The increase in open water will increase use of portions of the closure landscape for waterfowl.

The loss of fen-type wetlands will be permanent. This loss is driven by the difficulty in fen restoration and by end land use objectives of creating upland forest communities and the desire for a well drained landscape for the removal of CT reclamation water. A poorly drained landscape fed by reclamation water could be negatively impacted by increases in salinity and other constituents in groundwater and surface water.

The release of reclamation drainage water from CT landforms will result in the discharge of water with elevated levels of salinity and other chemicals from both surface and groundwater sources. It is possible that there may be other sources of salinity due to sodic materials in overburden but these sources are likely to be relatively minor compared to the CT landforms. This discharge will inevitably affect the characteristics of the biological community in aquatic ecosystems and also in those terrestrial systems exposed to this water (e.g., the fringes of wetlands, groundwater discharge locations, poorly drained areas), perhaps decreasing biodiversity. To minimize any (unknown) impacts, reclaimed landscapes on CT landforms are designed to be well drained to enhance the flushing of salts and/or other chemicals from both soil and aquatic ecosystems.

E4.6 Maintenance Free End Land Use

E4.6.1 Land Capability for Forest Ecosystems

The protocols for identifying land capability for forest ecosystems are described in Section E of Volume 1 of this application. A class 3 soil, which can be made using a 20 cm layer of soil amendment over sand or overburden, is capable of supporting commercial timber harvesting. A higher class of soil (i.e., class 2) could be achieved by placing 50 cm of soil amendment on the CT deposits and/or overburden deposits and stockpiles. In the CT reclamation units, the soil amendment is placed over a sufficient thickness of tailings sand to mitigate the negative influences of reclamation water. As the landscape matures, the influence of this reclamation water is anticipated to diminish due to decreased consolidation rates of the CT deposits.

IRP guidelines are to restore forest capability to a level of use equivalent to pre-development levels. Similarly, the End Land Use Committee goals are to achieve equal or better capability. AEP guidelines are to restore to a mixed wood boreal forest using native species. The End Land Use Committee guidelines recommend that the cut blocks be planted with a similar species mix as occurred at pre-development and that the land be developed in contiguous blocks to facilitate efficient forest operations.

Land capability on the reclamation landscapes will be on average greater than or equal to pre-development conditions primarily because the reclaimed landscape will be better drained than the pre-development landscape. Table E-2 summarized the gains and/or losses in soil and forestry capability classes for the post- versus pre-development scenario. The most significant result is the 352% increase in class 3 soils compared with pre-development conditions. Since this class encompasses the largest area (7,570 ha) within the LSA, the overall soil and forest capability will be substantially improved after mine closure.

Table E-2 Summary of Land Capability for Forest Ecosystems Classes

Capability Class	Predevelopment Areas (ha)	Closure Areas (ha)	% Gain(+) or Loss (-)
Class 1	465	343	-26%
Class 2	3,437	2,427	-29%
Class 3	1,675	7,570	+352%
Class 4	1,907	1,605	-16%
Class 5	8,697	3,319	-62%
Open Water		918	
Total	**16,181**	**16,181**	

E4.6.2 Traditional Land Use

The wetlands of the closure landscape will be of the marsh-type rather than the fen and bog-type. Marsh wetlands tend to be more nutrient-rich since they drain substantial catchment areas as compared with bog/fens which are fed primarily (if at all) from nutrient-poor groundwater. Hence marshes tend to be more diverse than the existing fens although the latter provide a better environment for some rare plants. The change in riparian habitats will support a diverse community of plant communities, many of which have important traditional uses. The increased amount of open water will increase waterfowl habitat which again will lead to enhanced traditional land use.

Since one component of wildlife diversity depends on access to riparian areas, a key issue is the nature of the wetlands and drainage streams in the reclaimed landscape compared with the pre-development landscape. In addition, there will be increased transition areas from forest to marsh. This comparison is favourable to an increase in wildlife abundance and diversity since the reclaimed wetlands will be more accessible to wildlife (i.e., better drainage).

In addition, upland areas in the reclaimed landscape will be less isolated (i.e., less surrounding areas of poorly drained land) and this will likely enhance the terrestrial habitat. The Alsands clearing area provides one demonstration that well drained upland sites have the capability for support of many of the species of plants and animals that have desirable traditional uses. This combined with the increased access to the site, make it likely that traditional land uses, most notably fur trapping and hunting but also berry picking and as others, will increase in the reclaimed landscape.

E4.6.3 Forest Industry Impact

The forest industry impact can be assessed by comparing calculations for the annual allowable cut for the predevelopment and closure cases in the east bank mining area. Merchantable forests are defined as having contiguous sizes of 4 ha or more. A summary of the existing and predicted annual cuts for the closure is provided in Table E-3.

Table E-3 Annual Allowable Cut for East Bank Mine Area

Merchantable Forest	Ecosite Phase	Area (ha)		Estimated Allowable Cut	
		Pre-development	Closure	Pre-development	Closure
White Spruce-Balsam Poplar	e3	14	277	23	468
White Spruce-Aspen	b3, d2, d3	466	3,292	788	5,563

Aspen-Balsam Poplar	b2, d1, e1	752	3,398	1,271	5,743
Jack pine	b1	101	180	171	304
Total		**1,333**	**7,147**	**2,253**	**12,078**

The results shown on Table E-3 indicate that the AAC will be increased by approximately 9,800 m^3 per year in the east bank mining area.

E4.6.4 Moose Habitat

Habitat Suitability Index (HSI) analyses for the LSA for moose show a 13% increase in the number of habitat units in the closure landscape as opposed to the predevelopment. The HSI model for moose is a winter model. This increase meets the IRP recommendation that moose habitat should be restored or increased to rebuild the wintering population to levels greater than the present population.

E4.6.5 Compatibility with Nearby Developments

The east bank mining area is bounded by the Athabasca and Steepbank Rivers on the west and northeast sides. Compatibility issues relate to the southern side of the site where there is no current plan to mine. In this area, there is a transition from the more upland closure landscape to the fens that presently exist. Drainage compatibility has been provided by linking Wood Creek to the end pit lake system.

As described in the introduction of this section, compatibility issues related to Lease 86/17 and Syncrude Mildred Lake are considered to be outside the scope of this closure plan. In summary, however, the vegetation community proposals for both projects compliment each other However, detailed planning for drainage and community transitions will be necessary where the projects abut each other.

E4.6.6 Engineered Structures

The current closure plan includes one engineered structure to take the flow from Ponds 7, 9, and the north half of 10 along with the northeast dump down the Athabasca escarpment to Shipyard Lake. The design of this structure will be based on hydraulic principles taking into account the maximum probable flood. This will be a permanent structure that will require some long term maintenance. The alternate "maintenance-free" system will be to move the south boundary of Pit 1 thereby keeping the gully for Unnamed Creek undisturbed. This gully can then be enhanced by "natural" structures to accommodate the closure flows.

Other "natural" structures will be incorporated into the overall drainage system to blend into the environment. These structures will also be used to enhance the performance of existing drainage areas such as McLean Creek and in new drainage channels such as the one from Pond 8a to the end pit lake. The design goal for these structures will be for maintenance free performance.

E4.6.7 Public Health and Safety

The objective of the closure landscape is that there will be no substantial risks to public health and safety in terms of both physical and chemical exposure. The human health risk assessment scenario that applies to the closure landscape assumes a hunter/trapper living on the reclaimed landscape. This analyses is described in Section F1.3 and indicates that the only potential exposure pathway with health implications is the ingestion of end pit lake water. Water quality issues in the end pit lake have been discussed in other sections of this closure plan assessment. Overall uncertainties and assumptions related to the human health risk assessment are provided in Section F1.3.

It is not anticipated that there will be physical hazards associated with the reclaimed landscape with the possible exception of the end pit lake. The hazards associated with this lake should not be different compared to other lakes in the area although there will be some relatively steeply sloping terrain above the lake.

E5 MONITORING AND RESEARCH PROGRAMS

The nature of the mature community on reclaimed lands cannot be completely predicted and therefore any comparison of between pre-development and post-reclamation conditions involves a certain level of uncertainty. Factors contributing to this uncertainty include the complex interrelationships between all the biotic and abiotic factors in the environment and the lack of area-specific long term reclamation data. The latter is particularly important since the time required to achieve (and assess) a stable, self-sustaining biological community is significantly less than the current reclamation experience of approximately 20 years. For this reason, research and monitoring programs are needed to assess existing reclaimed sites in more detail and to provide innovative approaches to reclamation protocols if warranted by these surveys.

Ongoing monitoring and research is necessary to address issues that have been identified in developing this Closure Plan Assessment. This monitoring and research is conducted in recognition that closure planning is an iterative process responding to changes in regulatory guidelines, improved knowledge bases, further clarification of stakeholder goals, and other factors. A detailed description of Suncor's current reclamation monitoring and research programs is provided in Section E of Volume 1 of this application.

Suncor has an ongoing program of reclamation research and monitoring that has been described in Sections E4 and E5 of Volume 1 of this application. The current program includes annual vegetation cover assessment and soil sampling on areas reclaimed within the preceding three to four years followed by assessment and sampling of all reclaimed areas on a less frequent basis and wildlife monitoring. Extensive research has been conducted on CT including wetlands, provision of a stable surface, and monitoring the viability of reclamation species. Further research work is also recommended on wetlands reclamation, reclamation drainage systems to support fish habitat, and the potential for the end pit lake to be a viable aquatic habitat.

These monitoring and research programs address the majority of the uncertainties that have been identified in this closure plan assessment. In addition, the following issues should also be addressed as part of operations monitoring in the east bank mining area:

- CT settlement and reclamation drainage from the CT landforms; and
- water quality of releases to Shipyard Lake and McLean Creek (from the end pit lake) in the final reclamation period.

Once active reclamation is complete and vegetation has been re-established, progress toward maturation of landscapes and ecosystems will be monitored to allow evaluation of the reclamation program, as well as to provide the basis for future submissions for reclamation certification. Monitoring is the foundation of adaptive management, providing on-going feedback to adjust future plans and methods as well as establishing and directing the kinds of research required to mitigate unresolved issues. Practical criteria will be established which can serve as milestones in the maturation process (to determine whether long-term goals are likely to be achieved). The monitoring and research process will include continued refinement and application of the Oil Sands Reclamation Performance Assessment Framework as one method for evaluation of the success of reclamation plans and process.

The proposed Closure Plan provides considerable flexibility and opportunities to address specific future land uses including wildlife habitat, traditional land use, recreation and possibilities for commercial forest production. It is anticipated that future large-scale demonstrations followed by monitoring of fully-reclaimed areas will establish the basis for the final design of measures to achieve the desired final land use of the reclaimed land. Suncor has, and will continue to participate in existing reclamation research strategies conducted by the existing oil sands mines.

E6 CONCLUSION

This closure plan assessment has provided an analysis of predicted reclamation performance within the framework of meeting Suncor's corporate goals and regulatory requirements. These goals and requirements have been systematically evaluated for twenty-two key issues. The results indicate that the closure landscape has a high probability of attaining the closure objectives and will support a stable geomorphological and ecological system which will be compatible with desired end land uses.

While there is currently a demonstration of successful reclamation in the existing operations on Lease 86/17, it is recognized that there are uncertainties related to certain aspects of this performance assessment. These uncertainties will be reduced during detailed design, by further research, or by ongoing monitoring activities that will provide continuing feedback into the iterative design process.

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GLOSSARY

Abiotic	Non-living factors that influence an ecosystem, such as climate, geology and soil characteristics.
Activity Area	A limited portion of a site in which a specialized cultural function was carried out, such as hide scraping, tool manufacture, food preparation and other activities.
Acute Exposures	Exposures occurring over a short period of time, usually at high concentrations.
Adverse Effect	An undesirable or harmful effect to an organism (human, animal or plant), indicated by some result such as mortality, growth inhibition, reproductive abnormalities, altered food consumption, altered body and organ weights, altered enzyme concentrations, visible pathological changes or carcinogenic effects.
Age-to-maturity	Most often refers to the age at which more than 50% of the individuals of a particular sex within a population reach sexual maturity. Age-to-maturity of individuals within the same population can vary considerably from the population median value. In fish species, males often reach sexual maturity at a younger age than female.
Airshed	Describes the geographic area requiring unified management for achieving air pollution control.
Alkalinity	A measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, bicarbonates and hydroxides, and less significantly, borates, silicates, phosphates and organic substances. It is expressed as an equivalent of calcium carbonate. The composition of alkalinity is affected by pH, mineral composition, temperature and ionic strength. However, alkalinity is normally interpreted as a function of carbonates, bicarbonates and hydroxides. The sum of these three components is called total alkalinity.
Alluvium	Sediment deposited in land environments by streams.
Ambient	The conditions surrounding an organism or area.
AOSERP	Alberta Oil Sands Environmental Research Program.
Aquifer	A body of rock or soil that contains sufficient amounts of saturated permeable material to yield economic quantities of water to wells or springs.
Archaeology	The scientific discipline responsible for studying the unwritten portion of man's historic and prehistoric past.
Armouring	Channel erosion protection by covering with protection material.

Artifact	Any portable object modified or manufactured by man.
ASL	Above sea level.
Aspect	Compass orientation of a slope as an inclined element of the ground surface.
ASWQO	Alberta Surface Water Quality Objectives. Numerical concentrations or narrative statements established to support and protect the designated uses of water. These are minimum levels of quality, developed for Alberta watersheds, below which no waterbody is permitted to deteriorate. These objectives were established as minimum levels that would allow for the most sensitive use. These concentrations represent a goal to be achieved or surpassed.
Available Drawdown	The vertical distance that the equipotential surface of an aquifer can be lowered; in confined aquifers, this is to the top of the aquifer; in unconfined aquifers, this is to the bottom of the aquifer.
Background	An area not influenced by chemicals released from the site under evaluation.
Background Concentration (environmental)	The concentration of a chemical in a defined control area during a fixed period before, during or after data-gathering.
Backwater	Discrete, localized area exhibiting reverse flow direction and, generally lower stream velocity than main current; substrate similar to adjacent channel with more fines.
Baseline	A surveyed condition that serves as a reference point on which later surveys are coordinated or correlated.
Beaver River Sandstone	A light gray, medium to fine-grained quartz sandstone cemented in a silica matrix.
Bedrock	The body of rock which underlies gravel, soil or other superficial material.
Benthic Invertebrates	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their lifestages dwelling on bottom sediments in the river. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the open water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.

Bile	An alkaline secretion of the vertebrate liver. Bile, which is temporarily stored in the gall bladder, is composed of organic salts, excretion products and bile pigments. It primarily functions to emulsify fats in the small intestine.
Bioaccumulation	A general term meaning that an organism stores within its body a higher concentration of a substance than is found in the environment. This is not necessarily harmful. For example, freshwater fish must bioaccumulate salt to survive in intertidal waters. Many toxicants, such as arsenic, are not included among the dangerous bioaccumulative substances because they can be handled and excreted by aquatic organisms.
Bioavailability	The amount of chemical that enters the general circulation of the body following administration or exposure.
Bioconcentration	A process where there is a net accumulation of a chemical directly from an exposure medium into an organism.
Biodiversity	The variety of organisms and ecosystems that comprise both the communities of organisms within particular habitats and the physical conditions under which they live.
Biological Indicators	Any biological parameter used to indicate the response of individuals, populations or ecosystems to environmental stress. For example, growth is a biological indicator.
Biomarker	Biomarker refers to a chemical, physiological or pathological measurement of exposure or effect in an individual organism from the laboratory or the field. Examples include: contaminants in liver enzymes, bile and sex steroids.
Biome	A major community of plants and animals such as the boreal forest or tundra biome.
Biotic	The living organisms in an ecosystem.
Bitumen	A highly-viscous, tarry, black hydrocarbon material having an API gravity of about 9° (specific gravity about 1.0). It is a complex mixture of organic compounds. Carbon accounts for 80% to 85% of the elemental composition of bitumen, hydrogen - 10%, sulphur - 5%, and nitrogen, oxygen and trace elements the remainder.
BOD	The biochemical oxygen demand (BOD) determination is an imperical test in which standardized laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents and polluted waters.
Bottom Sediments	Substrates that lie at the bottom of a body of water. For example, soft mud, silt, sand, gravel, rock and organic litter, that make up a river bottom.

Bottom-feeding Fish	Fish that feed on the substrates and/or organisms associated with the river bottom.
Cancer	A disease characterized by the rapid and uncontrolled growth of aberrant cells into malignant tumours.
Canopy	An overhanging cover, shelter or shade; the tallest layer of vegetation in an area.
Carcinogen	An agent that is reactive or toxic enough to act directly to cause cancer.
Carrying capacity	The maximum population size that can be supported by the available resources.
Centre Reject	A non bituminous baring material found within a central zone of the oil sand ore body.
Cervid	Of the family Cervidae, which includes elk, deer, moose, and caribou.
Chert	A fine-grained siliceous rock. Impure variety of chalcedony which is generally light-coloured.
Chronic Exposure	Exposures occurring over a relatively long duration of time (Health Canada considers periods of human exposure greater than three months to be chronic while the U.S. EPA only considers human exposures greater than seven years to be chronic).
Chronic Toxicity	The development of adverse effects after an extended exposure to relatively small quantities of a chemical.
Chronic Toxicity Unit (TU_c)	Measurement of long duration toxicity that produces an adverse effect on organisms.
Climax	The culminating stage in plant succession for a given site where the vegetation has reached a stable condition.
Cline	A gradual change in a feature across the distributional range of a species or population.
Closure	The point after shutdown of operations when regulatory certification is received and the area is returned to the Crown.
Community	Pertaining to plant or animal species living in close association or interacting as a unit.
Composite Tailings (CT)	A non-segregating mixture made by Syncrude Canada Ltd. of oil sands extraction tailings that consolidates relatively quickly in deposits. Composed of sand tailings, mature fine tailings and a chemical stabilizer (e.g., $CaSO_4$).
Concentration	Quantifiable amount of a chemical in environmental media.

Conceptual Model	A model developed at an early stage of the risk assessment process that describes a series of working hypotheses of how the chemicals of concern may affect potentially exposed populations. The model identifies the populations potentially at risk along with the relevant exposure pathways and scenarios.
Condition Factor	A measure of the relative "fitness" of an individual or population of fishes by examining the mathematical relationship between length and weight. The values calculated show the relationship between growth in length relative to growth in weight. In populations where increases in length are matched by increases in weight, the growth is said to be isometric. Allometric growth, the most common situation in wild populations, occurs when increases in either length or weight are disproportionate.
Conditioning Drums	Large, inclined cylindrical tumblers that rotate slowly, used for preparing (conditioning) oil sand for primary extraction by mixing it with hot water and steam.
Conductivity	A measure of a waterbody's capacity to conduct an electrical current. It is the reciprocal of resistance. This measurement provides the limnologist with an estimation of the total concentration of dissolved ionic matter in the water. It allows for a quick check of the alteration of total water quality due to the addition of pollutants to the water.
Confined Aquifer	An aquifer in which the potentiometric surface is above the top of the aquifer.
Conifers	White and black spruce, balsam fir, jack pine and tamarack.
Conservative Approach	Approach taken to incorporate protective assumptions to ensure that risks will not be underestimated.
Consolidated Tailings (CT)	Consolidated Tailings (CT) is a non-segregating mixture made by Suncor Energy Inc., Oil Sands of plant tailings which consolidates relatively quickly in tailings deposits. At Suncor, Consolidated Tailings are prepared by combining mature fine tails with thickened (cycloned) fresh sand tailings. This mixture is chemically stabilized (to prevent segregation of fine and coarse mineral solids) using gypsum ($CaSO_4$).
Consolidated Tailings Release Water	Water is expelled from Consolidated Tailings mixtures during the course of consolidation. The water is referred to as Consolidated Tailings (or CT) release water.
Consolidation	The gradual reduction in volume of a soil or semi-solid mass.
Contaminant Body Burdens	The total concentration of a contaminant found in either whole-body or individual tissue samples.

Contaminants	A general term referring to any chemical compound added to a receiving environment in excess of natural concentrations. The term includes chemicals or effects not generally regarded as "toxic," such as nutrients, colour and salts.
Control	A treatment in a toxicity test that duplicates all the conditions of exposure treatments but contains no test material. The control is used to determine basic test conditions in the absence of toxicity (e.g., health of test organisms, quality of dilution water).
Cratering	The act of creating depressions, or craters, in the snow when foraging for food. Usually done by elk or other ungulates.
Crop Tree Regeneration	The renewal of a forest or stand of trees by natural or artificial means, usually white spruce, jack pine or aspen.
Culture	The sum of man's non-biological behavioural traits: learned, patterned and adaptive.
CWQG	Canadian Water Quality Guidelines. Numerical concentrations or narrative statements recommended to support and maintain a designated water use in Canada. The guidelines contain recommendations for chemical, physical, radiological and biological parameters necessary to protect and enhance designated uses of water.
Cyclofeeder	A cyclofeeder is a vertical, open-topped cylindrical vessel with a conical bottom. The purpose of a cyclofeeder is to mix oil sand with warm water to form a slurry which can be pumped via a pipeline to Extraction. Warm water is introduced through horizontal ports situated at the bottom of the vertical portion to produce a vortex inside the vessel, into which incoming oil sands falls. The energy imparted to the oil sand forms a slurry, which is withdrawn at the bottom of the cone.
Darcy's Law	A law describing the rate of flow of water through porous media. (Named for Henry Darcy of Paris who formulated it in 1856 from extensive work on the flow of water through sand filter beds.)
DEM (Digital Elevation Model)	A three-dimensional grid representing the height of a landscape above a given datum.
Dendritic Drainage Pattern	A drainage pattern characterized by irregular branching in all directions with the tributaries joining with the main stream at all angles.
Deposit	Material left in a new position by a natural transporting agent such as water, wind, ice or gravity, or by the activity of man.
Depressurization	The process of reducing the pressure in an aquifer, by withdrawing water from it.

Depuration	Loss of accumulated chemical residues from an organism placed in clean water or clean solution.
Detection Limit (DL)	The lowest concentration at which individual measurement results for a specific analyte are statistically different from a blank (that may be zero) with a specified confidence level for a given method and representative matrix.
Deterministic	Risk approach using a single number from each parameter set in the risk calculation and producing a single value of risk.
Detoxification	To decrease the toxicity of a compound. Bacteria decrease the toxicity of resin and fatty acids in mill effluent by metabolizing or breaking down these compounds; enzymes like the EROD or P4501A proteins begin the process of breaking down and metabolizing many "oily" compounds by adding an oxygen atom.
Development Area	Any area altered to an unnatural state. This represents all land and water areas included within activities associated with development of the oil sands leases.
Diameter at Breast Height (DBH)	The diameter of a tree 1.5 m above the ground on the uphill side of the tree.
Discharge	In a stream or river, the volume of water that flows past a given point in a unit of time (i.e., m^3/s).
Disclimax	A type of climax community that is maintained by either continuous or intermittent disturbance to a severity that the natural climax vegetation is altered.
Disturbance (Historic)	A cultural deposit is said to be disturbed when the original sequence of deposition has been altered. Examples of agents of disturbance include erosion, plant or animal activity, cultivation and excavations.
Disturbance (Terrestrial)	A force that causes significant change in structure and/or composition of a habitat.
Disturbance coefficient	The effectiveness of the habitat within the disturbance zone of influence in fulfilling the requirements of a species.
Disturbance zone of influence	The maximum distance to which a disturbance (e.g., traffic noise) is felt by a species.
Diversity	The variety, distribution and abundance of different plant and animal communities and species within an area.
Dose	A measure of integral exposure. Examples include (1) the amount of chemical ingested, (2) the amount of a chemical taken up, and (3) the product of ambient exposure concentration and the duration of exposure.

Dose Rate	Dose per unit time, for example in mg/day, sometimes also called dosage. Dose rates are often expressed on a per-unit-body-weight basis, yielding units such as mg/kg body weight/day expressed as averages over some period, for example a lifetime.
Dose-Response	The quantitative relationship between exposure of an organism to a chemical and the extent of the adverse effect resulting from that exposure.
Drainage Basin	The total area that contributes water to a stream.
Dry Landscape Reclamation	A reclamation approach that involves dewatering or incorporation of fine tailings into a solid deposit capable of being reclaimed as a land surface or a wetland.
Ecological Land Classification	A means of classifying landscapes by integrating landforms, soils and vegetation components in a hierarchical manner.
Ecoregion	Ecological regions that have broad similarities with respect to soil, terrain and dominant vegetation.
Ecosection	Clearly-recognizable landforms such as river valleys and wetlands at a broad level of generalization.
Ecosite	Ecological units that develop under similar environmental influences (climate, moisture and nutrient regime). Ecosites are groups of one or more ecosite phases that occur within the same portion of the moisture/nutrient grid. Ecosite is a functional unit defined by the moisture and nutrient regime. It is not tied to specific landforms or plant communities, but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth.
Ecosite Phase	A subdivision of the ecosite based on the dominant tree species in the canopy. On some sites where the tree canopy is lacking, the tallest structural vegetation layer determines the ecosite phase.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location.
Edaphic	Referring to the soil. The influence of the soil on plant growth is referred to as an edaphic factor.
Edge	Where plant communities meet; and where plant communities meet a disturbance.
Effluent	Stream of water discharging from a source.
Environmental Impact Assessment	A review of the effects that a proposed development will have on the local and regional environment.

Environmental Media	One of the major categories of material found in the physical environment that surrounds or contacts organisms (e.g., surface water, groundwater, soil, food or air) and through which chemicals can move and reach the organism.
Ephemeral	A phenomenon or feature that last only a short time (i.e., an ephemeral stream is only present for short periods during the year).
EROD	Ethoxyresorufin-O-deethylase (EROD) are enzymes that can increase in concentration and activity following exposure of some organisms to chemicals such as polycyclic aromatic hydrocarbons. EROD measurement indirectly measures the presence of catalytical proteins that remove a CH_3CH_2-group from the substrate ethoxyresorufin.
Escarpment	A cliff or steep slope at the edge of an upland area. The steep face of a river valley.
Exposure	The contact reaction between a chemical and a biological system, or organism.
Exposure Assessment	The process of estimating the amount (concentration or dose) of a chemical that is taken up by a receptor from the environment.
Exposure Concentration	The concentration of a chemical in its transport or carrier medium at the point of contact.
Exposure Limit or Toxicity Reference Value	For a non-carcinogenic chemical, the maximum acceptable dose (per unit body weight and unit of time) of a chemical that a specified receptor can be exposed to, without the development of adverse effects. For a carcinogenic chemical, the maximum acceptable dose of a chemical to which a receptor can be exposed to, assuming a specified risk (e.g., 1 in 100 000). May be expressed as a Reference Dose (RfD) for non-carcinogenic (threshold-response) chemicals or as a Risk Specific Dose (RsD) for carcinogenic (non-threshold response) chemicals. Also referred to as a toxicity reference value.
Exposure Pathway or Route	The route by which a receptor comes into contact with a chemical or physical agent. Examples of exposure pathways include: the ingestion of water, food and soil; the inhalation of air and dust; and dermal absorption.
Exposure Ratio (ER) or Hazard Quotient (HQ)	A comparison between total exposure from all predicted routes of exposure and the exposure limits for chemicals of concern. This comparison is calculated by dividing the predicted exposure by the exposure limit. Also referred to as hazard quotient (HQ).
Exposure Scenario	A set of facts, assumptions and inferences about how exposure takes place, that helps the risk assessor evaluate, estimate and quantify exposures.

Fate	In the context of the study of contaminants, fate refers to the chemical form of a contaminant when it enters the environment and the compartment of the ecosystem in which that chemical is primarily concentrated (e.g., water or sediments). Fate also includes transport of the chemical within the ecosystem (via water, air or mobile biota) and the potential for food chain accumulation.
Fauna	An association of animals living in a particular place or at a particular time.
Fecundity	The most common measure of reproductive potential in fishes. It is the number of eggs in the ovary of a female fish. It is most commonly measured in gravid fish. Fecundity increases with the size of the female.
Filter-Feeders	Organisms that feed by straining small organisms or organic particles from the water column.
Filterable Residue	Materials in water that pass through a standard-size filter (often 0.45 µm). This is a measure of the "total dissolved solids" (TDS), i.e., chemicals that are dissolved in the water or that are in a particulate form smaller than the filter size. These chemicals are usually salts, such as sodium ions and potassium ions.
Fine Tailings	A suspension of fine silts, clays, residual bitumen and water that forms in the course of bitumen extraction from oil sands using the hot water extraction process. This material segregates from coarse sand tailings during placement in tailings ponds and accumulates in a layer (referred to as fine tailings) that dewaters very slowly. The top of the fine tailings deposit is typically about 85% water, 13% fine minerals and 2% bitumen by weight.
Fines	Silt and clay particles.
Fish Health Parameters	Parameters used to indicate the health of an individual fish. May include, for example, short-term response indicators such as changes in liver mixed function oxidase activity and the levels of plasma glucose, protein and lactic acid. Longer-term indicators include internal and external examination of exposed fish, changes in organ characteristics, hematocrit and hemoglobin levels. May also include challenge tests such as disease resistance and swimming stamina.
Fisheries Act	Federal legislation that protects fish habitat from being altered, disrupted or destroyed by chemical, physical or biological means. Destruction of the habitat could potentially undermine the economic, employment and other benefits that flow from Canada's fisheries resources (DFO 1986).
Floodplain	Land near rivers and lakes that may be inundated during seasonally high water levels (i.e., floods).

Flue Gas Desulphurization (FGD)	A process involving removal of a substantial portion of sulphur dioxide from the combustion gas (flue gas) formed from burning petroleum coke. Desulphurization is accomplished by contacting the combustion gases with a solution of limestone. Gypsum ($CaSO_4$) is formed as a byproduct of this process.
Fluvial	Relating to a stream or river.
Food Chain Transfer	A process by which materials accumulate in the tissues of lower trophic level organisms and are passed on to higher trophic level organisms by dietary uptake.
Forage Area	The area used by an organism for hunting or gathering food.
Forage Fish	Small fish that provide food for larger fish (e.g., longnose sucker, fathead minnow)
Forb	Broadleaved herb, as distinguished from grasses.
Forest	A collection of stands of trees that occur in similar space and time.
Forest Fragmentation	The change in the forest landscape, from extensive and continuous forests.
Forest Landscape	Forested or formerly forested land not currently developed for non-forest use.
Forest Succession	The orderly process of change in a forest as one plant community or stand condition is replaced by another, evolving toward the climax type of vegetation.
Fragmentation	The process of reducing size and connectivity of stands of trees that compose a forest.
Froth	Air-entrained bitumen with a froth-like appearance that is the product of the primary extraction step in the hot water extraction process.
Fugitive Emissions	Contaminants emitted from any source except those from stacks and vents. Typical sources include gaseous leakages from valves, flanges, drains, volatilization from ponds and lagoons, and open doors and windows. Typical particulate sources include bulk storage areas, open conveyors, construction areas or plant roads.
Genetic diversity	Describes the range of possible genetic characteristics found within a species and amongst different species (e.g., variations in hair colour, eye colour, and height in humans).
Geomorphic	Pertaining to natural evolution of surface soils and landscape over long periods.
Geomorphical Processes	The origin and distribution of landforms, with the emphasis on the nature of erosional processes.

Geomorphology	That branch of science which deals with the form of the earth, the general configurations of its surface and the changes that take place in the evolution of landforms.
GIS	Geographic Information System. Pertains to a type of computer software that is designed to develop, manage, analyze and display spatially-referenced data.
Glacial Till	Unsorted and unstratified glacial drift (generally unconsolidated) deposited directly by a glacier without subsequent reworking by water from the glacier. Consisting of a heterogeneous mixture of clay, silt, sand, gravel and boulders (i.e., drift) varying widely in size and shape.
Glaciolacustrine (or Glacio-Lacustrine)	Relating to the lakes that formed at the edge of glaciers as the glaciers receded. Glaciolacustrine sediments are commonly laminar deposits of fine sand, silt and clay.
Golder	Golder Associates Ltd.
Gonads	Organs responsible for producing haploid reproductive cells in multi-cellular cells in multi-cellular animals. In the male, these are the testes and in the female, the ovaries.
Groundtruth	Conductive site visits to confirm accuracy of remotely sensed information.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Groundwater Level	The level below which the rock and subsoil, to unknown depths, are saturated.
Groundwater Regime	Water below the land surface in a zone of saturation.
Groundwater Velocity	The speed at which groundwater advances through the ground. In this document, the term refers to the average linear velocity of the groundwater.
GSI	Gonad-Somatic Index. The proportion of reproductive tissue in the body of a fish. It is calculated by dividing the total gonad weight by the total body weight and multiplying the result by 100. It is used as an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth.
Guild	A set of co-existing species that share a common resource.
Habitat	The place where an animal or plant naturally or normally lives and grows, for example, a stream habitat or a forest habitat.
Habitat alienation	The loss of habitat effectiveness as a result of sensory disturbances from human activities at disturbed sites.

Habitat effectiveness	Including the physical characteristics suitability of a habitat, the ability of a habitat to be used by wildlife. The effectiveness of a habitat can be decreased through visual, auditory, or olfactory disturbance even though the physical characteristics of the habitat remain unchanged.
Habitat fragmentation	Occurs when extensive, continuous tracts of habitat are reduced by habitat loss to dispersed and usually smaller patches of habitat. Generally reduces the total amount of available habitat and reduces remaining habitat into smaller, more isolated patches
Habitat generalist	Wildlife species that can survive and reproduce in a variety of habitat types (e.g., red-backed vole).
Habitat specialist	Wildlife species that is dependent on a few habitat types for survival and reproduction (e.g., Cape May warbler).
Habitat Suitability Index (HSI) model	Analytical tools for determining the relative potential of an area to support individuals or populations of a wildlife species. They are frequently used to quantify potential habitat losses and gains for wildlife as a result of various land use activities.
Habitat unit	Generally, used in HSI models. A habitat is ranked in regards to its suitability for a particular wildlife species. This ranking is then multiplied by the area (ha) of the particular habitat type to give the number of habitat units available to the wildlife species in question.
Hazard	A condition with the potential for causing an undesirable consequence.
Head	The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. It is used in various compound terms such as pressure head, velocity head and loss of head.
Herb	Tender plant, lacking woody stems, usually small or low; it may be annual or perennial, broadleaf (forb) or graminoid (grass).
Heterogeneity	Variation in the environment over space and time.
Histology/ Histological	The microscopic study of tissues.
Historical Resources Impact Assessment	A review of the effects that a proposed development will have on the local and regional historic and prehistoric heritage of an area.
Historical/Heritage Resources	Works of nature or of man, valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific, or aesthetic interest.

Human Health Risk Assessment	The process of defining and quantifying risks and determining the acceptability of those risks to human life.
Hydraulic Conductivity	The permeability of soil or rock to water.
Hydraulic Gradient	A measure of the force of moving groundwater through soil or rock. It is measured as the rate of change in total head per unit distance of flow in a given direction. Hydraulic gradient is commonly shown as being dimensionless, since its units are m/m.
Hydraulic Head	The elevation, with respect to a specified reference level, at which water stands in a piezometer connected to the point in question in the soil. Its definition can be extended to soil above the water table if the piezometer is replaced by a tensiometer. The hydraulic head in systems under atmospheric pressure may be identified with a potential expressed in terms of the height of a water column. More specifically, it can be identified with the sum of gravitational and capillary potentials, and may be termed the hydraulic potential.
Hydraulic Structure	Any structure designed to handle water in any way. This includes retention, conveyance, control, regulation and dissipation of the energy of water.
Hydrocyclone	A device for separating out sand from extraction tailings slurry by imparting a rotating (cyclone) action to the slurry. Water, fine tailings and residual bitumen report to the overflow of the device. Sand flows out the bottom of the device in a dense slurry.
Hydrogeology	The study of the factors that deal with subsurface water (groundwater), and the related geologic aspects of surface water.
Hydrotransport	Refers to the transport of granular materials (e.g., oil sands ore or extraction tailings) by means of a water-based slurry in a pipeline.
ICP (Metals)	Inductively Coupled Plasma (Atomic Emission Spectroscopy). This analytical method is a U.S. EPA designated method (Method 6010). The method determines elements within samples of groundwater, aqueous samples, leachates, industrial wastes, soils, sludges, sediments and other solid wastes. Samples require chemical digestion before analysis.
Induction	Response to a biologically active compound — involves new or increased gene expression resulting in enhanced synthesis of a protein. Such induction is commonly determined by measuring increases in protein levels and/or increases in the corresponding enzyme activity. For example, induction of EROD would be determined by measuring increases in cytochrome P4501A protein levels and/or increases in EROD activity.
Inorganics	Pertaining to a compound that contains no carbon.

Integrated Resource Management	A coordinated approach to land and resource management, which encourages multiple-use practices.
Interspersion	The percentage of map units containing categories different from the map unit surrounding it.
Inversion	An atmospheric condition when temperatures increase with height above the ground. During inversion conditions the vertical mixing of emissions are restricted.
Isolated Find	The occurrence of a single artifact with no associated artifacts or features.
KIRs	Key indicator resources are the environmental attributes or components identified as a result of a social scoping exercise as having legal, scientific, cultural, economic or aesthetic value.
Landform	General term for the configuration of the ground surface as a factor in soil formation; it includes slope steepness and aspect as well as relief. Also, configurations of land surface taking distinctive forms and produced by natural processes (e.g., hill, valley, plateau).
LANDSAT	A specific satellite or series of satellites used for earth resource remote sensing. Satellite data can be converted to visual images for resource analysis and planning.
Landscape	A heterogeneous land area with interacting ecosystems.
Landscape Diversity	The size, shape and connectivity of different ecosystems across a large area.
Leaching	The removal, by water, of soluble matter from regolith or bedrock.
Lean Oil Sands	Oil bearing sands, which do not have a high enough saturation of oil to make extraction of them economically feasible.
Lesions	Pathological change in a body tissue.
Lethal	Causing death by direct action.
Linear corridor	Roads, seismic lines, pipelines and electrical transmission lines, or other long, narrow disturbances.
Lipid	One of a large variety of organic fats or fat-like compounds, including waxes, steroids, phospholipids and carotenes. Refers to substances that can be extracted from living matter using hydrocarbon solvents. They serve several functions in the body, such as energy storage and transport, cell membrane structure and chemical messengers.
Littoral Zone	The zone in a lake that is closest to the shore.

Loading Rates	The amount of deposition, determined by technical analysis, above which there is a specific deleterious ecological effect on a receptor.
LOAEL	Lowest Observed Adverse Effect Level. In toxicity testing it is the lowest concentration at which adverse effects on the measurement end point are observed.
LOEC	Lowest Observed Effect Concentration. The lowest concentration in a medium that causes an effect that is a statistically significant difference in effect compared to controls.
LOEL	Lowest Observed Effect Level. In toxicity testing it is the lowest concentration at which effects on the measurement end point are observed.
LSI	Liver Somatic Index. Ratio of liver versus total body weight. Expressed as a percentage of total body weight.
m^3/s	Cubic metres per second. The standard measure of water flow in rivers; i.e., the volume of water in cubic metres that passes a given point in one second.
Mature Fine Tailings (MFT)	These are fine tailings that have dewatered to a level of about 30% solids over a period of about three years after deposition. The rate of consolidation beyond this point is substantially reduced. Mature fine tailings behave like a viscous fluid.
Mature Forest	A forest greater than rotation age with moderate to high canopy closure; a multi-layered, multi-species canopy dominated by large overstory trees; some with broken tops and other decay; numerous large snags and accumulations of downed woody debris.
Mature Stand	A stand of trees for which the annual net rate of growth has peaked.
Media	The physical form of the environmental sample under study (e.g., soil, water, air).
Merchantable Forest	A forest area with potential to be harvested for protection of lumber/timber or wood pulp. Forests with a timber productivity rating of moderate to good.
Mesic	Pertaining to, or adapted to an area that has an intermediate supply of water; neither wet not dry.
Metabolism	Metabolism is the total of all enzymatic reactions occurring in the cell; a highly coordinated activity of interrelated enzyme systems exchanging matter and energy between the cell and the environment. Metabolism involves both the synthesis and breakdown (catabolism) of individual compounds.

Metabolites Organisms alter or change compounds in various ways, such as removing parts of the original or parent compound, or in other cases adding new parts. Then, the parent compound has been metabolized and the newly converted compound is called a metabolite.

MFO Mixed Function Oxidase. A term for reactions catalyzed by the Cytochrome P450 family of enzymes, occurring primarily in the liver. These reactions transform organic chemicals, often altering toxicity of the chemicals.

Microclimate The temperature, precipitation and wind velocity in a restricted or localized area, site or habitat.

Microtox© A toxicity test that includes an assay of light production by a strain of luminescent bacteria (*Photobacterium phosphoreum*).

Mineral Soil Soils containing low levels of organic matter. Soils that have evolved on fluvial, glaciofluvial, lacustrine and morainal parent material.

Mixing Height The depth of surface layer in which atmospheric mixing of emissions occurs.

Modelling A simplified representation of a relationship or system of relationships. Modelling involves calculation techniques used to make quantitative estimates of an output parameter based on its relationship to input parameters. The input parameters influence the value of the output parameters.

Movement corridor Travel way used by wildlife for daily, seasonal, annual and/or dispersal movements from one area or habitat to another.

Multilayered Canopy Forest stands with two or more distinct tree layers in the canopy; also called multistoried stands.

Muskeg A soil type comprised primarily of organic matter. Also known as bog peat.

Mycorrhizal A fungi that forms a symbiotic relationship with plants, resulting in improved nutrient uptake by the plant.

NMHC Non-Methane Hydrocarbons is a measure of the airborne hydrocarbons, less methane.

NOAEL No observed adverse effect level. In toxicity testing, it is the highest concentration at which no adverse effects on the measurement end point are observed.

Node Location along a river channel, lake inlet or lake outlet where flows, sediment yield and water quality have been quantified.

NOEC	No observed adverse effect concentration. The highest concentration in a medium that does not cause a statistically significant difference in effect as compared to controls.
NOEL	No observed effect level. In toxicity testing, it is the highest concentration at which no effects on the measurement end point are observed.
Non-Filterable Residue	Material in a water sample that does not pass through a standard size filter (often 0.45 mm). This is considered to represent "total suspended solids" (TSS), i.e., particulate matter suspended in the water column.
Noncarcinogen	A chemical that does not cause cancer and has a threshold concentration, below which adverse effects are unlikely.
NO_X	A measure of the oxides of nitrogen comprised of nitric oxide (NO) and nitrogen dioxide (NO_2).
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles. Typical oil sands comprise approximately 10 wt% bitumen, 85% coarse sand (>44μm) and a fines (<44μm) fraction, consisting of silts and clays.
Organic Soil	Soils containing high percentages of organic matter (fibric and humic inclusions).
Organics	Chemical compounds, naturally occurring or otherwise, which contain carbon, with the exception of carbon dioxide (CO_2) and carbonates (e.g., $CaCo_3$).
Overburden	The soil, sand, silt or clay that overlies bedrock. In mining terms, this includes all material that has to be removed to expose the ore.
Overstory	Those trees that form the upper canopy in a multi-layered forest.
Overwintering Habitat	Habitat used during the winter as a refuge and for feeding.
PAH(s)	Polycyclic Aromatic Hydrocarbon. A chemical byproduct of petroleum-related industry. Aromatics are considered to be highly toxic components of petroleum products. PAHs, many of which are potential carcinogens, are composed of at least two fused benzene rings. Toxicity increases along with molecular size and degree of alkylation of the aromatic nucleus.

PAI	The Potential Acid Input is a composite measure of acidification determined from the relative quantities of deposition from background and industrial emissions of sulphur, nitrogen and base cations.
Paleosol	A paleosol is a soil that was formed in the past. Paleosols are usually buried beneath a layer of sediments and are thus no longer being actively created by soil formation processes like organic decay.
PANH	Polycyclic Aromatic Nitrogen Heterocycle. See PAH.
PASH	Polycyclic Aromatic Sulphur Heterocycle.
Patch	This term is used to recognize that most ecosystems are not homogeneous, but rather exist as a group of patches or ecological islands that are recognizably different from the parts of the ecosystem that surround them but nevertheless interact with them.
Pathology	The science that deals with the cause and nature of disease or diseased tissues.
Peat	A material composed almost entirely of organic matter from the partial decomposition of plants growing in wet conditions.
Performance Assessment	Prediction of the future performance of a reclaimed lease to allow identification of potential adverse effects with respect to geotechnical, geomorphic and ecosystem sustainability.
Permit Holder	The director of an Historical Resource Impact Assessment. Responsible for the satisfactory completion of all field and laboratory work and author of the technical report.
Physiological	Related to function in cells, organs or entire organisms, in accordance with natural processes of life.
Pictograph	Aboriginally painted designs on natural rock surfaces. Red ochre is the most frequently used pigment.
Piezometer	A pipe in the ground in which the elevation of water level can be measured.
Piezometric Surface	If water level elevations in wells completed in an aquifer are plotted on a map and contoured, the resulting surface described by the contours is known as a potentiometric or piezometric surface.
Plant Community	An association of plants of various species found growing together.
PM_{10}	Airborne particulate matter with mean diameter less than 10 μm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled into the upper respiratory tract.

$PM_{2.5}$	Airborne particulate matter with mean diameter less than 2.5 μm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled deeply into the pulmonary tissue.
Polishing Pond	Pond where final sedimentation takes place before discharge.
Polygon	The spatial area delineated on a map to define one feature unit (e.g., one type of ecosite phase).
Population	A collection of individuals of the same species that potentially interbreed.
Porewater	Water between the grains of a soil or rock.
Problem Formulation	The initial step in a risk assessment that focuses the assessment on the chemicals, receptors and exposure pathways of greatest concern.
Productive Forest	Forests on lands with a capability rating of equal to or greater than 3, and stocked with trees to meet the stocking standards of a merchantable forest.
Propagules	Root fragments, seeds, and other plant materials which can develop into a plant under the right conditions.
QA/QC	Quality Assurance/Quality Control refers to a set of practices that ensure the quality of a product or a result. For example, "Good Laboratory Practice" is part of QA/QC in analytical laboratories and involves such things as proper instrument calibration, meticulous glassware cleaning and an accurate sample information system.
QA/QC Plan	Quality Assurance/Quality Control Plan.
Rearing Habitat	Habitat used by young fish for feeding and/or as a refuge from predators.
Receptor	The person or organism subjected to exposure to chemicals or physical agents.
Reclamation	The restoration of disturbed or wasteland to a state of useful capability. Reclamation is the initiation of the process that leads to a sustainable landscape (see definition), including the construction of stable landforms, drainage systems, wetlands, soil reconstruction, addition of nutrients and revegetation. This provides the basis for natural succession to mature ecosystems suitable for a variety of end uses.
Reclamation Certificate	A certificate issued by an Alberta Environmental Protection, Conservation, and Reclamation Inspector, signifying that the terms and conditions of a conservation and reclamation approval have been complied with.
Reclamation Unit	A unique combination of reclamation conditions, namely surface shape, sub-base material, cover material and initial vegetation.

Refugia	Areas of natural ecosystems within, or adjacent to, a development area from which plants or animals may move back into the development area, or to which animals may move from the development area.
Regeneration	The natural or artificial process of establishing young trees.
Rejects	Hard clusters of clays or lean oil sands that do not pass sizing screens in the extraction process and are rejected. Rejects contain residual bitumen and account for a portion of extraction recovery loss.
Relative Abundance	The proportional representation of a species in a sample or a community.
Remote Sensing	Measurement of some property of an object or surface by means other than direct contact; usually refers to the gathering of scientific information about the earth's surface from great heights and over broad areas, using instruments mounted on aircraft or satellites.
Replicate	Duplicate analyses of an individual sample. Replicate analyses are used for measuring precision in quality control.
Reproductive success	The production of healthy offspring which live to reproduce themselves.
RfD (Reference Dose)	The maximum recommended daily exposure for a non-carcinogenic chemical exhibiting a threshold (highly nonlinear) dose-response based on the NOAEL determined for the chemical from human and/or animals studies and the use of an appropriate uncertainty factor.
Richness	The number of species in a biological community (e.g., habitat).
Riffle Habitat	Shallow rapids where the water flows swiftly over completely or partially submerged materials to produce surface agitation.
Riparian Area	A geographic area containing an aquatic ecosystem and adjacent upland areas that directly affect it.
Risk	The likelihood or probability that the toxic effects associated with a chemical or physical agent will be produced in populations of individuals under their actual conditions of exposure. Risk is usually expressed as the probability of occurrence of an adverse effect, i.e., the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to the factor. Risk is expressed as a fraction without units and takes values from 0 (absolute certainty that there is no risk, which can never be shown) to 1.0, where there is absolute certainty that a risk will occur.

Risk Analysis Quantification of predictions of magnitudes and probabilities of potential impacts on the health of people, wildlife and/or aquatic biota that might arise from exposure to chemicals originating from a study area.

Risk Assessment Process that evaluates the probability of adverse effects that may occur, or are occurring on target organism(s) as a result of exposure to one or more stressors.

Risk Characterization The process of evaluating the potential risk to a receptor based on comparison of the estimated exposure to the toxicity reference value.

Risk Management The managerial, decision-making and active hazard control process used to deal with those environmental agents for which risk evaluation has indicated the risk is too high.

Risk-Based Concentration (RBC) Concentration in environmental media below which health risks are not expected to occur.

Robust Landscape Landscape with either an capability to self-correct after extreme events or one with hazard triggers reducing with time.

RsD (Risk Specific Dose) The exposure limit determined for chemicals assumed to act as genotoxic, non-threshold carcinogens. An RsD is a function of carcinogenic potency (q_1^*) and defined acceptable risk (i.e., q_1^* , target level of risk); for example, the RsD for a lifetime cancer risk of one-in-one-million would equal q_1^*, 1×10^{-6}.

Run Habitat Areas of swiftly flowing water, without surface waves, that approximate uniform flow and in which the slope of water surface is roughly parallel to the overall gradient of the stream reach.

Run-off The portion of water from rain and snow which flows over land to streams, ponds or other surface water bodies. It is the portion of water from precipitation which does not infiltrate into the ground, or evaporate.

Run-on Essentially the same as runoff, but referring to water that flows onto a property, or any piece of land of interest. Includes only those waters that have not been in contact with exposed oil sands, or with oil sands operational areas.

Runoff The portion of water from rain and snow that flows over land to streams, ponds or other surface waterbodies. It is the portion of water from precipitation that does not infiltrate into the ground, or evaporate.

Sanitary Can Specific design of metal can also known as an open topped can. Typically consists of a lapped or locked side seam and rolled or crimped lip. Invented in 1896.

Saturation Percentage Percent water content where the soil is completely saturated with water.

Scale Level of spatial resolution.

Screening The process of filtering and removal of implausible or unlikely exposure pathways, chemicals or substances, or populations from the risk assessment process to focus the analysis on the chemicals, pathways and populations of greatest concern.

Secondary Extraction In this step, bitumen froth from the primary extraction step is diluted with light hydrocarbon, and water and fine solids are removed by centrifuges in two stages.

Sediment Sampling A field procedure relating to a method for determining the configuration of sediments.

Sedimentation The process of subsidence and deposition of suspended matter carried by water, wastewater or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Sensory disturbance Visual, auditory, or olfactory stimulus which creates a negative response in wildlife species.

Separation Cells Large, cylindrical open-top vessels which are used as the primary extraction device in the hot water extraction process. Bitumen is recovered from the top of the vessel (as well as from a sidestream in a secondary circuit). Tailings are removed from the bottom.

Shell Shell Canada Limited

Silviculture The science and practice of controlling the establishment, composition and growth of the vegetation in forest stands. It includes the control or production of stand structures such as snags and down logs, in addition to live vegetation.

Site [Human Health] The area determined to be significantly impacted after the iterative evaluations of the risk assessment. Can also be applied to political or legal boundaries.

Site [Historic] Any location with detectable evidence of past human activity.

Slumps Small shallow slope failure involving relocation of surficial soil on a slope without risk to the overall stability the facility.

Snag Any standing dead, or partially-dead tree.

Snye Discrete section on non-flowing water connected to a flowing channel only at its downstream end, generally formed in a side channel or behind a peninsula (bar).

Sodium Adsorption Ratio (SAR)	Concentrations of sodium, calcium and magnesium ions in a solution.
Soil Structure	The combination or arrangement of primary soil particles into secondary particles, units or peds.
Spawning Habitat	A particular type of area where a fish species chooses to reproduce. Preferred habitat (substrate, water flow, temperature) varies from species to species.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species abundance	The number of individuals of a particular species within a biological community (e.g., habitat).
Species Composition	A term that refers to the species found in the sampling area.
Species Distribution	Where the various species in an ecosystem are found at any given time. Species distribution varies with season.
Species Diversity	A description of a biological community that includes both the number of different species and their relative abundances. Provides a measure of the variation in number of species in a region. This variation depends partly on the variety of habitats and the variety of resources within habitats and, in part, on the degree of specialization to particular habitats and resources.
Species Richness	The number of different species occupying a given area.
Sport/Game Fish	Large fish caught for food or sport (e.g., northern pike, Arctic grayling).
Stability	A measure of the atmosphere's ability to disperse emissions. Stable atmospheric conditions create poorer dispersion of plumes and increased concentrations. Unstable conditions promote dispersion and result in lower concentrations.
Stand	An aggregation of trees occupying a specific area and sufficiently uniform in composition, age, arrangement and condition so that it is distinguishable from trees in adjoining areas.
Stand Age	The number of years since a stand experienced a stand-replacing disturbance event (e.g., fire, logging).
Stand Density	The number and size of trees on a forest site.
Standard Deviation (Sd)	A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.

Stratigraphy	The succession and age of strata of rock and unconsolidated material. Also concerns the form, distribution, lithologic composition, fossil content and other properties of the strata.
Strip Mining	Mining method in which overburden is first removed from a seam of coal, or a sedimentary ore such as oil sands, allowing the coal or ore to be removed.
Structure (Stand Structure)	The various horizontal and vertical physical elements of the forest. The physical appearance of canopy and subcanopy trees and snags, shrub and herbaceous strata and downed woody material.
Subchronic toxicity	Adverse effects occurring as a result of the repeated daily exposure to a chemical for a short time. In Canada, human exposures lasting between two weeks and three months may be termed subchronic while in the U.S., human exposures lasting between two weeks and seven years may be termed subchronic.
Succession	A series of dynamic changes by which one group of organisms succeeds another through stages leading to a climax community.
Successional Stage	A stage or recognizable condition of a forest community that occurs during its development from bare ground to climax.
Suncor	Suncor Energy Inc., Oil Sands (also Suncor Inc., Oil Sands Group)
Surficial Aquifer	A surficial deposit containing water considered an aquifer.
Surficial Deposit	A geologic deposit (clay, silt or sand) that has been placed above bedrock. (See also "Overburden")
Suspended Sediments	Particles of matter suspended in the water. Measured as the oven dry weight of the solids, in mg/L, after filtration through a standard filter paper. Less than 25 mg/L would be considered clean water, while an extremely muddy river might have 200 mg/L of suspended sediments.
Sustainable Landscape	Ability of landscape (including landforms, drainage, water bodies and vegetation) to survive extreme events and natural cycles of change, without causing accelerated erosion and environmental impacts much more severe than that of the natural environment.
Syncrude	Syncrude Canada Ltd.
Tailings	A byproduct of oil sands extraction which are comprised of water, sands and clays, with minor amounts of residual bitumen.
Tailings Ponds	Man-made impoundment structures required to contain tailings. Tailings ponds are enclosed dykes made with tailings and/or overburden materials to stringent geotechnical standards.
TDS	Total dissolved solids.

Thalweg	The (imaginary) line connecting the lowest points along a streambed or valley. Within rivers, the deep channel area.
THC	Total Hydrocarbons include all airborne compounds containing only carbon and hydrogen.
TID	Tar Island Dyke.
Till	Sediments laid down by glaciers.
TOC	Total Organic Carbon. TOC is composed of both dissolved and particulate forms. TOC is often calculated as the difference between total carbon (TC) and total inorganic carbon (TIC). TOC has a direct relationship with both biochemical and chemical oxygen demands, and varies with the composition of organic matter present in the water. Organic matter in soils, aquatic vegetation and aquatic organisms are major sources of organic carbon.
Total Dissolved Solids (TDS)	The total concentration of all dissolved compounds solids found in a water sample. See filterable residue.
Toxic	A substance, dose or concentration that is harmful to a living organism.
Toxic Threshold	Almost all compounds (except genotoxic carcinogens) become toxic at some level with no evident harm or adverse effect below that level. Scientists refer to the level or concentration where they can first see evidence for an adverse effect on an organism as the toxic threshold. Genotoxic carcinogens exhibit some toxic potential at any level.
Toxicity	The inherent potential or capacity of a material to cause adverse effects in a living organism.
Toxicity Assessment	The process of determining the amount (concentration or dose) of a chemical to which a receptor may be exposed without the development of adverse effects.
Toxicity Reference Value (TRV)	For a non-carcinogenic chemical, the maximum acceptable dose (per unit body weight and unit of time) of a chemical to which a specified receptor can be exposed, without the development of adverse effects. For a carcinogenic chemical, the maximum acceptable dose of a chemical to which a receptor can be exposed, assuming a specified risk (e.g., 1 in 100,000). May be expressed as a Reference Dose (RfD) for non-carcinogenic (threshold-response) chemicals or as a Risk Specific Dose (RsD) for carcinogenic (non-threshold response) chemicals. Also referred to as exposure limit.
TSP	A measure of the total particulate matter suspended in the air. This represents all airborne particles with a mean diameter less than 30 μm (microns) in diameter.
TSS	Total suspended solids. See non-filterable residue.

U.S. EPA U.S. Environmental Protection Agency.

Uncertainty Imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution.

Uncertainty Factor A unitless numerical value that is applied to a reference toxicological value (i.e., NOAEL) to account for uncertainties in the experimental data used to derive the toxicological value (e.g., short testing period, lack of species diversity, small test group, etc.) and to increase the confidence in the safety of the exposure dose as it applies to species other than the test species (e.g., sensitive individuals in the human population). RfD equals the NOAEL divided by the uncertainty factor.

Unconfined Aquifer An aquifer in which the water level is below the top of the aquifer.

Understory Those trees or other vegetation in a forest stand below the main canopy level.

Upgraded Crude Oil Often referred to as synthetic oil, upgraded crude oil is bitumen that has undergone alteration to improve its hydrogen-carbon balance to a lighter specific gravity product. At Suncor upgraded crude oil products may include:

- Oil Sands A, a blend of low sulphur (hydrotreated) naphtha, kerosene and gas oil
- Oil Sands Diesel, hydrotreated kerosene
- Oil Sands E, a sour (higher sulphur) blend of coker distillate
- Oil Sand Virgin, an uncracked vacuum tower product

Uptake The process by which a chemical crosses an absorption barrier and is absorbed into the body.

Valued Ecosystem Component (VEC) Components of an ecosystem (either plant, animal, or abiotic feature) considered valuable by various sectors of the public.

Vegetation Community See "Plant Community".

VOC Volatile Organic Compounds include aldehydes and all of the hydrocarbons except for ethane and methane. VOCs represent the airborne organic compounds likely to undergo or have a role in the chemical transformation of pollutants in the atmosphere.

Waste Area The area where overburden materials are placed that are surplus to the need of the mine. Also referred to as a "waste dump".

Water Equivalent	As relating to snow; the depth of water that would result from melting.
Water Table	The shallowest saturated ground below ground level - technically, that surface of a body of unconfined groundwater in which the pressure is equal to atmospheric pressure.
Watershed	The entire surface drainage area that contributes water to a lake or river.
Wet Landscape Reclamation	A reclamation approach that involves a lake system, whereby contained fluid tailings are capped with a layer of water of sufficient depth to isolate fine tailings from direct contact with the surrounding environment.
Wetlands	Term for a broad group of wet habitats. Wetlands are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands include features that are permanently wet, or intermittently water-covered such as swamps, marshes, bogs, muskegs, potholes, swales, glades, slashes and overflow land of river valleys.
Worst-Case	A semi-quantitative term referring to the maximum possible exposure, dose or risk, that can conceivably occur, whether or not this exposure, dose, or risk actually occurs is observed in a specific population. It should refer to a hypothetical situation in which everything that can plausibly happen to maximize exposure, dose, or risk does happen. The worst-case may occur in a given population, but since it is usually a very unlikely set of circumstances in most cases, a worst-case estimate will be somewhat higher than what occurs in a specific population.
WSC	Water Survey of Canada
Xeric	Referring to habitats in which plant production is limited by availability of water.
YOY	Young of the year. Fish at age 0, within the first year after hatching.