Golder Associates Ltd.

10th Floor, 940 6th Avenue S.W.
Calgary, Alberta, Canada T2P 3T1
Telephone (403) 299-5600
Fax (403) 299-5606

Golder Associates

REPORT ON

ECOLOGICAL LAND CLASSIFICATION (ELC) BASELINE FOR PROJECT MILLENNIUM

Submitted to:
Suncor Energy Inc., Oils Sands

972-2205

Golder Associates Ltd.

10th Floor, 940 6th Avenue S.W.
Calgary, Alberta, Canada T2P 3T1
Telephone (403) 299-5600
Fax (403) 299-5606

April 27, 1998

Proj. No. 972-2205

Mr. Martin Holysh
Senior Environmental Specialist
Sustainable Development
Suncor Energy Inc., Oil Sands
P.O. Box 4001
Fort McMurray, AB
T3H 3E3

RE: Final Report on the Ecological Land Classification Baseline for Project Millennium

Dear Martin:

Attached are five copies of the Ecological Land Classification Baseline Conditions for Project Millennium.

The objective of the Ecological Land Classification (ELC) is to provide an integrated and comprehensive land classification scheme of the project area so that landscape, soil, vegetation, and drainage conditions can be evaluated at a variety of scales and levels of complexity. The ELC approach involves categorizing and delineating areas of land and water having similar characteristic combinations of physical environment and biological communities.

If you have any additional questions about the report, please contact either Veronica Chisholm at 299-8920 or me at 299-5640.

Yours very truly,

GOLDER ASSOCIATES LTD.

John R. Gulley, M.Sc., P. Biol.
Oil Sands Project Director

attachments (5)

R:\1997\2200\972-2205\5000\SUN0427C.DOC

EXECUTIVE SUMMARY

This document details the Ecological Land Classification (ELC) within the Local and Regional Study Areas for Suncor's Project Millennium (the Project) in support of an Environmental Impact Assessment. An Ecological Land Classification is an approach to categorizing and delineating, at different levels of resolution, areas of land and water having similar characteristic combinations of physical environment (such as geomorphic processes, geology, soil and hydrologic function) and biological communities (plant, animals and microorganisms). At the broadest or landscape level of classification, five macroterrain units (Athabasca Floodplain, Athabasca Escarpment, Steepbank Escarpment, Steepbank Organic Plain and Steepbank Upland) were identified from the terrain mapping. These units were divided into mineral and organic soils, and finally, delineated on the basis of ecosite phase (Athabasca Escarpment/mineral soil/low-bush cranberry trembling aspen dominated).

The objective of the ELC was to provide an integrated and comprehensive land classification scheme of the Project area so that landscape, soil, vegetation and drainage conditions could 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 and in reclamation planning and monitoring following mine closure.

TABLE OF CONTENTS

SECTION **PAGE**

1. INTRODUCTION 1

1.1 STUDY AREAS 2
1.1.1 Local Study Area 2
1.1.2 Regional Study Area 4

2. METHODS 6

2.1 ECOLOGICAL LAND CLASSIFICATION 6

2.2 MAPPING 6

2.3 BIODIVERSITY 8
2.3.1 Composition 8
2.3.2 Structure 9
2.3.2.1 Patch Size 9
2.3.2.2 Patch Shape 9

3. RESULTS 11

3.1 TERRAIN 11

3.2 SOILS 11

3.3 VEGETATION 12

3.4 ECOLOGICAL LAND CLASSIFICATION UNITS 14
3.4.1 Athabasca Floodplain 16
3.4.2 Athabasca Escarpment 19
3.4.3 Steepbank Escarpment 20
3.4.4 Steepbank Organic Plain 22
3.4.5 Steepbank Upland 22

3.5 BIODIVERSITY 24
3.5.1 Landscape Level Biodiversity 24
3.5.2 Composition 25
3.5.3 Structural Biodiversity 25
3.5.4 ELC Unit Richness and Diversity 25
3.5.5 Species Level Richness, Diversity, Rare Plants and Old Growth Forests For ELC units 26
3.5.5.1 ELC Unit Size (Patch Size) 27
3.5.5.2 Patch Shape 29
3.5.6 Functional Diversity 31

4. CLOSURE 32

4.1 REFERENCES 33

LIST OF TABLES

Table 1	Biodiversity Assessment	10
Table 2	Terrain Units in the Project Millennium LSA	12
Table 3	Soil Series Areas in the Project Millennium LSA	12
Table 4	Ecosite Phases Represented in the Millennium Project LSA	14
Table 5	Macroterrain Units Found Within the LSA	15
Table 6	Ecological Land Classification Units for the Athabasca Floodplain Macroterrain	19
Table 7	Ecological Land Classification Units for the Athabasca Escarpment Macroterrain	20
Table 8	Ecological Land Classification Units for the Steepbank Escarpment Macroterrain	21
Table 9	Ecological Land Classification Units for the Steepbank Organic Plain Macroterrain	23
Table 10	Ecological Land Classification Units for the Steepbank Upland Macroterrain	24
Table 11	Macroterrain Biodiversity Measures at the Landscape Scale in the LSA	25
Table 12	ELC Richness and Diversity Indices	26
Table 13	Number of ELC Patches	26
Table 14	Summary of Species Level Richness, Diversity, Rare Plants and Old Growth Forests	28
Table 15	Mean, Minimum and MaximumELC Polygon Patch Size	29
Table 16	Mean, Minimum and Maximum Patch Shape for Macroterrain Units	29
Table 17	Mean, Minimum and Maximum Patch Shape for ELC Units	30

LIST OF FIGURES

Figure 1	Terrestrial Local Study Area	3
Figure 2	Regional Study Area	5
Figure 3	Orthophotograph	7
Figure 4	Project Millennium Macroterrain Classification	17
Figure 5	Project Millennium Ecological Land Classification	18

1. INTRODUCTION

An Ecological Land Classification (ELC) is an approach to categorizing and delineating, at different levels of resolution, areas of land and water 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 Provincial Ecoregions of Alberta map at 1:1,000,000 scale.

The development of the Project will have impacts on ELCs at the landscape, plant community and plant species levels. An ELC provides a geographical basis for assessment because in the ELC approach there is a strong emphasis on physical attributes. ELC units are based on landforms, which represent permanent features of the landscape (e.g., Athabasca Escarpment). Because vegetation cover, for example, can change in relatively short periods, units that are based solely on vegetation can be quite ephemeral and are therefore less useful for predicting land use capability and land use suitability values following mine closure.

There are four reasons the ELC uses landforms to define basic units:

- landforms represent permanent features that do not change with seasons, logging or fire;
- landforms are integral part of any ecosystem, often providing movement corridors for wildlife;
- landforms can be defined at various scales and sites; and
- landforms are easily identified areas on aerial photo.

The objective of the ELC component is to provide an integrated and 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 units 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: rare plants, richness, diversity, patch size and patch shape to assess how unique or rare ELC units are. It does not profess to provide the "final answer" on biodiversity but rather attempts to merely quantify the baseline parameters measured. The levels for measuring biodiversity are based on a hierarchy similar to that of the ELC. 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."

The purpose of this report is to describe the ELC units identified in the LSA. This report will provide a summary of the terrain, soil, vegetation and wetland resources as they pertain to the ELC. More detailed information on these resources are described in the baseline Soils and Terrain (Golder 1998a), baseline Terrestrial Vegetation (Golder 1998b), and baseline Wetlands (Golder 1998c) Reports.

1.1 STUDY AREAS

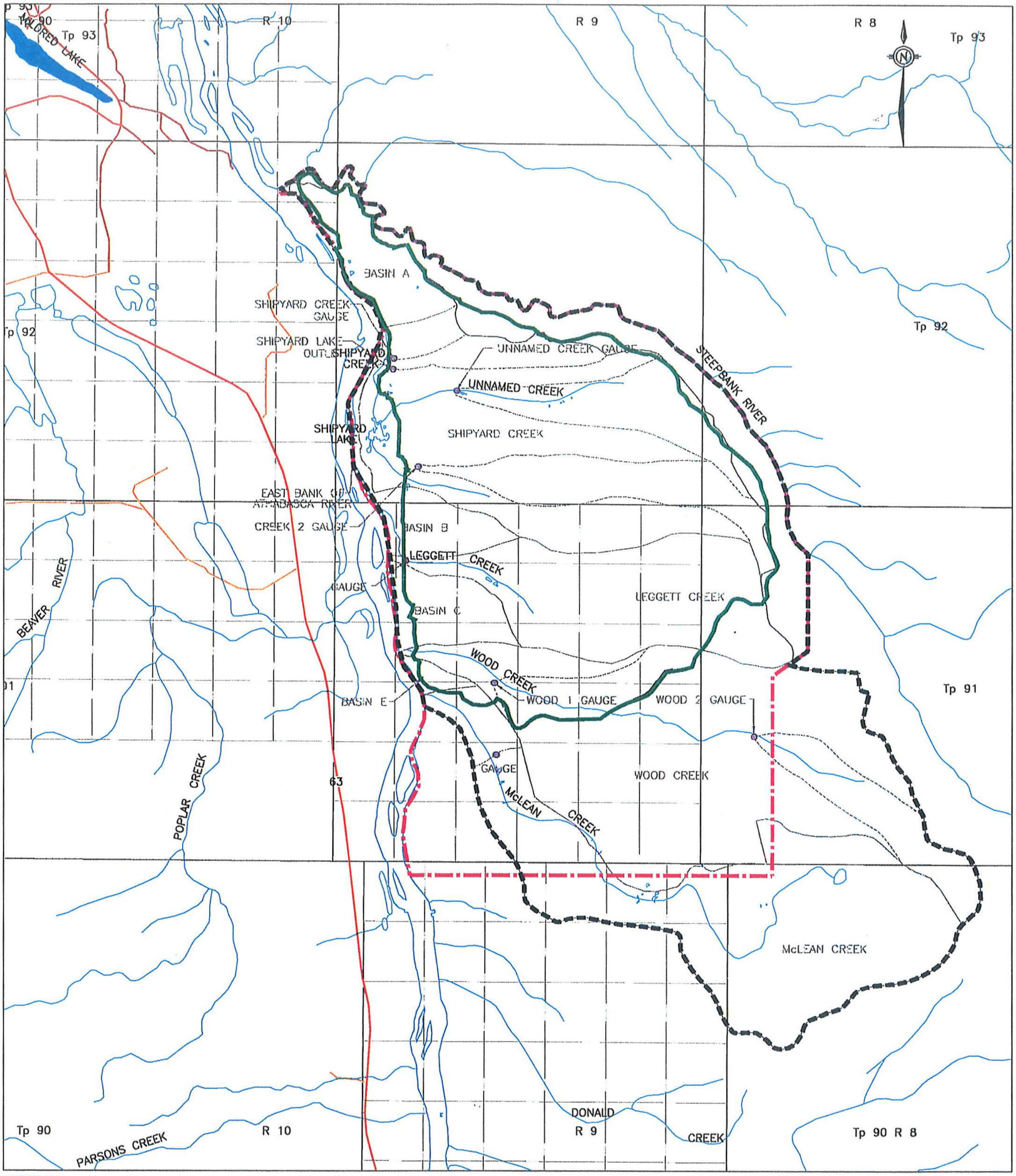
1.1.1 Local Study Area

The Local Study Area (LSA) is located approximately 30 km from the community of Fort McMurray east of the Athabasca River (Figure 1). The LSA, which is bordered to the north and east by the Steepbank River, occupies an area of 16,181 ha.

The LSA is located in the Central Mixedwood Natural Subregion (AEP 1994), referred to as the Boreal Mixedwood Ecoregion in 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 that often contain large trees which 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 trees that size 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 that are the most abundant in the Boreal region of Alberta (Halsey and Vitt 1996)]. These wetlands are characterized by extensive areas with complexes of non-permafrost wooded

J:\1997\2205\7550\TERRESTL.dwg



LEGEND

- EAST BANK MINING AREA
- LOCAL DRAINAGE BASIN
- LOCAL DRAINAGE SUB BASIN
- LOCAL BASIN GAUGE
- LOCAL STUDY AREA FOR TERRESTRIAL AND ARCHEAOLOGY
- LOCAL STUDY AREA FOR HYDROLOGY, HYDROGEOLOGY, WATER QUALITY AND AQUATICS

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

SUNCOR ENERGY

Project Millennium
Taking Suncor into the 21st Century

TERRESTRIAL LOCAL STUDY AREA FOR PROJECT MILLENNIUM

23 Mar. 1998	Figure 1	DRAWN BY: CG

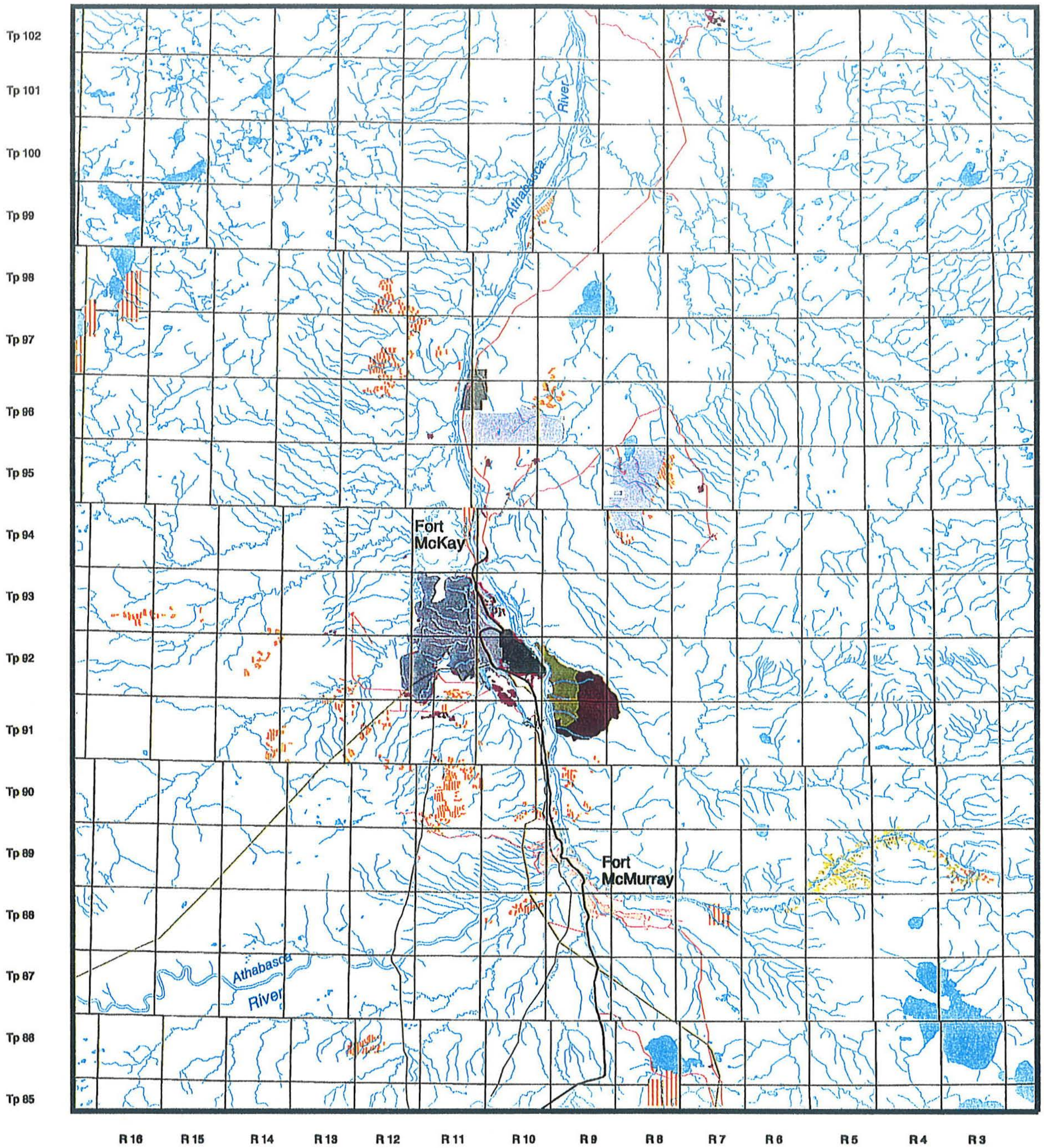
fens and wooded bogs. The dominant tree species in these areas are black spruce and tamarack.

1.1.2 Regional Study Area

The Regional Study Area (RSA) occupies an area of 2,428,645 ha (Figure 2). This area is predominantly situated within the Central Mixedwood Natural Subregion referred by Beckingham and Archibald (1996) as the Boreal Mixedwood Ecological Area. Both Boreal Highlands and Subarctic Natural Subregions are represented in the northeast portion of the RSA, in the Birch Mountains area.

The Boreal Highlands is situated on the slopes of the Birch Mountains, while the Subarctic Ecoregion extends along the plateau of the mountains. 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 moister summer conditions may promote more white spruce relative to trembling 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 occuring on better-drained upland sites.



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Golder

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Highway
- Secondary Roads
- Pipelines
- Power Lines
- Open Water
- Municipalities
- Suncor Lease 86/17
- Suncor Steepbank Mine
- Project Millennium
- Syncrude Mildred Lake
- Aurora Mines
- SOLV-EX
- Northstar Energy
- Cutblocks (recent)
- Cutblocks (reforested)
- Other Disturbances
- Indian Reserves

N

SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA

22 Apr. 1998	Figure 2	PRODUCED BY: K.K.O. REVIEWED BY:

/data14/suncor/regional/9700/9710/arcview/devels.apr

2. METHODS

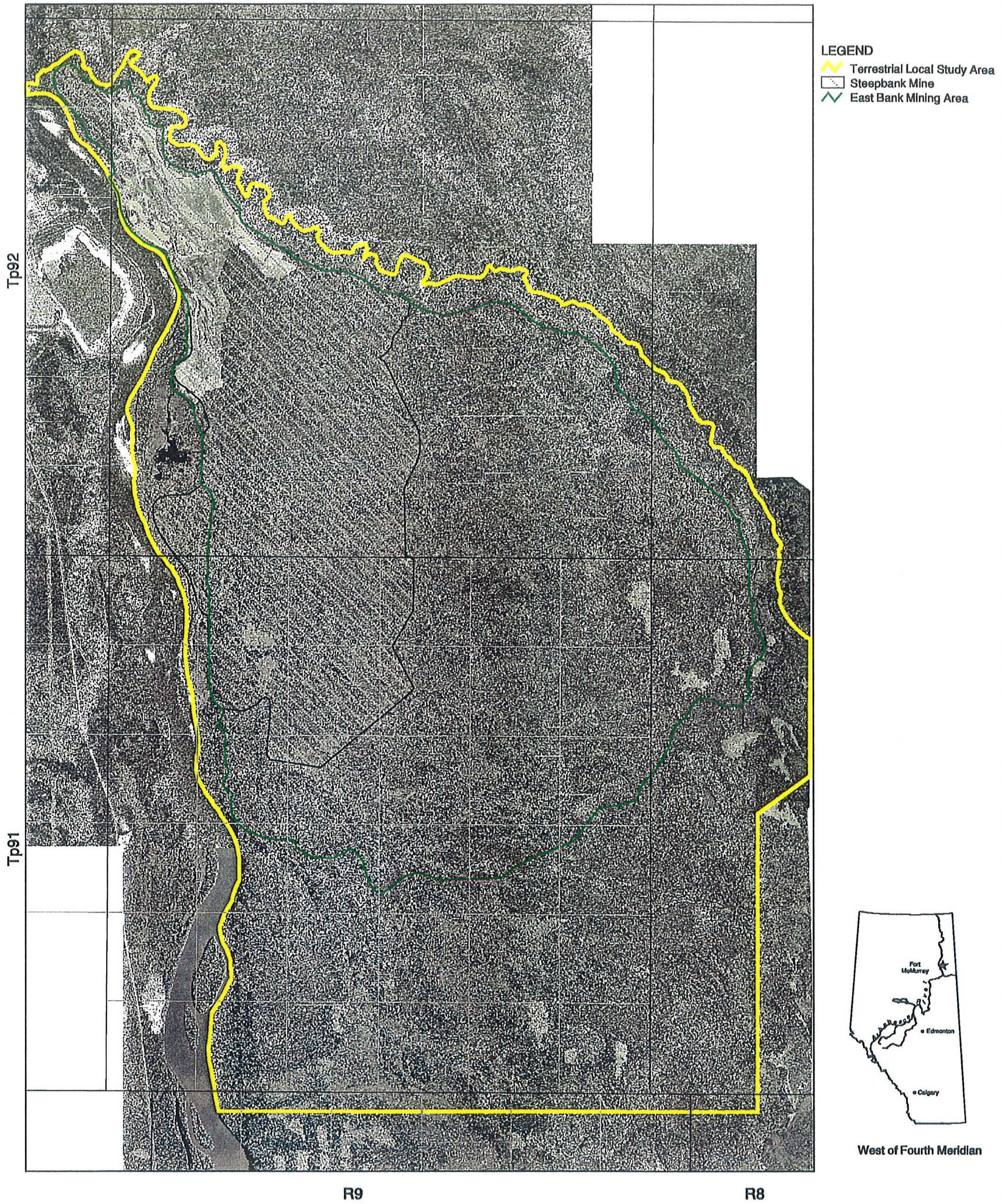
2.1 ECOLOGICAL LAND CLASSIFICATION

An ecological land classification (ELC) was utilized within both the LSA and 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 (e.g., Athabasca Escarpment). Boundaries of macroterrain units were based on terrain units described in the Soils and Terrain baseline report (Golder 1998a). The second level of classification was to link soil, vegetation and wetlands attributes to each macroterrain unit. Soil was classified either as mineral or organic as described in the Canadian Soil Classification System (Agriculture Canada 1983) and Alberta Soil Names File (RRTAC 1993). The vegetation was described to the ecosite phase (Beckingham and Archibald 1996) and wetlands were classified according to the Alberta Wetland Inventory (Halsey and Vitt 1996). An ELC unit is expressed according to its macroterrain, soil type and ecosite phase or wetlands class. For example, within the Athabasca Escarpment on mineral soil, low bush cranberry-trembling aspen (ATE/M/d1) is a dominant unit on steep slopes.

2.2 MAPPING

Macroterrain, terrain, soil, vegetation and wetlands were mapped on 1:20,000 black and white aerial photographs. These features were transferred to a 1:20,000 orthophotograph (Figure 3). A database of macroterrain, soil, vegetation and wetlands links each map polygon within a geographical information system (GIS) system. Within the GIS system, the relative abundance of ELC units is expressed in hectares and as percentages of the LSA.

Map delineations were chosen to correspond with recognizable landscapes, slopes, elevation and modifying landform processes. Ecological classes were also identified as part of the ELC process. These classes were distinguished based on homogeneity of terrain, soil and vegetation as well as features that perform vital ecological functions in the region, such as movement corridors for wildlife.



N

1000 0 1000 2000 3000

Metres

Scale 1:100,000

SOURCES: Suncor
Golder
UMA Geomatics

Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA ORTHOPHOTO

08 Apr. 1998	Figure 3	PRODUCED BY: JS REVIEWED BY:

/data14/suncor/local/9700/9701/arcview/old_growth.apr

2.3 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 analysis of ecological diversity within the LSA. These measurements can be used as a reference point for future monitoring and to assess the relative reclamation success on the reclaimed landforms. According to the literature, a description of ecological diversity 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 or levels of biodiversity that should be included:

- landscape (i.e., macroterrain)
- plant communities (i.e., ELC, ecosite phases, wetlands)
- species (i.e., rare plants, species richness, diversity)
- genes

In addition, each scale of biodiversity can be described in terms of its levels of:

- composition
- structure
- function

2.3.1 Composition

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.

Ecological diversity indices measured included the following:

- richness, expressed as the number of species or ELC units present;
- diversity, which is calculated using the Shannon Diversity Index;
- rare plants present;
- patch size; and

- patch shape.

This Shannon Index is used to provide a further assessment of species and community richness. It is not intended to be used as a definitive measurement of ecological diversity but rather to provide a reference point for monitoring reclamation success. The Shannon 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*.

2.3.2 Structure

2.3.2.1 Patch Size

Measurements of patch size and patch shape will provide some indication of the natural variability in size and shape 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 patches of habitats that influence, for example, the distribution, abundance and movement of wildlife (Wildlife Baseline Report; Golder 1998e). Patch size refers to the size or shape of a landform, ELC unit, ecosite phase or stand.

2.3.2.2 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:

$$\text{Shape index} = \text{perimeter} / [\ 2 \times (\text{area} \times \text{perimeter})^{0.5}\ ]$$

Table 1 outlines the scale, level indices and measures of assessment for assessing biodiversity. Biodiversity has been evaluated for the Project at the landscape scale for ELC units in the LSA. The Project Millennium baseline Terrestrial Vegetation (Golder 1998b) and baseline Wetlands

(Golder 1998c) reports discuss biodiversity at the plant community and species scale. Impacts to diversity at the species scale are only discussed conceptually since it is difficult to determine how species composition and structure will change. Discussion of genetic scale biodiversity is beyond the scope of this EIA.

Biodiversity indices were developed for: ELC richness, plant community richness, wetland richness, patch size, patch shape, rare plant potential, species richness and diversity (Shannon Index).

Table 1 Biodiversity Assessment

Scale	Level	Indices	Measures of Assessment
Landscape (ELC Section)	Composition	Richness • number of macroterrain units Diversity • macroterrain	 decrease = loss in biodiversity decrease = loss in biodiversity
	Structure	Patch size (macroterrain) • mean • range (min-max) Patch Shape • mean • range (min-max)	 increase/decrease = change in biodiversity decrease = loss in biodiversity increase/decrease = change in biodiversity 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 biodiversity decrease = loss of biodiversity
	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 biodiversity decrease = loss in biodiversity
Species	Composition	Species Richness and Diversity Rare Plants	
	Structural	Richness in Layers Diversity in Layers	

3. RESULTS

As stated previously, the ELC is an integration of terrain, soil, vegetation and wetlands features to describe spatially distinct ELC units. The following section provides a summary of each of the terrestrial resources which forms the framework for the ELC.

3.1 TERRAIN

Terrain analysis was based on integrating data from: the soil map units, Alberta Vegetation Inventory (AVI) map units, a digital elevation model of the LSA with a 2 m contour interval and the composition of the surficial deposits. Upon review and analysis of these components, the initial terrain amalgamation was derived by combining soil units with similar parent materials; for example, all the soil units developed on glaciofluvial deposits were merged to produce larger units with similar morphological and mechanical properties. A detailed description of the terrain units is included in the Soils and Terrain Baseline Report (Golder 1998a).

It is important to note that there are differences between bogs and fens classified in the terrain system and those identified according to the AWI. The differences are mainly based on soil versus vegetation distinctions. For the purposes of the ELC, wetlands identified according to the AWI system (Halsey and Vitt 1996) were incorporated into the ELC.

Due to the complexity of the LSA, broad terrain or macroterrain units were developed. These macroterrain units were delineated based on predominant terrain unit, elevation, slope and modifying landform processes. Macroterrain units were named after known geographical regions in the LSA and RSA. There are five macroterrain units - Athabasca Floodplain, Athabasca Escarpment, Steepbank Escarpment, Steepbank Organic Plain and Steepbank Upland. Ten general terrain units are identified within the macroterrain units. The areas of terrain units in the LSA is shown in Table 2.

3.2 SOILS

Two major classes of soils are found in the LSA, those developed in organic deposits and those which have formed from mineral parent materials. Organic order soils include the McLelland and Muskeg series of the Mesisolic great group. Mineral soils include Bitumount and Steepbank series of the Gleysolic order; Kinosis of the Luvisolic order; Mildred of the Brunisolic order and McMurray series of the Regosolic order (Agriculture Canada 1983; Alberta Soil Advisory Committee 1987). The distribution of the soil series is detailed in Golder (1998a). The area of each soil series is presented in Table 3.

Table 2 **Area of Terrain Units in the Project Millennium LSA**

Terrain Unit	LSA	
	(ha)	%
Bog (B)	316	2
Shallow Bog (Bs)	3,671	23
Bogs, total	**3,988**	**25**
Fen (N)	1,531	9
Shallow Fen (Ns)	3,037	19
Fens, total	**4,568**	**28**
Fluvial (F)	784	5
Glaciofluvial (Fg)	36	<1
Glaciofluvial (Fg1)	217	1
Glaciofluvial (Fg2)	1,462	9
Morainal/Till (Mor/T)	3,086	19
Rough Broken (RB)	1,898	12
Total Area of Terrain Units	**7,483**	**46**
Disturbed Lands (AIH, AIM, CIP, CIW) [a]	22	<1
Water (NWR, NWL) [a]	120	1
Total Area, Other Features	**142**	**1**
Total Area in LSA	**16,181**	**100**

[a] AIH, AIM, CIP, CIW, NWR and NWL are spatial features that occur within the Project area, but are not terrain units; the abbreviations used are AVI codes.

Table 3 **Soil Series Areas in the Project Millennium LSA**

Soil Series	LSA	
	(ha)	%
Bitumount	65	<1
Kinosis	3,086	19
McMurray	784	5
Mildred	188	1
McLelland	4,568	28
Rough Broken 2	1,158	7
Rough Broken 3	740	5
Muskeg	3,988	25
Steepbank	1,462	9
Disturbed Land	22	<1
Water	120	1
Total	**16,181**	**100**

3.3 VEGETATION

The preliminary delineation of the vegetation communities was based on the AVI polygons that were reclassified following the Beckingham and

Archibald (1996) Field Guide to Ecosites of Northern Alberta. The classification system is based on a hierarchical system where ecosite ELC units are determined from the nutrient and moisture regimes (e.g., medium, mesic) and ecosite phase ELC units are determined by the dominant tree species, or tallest vegetation layer (e.g., trembling aspen). The subdivision of plant community types is based on the understory species composition and abundance (e.g., low-bush cranberry).

In the LSA, 14 ecosite phases are found, including: lichen-jack pine; blueberry-jack pine-trembling aspen; blueberry trembling aspen-white birch; blueberry-trembling aspen-white spruce; blueberry white spruce-jack pine; Labrador tea-mesic-jack pine-black spruce; low-bush cranberry-trembling aspen; low-bush cranberry trembling aspen-white spruce; low-bush cranberry white spruce; dogwood-balsam poplar-trembling aspen; dogwood-balsam poplar-white spruce; dogwood-white spruce; Labrador tea-subhygric-black spruce jack pine; and Labrador tea-horsetail-white spruce-black spruce. These are described fully in the Terrestrial Vegetation Baseline report for the Millennium Project (Golder 1998b). For the purposes of this report, the wetlands classes were not utilized in this assessment, rather the Alberta Wetlands classification was used. The area and percent coverage of the ecosite phases is presented in Table 4. The most widely occurring ecosite phase is low-bush cranberry-trembling aspen at 21% or 3,348 ha of the LSA.

The Alberta Wetland classification system (Halsey and Vitt 1996) uses variables that are distinguishable on aerial photographs to classify wetlands. The Alberta Wetland Inventory (AWI) classification system was developed by Linda Halsey and Dale Vitt using similar classes to those developed by the National Wetlands Working Group NWWG (1988). However, the subdivision of these 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. Approximately 14 of all the possible combinations typically occur in Alberta. In the LSA, there are 12 wetlands classes occur, including: forested bog; wooded bogs; forested fens; wooded fens; shrubby fens; graminoid fens; forested swamps; wooded swamps; shrubby swamps; shruby marshes; graminoid marshes; and shallow open water. Areas of wetlands occuring in the LSA are also presented in Table 4. Wetlands collectively occupy 9,992 ha or 61.7% of the LSA with wooded fen alone occupying 37%.

There are three vegetation units - black spruce-tamarack, shrublands, and grassland regeneration in cutblocks that could not be classified to ecosite phase or wetlands. These vegetation classes occupy less than 1% of the LSA.

Table 4 Ecosite Phases Represented in the Millennium Project LSA

Ecosite Phase	Map Code	LSA	
		ha	%
Lichen Pj	a1	1	0
Blueberry Pj-Aw	b1	226	1
Blueberry Aw(Bw)	b2	28	0
Blueberry Aw-Sw	b3	60	0
Blueberry Sw-Pj	b4	50	0
Labrador Tea-mesic Pj-Sb	c1	1	0
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	0
Dogwood Sw	e3	127	1
Labrador Tea-subhygric Sb-Pj	g1	1	0
Labrador Tea/Horsetail Sw-Sb	h1	59	0
Forested Bog	BFNN	26	0
Wooded Bog	BTNN	20	0
Forested Fen	FFNN	966	6
Wooded Fen	FTNN	6,010	37
Graminoid Fen	FONG	4	<1
Shrubby Fen	FONS	426	3
Graminoid Marsh	MONG	107	1
Shrubby Marsh	MONS	211	1
Forested Swamp	SFNN	687	4
Shrubby Swamp	SONS	161	1
Wooded Swamp	STNN	1,359	8
Shallow Open Water	WONN	15	<1
Black Spruce/ Tamarack	Sb/Lt	20	<1
Shrub	Shrub	131	1
Regeneration cutblocks (Graminoid)	HG/CC	170	1
Disturbed Land	AIG,AIH,CIP,CIW	22	<1
Cutbank	NMC	33	<1
Sand	NMS	1	<1
Flooded	NWF	6	<1
Lake	NWL	20	<1
River	NWR	79	<1
Total		**16,181**	**100**

3.4 ECOLOGICAL LAND CLASSIFICATION UNITS

The Ecological Land Classes are presented in Table 5. These classes represent the integration of terrain, soil, vegetation and wetlands units described in the proceeding sections. These five units include: Athabasca

Table 5 Macroterrain Units Found Within the LSA

Macroterrain	Area ha	% of LSA	Dominant Terrain Units	Soil Unit	Vegetation Unit	% Cover	Wetlands Unit	% Cover
Athabasca	691	4	Fluvial (97%)	Mineral	b1	2	FTNN	1
Floodplain (ATF)				(98%)	d1	9	MONG	11
					d2	1	MONS	6
					d3	11	SONS	17
				Organic	e1	19	STNN	4
				(2%)	e2	3		
					e3	7		
					shrub	7		
Athabasca	2,307	14	Rough	Mineral	a1	<1	FTNN	2
Escarpment (ATE)			Broken	(95%)	b1	3	MONG	<1
			(67%)		b2	1	MONS	<1
					b3	2	SFNN	<1
				Organic	b4	1	SONS	1
			Morainal/Till	(5%)	d1	62	STNN	3
			(24%)		d2	4		
					d3	13		
					e1	2		
					e2	1		
					e3	1		
					h1	1		
					shrub	2		
Steepbank	1,135	7	Morainal/Till	Mineral	b1	5	FONS	<1
Escarpment (STE)			(40%)	(97%)	b3	2	FTNN	4
					b4	<1	SFNN	<1
					d1	49	STNN	<1
			Rough	Organic	d2	19		
			Broken	(3%)	d3	11		
			(30%)		e1	3		
					e2	1		
					e3	2		
					h1	<1		
Steepbank	9,201	57	Shallow fens	Mineral	b1	<1	BTNN	<1
Organic Plain			(32%)	(11%)	b4	<1	FFNN	10
(STOP)					d1	1	FONG	<1
					d2	<1	FONS	5
			Fens (17%)	Organic	d3	1	FTNN	63
				(89%)	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	2,707	17	Morainal/Till	Mineral	b1	2	BFNN	1
(STU)			(72%)	(91%)	b3	<1	BTNN	<1
					d1	46	FFNN	1
					d2	10	FONS	<1
			Glaciofluvial	Organic	d3	14	FTNN	6
			(15%)	(9%)	e1	<1	MONS	<1
					e2	<1	SFNN	4
					e3	1	SONS	<1
					h1	1	STNN	8
					shrub	<1		

Floodplain, Athabasca Escarpment, Steepbank Escarpment, Steepbank Organic Plain and Steepbank Upland. Due to the complexity of the terrain, five broadly based terrain or macroterrain units were developed. The units were named according to known geographic regions in the LSA. Each macroterrain is composed of dominant terrain types, mineral and organic soil with associated ecosite phases or wetlands. The macroterrain is presented in Figure 4 and a description of each macroterrain unit is provided in the following sections. Figure 5 shows the ELC units represented in the LSA.

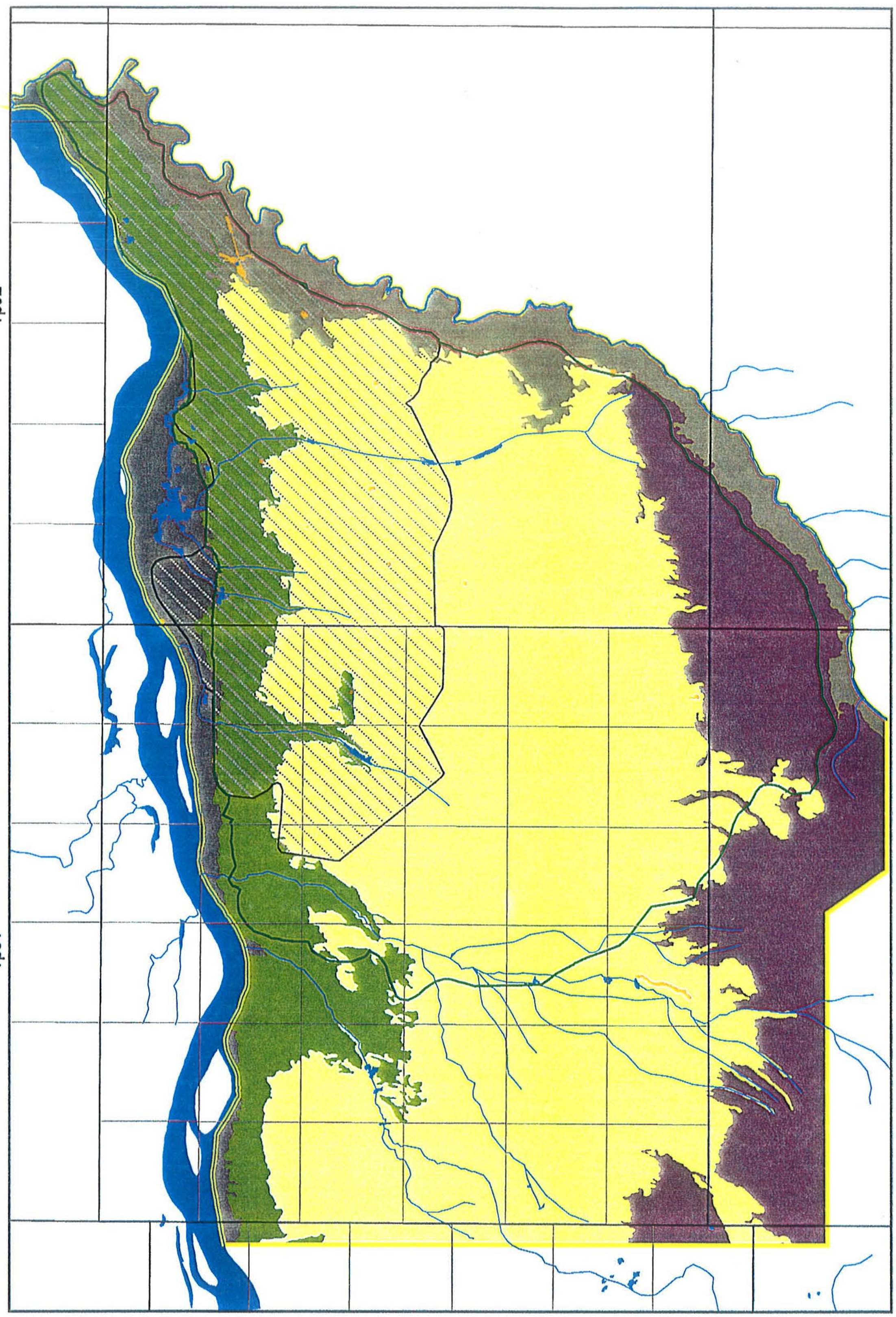
3.4.1 Athabasca Floodplain

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%.

As expected in a floodplain, the terrain is dominated by unconsolidated fluvial material (97% of the ATF) deposited by periodic flooding and lateral migration of the river channel. Accordingly, the floodplain is dominated by regosols (mineral) of the McMurray series (97%). Regosols are thin, immature soils which develops on newly deposited unconsolidated deposits that are typical of floodplains.

The ELC units are shown in Table 6. There are 17 ELC units in the Athabasca Floodplain. The ATF is a mixture of both upland (53%) and wetlands vegetation (47%) communities. Upland areas are dominated by the dogwood (e) and low-bush cranberry (d) ecosites; specifically, dogwood balsam poplar-trembling aspen (e1, 19% of the ATF), low-bush cranberry white spruce (d3, 11% of the ATF), low-bush cranberry trembling aspen (d1, 9% of the ATF) and dogwood white spruce (e3, 7% of the ATF) and shrub (7% of the ATF). Wetlands communities are dominantly shrubby swamp (SONS, 17% of the ATF) graminoid marsh (MONG, 11% of the ATF) and shrubby marsh (MONS, 6% of the ATF).

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 Forestry Resources Baseline Report (Golder 1998d). 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 Mine 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%).



West of Fourth Meridian

N

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

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

Map Projection: UTM 12
Datum: NAD 83

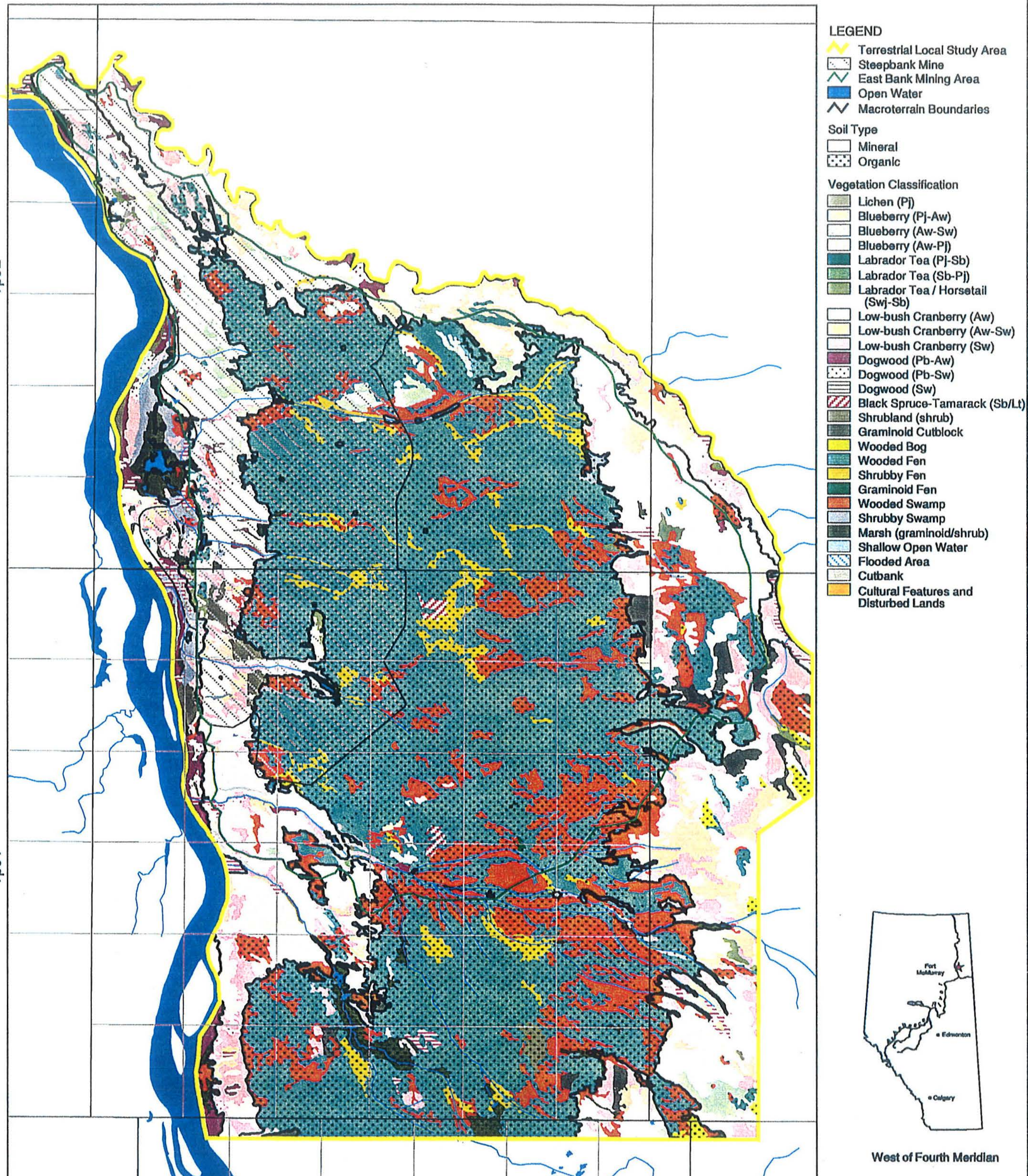
SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
MACROTERRAIN CLASSIFICATION

22 Apr. 1998	Figure 4	PRODUCED BY: JS REVIEWED BY:

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



/data14/suncor/local/9700/9701/arcview/lsa_elc.apr

N

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

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

Map Projection: UTM 12
Datum: NAD 83

SUNCOR ENERGY

Project Millennium

LOCAL STUDY AREA
ECOLOGICAL LAND CLASSIFICATION

22 Apr. 1998

Figure 5

PRODUCED BY: JS
REVIEWED BY:

Table 6 **Ecological Land Classification Units for the Athabasca Floodplain Macroterrain**

ELC Unit	Pre-development ha	% Athabasca Floodplain
ATF/M/b1	15	2
ATF/M/d1	65	9
ATF/M/d2	8	1
ATF/M/d3	74	11
ATF/M/e1	134	19
ATF/M/e2	22	3
ATF/M/e3	51	7
ATF/M/FTNN	4	1
ATF/M/MONG	78	11
ATF/M/MONS	30	4
ATF/M/NMS	1	<1
ATF/M/Shrub	45	7
ATF/M/SONS	121	17
ATF/M/STNN	25	4
ATF/O/FTNN	1	<1
ATF/O/MONS	14	2
ATF/O/STNN	3	<1
Total	**691**	**100**

3.4.2 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 (0-27%), 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 (RB2, RB3, occupy 67% of the ATE unit). In addition, the poorly developed regosols of the McMurray series occupy 21% of the ATE unit.

The 26 ELC units for the Athabasca Escarpment are presented in Table 7. Low-bush cranberry-trembling aspen (d1) and low-bush cranberry-white spruce are the most dominant ecosite phases occurring on the escarpment; respectively occupying 1,425 ha or 62% and 307 ha or 13% of the LSA. All other ecosite phases, which are upland phases, occupy less than 5% of the unit area.

The Athabasca Escarpment, supports some white spruce-dominant, old growth forest (age of stand >160 years). There is also one small stand of trembling aspen-dominated, old growth (age of stand >100 years) on the crest of the escarpment. The escarpment also 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 would not be merchantable because of the relatively steep slopes.

Table 7 Ecological Land Classification Units for the Athabasca Escarpment Macroterrain

ELC Unit	Pre-development	
	ha	% Athabasca Escarpment
ATE/M/a1	1	<1
ATE/M/b1	67	3
ATE/M/b2	28	1
ATE/M/b3	36	2
ATE/M/b4	32	1
ATE/M/d1	1,425	62
ATE/M/d2	83	4
ATE/M/d3	307	13
ATE/M/e1	36	2
ATE/M/e2	23	1
ATE/M/e3	18	1
ATE/M/FTNN	3	<1
ATE/M/h1	21	1
ATE/M/HG/CC	12	1
ATE/M/MONS	4	<1
ATE/M/NMC	15	1
ATE/M/SFNN	3	<1
ATE/M/Shrub	55	2
ATE/M/SONS	9	<1
ATE/M/STNN	21	1
ATE/O/FTNN	41	2
ATE/O/MONG	7	<1
ATE/O/MONS	2	<1
ATE/O/SFNN	8	<1
ATE/O/SONS	6	<1
ATE/O/STNN	43	2
Total	**2,307**	**100**

3.4.3 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 (0-29%), with an average slope of about 5%. This area is dominated by rough broken terrain units which are characterized by steep, eroding slopes occupying 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 (39% of the STE) as well as rough broken types (RB2, 16% of the STE; RB3, 15% of the STE). Both these soil types support upland ecosite phases.

The 18 ELC units within the Steepbank Escarpment are presented in Table 8. The Steepbank Escarpment is dominated by upland ecosite phases, specifically low-bush cranberry-trembling aspen (d1, 49% of the STE), low-bush cranberry-trembling aspen-white spruce (d2, 19% of the STEP) and low-bush cranberry white spruce (d3, 11% of the STE). 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).

Table 8 Ecological Land Classification Units for the Steepbank Escarpment Macroterrain

ELC Unit	Pre-development	
	ha	% Steepbank Escarpment
STE/M/b1	53	5
STE/M/b3	20	2
STE/M/b4	4	0
STE/M/d1	556	49
STE/M/d2	215	19
STE/M/d3	127	11
STE/M/e1	37	3
STE/M/e2	15	1
STE/M/e3	26	2
STE/M/FTNN	20	2
STE/M/h1	2	0
STE/M/HG/CC	1	0
STE/M/NMC	19	2
STE/M/STNN	5	0
STE/O/FONS	4	0
STE/O/FTNN	28	2
STE/O/SFNN	2	0
STE/O/STNN	1	
Total	**1,135**	**100**

3.4.4 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 (37% of the STOP), fens (17% of the STOP) and shallow fens (32% of the STOP). Overlying soils are organic, with the mildred (49% of the STOP) and muskeg soils (37% of the STOP) dominating the unit.

The ELC units associated with the STOP are presented in Table 9. There are 32 ELC units. The STOP is dominated by wetlands vegetation types (98% of the STOP). 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, 1,047 ha or 11% STOP) and forested swamp (SFNN, 278 ha or 6% of the STOP). Differences in the distribution of fen and bog types between the terrain and vegetation is a result of differences in the classification methodology employed.

No old growth forests were documented within this macroterrain unit. The majority, 5,513 ha or 60%, of the STOP has been classified as unproductive timber.

3.4.5 Steepbank Upland

The Steepbank Upland (STU) is 2,707 ha or 14% 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 luvisols of the kinosis series dominant (72% of the STU).

Table 9 **Ecological Land Classification Units for the Steepbank Organic Plain Macroterrain**

ELC Unit	Pre-development ha	Pre-development % Steepbank Organic Plain
STOP/M/b1	33	<1
STOP/M/b4	14	<1
STOP/M/c1	1	<1
STOP/M/d1	47	1
STOP/M/d2	3	<1
STOP/M/d3	61	1
STOP/M/e1	3	<1
STOP/M/e2	2	<1
STOP/M/e3	12	<1
STOP/M/FFNN	67	1
STOP/M/FONS	14	<1
STOP/M/FTNN	289	3
STOP/M/g1	1	<1
STOP/M/h1	4	<1
STOP/M/HG/CC	6	<1
STOP/M/Sb/Lt	11	<1
STOP/M/SFNN	118	1
STOP/M/Shrub	3	<1
STOP/M/STNN	381	4
STOP/O/BTNN	12	<1
STOP/O/FFNN	881	10
STOP/O/FONG	4	<1
STOP/O/FONS	404	4
STOP/O/FTNN	5,463	59
STOP/O/HG/CC	12	<1
STOP/O/MONG	21	<1
STOP/O/MONS	151	2
STOP/O/Sb/Lt	9	<1
STOP/O/SFNN	461	5
STOP/O/Shrub	24	<1
STOP/O/SONS	19	<1
STOP/O/STNN	667	7
Total	**9,201**	**100**

The ELC units associated with the STOP are presented in Table 10. There are 26 ELC units. The Steepbank upland is dominated by upland ecosite phases, specifically low-bush cranberry-trembling aspen (d1, 46% of the STE), low-bush cranberry trembling aspen-white spruce (d2, 10% of the STEP) and low-bush cranberry white spruce (d3, 14% of the STE). 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 (DL, 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.

Table 10 Ecological Land Classification Units for the Steepbank Upland Macroterrain

ELC Unit	Pre-development	
	ha	% Steepbank Upland
STU/M/b1	58	2
STU/M/b3	3	<1
STU/M/d1	1,255	46
STU/M/d2	279	10
STU/M/d3	372	14
STU/M/e1	2	<1
STU/M/e2	1	<1
STU/M/e3	21	1
STU/M/FONS	2	<1
STU/M/FTNN	33	1
STU/M/h1	32	1
STU/M/HG/CC	139	5
STU/M/MONS	6	<1
STU/M/SFNN	86	3
STU/M/Shrub	4	<1
STU/M/SONS	3	<1
STU/M/STNN	145	5
STU/O/BFNN	26	1
STU/O/BTNN	8	<1
STU/O/FFNN	18	1
STU/O/FONS	1	<1
STU/O/FTNN	128	5
STU/O/MONS	4	<1
STU/O/SFNN	10	<1
STU/O/SONS	3	<1
STU/O/STNN	68	3
Total	**2,707**	**100**

3.5 BIODIVERSITY

Biodiversity has been evaluated in this section at the landscape and community level scale for both macroterrain and ELC units. The Terrestrial Vegetation (Golder 1998b) and Wetlands (Golder 1998c) baseline reports discuss biodiversity at the plant community and species scale.

Biodiversity indices were developed for: richness, community richness, community diversity (Shannon Index), patch size and patch shape.

3.5.1 Landscape Level Biodiversity

The use of landscape or macroterrain units as a framework for the setting of landscape scale biodiversity 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 4). The macroterrain richness in the LSA is 5. The size of the macroterrain ranges from 63 ha to 769 ha.

3.5.2 Composition

Species 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 11). There are 5 macroterrain units in the LSA with an overall diversity of 0.54 which suggests that there is a disproportionate distribution of macroterrain units.

Table 11 Macroterrain Biodiversity Measures at the Landscape Scale in the LSA

Measures	Pre-Development
Richness	5 types
Shannon Index	0.54
Shape	2.16

3.5.3 Structural Biodiversity

The landscape level structural biodiversity 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.

3.5.4 ELC Unit Richness and Diversity

The number of ELC units represented in the LSA are presented in Table 12. Patch number and size provided an assessment of structural changes in biodiversity 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 has 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.

Table 12 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 13 shows the number of ELC unit patches or polygons associated with each macroterrain unit. 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.

Table 13 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**

3.5.5 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 14. The Terrestrial Vegetation (Golder 1998b) and Wetlands (Golder 1998c) baseline reports provides a full description of richness, diversity, rare plants and old growth forests in the LSA. Table 14, however, provides this species level information as it relates to ELC units. Not all ELC units within the LSA were surveyed in the field. Low-bush cranberry aspen (d1) on mineral soils, was sampled within the Athabasca Escarpment, Steepbank Escarpment Steepbank Upland and the Steepbank Organic Plain. There are differences in the range of species richness and diversity based on macroterrain location. In addition, only the Athabasca Escarpment ELC unit supported a rare plant (wool-grass). Old growth aspen-dominant forests were restricted to the escarpments and upland. For the data collected it appears that the spatial location and macroterrain influenced some of the parameters measured. This information is useful on determining the most suitable areas for assessing plant diversity on reclaimed landforms.

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.

3.5.5.1 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 15. 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.

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 (Figure 5). Steepbank Escarpment is 1,135 ha with ELC units that range from <1 to 265 ha, with a mean of 7 ha. The Athabasca Escarpment is 2,307 ha in size. The ELC unit patches range from <1 to 265 ha, with a mean size of 265 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 (Figure 5).

Table 14 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-lily [(a)]	
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.

Table 15 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

3.5.5.2 Patch Shape

Table 16 and Table 17 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 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).

Table 16 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 17 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

The mean shape index of the Athabasca Floodplain is 2.73, which indicates relatively high ecotonal area but less than the Athabasca Escarpment (Table 16). 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 5.88 with a mean of 2.45 (Table 17). This indicates that the majority of ELC patches are irregular in shape.

The Athabasca Escarpment includes both the 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 1.03 to 6.56 with a mean of 2.04 (Table 17).

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. The mean shape index of the Steepbank Escarpment is 2.68, which indicates higher ecotonal area than the STOP but less than the Athabasca Escarpment. The mean shape index for the Steepbank Upland is 3.15 (Table 16). 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 1.04 to 12.39 with a mean of 2.17 (Table 17).

The Steepbank Upland has a mean shape of 3.15 (Table 16). The ELC unit patches range in shape from 1.03 to 6.56, with a mean of 2.04 (Table 17). The macroterrain is irregularly shaped due to the transitional nature from lowland to upland.

3.5.6 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 1998e). 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.

4.1 REFERENCES

Alberta Environment Protection (AEP). 1994. Natural Regions and Subregions of Alberta: Summary. Public. # I/531, Environ. Protection, Edmonton, 18 pp. plus map sheet.

AEP. 1998. Final Terms of Reference for the Proposed Suncor Energy Inc. Project Millennium. Alberta Environmental Protection, Edmonton, March 4, 1998.

Agriculture Canada. 1983. The Canadian Soil Information System (CanSIS), Manual for Describing Soils in the Field (1982 revised). Compiled by Working Group on Soil Survey Data, Canada Expert Committee on Soil Survey, Research Branch-Agriculture Canada, Ottawa, LRRI Contrib. #82-52, 97 pp. plus appendices.

Agriculture Canada Expert Committee on Soil Survey. 1987. The Canadian System of Soil Classification. 2nd ed. Agric. Can. Publ. 1646. 164 pp.

Alberta Soil Advisory Committee. 1987. Soil Quality Criteria Relative to Disturbance and Reclamation (Revised). Prepared by the Soil Quality Criteria Working Group, Soil Reclamation Subcommittee, Alberta Soils Advisory Committee, Alberta Agriculture, Edmonton, 56 pp.

Art, H.W. 1993. The Dictionary of Ecology and Environmental Science. Henry Holt and Company. New York, U.S.A.

Beckingham, J.D. and J.H. Archibald. 1996. Field Guide to Ecosites of Northern Alberta. Northern Forestry Centre, Forestry Canada, Northwest Region. Edmonton, Alberta. Spec. Rep. 5.

Golder (Golder Associates Ltd.). 1998a. Soils and Terrain Baseline for Project Millennium. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

Golder. 1998b. Terrestrial Vegetation Baseline for Project Millennium. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

Golder. 1998c. Wetlands Baseline for Project Millennium. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

Golder. 1998d. Forestry Resources (AVI) Baseline for Project Millennium. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

Golder. 1998e. Wildlife Baseline Conditions for Project Millennium. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

Halsey, L., and D.H. Vitt. 1996. Alberta Wetland Inventory Standards - Version 1.0. *In* Nesby, R. (ed.). Alberta Vegetation Inventory Standards Manual. 1997. Alberta Environmental Protection Resource Data Division.

Iacobelli, T., K. Kavanaugh and S. Rowe. 1995. A Protected Areas Gap Analysis Methodology: Planning for the Conservation of Biodiversity. World Wildlife Fund, Canada. Toronto, ON.

Noss, R.F. and A.Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Island Press. Washington, DC.

NWWG (National Wetlands Working Group). 1988. Wetlands of Canada. Ecological Land Classification Series No. 24. Sustainable Development Branch. Environment Canada. Ottawa, Ontario.

RRTAC. 1993. Soil Series Information for Reclamation Planning in Alberta, Vols. 1 and 2. Report RRTAC 93-7. Prepared for Alberta Conservation and Reclamation Council (Reclamation Research Technical Advisory Committee - RRTAC). By Pedocan Land Evaluation Ltd., Edmonton.

Strong, W.L. 1992. Ecoregions and Ecodistricts of Alberta. Alberta Forestry Lands and Wildlife. Edmonton, Alberta. Publication No. T1244.