APPENDIX C

Ref: H-065

Biophysical Description of Soils (Soil Inventory) within the FMA of Tolko Industries Ltd. (High Level)

Prepared as a draft copy for Tolko Industries Ltd development of the Integrated Detailed Forest Management Plan

Prepared by Eco-West Environmental Services Ltd

September, 2001

Table of Contents:

Introduction:

The landscape of north-west Alberta shows an interesting geological history. The general dynamics of the area can be mostly attributed to the Pleistocene glaciations which initiated their advance 30,000 years ago (Matthews, 1979 and Lindsay et.al., 1958). These massive walls of ice, up to one mile thick scoured the highlands and deposited the till into the vast valley basins below. These glacial deposits are up to 150 metres thick within some areas of the FMA. As well as moving the rock from place to place, the scouring action also exposed different formational layers (Interpreted from Green 1972 and Pawlowicz and Fenton, 1995).

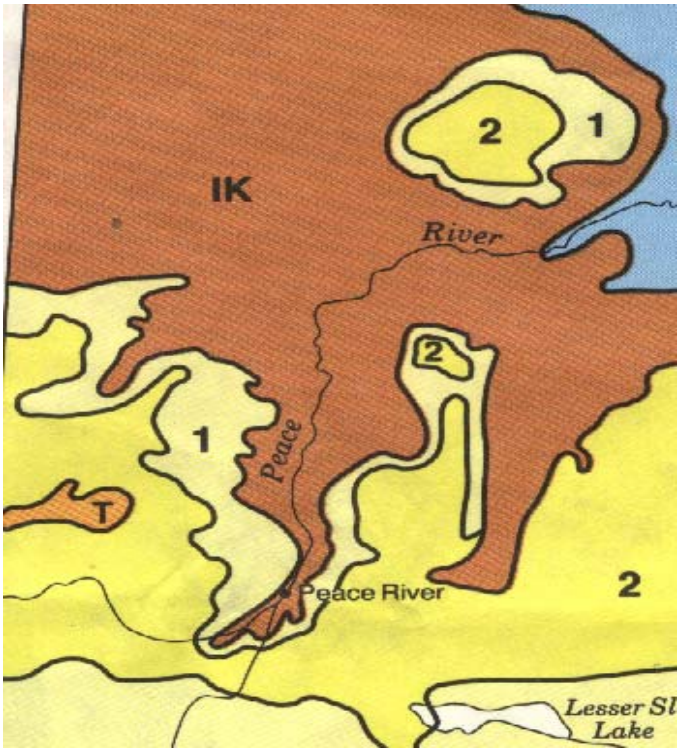


Figure 1: Bedrock Geology, Green 1972. Taken from Physiographic Subdivisions of Alberta. Land Reasearch Center, Research Branch, Agriculture Canada, Ottawa, 1986.

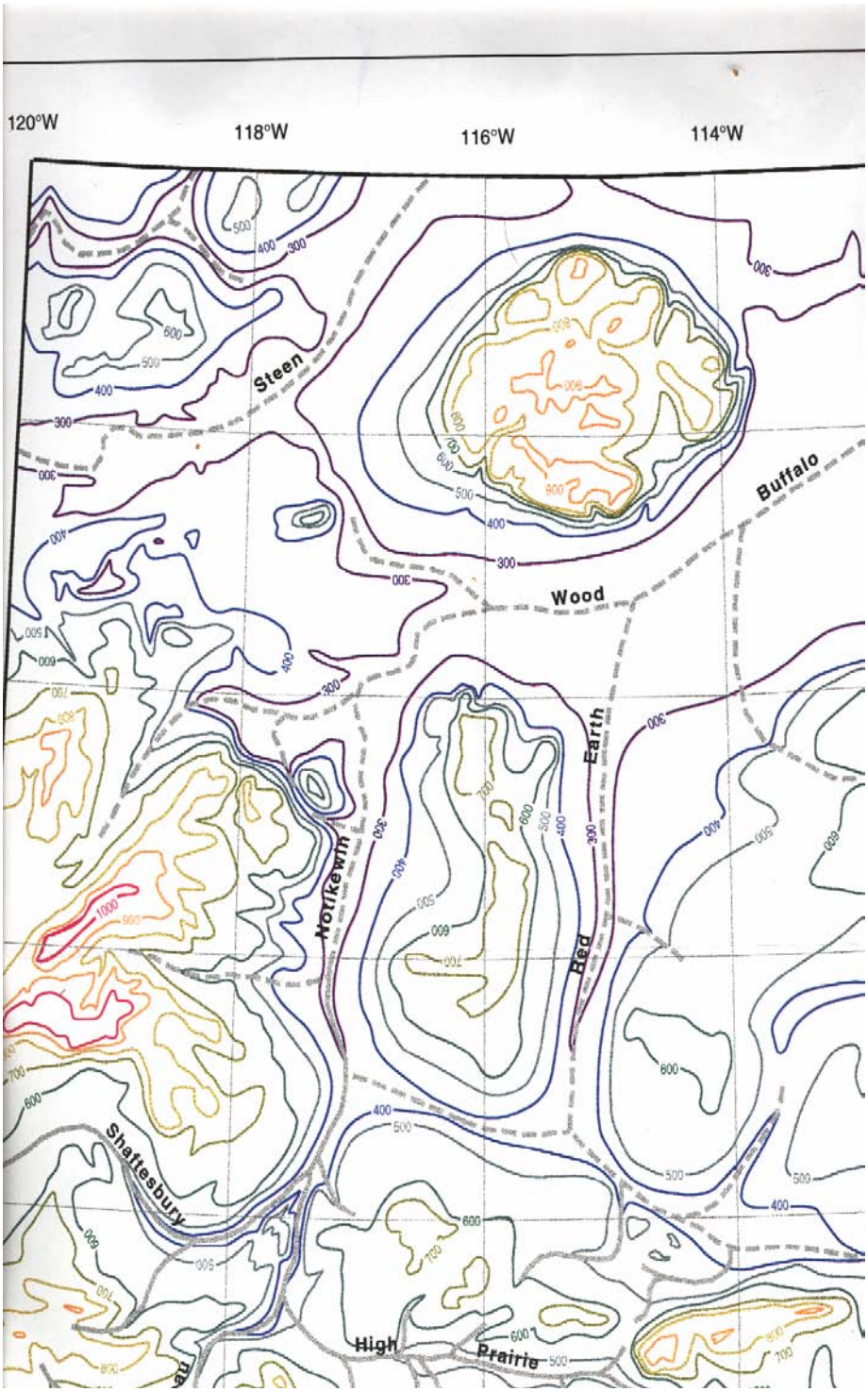


Figure 2: Bedrock Topography of North-west Alberta. Modified from Bedrock Topography of Alberta, compiled by J.G. Pawlowicz and M.M. Fenton. Alberta Geological Survey. Map 226, August 1995.

Although parent structure is a large determinant of soil composition and development, it is temperature, moisture, and overlying vegetation which have the most influence (Canada Soil Survey Committee, 1977) Although many different forms of soils can be found in the area, it is dominated by just a few types, to be discussed later.

The soil descriptions for the area have been modified in large part from the Exploratory Soil Survey, conducted in the late fifties and early sixties (Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report. Research Council of Alberta. Edmonton, 1958). Tolko's FMA resides entirely within map-sheet 84. More specifically, the area covered is 84-E, 84-F, 84-G, 84-J, 84-K,84-L, 84-M, and 84-N. This translates to a square that occupies 57degrees North latitude to 60 degrees North latitude and 114 degrees West latitude to 120 degrees West latitude. The reduced scale of these maps allows for more specific analysis of the area.

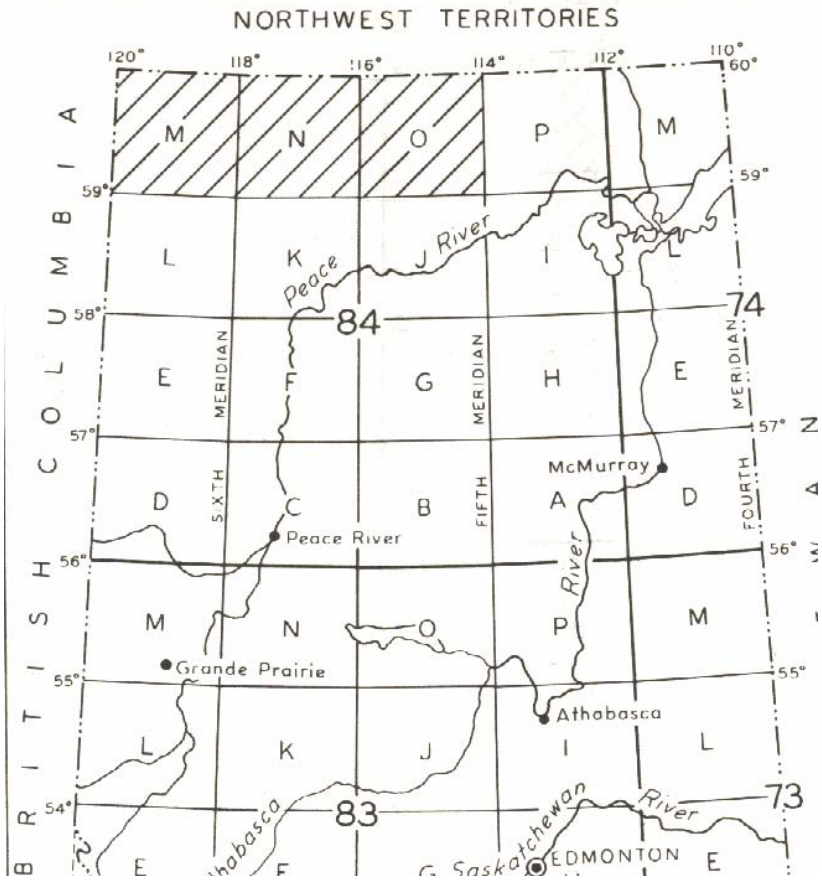


Figure 3: Map Sheets of Northern Alberta Modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report. Research Council of Alberta. Edmonton, 1958

Each map has specific information written directly on each of the maps, along with soil composition.

Each number written directly on the map has three sections:

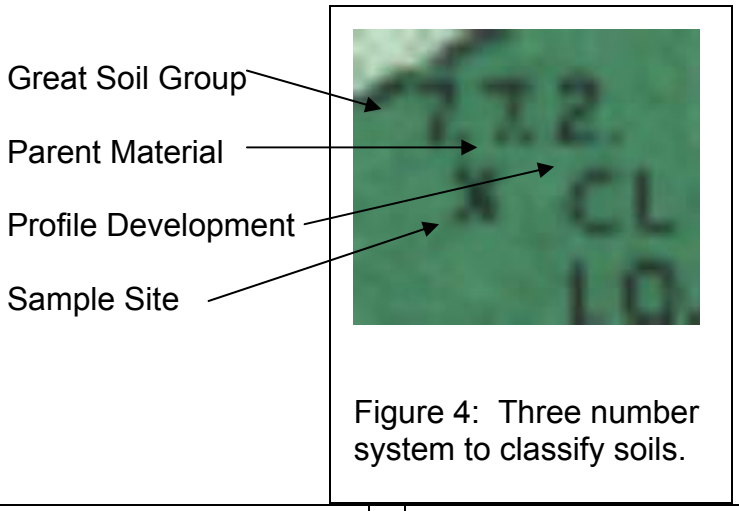


Figure 4: Three number system to classify soils.

#	Great Soil		Parent Material		Profile Development
0					Little Development
1			Modified Residual		Hillside Soils
2			Glacial Till		Modal Soils
3			Reworked Till		Depression (non-saline)
4	Black		Gravelly Outwash		Saline or alkaline
5	Degraded Black		Alluvial (Water-sorted)		Saline
6	Brown Wooded		Alluvial/Aeolian (stone-free)		Solonetz
7	Grey Wooded		Lacustrine		High lime to surface
8	Podzol-Grey Wooded				
9	Podzol				

Table 1: Great soil groups (To assign number, read left to right, and assign one number per group. Ex. A grey wooded soil made from lacustrine material, with depressional profile development would be classified 7.7.3)

One last note of importance is the incorporation of topographical information with each map. Since soil is quite dependent on amount of moisture, a visualization of this topography is incorporated so that drainage information may be inferred.

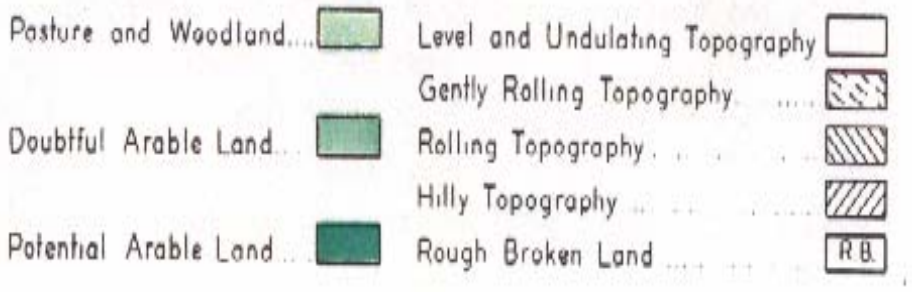


Figure 5: Legend for maps associated with the Alberta Soil Survey.

Each map sheet is broken down into similar areas so that the map has precise sample points resulting in a generalized area map. These areas are described below the map, describing the common group and parent materials.

When information was available, percentage of land base was evaluated as to widespread occurances, such as moss bogs.

MapSheet 84-G

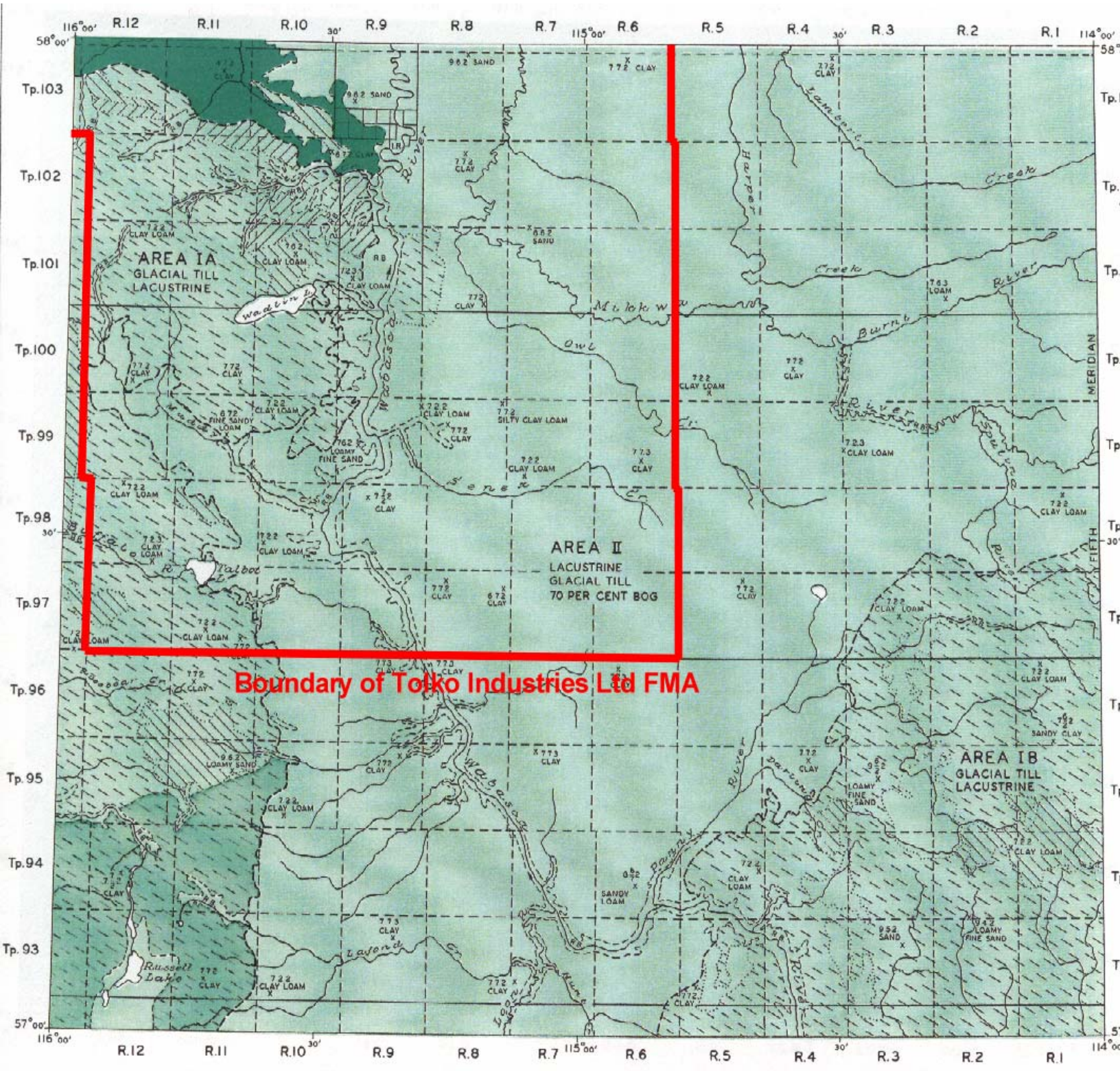


Figure 6: Map sheet 84-G Modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report. Research Council of Alberta. Edmonton, 1958

Map Sheet 84-G

AREA I

Area I comprises approximately 50% of Tolko Industries Ltd FMA area in Map sheet G (34% of this entire map sheet area). This area is typified by gently rolling to rolling hills> Generally the soils are grey wooded and have originated from glacial till. Morainal material is evident in some areas. Although it is limited there are small occurances of lacustrine material, podzol soils, and podzol-grey soils.

AREA II

Area II comprises the remaining 66% of the map sheet, and the remaining 50% of Tolko Industries Ltd FMA area. Topography in the area is level to depressional. Vast bogs cover this area, which historically was a glacial laking basin, producing lacustrine clay and silty clay. Due to the numerous varients in draingage systems, there are both grey wooded and brown wooded soils contained within this area.

Map Sheet 84-J

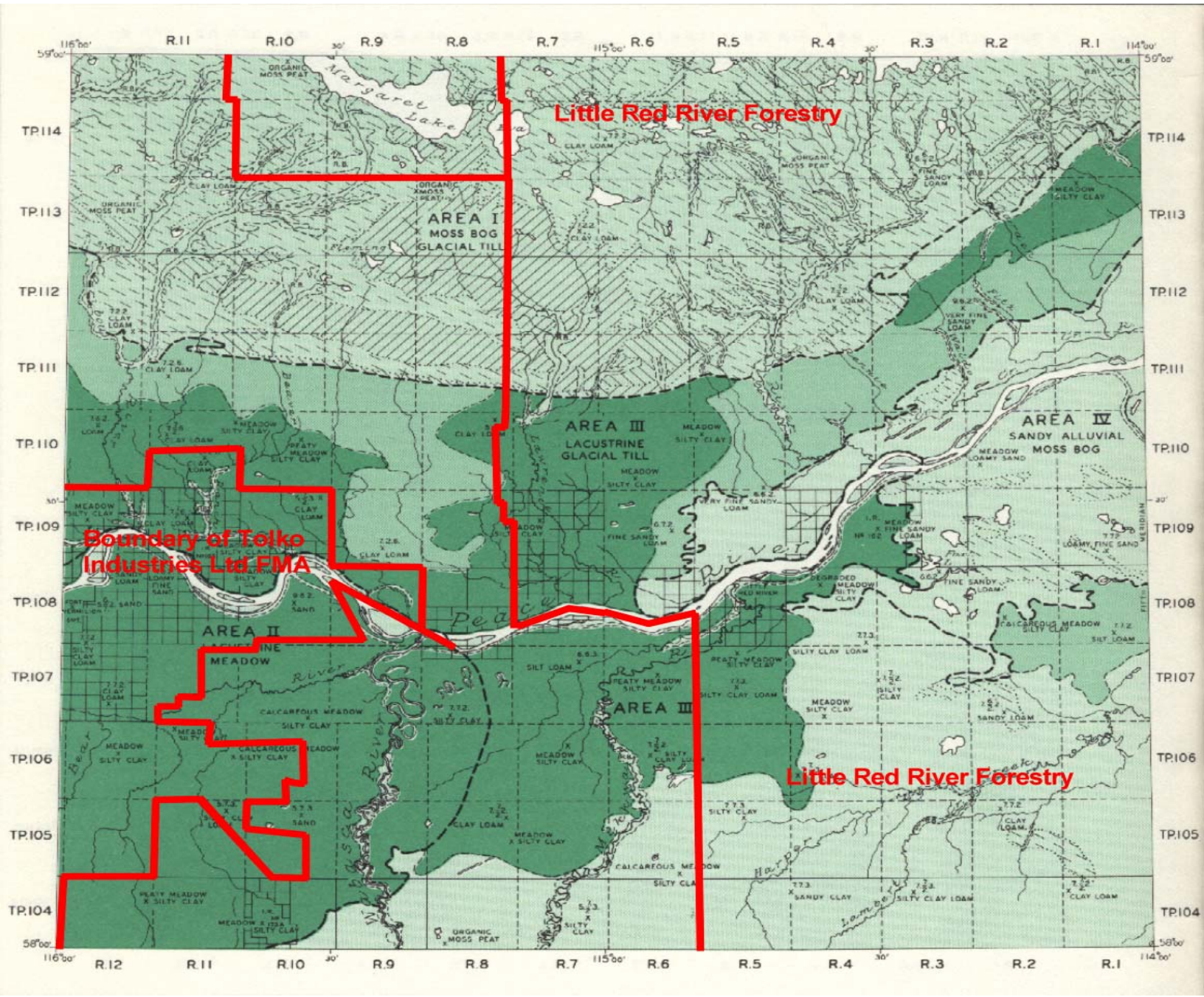


Figure 7: Map sheet 84-J Modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report. Research Council of Alberta. Edmonton, 1958

Map Sheet 84-J

AREA I

Area I comprises approximately 30% of the area of this map sheet, as well as 30% of Tolko Industries Ltd FMA area. This area comprises the dramatic rise of the Caribou Mountains escarpment. The mountains are up to 1800 feet above the lowlands associated with the nearby Peace River. The general topography of the area is rolling to hilly, but despite this the area is composed of largely moss bog. The soil is typically grey wooded and developed from glacial till. One point of interest is small localized areas of quite acidic sand.

AREA II

Area II comprises about 15% of both the map sheet and of Tolko Industries Ltd FMA area. The topography is level to depressional; however, draingage is considered quite good, resulting in few moss bogs. Silty clay loam has resulted from lacustrine material, producing degraded black to grey wooded soils.

AREA III

Area III comprises about 46% of the map sheet, and 40% of Tolko Industries Ltd FMA area. The level to varied topography leads to quite varied draingage patterns. There is a very shallow layer of lacustrine material (10-15 inches) laid over glacial till. Both topography and parent material have resulted in a varied soil distribution in this area. There are wide areas of organic soils, degraded black soils, and grey wooded soils

Map Sheet 84-K

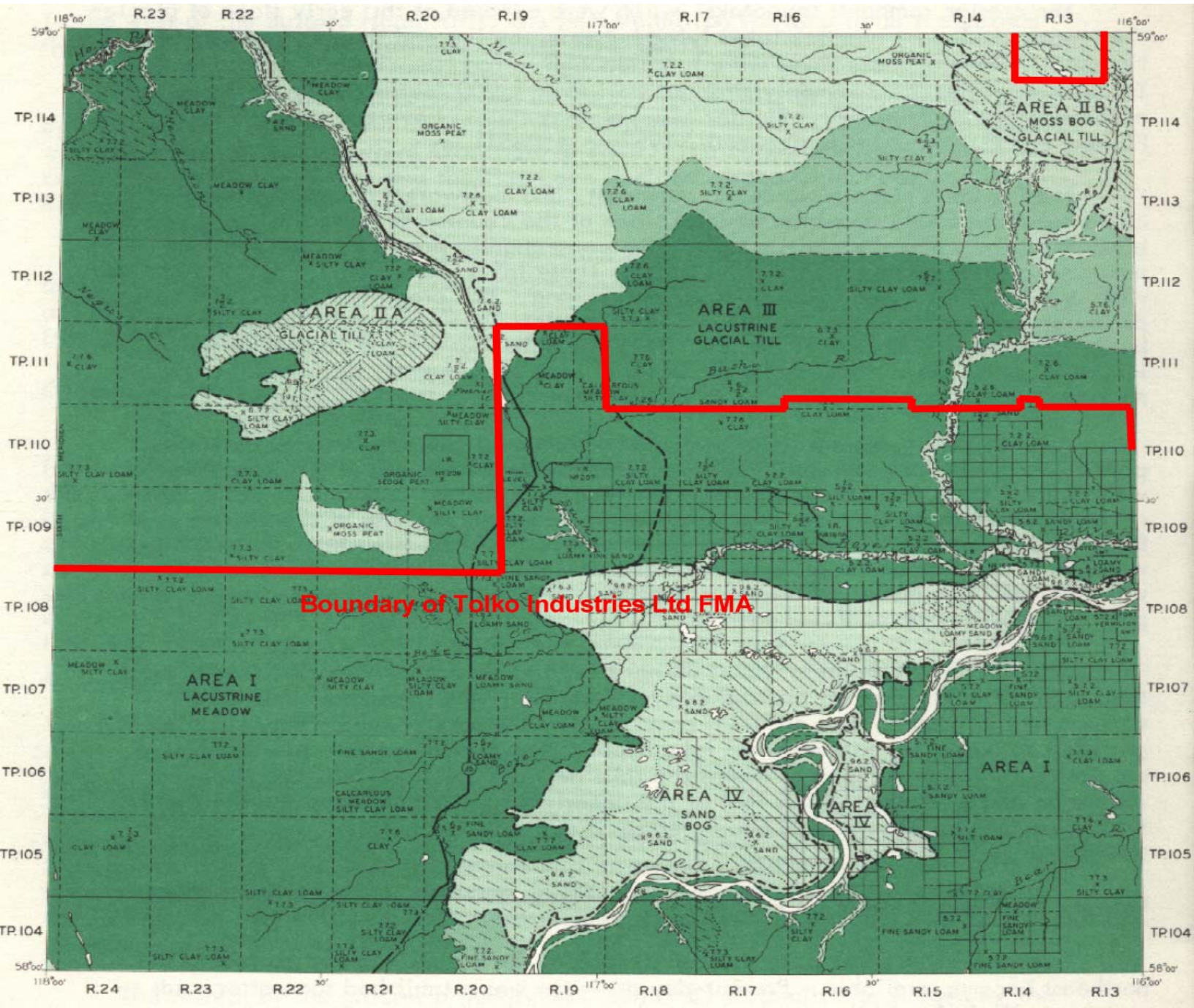


Figure 8: Map sheet 84-K modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report. Research Council of Alberta. Edmonton, 1958

Map Sheet 84-K

AREA I

Area I comprises approximately 56% of the entire map sheet and about 30% of Tolko Industries Ltd FMA area. Topography is level to depressional with poorly drained organic soils. Parent material is generally lacustrine, with deposits averaging thirty to forty feet deep. In the better-drained areas, some gray wooded soils are apparent. A note of interest is the deposition of some glacial deposits.

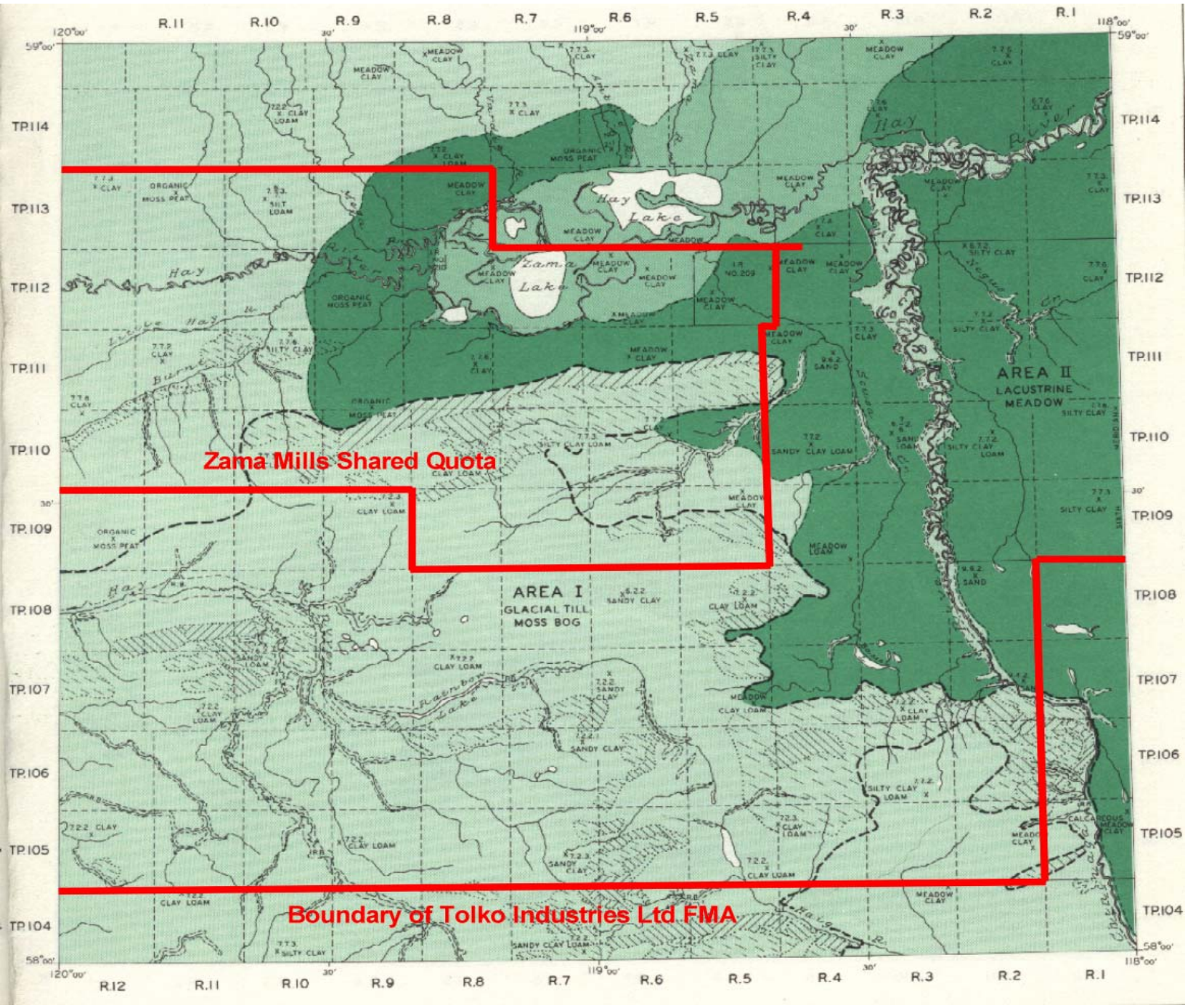
AREA II

Area II comprises 4% of the total map area and 10% of Tolko Industries Ltd FMA area. These two areas, the highland areas of Watt Mountain and the southwestern aspect of the Caribou Mountain escarpment, rise upward to 2500 feet above sea level. The moderately well drained area leads to gray wooded soils, developed on glacial till. Like Area I on map sheet 84-J, there are isolated areas of high acidity.

AREA III

This area, 30% of the map sheet, makes up more then 50% of Tolko Industries Ltd FMA area. The topography, level to depressional, has a variety of drainage patterns. This leads to a variety of soil types, from degraded black soils to grey wooded. Another reason for the differences in soil types is the variety of parent materials, which include glacial till, lacustrine materials (shallower then Area I), and alluvial materials.

Map Sheet 84-L



Map Sheet 84-L

AREA I

Approximately 60% of the map area is covered by Area I. This area exhibits extremely variable topography, from depressional to hilly. There are extensive moss bogs in the area, up to 60%. Where the soil is more adequately drained gray wooded soils are evident upon glacial till.

AREA II

The remaining 40% of this map sheet is covered by Area II. The Hay River watercourse shows uniform topography from depressional to level. Vast moss bogs cover the area. These meadow soils are definitely the norm, however some gray wooded soils are evident. The principal parent material is lacustrine clay and or silty clay (approximately 100%). The only exception to the above are isolated sandy sections evident on the Chinchaga River.

Map Sheet 84-M

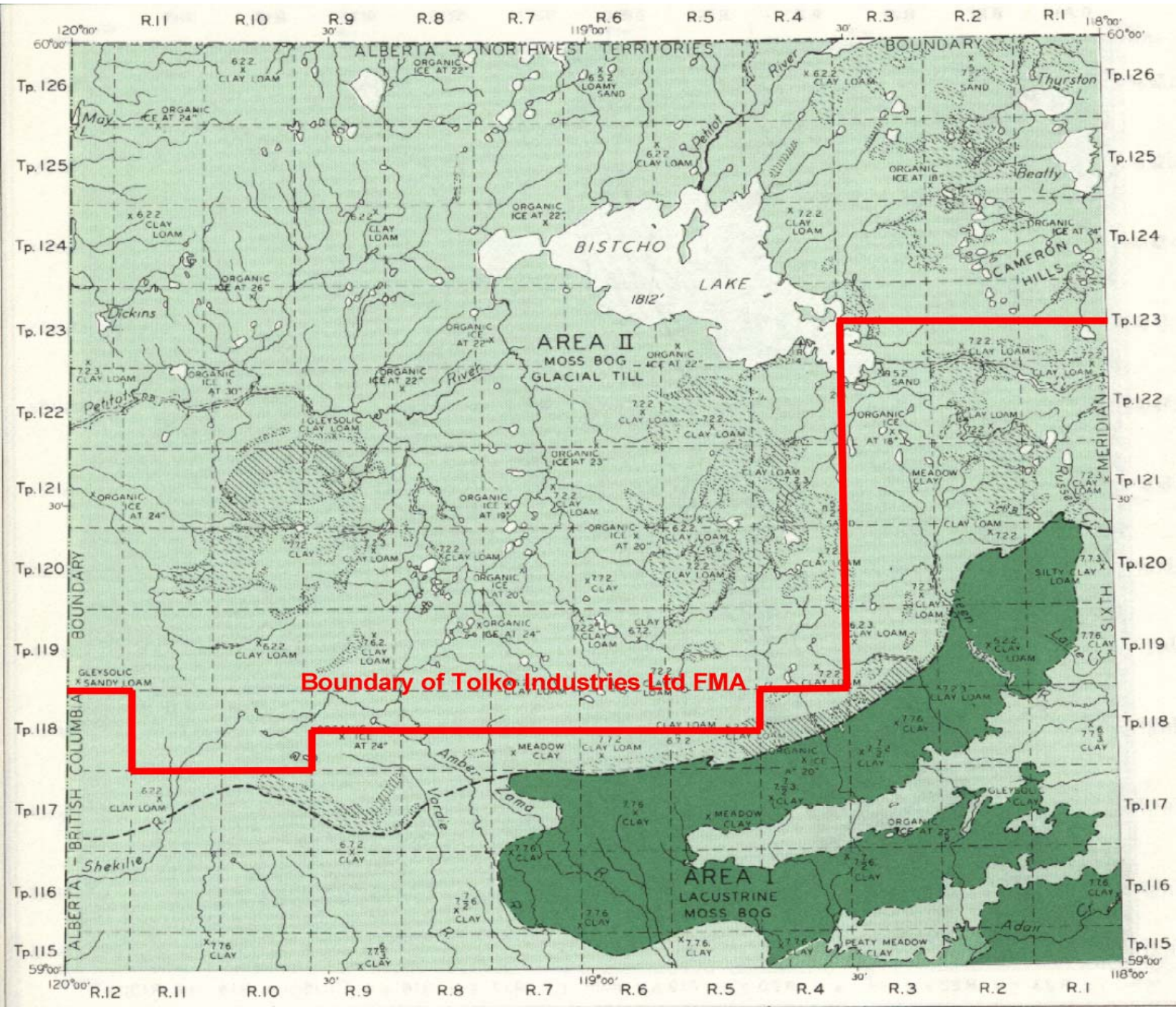


Figure 10: Map sheet 84-M modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report 61-1. Research Council of Alberta. Edmonton, 1960.

Map sheet 84-M

AREA I

Area I comprises 24% of the entire map sheet, but approximately 50% of Tolko Industries Ltd FMA area. The area's topography is in general a gentle slope down in a northerly direction. Moss bogs are common throughout the area, as well is permafrost (see later section). Gray wooded solodized-solonetz soils are the principle group here. The parent material is lacustrine clay based.

AREA II

Area II comprises 76% of the map sheet, but only 50% of Tolko Industries Ltd FMA area. Topography is undulating to depressional, with gentle hills. Organic soils dominate the area, with about 80% coverage. Like Area I, area II has vast areas of permafrost. The remaining soils are gray wooded or brown wooded, produced from glacial till. Since the average temperatures are low throughout the year, profile development is quite weak.

Map Sheet 84-N

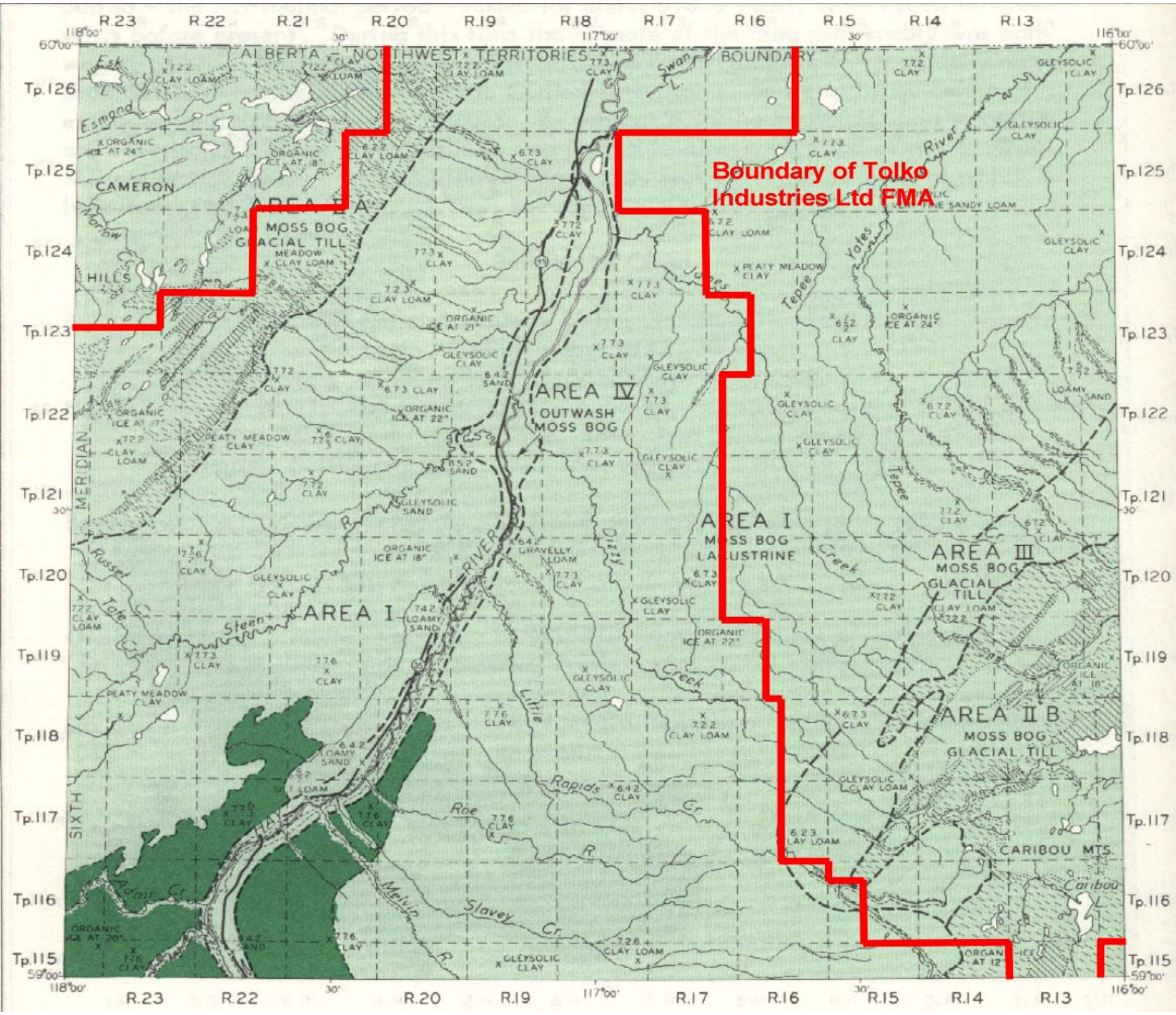


Figure 11: Map sheet 84-N modified from Lindsay, JD. S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report 61-1. Research Council of Alberta. Edmonton, 1960.

Map Sheet 84-N

AREA I

Area I comprises 71% of the map sheet, but only 50 of Tolko Industries Ltd FMA area. Topography of the area is level to depressional encouraging moss bog formation (75% of Area I). Organic soils are the common occurrence, with some patches of gray wooded and brown wooded soils. The majority of parent material is of lacustrine origin. Some solodized-solonetz profiling exists, but is not common. One last area of interest is the presence of some alluvial formations.

AREA II

Area II comprises 19% of the map sheet, but only 5% of FMA area. Soil composition is almost exclusively gray wooded and brown wooded due to good drainage through the Cameron Hills. Parent material is predominantly glacial till. Permafrost is not widespread as in other areas.

AREA III

Only 1 percent of Area III lies within Tolko Industries Ltd FMA.

AREA IV

Area IV comprises the remaining 44% of the FMA area. Topography is variable, from undulating to depressional. This area is an alluvial product of the Hay River, producing gravelly gray wooded and gravelly brown wooded soils on lacustrine parent material.

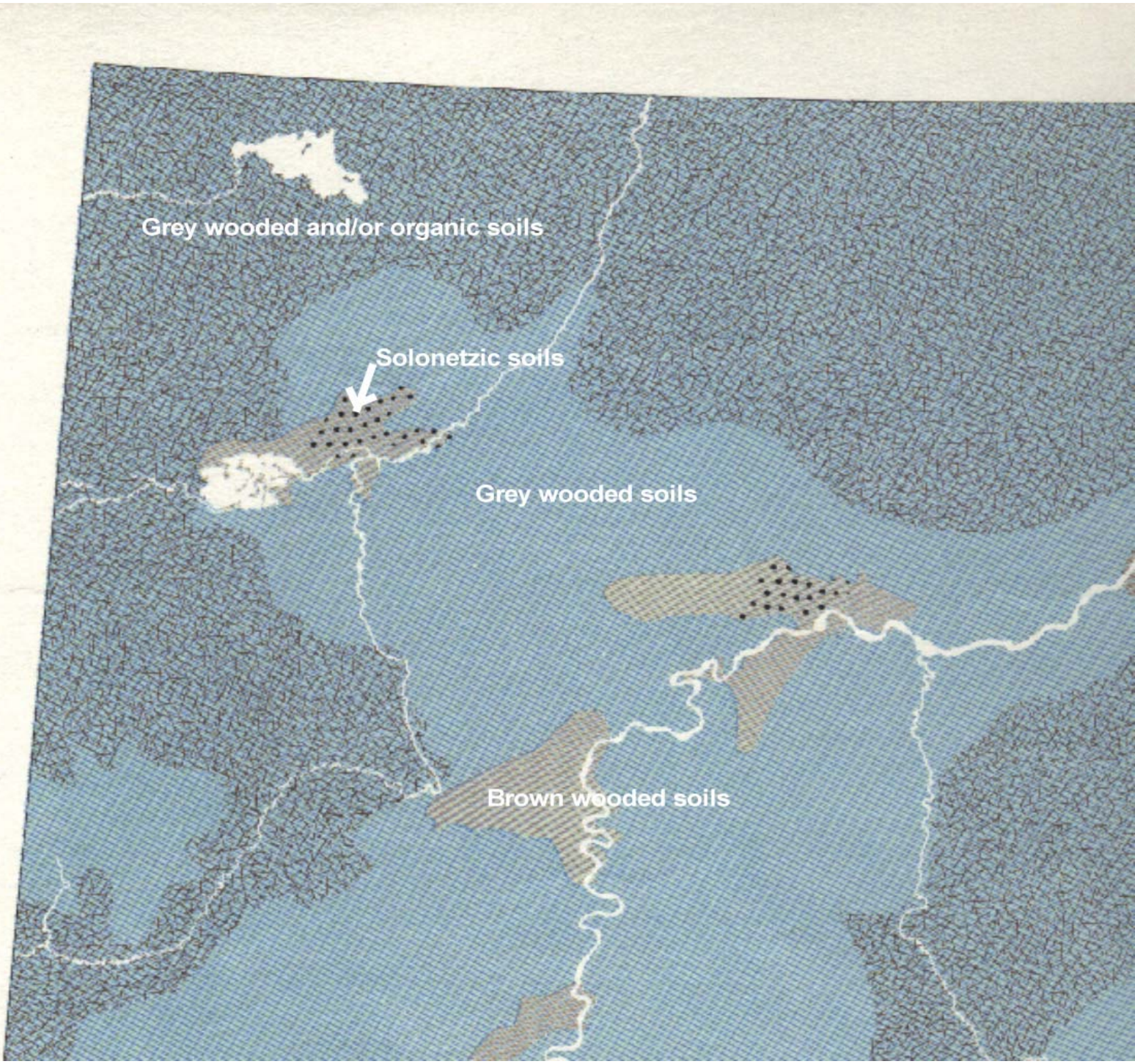


Figure 12: Depiction of dominant soil groups modified from Soil Groups of Alberta. Alberta Institute of Pedology. University of Alberta. 1970.

Another depiction of the soils of Northwest Alberta, to show alternate detail of soil groups, can be seen by another map; Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988. To study the map the following legend has been added.

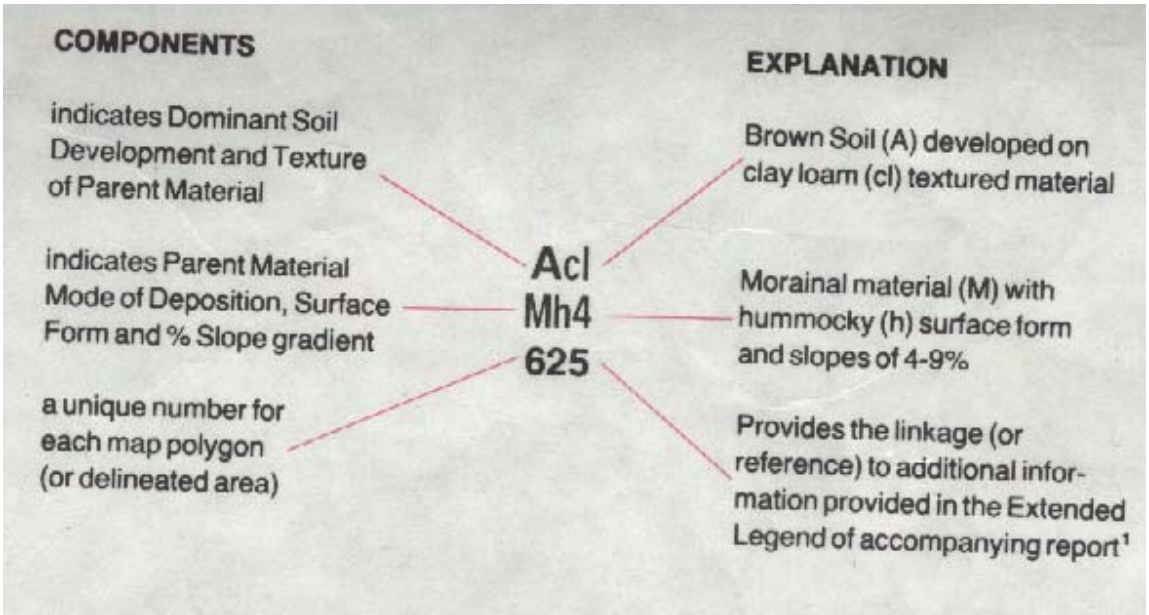


Figure 13: Legend explaining the following maps modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Letter	Group Name		Letter	Group Name
C	Chernozemic Soils		R	Regosolic
F	Gray Luvisolic Soils		U	Gleysolic
K	Gray Solonetzic		X	Organic Fibrosols
M	Eutric Brunisolic		Y	Organic Mesisols
O	Organic Cryosolic			

Table 2: Dominant Soil Development in Tolko Industries Ltd. FMA area modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Letters	Description		Letters	Description
sd	**sand parent material**		**o**	**organic bog material**
sl	**sandy loam**		**x**	**bog material**
lm	**loam**		**y**	**fen material**
cl	**clay loam**		**R2**	**acidic material**
cy	**clay**		**R3**	**basic material**

Table 3: Texture description of parent material in Tolko Industries Ltd. FMA area modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Letter	Description		Letter	Description
M	Morrainal		F	Fen
B	Bog		Eh	Aeolian
A	Alluvial		Mu	Morrainal/Glacial
U	Undifferentiated		Fu	Fluvial
L	Lacustrine		Mm	Morrainal

Table 4: Deposition description of parent material in Tolko Industries Ltd. FMA area modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Symbol	Description		Symbol	Description
u	Undulating		m	Rolling
h	Hummocky		d	Dissected
l	Level		16	Blanket
07	Plataeu		13	Horizonatl

Table 5: Surface form of parent material in Tolko Industries Ltd. FMA area modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Number	Description		Number	Description
1	1-3%		16	16-30
4	4-9		31	31-60
10	10-15			

Table 5: Soil slope description in Tolko Industries Ltd. FMA area modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

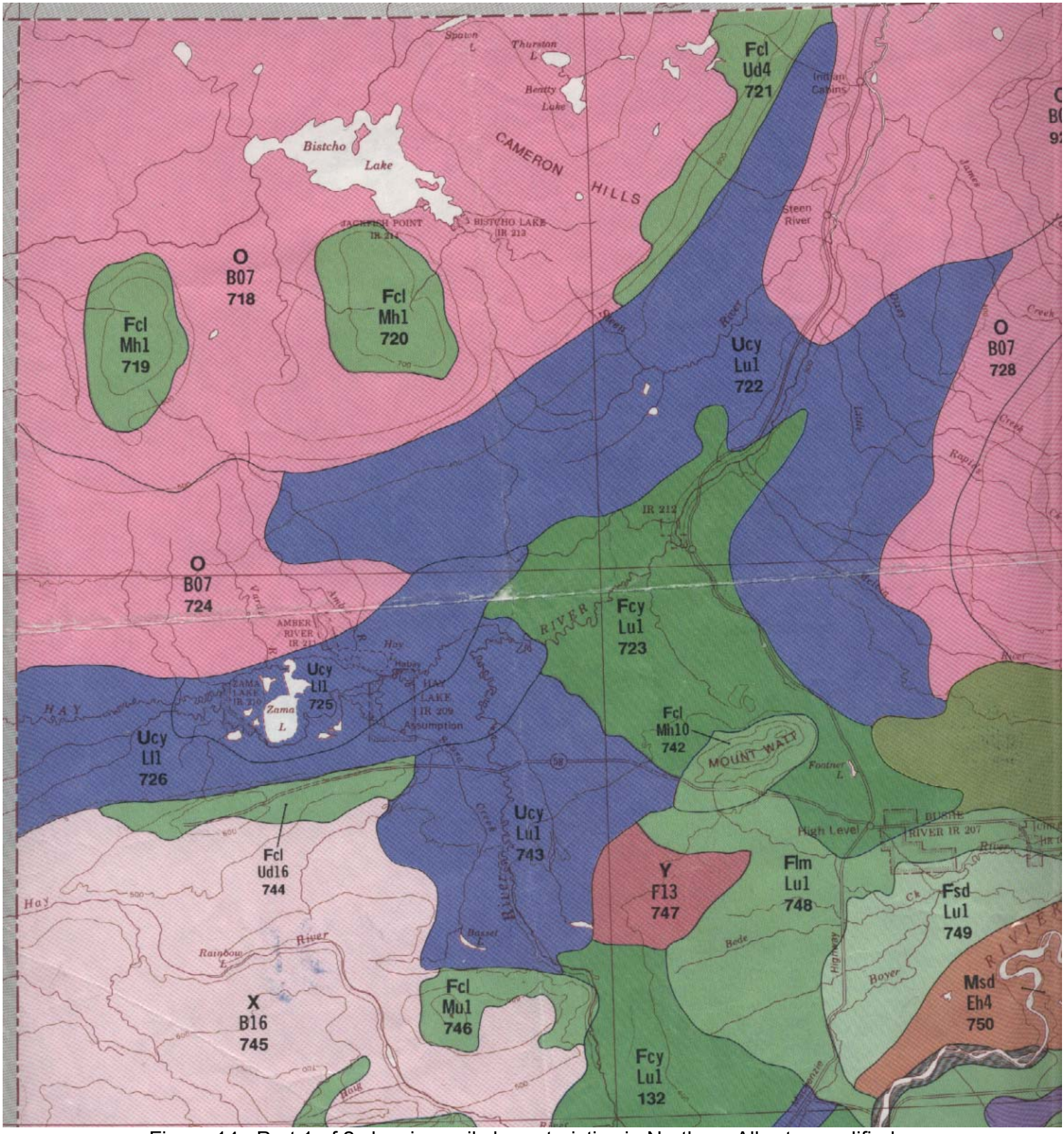


Figure 14: Part 1 of 2 showing soil characteristics in Northern Alberta, modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa, 1988.

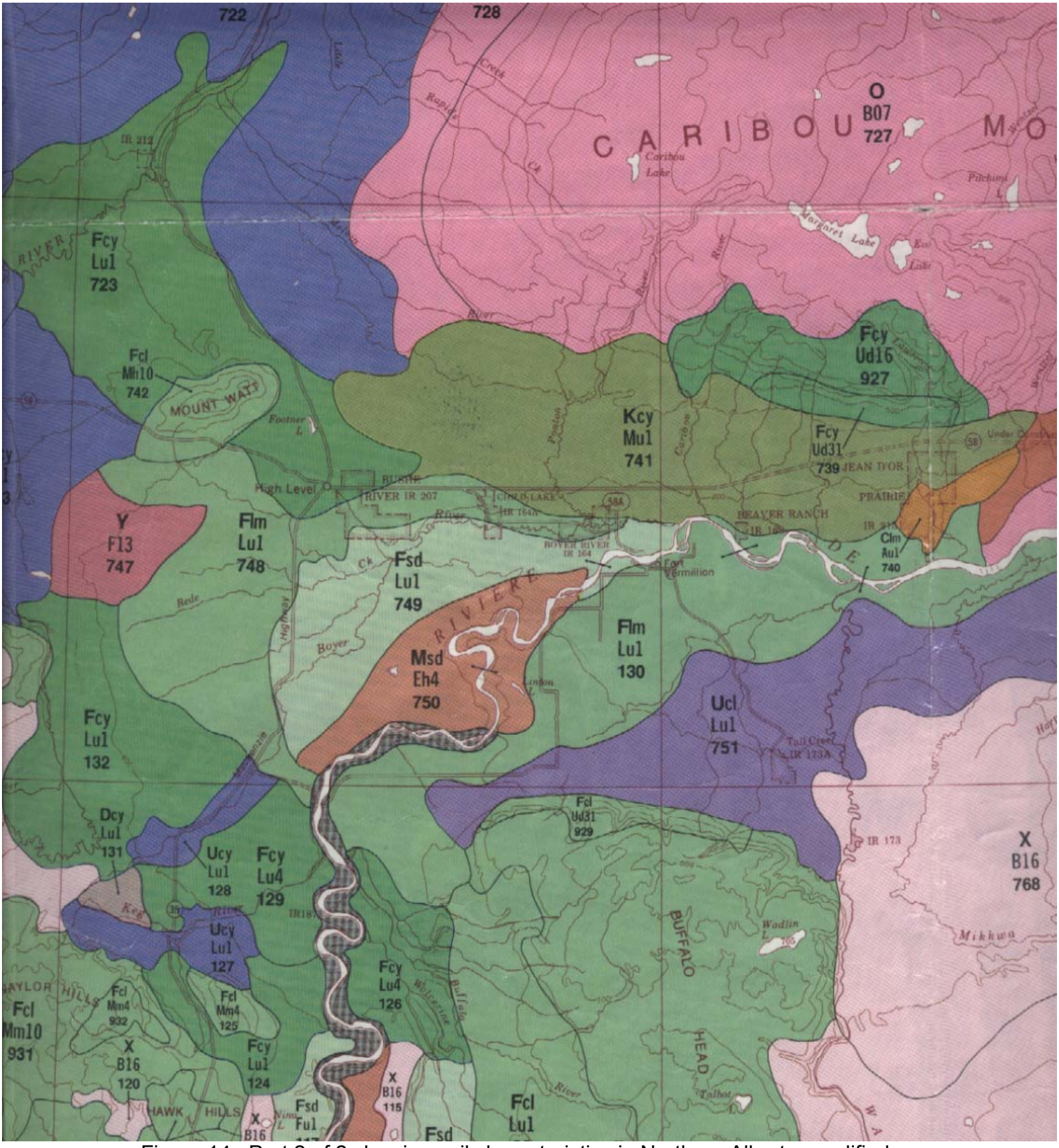


Figure 14: Part 2 of 2 showing soil characteristics in Northern Alberta, modified from Soil Landscapes of Canada, Alberta. Agriculture Canada, Ottawa. 1988.

Summary of Soil Composition

Soils within Tolko Industries Ltd FMA area are quite varied. These differences can be attributed to many factors, such as temperature, moisture, topography and parent material. Some stony deposits can be found in higher elevations, while clays and loams are the norm in valley floors. The Alberta Exploratory Soil Survey exhibits soils from six groups, while the more recent Canada survey is more comprehensive with different classifications showing nine soils groups. Both studies show that the abundance of soils in the region are gray based, gleysolic or organic, and derived from morainal or lacustrine deposits.

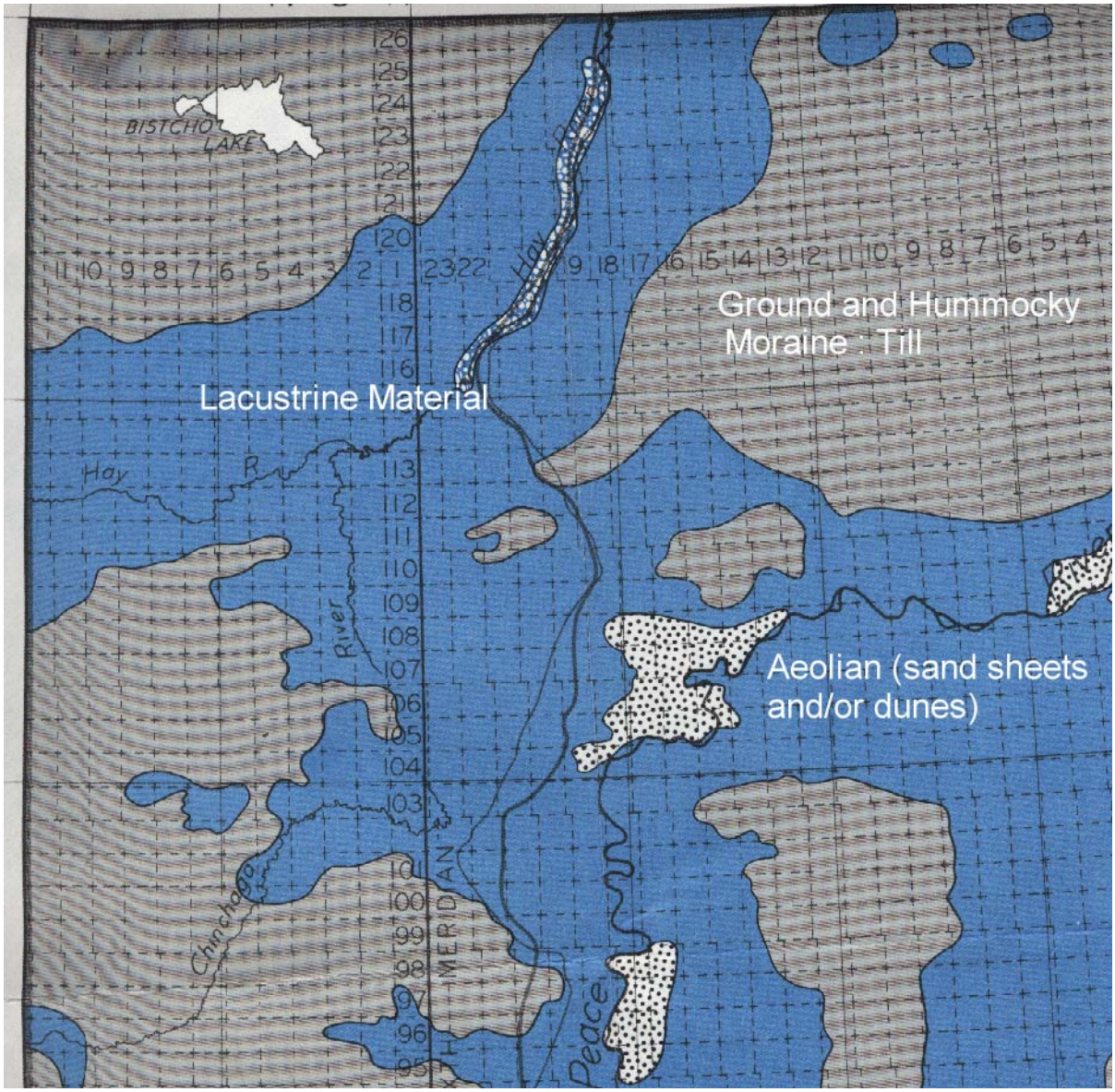


Figure 15: Dominant parent material distribution, modified from Hamilton, WN. Superficial Clay Resources. Alberta Research and Geological Survey of Canada. 1974.

The following maps have been divided so that detail may be seen. These show the occurance of peatlands (bogs, fens, etc) in Northern Alberta. A set of maps on Permafrost will follow.

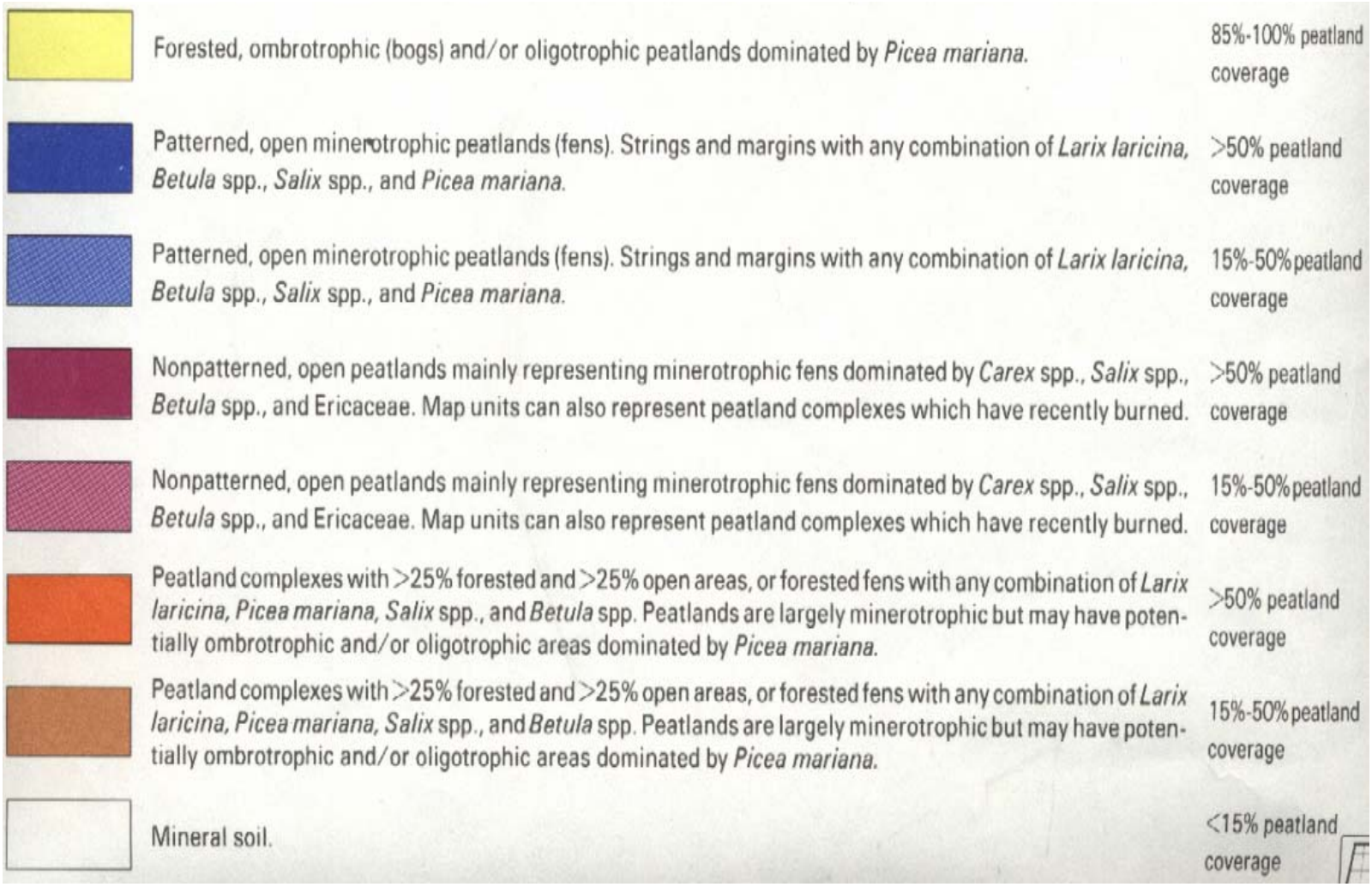


Figure 16: Legend modified and used from Vitt, DH. Peatlands of Alberta. Alberta Forestry, Lands, and Wildlife. Alberta. 1992. 1:1 000 000.

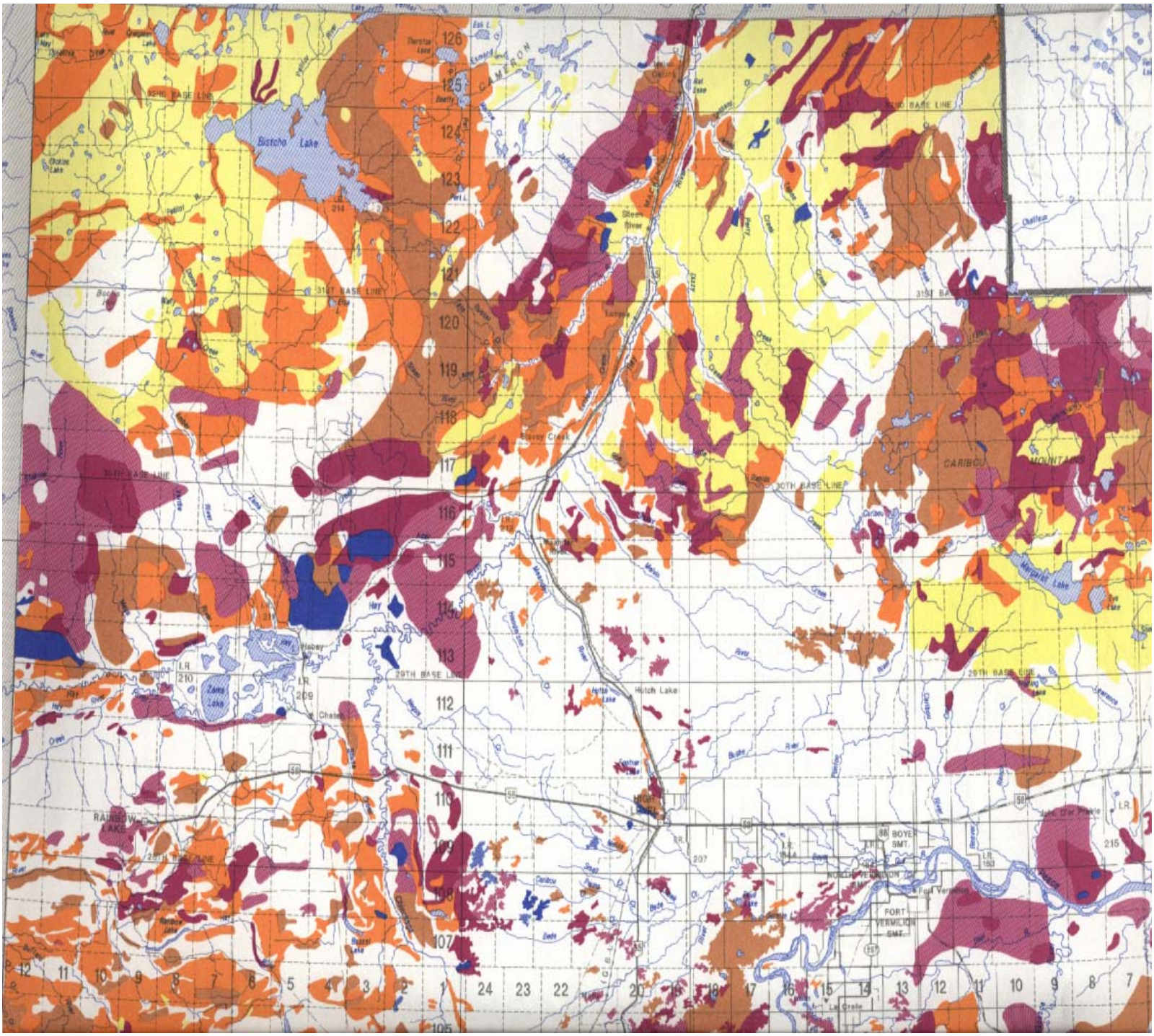


Figure 17: Majority of Tolko Industries Ltd FMA area showing peatland distribution, modified from Vitt, DH. Peatlands of Alberta. Alberta Forestry, Lands, and Wildlife. Alberta. 1992. 1:1 000 000.

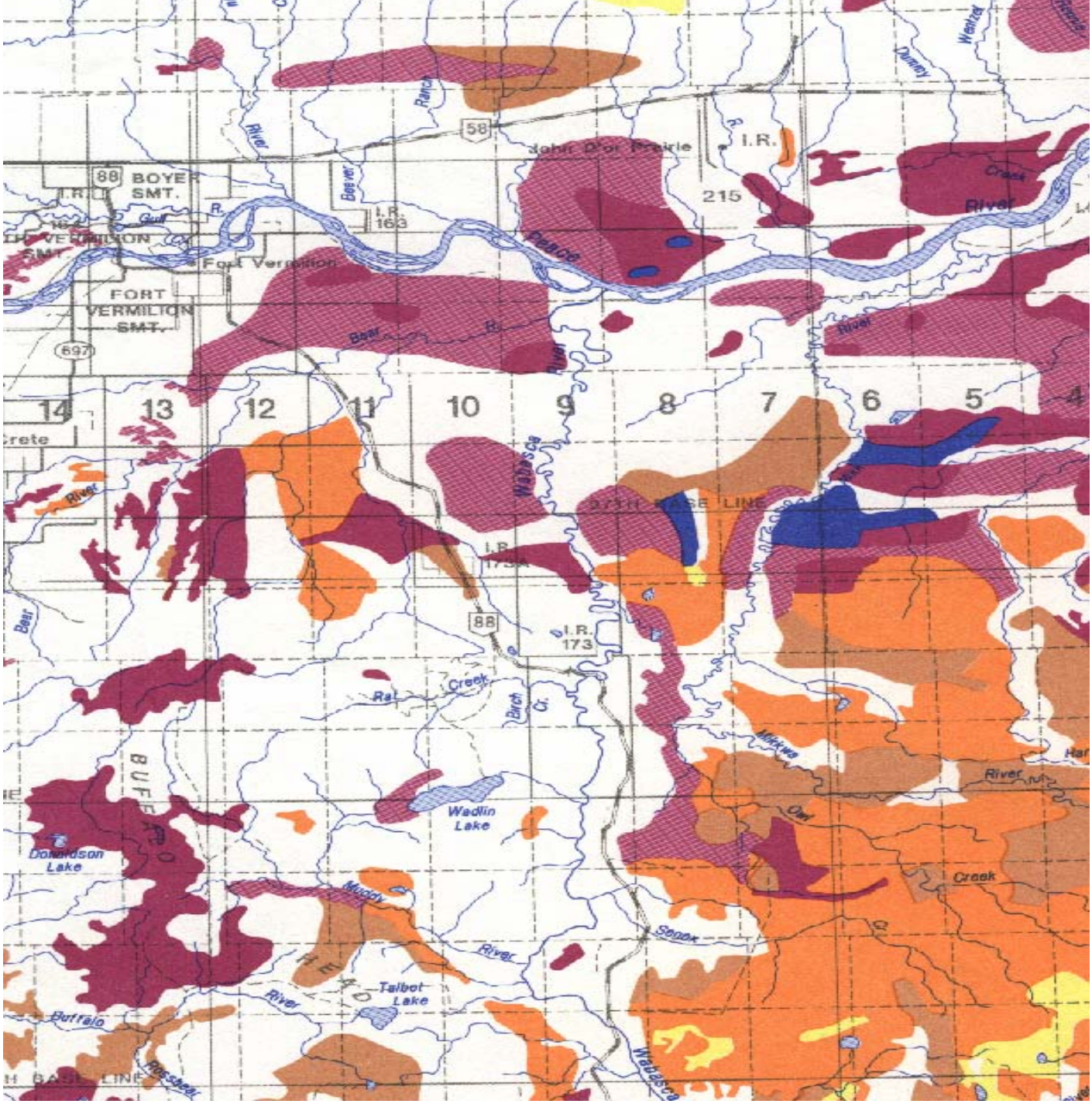


Figure 18: Southernmost range of Tolko Industries Ltd FMA area including FMUs F2 and F5, modified from Vitt, DH. Peatlands of Alberta. Alberta Forestry, Lands, and Wildlife. Alberta. 1992. 1:1 000 000

One last component of soils that must be addressed is Permafrost. Areas of Permafrost are abundant in the northern aspect of the Northwest Boreal Region of Alberta. These very fragile areas provide microclimates, where unique ecological processes exist. Any human use of these areas results in degredation. Once a permafrost patch is damaged, its soil moisture melts and the system is altered through *thermal erosion*, resulting in melt water mixing with silt and clay to form mud. This pollutant can create more problems, such as transporting and depositing sediments, clouding water and impeding water flow in the peatland system. Trenches can also be carved from the landscape producing permanent scarring (Strahler,AH and Strahler AN, 1992).

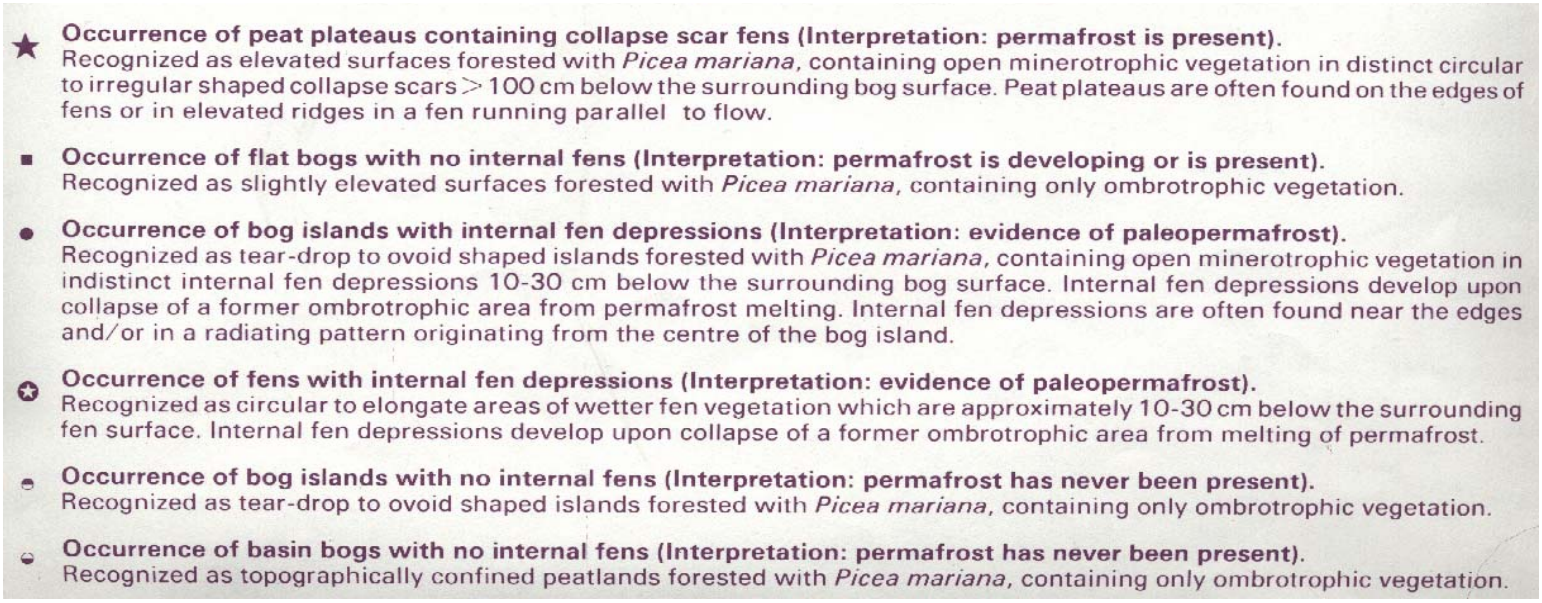


Figure 19: Legend modified for use with Halsey, LA, Vitt, DH, and Zoltai SC. Distribution of Past and Present Ombriotrophic and Permafrost Landform Features. Alberta Environmental Protection. Edmonton. 1993. 1:1,000,000

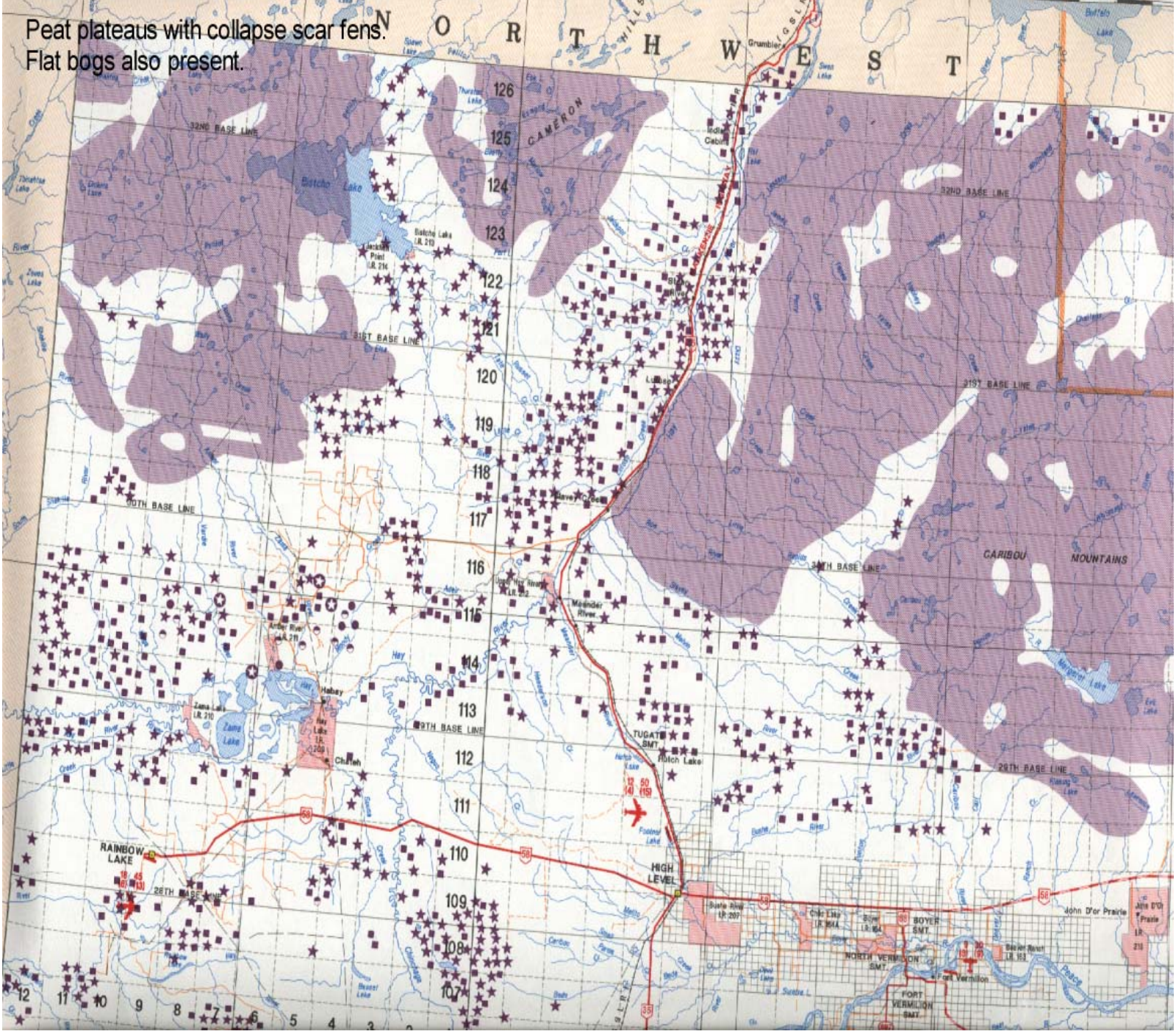


Figure 20: Northwest region of Tolko Industries Ltd FMA area showing the prevalence of permafrost, modified from Halsey, LA, Vitt, DH, and Zoltai SC. Distribution of Past and Present Ombriotrophic and Permafrost Landform Features. Alberta Environmental Protection. Edmonton. 1993. 1:1,000,000

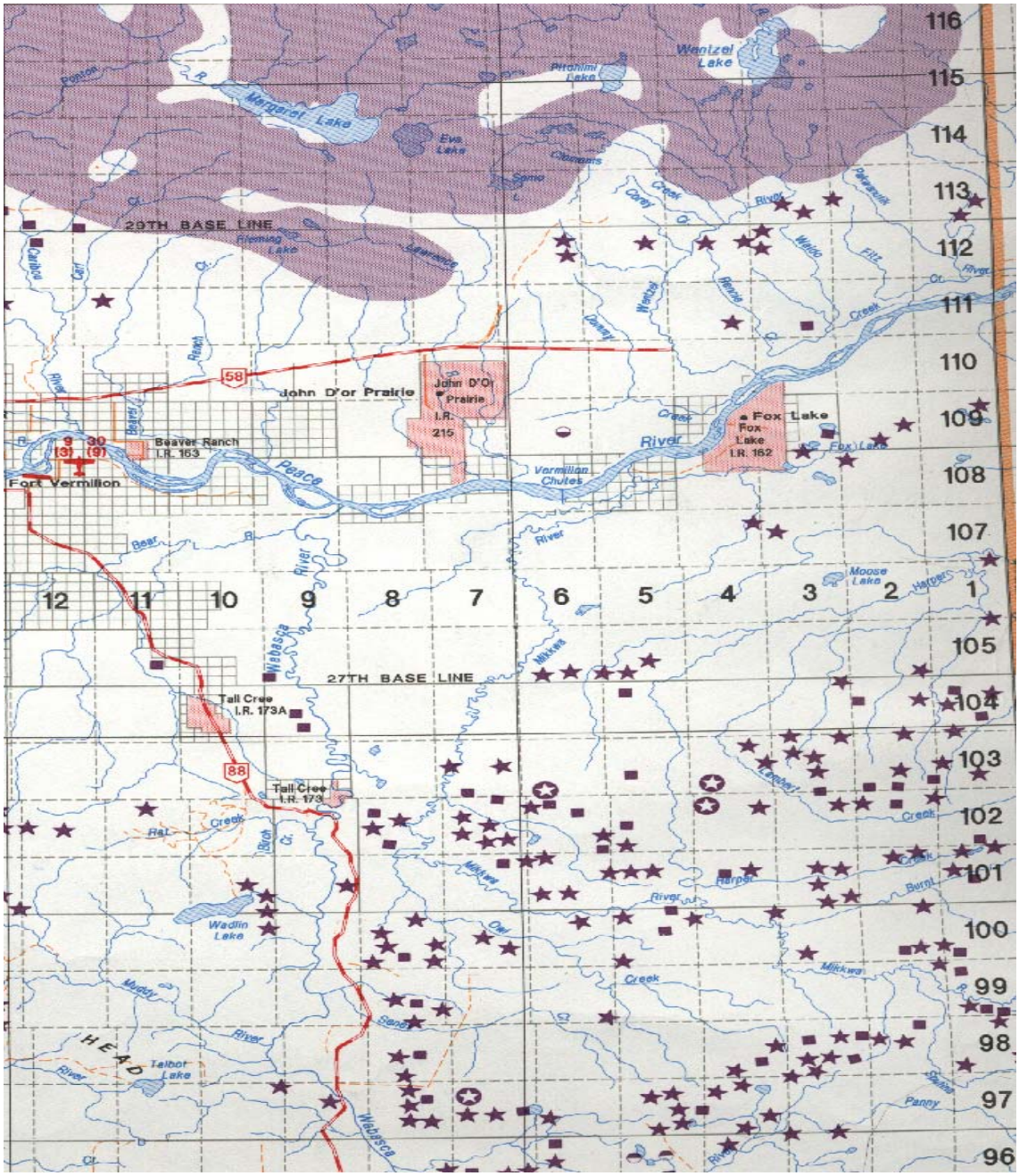


Figure 21: Southeastern area of Tolko Industries Ltd FMA, including FMUs F2 and F5, modified from Halsey, LA, Vitt, DH, and Zoltai SC. Distribution of Past and Present Ombriotrophic and Permafrost Landform Features. Alberta Environmental Protection. Edmonton. 1993. 1:1,000,000.

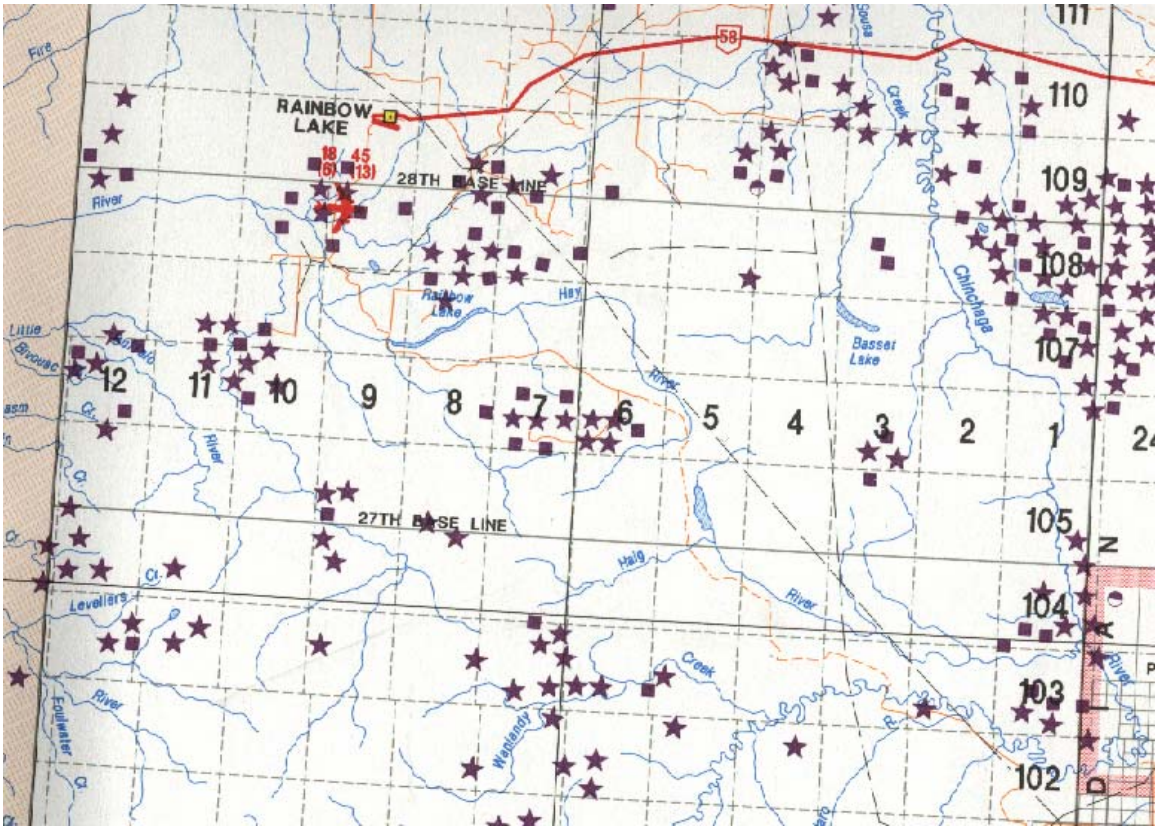


Figure 22: Southwestern area of Tolko Industries Ltd FMA, including FMUs F12 and F13, modified from Halsey, LA, Vitt, DH, and Zoltai SC. Distribution of Past and Present Ombriotrophic and Permafrost Landform Features. Alberta Environmental Protection. Edmonton. 1993. 1:1,000,000.

Literature Cited

- Canada Soil Survey Committee. The Canadian System of Soil Classification. Agriculture Canada. Can. Dep. Arig. Publ. 1646. 1977. 164pp.
- Green. Physiographic Subdivisions of Alberta. Land Research Center, Research Branch, Agriculture Canada. Ottawa, 1986
- Halsey, L.A., D.H. Vitt, and S.C. Zoltai. Distribution of Past and Present Ombriotrophic and Permafrost Landform Features. Alberta Environmental Protection. Alberta. 1993.
- Hamilton, W.N. Superficial Clay Resources. Alberta Research and Geological Survey of Canada. Alberta. 1974.
- Lindsay, J.D., S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report 59-1. Research Council of Alberta. Edmonton. 1958.
- Lindsay, J.D., S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report 60-1. Research Council of Alberta. Edmonton. 1959.
- Lindsay, J.D., S. Pawluk, and W. Odynsky. Preliminary Soil Survey Report 61-1. Research Council of Alberta. Edmonton. 1960
- Matthews, J.V. Jr. 1979. Tertiary and Quaternary Environments: Historical Background for an Analysis of the Canadian Insect Fauna. pp 31-86. From Danks, H.V. 1989. An Analysis of the Canadian Insect Fauna. Mem. Ent. Soc.Can. 108. pp573.
- Pawlowicz, J.G. and M.M. Fenton. Bedrock Topography of Alberta. Alberta. Alberta Geological Survey. Map 226, August 1995.

- Pawlowicz, J.G. and M.M. Fenton. Drift thickness of Alberta. Alberta. Alberta Geological Survey. Map 227, August 1995.
- Soil Groups of Alberta. Alberta Institute of Pedology, University of Alberta. Edmonton, 1970.
- Soil Landscapes of Canada. Agriculture Canada. Ottawa, 1988.
- Strahler, A.H. and A.N. Strahler.Modern Physical Geography 4th Ed. John Wiley and Sons Inc. USA. 1992
- Vitt, D.H. Peatlands of Alberta. Alberta Forestry, Lands, and Wildlife. Alberta. 1992.