

URBAN GEOLOGY OF EDMONTON

C. P. KATHOL AND R. A. McPHERSON

BULLETIN 32

ALBERTA RESEARCH COUNCIL

1975

CONTENTS

	Page
Abstract	1
Introduction	3
Purpose of study	3
Location of study area	3
Previous work	3
Method of study	5
Acknowledgments.....	5
Climate	8
Introduction	8
Temperature	8
Wind speed and humidity.....	11
Precipitation	11
Cloud and sunshine.....	13
Bedrock geology	15
Geologic setting	15
Bedrock geology of the study area.....	15
Edmonton Formation.....	17
Bearpaw Formation.....	19
Belly River Formation.....	19
Lower rock sequences.....	20
Bedrock surface topography	20
Bedrock uplands.....	23
Bedrock valleys.....	23
Beverly Valley	23
Stony Valley	23
Namao Valley.....	23
New Sarepta and Eilerslie Valleys.....	24
Other preglacial bedrock valleys.....	24
Surficial geology	24
Geomorphology	24
Quaternary landforms.....	24
Stratigraphy and distribution of surficial deposits.....	28
Distribution of surficial deposits.....	28
Saskatchewan gravels and sands.....	31
Glacial till	32
Glaciolacustrine sediments.....	32
Other sediments.....	33
Natural resources of the Edmonton area	33
Groundwater.....	33
Aquifers.....	33
Sand and gravel resources.....	37
Previous work	37
Classification of sand and gravel deposits.....	37

Preglacial gravels and sands.....	37
Onoway Valley.....	39
Beverly Valley.....	39
Glacial deposits.....	40
Recent alluvial deposits.....	40
Other resources.....	43
Oil and gas.....	43
Coal.....	44
Bentonite.....	44
Marl.....	44
Ceramic and brick clay.....	44
Peat.....	44
Silica sand.....	44
Salt.....	44
Geology for land use planning.....	44
Geotechnical characteristics of the geologic deposits.....	45
Land use capabilities in the Edmonton area.....	45
General construction conditions.....	45
Solid waste disposal.....	47
Criteria for selection of sites for solid waste disposal.....	47
Susceptibility of geologic deposits to erosion.....	48
Slope stability.....	49
Deep sewer construction.....	49
Summary and recommendations.....	50
Summary.....	50
Recommendations.....	50
References.....	51
Appendix.....	53
Glossary of terms.....	55

ILLUSTRATIONS

Plate 1, Figure 1. Bedrock (Edmonton Formation) contorted by glacial ice.....	22
Plate 1, Figure 2. Saskatchewan gravels and sands.....	22
Plate 2, Figure 1. Knob and kettle topography.....	27
Plate 2, Figure 2. Rhythmically bedded glacial Lake Edmonton sediments.....	27
Plate 3, Figure 1. Terraces along the North Saskatchewan River.....	29
Plate 3, Figure 2. Terrace deposits of sand and gravel.....	29
Figure 1. Location map of the study area.....	2

Figure 2.	Location of drillholes and stratigraphic sections	6
Figure 3.	Density of outcrop and drillhole information in the study area	7
Figure 4.	Mean monthly temperatures in the Edmonton area	8
Figure 5.	Temperature data and mean monthly temperatures for January, April, July and October in the Edmonton area	9
Figure 6.	Heating degree days in the Edmonton area	10
Figure 7.	Mean monthly heating degree days in the Edmonton area	10
Figure 8.	Mean monthly wind speed in the Edmonton area	11
Figure 9.	Mean relative humidity in the Edmonton area	13
Figure 10.	Probability of total precipitation exceeding specified ranges.....	12
Figure 11.	Probability of snowfall exceeding specified ranges.....	14
Figure 12.	Mean monthly snowfall in the Edmonton area.....	13
Figure 13.	Mean monthly total hours of bright sunshine in the Edmonton area.....	10
Figure 14.	Bedrock geology of the Edmonton area.....	16
Figure 15.	Topography of the upper surface of the Bearpaw Formation.....	15
Figure 16.	Topography of the upper surface of the Belly River Formation.....	17
Figure 17.	Topography of the upper surface of the Lea Park Formation	18
Figure 18.	Topography of the upper surface of the Fish Scale Zone.....	19
Figure 19.	Topography of the upper surface of the Wabamun Group	20
Figure 20.	Bedrock topography and preglacial thalwegs in the Edmonton area.....	in pocket
Figure 21.	Thalwegs of preglacial valleys in the Edmonton area.....	21
Figure 22.	Schematic cross-sections and longitudinal profiles in the major bedrock valleys in the Edmonton area	25
Figure 23.	Surficial geology of the Edmonton area	in pocket
Figure 24.	Thickness of surficial deposits in the Edmonton area	in pocket
Figure 25.	Index map showing lines of geological cross-sections	in pocket
Figure 26.	Geological cross-sections in the Edmonton area	in pocket

Figure 27.	Thicknesses of Saskatchewan gravels and sands and overburden in the Edmonton area	in pocket
Figure 28.	Thickness of glacial till in the Edmonton area.....	in pocket
Figure 29.	Thickness of glaciolacustrine sediments in the Edmonton area	in pocket
Figure 30.	Groundwater potential of buried valley aquifers in the study area.....	35
Figure 31.	Groundwater potential of glacial and postglacial deposits in the study area.....	36
Figure 32.	Schematic cross-section showing stratigraphic relationships of sand and gravel deposits, Edmonton area	38
Figure 33.	Surficial deposits of sand and gravel in the Edmonton region	in pocket
Figure 34.	Distribution of potential preglacial sand and gravel deposits, Edmonton area.....	41
Figure 35.	Oil and gas pools in the Edmonton area	43
Figure 36.	General construction conditions in the Edmonton area	in pocket
Figure 37.	Potential for sulfate attack on concrete in the Edmonton area at various depths below the surface	in pocket
Figure 38.	Potential sulfate hazard in the Edmonton area.....	in pocket
Figure 39.	Soils map of the Edmonton area	in pocket
Figure 40.	Suitability of the Edmonton area for solid waste disposal	in pocket
Figure 41.	Susceptibility of deposits to erosion in the Edmonton area	in pocket
Figure 42.	Susceptibility of deposits to slumping in the Edmonton area	in pocket
Figure 43.	Suitability of the Edmonton area for deep sewer construction 0 to 50 feet (0 to 15 m) below the surface	in pocket
Figure 44.	Suitability of the Edmonton area for deep sewer construction 50 to 100 feet (15 to 30 m) below the surface	in pocket
Figure 45.	Suitability of the Edmonton area for deep sewer construction at depths at depths greater than 100 feet (30 m) below the surface.....	in pocket

TABLES

Table 1.	Professional interrelationships during planning	4
Table 2.	Generalized stratigraphic column of bedrock deposits in the Edmonton area	in pocket
Table 3.	Succession and characteristics of near-surface geologic deposits in the Edmonton area	30

Table 4.	General hydrogeologic features of the near-surface sediments in the Edmonton area	34
Table 5.	Grain size analyses of sand and gravel samples from the Edmonton region	42
Table 6.	Description of surficial sand and gravel deposits in the Edmonton area in pocket	
Table 7.	Geotechnical characteristics of geologic deposits in the Edmonton area	46
Table 8.	Capabilities and limitations for development of the geologic deposits in the study area in pocket	

URBAN GEOLOGY OF EDMONTON

ABSTRACT

An urban geology study of the Edmonton area was undertaken by the Alberta Research Council in response to the increasing demand for the geologic information needed to formulate land use plans based on natural capabilities and limitations of the area. Initially, the geologic framework was established; this was then used as the basis for outlining geologic factors that may affect development.

The near-surface bedrock in the Edmonton area is the Upper Cretaceous Edmonton Formation except to the northeast of the city where the Belly River and Bearpaw Formations are present. The Edmonton Formation consists primarily of bentonitic sandstone, siltstone and silty claystone, with coal seams and bentonite beds. The Belly River Formation consists of bentonitic sandstone, silty to sandy shale and carbonaceous claystone.

The basic configuration of the bedrock surface was essentially determined during preglacial times by rivers flowing eastward from the Rocky Mountains; these established a series of dendritic drainage basins separated by low bedrock divides. In the Edmonton area, the Beverly Valley passes through the northern portion of the city and is the dominant feature of the bedrock topography; numerous tributary stream valleys are separated by flat-topped bedrock uplands. Preglacial sediments deposited along these ancient river channels are termed Saskatchewan gravels and sands.

During the Pleistocene Epoch, the Edmonton area was glaciated, and sediments were deposited on the bedrock and on the Saskatchewan gravels and sands. Landforms resulting from glaciation include ground moraine, hummocky dead-ice moraine, stream trenches, kames, outwash deposits, pitted delta deposits and glacial Lake Edmonton sediments.

Subsequent to glaciation, the North Saskatchewan River and several tributaries cut their present valleys, and alluvium has been deposited along the banks of most of these streams.

The thickness of the surficial deposits overlying the bedrock is variable, ranging from only a few feet on bedrock uplands to greater than 250 feet (76 m) in the Beverly Valley.

The most important natural resources in the Edmonton area are groundwater in the bedrock and buried channels, and sand and gravel in the buried channels and the North Saskatchewan River terraces. Other resources of lesser importance or lower potential include oil and gas, coal, marl, ceramic and brick clay, silica sand, peat and salt.

Data on the engineering properties of the geologic deposits have been integrated with information on the nature and distribution of the sediments and used as a basis for preparing a series of land use maps in which the Edmonton area is rated in terms of the following factors:

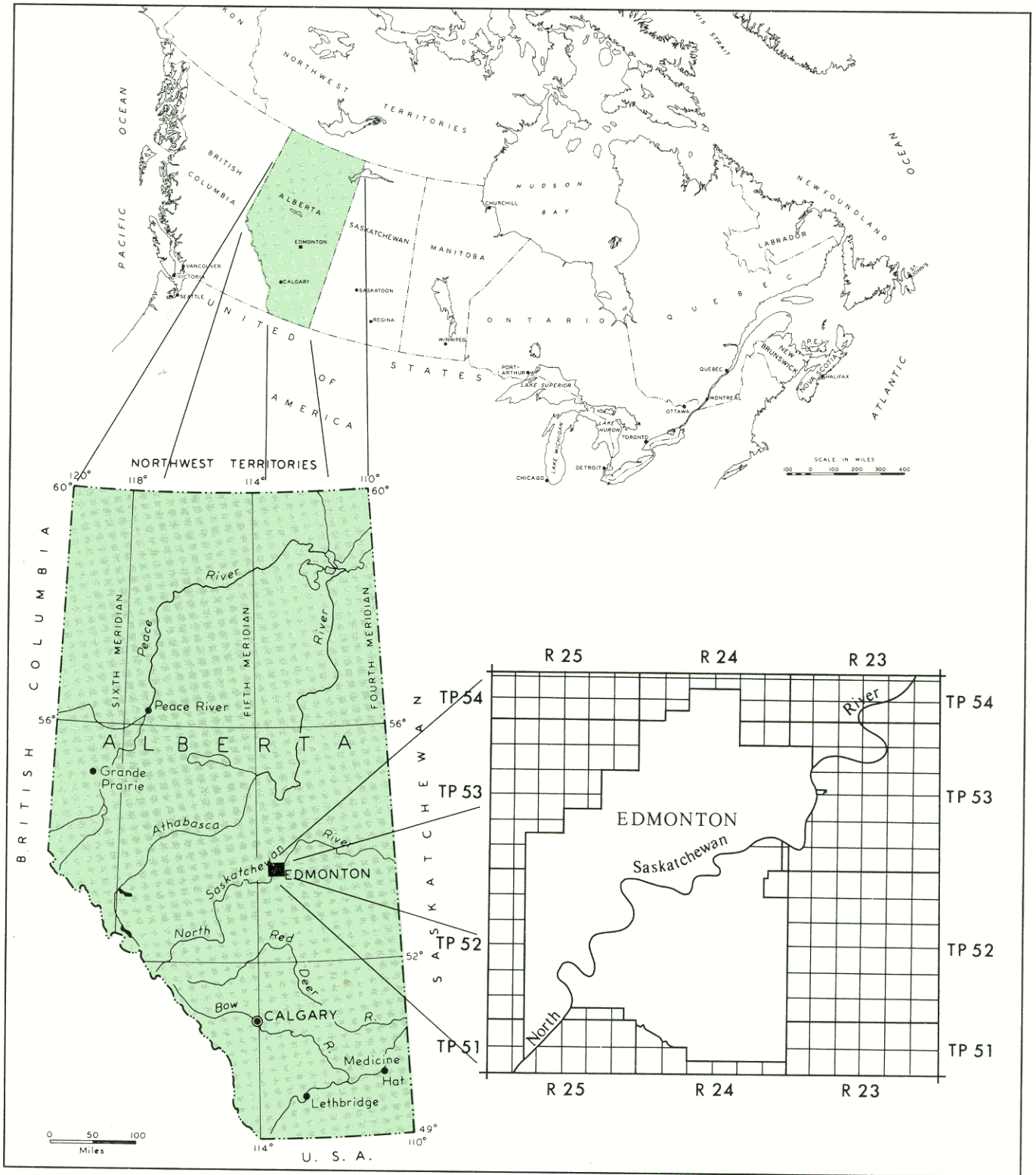


FIGURE 1. Location map of the study area.

- (1) general construction conditions
- (2) suitability for solid waste disposal
- (3) susceptibility to erosion
- (4) slope stability
- (5) deep sewer construction.

The main intent of these maps is that they be used as general guidelines for regional development or as a basis for conducting further studies. The maps should not be used in place of detailed site investigations because of the variability of geologic deposits over short distances.

INTRODUCTION

PURPOSE OF STUDY

Geology is applicable to many aspects of urban development because in any physical environment, the overall interdependent natural systems are built on a geologic framework. Mineral resources, water supply, waste disposal, landslides, construction conditions, flood control and transportation systems are all related to the distribution of geologic materials. The need for effective land use planning to ensure the orderly development of urban centers has created a much greater demand for geologic information.

This report presents a summary of the basic geologic data available for the Edmonton area. The information has been synthesized and presented as a report accompanied by a series of maps in which areas are evaluated in terms of their suitability for various land uses. These maps are not intended to replace detailed site investigations in areas where specific land uses are being considered but rather are to help formulate guidelines for future development. Because of the interrelationships among various disciplines involved in planning, as outlined in table 1, an attempt has been made to present the geologic data in a format that is readily usable by other disciplines.

LOCATION OF STUDY AREA

The study area, within which the City of Edmonton is located, is situated in central Alberta and encompasses approximately 288 square miles (746 km²) (Fig. 1). In addition to metropolitan Edmonton, the major towns of St. Albert and Sherwood Park and the smaller towns of Bremner, Bretona, Eilerslie, Winterburn and Wyeclif are present within the study area. The current estimate of population in this region is 527,000 persons.

PREVIOUS WORK

Most of the previous geologic work in the area was of a generalized nature. These previous studies provide useful information which is, however, not sufficiently detailed for planning land use.

Two of the earliest reports on the Edmonton area were by Selwyn (1874) and Dowling (1909). Selwyn described the major coal-bearing beds and Dowling outlined the Edmonton coalfields. Tyrrell (1887) discerned the major near-surface units including the Tertiary sands and gravels (mainly Saskatchewan gravels and sands), till and lacustrine deposits. Further insight into these deposits was provided by Taylor (1934) when he described the Quaternary stratigraphy along the North Saskatchewan River. Another generalized report by Rutherford (1937) outlines the distribution, mode of occurrence and lithology of the preglacial Saskatchewan gravels and sands in central Alberta.

Duff's 1951 report on Pleistocene deposits in the Edmonton area was the first of a series of more detailed studies. Ower (1958) described the bedrock geology of the area and Hughes (1958) described the history of glacial Lake Edmonton. Detailed surficial geology maps of the area were prepared by Bayrock and Hughes (1962) on a scale of 1 inch to 1 mile. Bowser *et al.* (1962) completed a soils survey of the Edmonton area (map sheet 83H). Domenico (1963) described the groundwater geology of the Edmonton Formation in the Edmonton area and included a brief description of the bedrock topography. Carlson (1967) provided additional data and produced a bedrock topography map. Bayrock and Berg (1966) and Roed (1966a, 1966b) gave detailed geological descriptions of small areas within the city. Thompson (1969) dealt with

the geotechnical properties of Lake Edmonton clay. Further studies of the Quaternary geology of the area were conducted by Westgate and Bayrock (1964), Westgate *et al.* (1969) and Westgate (1969).

As part of this study the authors published two preliminary reports (McPherson and Kathol, 1972 and 1973). The first summarized the results of a detailed drilling program and the second describes the sand and gravel resources of the Edmonton area. A 1:250,000 (approximately 1 inch to 4 miles) surficial geology map of the Edmonton area (map sheet 83H) was prepared by Bayrock (1972) and a copy is included with this report. The Groundwater Division of the Alberta Research Council is presently preparing detailed hydrogeological reports on the Edmonton area.

METHOD OF STUDY

The work of previous investigators provided a basic understanding of the geology but much additional information was required to obtain a comprehensive picture of the geology in the Edmonton area. In 1971, the Alberta Research Council initiated a field study program designed to collect the required information. A major drilling program was conducted during the summers of 1971, 1972 and 1973. In all, 225 6-inch (about 15 cm) diameter dry-auger holes were drilled to various depths depending upon the glacial drift thickness. These holes were located on a 1-mile grid (Fig. 2) and provided the basic framework for interpreting information available from other sources. The elevations of the holes were determined by levelling. Disturbed samples were recovered from each hole and used for classification and determination of engineering properties.

A river survey was conducted along the North Saskatchewan River from Devon, 10 miles (16 km) upstream from Edmonton, to Fort Saskatchewan, 10 miles (16 km) downstream, in the summer of 1971 (McPherson and Kathol, 1972). The elevations of major geologic contacts were determined by survey methods and representative samples of the deposits taken. Over 70 sections were described in detail (Fig. 2).

To augment a survey of sand and gravel deposits for aggregate supply, the existing pits within a 30-mile radius of Edmonton were field checked. Seventy-six active or abandoned pits were examined and 30 additional auger holes were drilled to establish the trend of potential aggregate deposits in the subsurface. The results of this survey are summarized in this report as well as in a previous report (McPherson and Kathol, 1973). Recent aerial photographs were used in conjunction with systematic field traverses to

delineate the surficial geology and determine the present land use in the map area.

Forty-two drillholes were available for a portion of the study area in a report of the geology of central Edmonton (Bayrock and Berg, 1966). In addition, the City of Edmonton Engineering Department contributed over 500 drillhole logs from their deep storm sewer projects. These logs were all within city limits, previously an area of sparse information. The holes were generally drilled to bedrock and the elevations determined by levelling. Also, many consulting engineering firms made their files of private drillholes available. This drilling was usually shallow but provided useful data on near-surface deposits. Further information was obtained from Alberta Highways and Transport, from the Groundwater and Soils Divisions of the Alberta Research Council, and from seismic shothole logs provided by various oil companies (Carlson, 1967).

Figure 3 indicates the density of subsurface drilling information per square mile from all sources. The bulk of this data has been computerized and is available from the Alberta Research Council for any portion of the study area.

ACKNOWLEDGMENTS

Dr. G. B. Mellon, former Head of the Geology Division of the Alberta Research Council,¹ initiated the Edmonton urban geology project in the spring of 1971. Supervision of drilling and other field assistance was provided by Mr. C. Waterman and Mr. G. D. Lobb, both of whom also worked on the data processing and map compilation. Computerization of the data was conducted by Dr. J. W. Kramers, in cooperation with the Computing Sciences Department of the University of Alberta. Sample analyses were performed by Mr. M. Baaske and Mr. J. Nelson and by the Highways Testing Laboratory of Alberta Highways and Transport.

Mr. R. Oster, engineer for the Sewer and Drainage Department, City of Edmonton and the City of Edmonton Engineering Department supplied valuable drilling information. Additional drillhole data was provided by Bernard and Hogan Engineering and Testing Ltd., R. M. Hardy and Associates Ltd., J. R. Paine and Associates Ltd., Underwood McLellan and Associates Ltd., and Alberta Highways and Transport.

¹ Dr. G. B. Mellon - presently Deputy Minister for Energy Resources, Alberta Energy and Natural Resources.

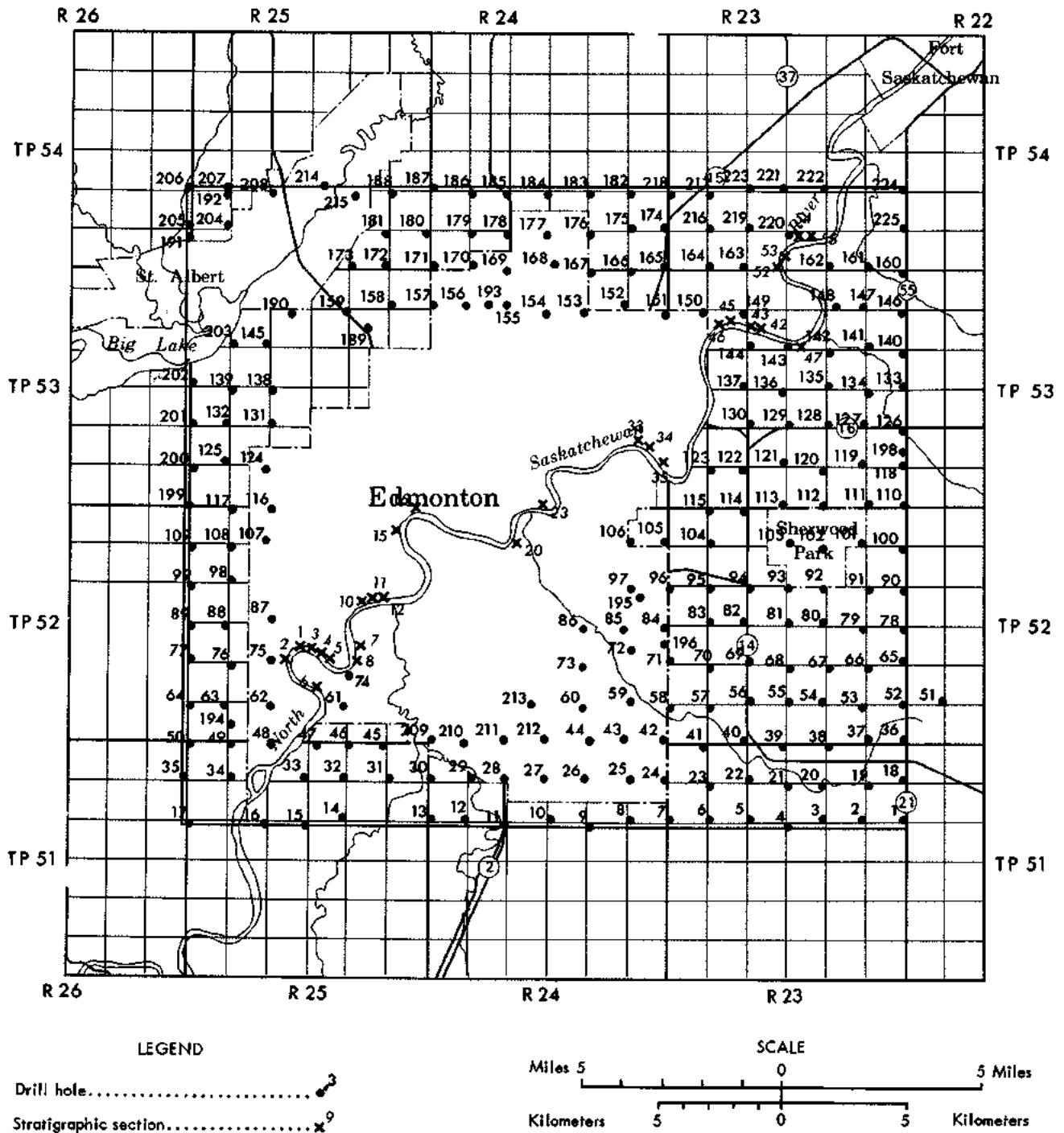


FIGURE 2. Location of drillholes and stratigraphic sections.

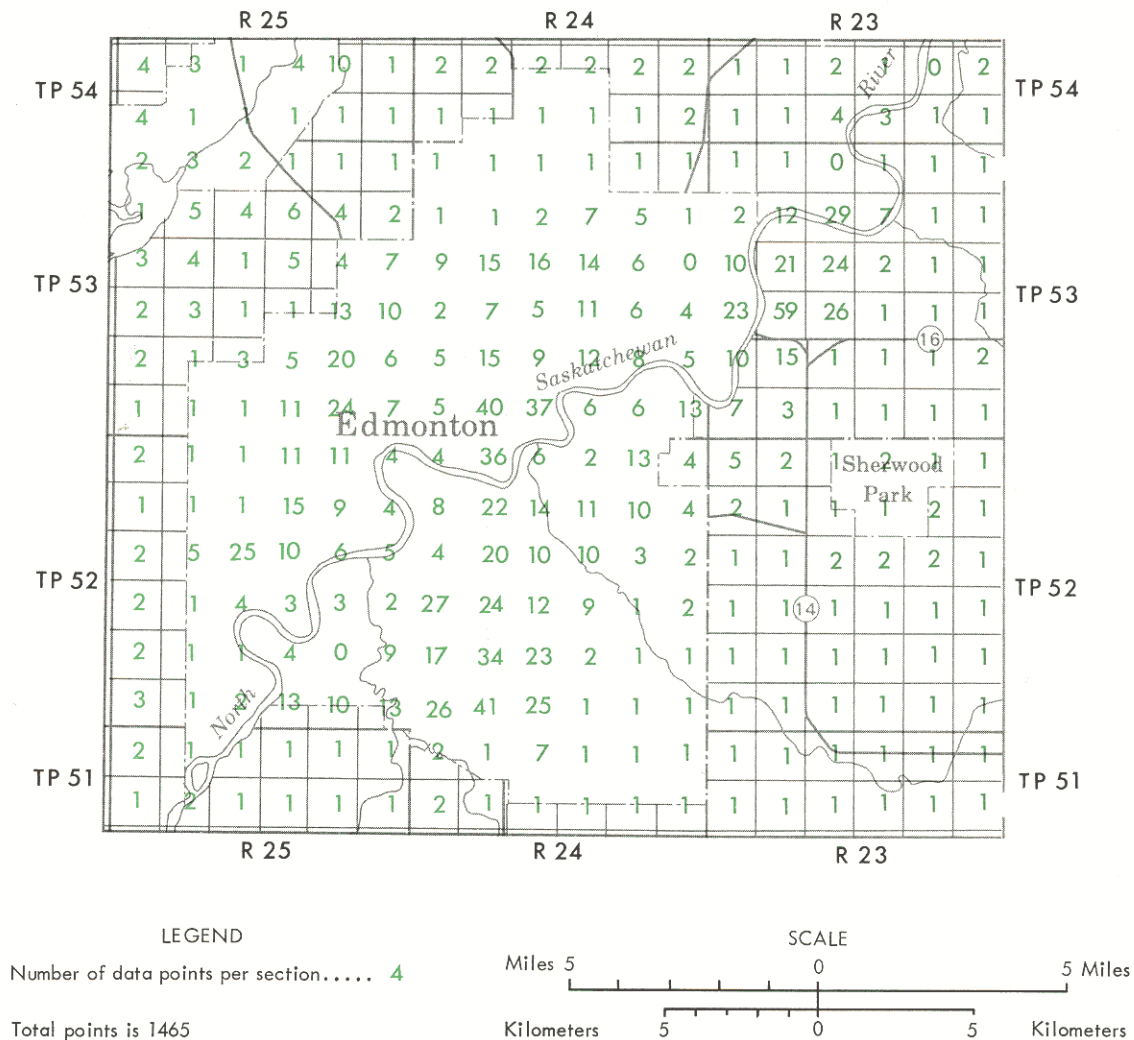


FIGURE 3. Density of outcrop and drillhole information in the study area.

Many colleagues at the Alberta Research Council contributed to the project; the authors would like to give particular thanks to Dr. R. Green for his ideas and constructive criticism, Dr. L. A. Bayrock for his advice regarding the surficial geology, Mr. V. A. Carlson for assistance with the bedrock geology, in particular the bedrock topography, and Mr. R. Porozni for his photographic assistance.

Most of the drilling for this project was performed by Mr. C. Pearson and Mr. D. MacRae of Canadian Geological

Drilling Ltd. Several of the deeper holes were drilled by Mr. V. Clark of Mobile Augers Ltd.

Editorial comments were provided by Dr. B. McLean of EBA Engineering Consultants Ltd., Mr. D. Greentree of Calmat Engineering Ltd., Mr. J. Paine of J. R. Paine and Associates Ltd., and Dr. S. Thomson of Department of Civil Engineering, University of Alberta.

Many other individuals offered advice and assistance on various aspects of the study and so aided the completion of this report.

CLIMATE

INTRODUCTION

In brief, Edmonton has a climate described as continental, varying between dry and moist subhumid; warm summers and cold winters are typical with moderate precipitation during all seasons. This description, while succinct and simple, is not sufficiently detailed for use in the complex process of planning land use. It is fortunate, then, that Edmonton has an extensive and reliable record of past weather conditions from which representative detailed climatic characteristics can be determined. The first regular weather observations were made at Fort Edmonton in 1880. In 1882 the Hudson's Bay Company moved the weather station to Jasper Avenue and 115th Street which is close to its present location. Weather stations were established at the Industrial Airport in 1937 and at the International Airport in 1960. Both stations have modern equipment which provides continuous and reliable data.

The approximate location of the Industrial Airport station is 53°34' north, 113°29' west. The station, which is situated on level ground, has an elevation of 2200 feet (670 m). The entire airport is surrounded by urban development so that values obtained are representative of the urban climate. The weather station at the International Airport is located approximately 12 miles (about 19 km) south of Edmonton and its coordinates are 53°19' north, 113°35' west. The station is located on level open ground at an elevation of 2373 feet (723 m). Data from the International Airport are representative of the rural climate in the Edmonton area.

There are often considerable differences between climatic values outside and within the city; therefore, data from stations at both airports are used whenever necessary. It is also important to realize that the microclimate of any given area can vary considerably from the climate at a weather station because of factors such as topographic position, vegetation, and surrounding buildings.

TEMPERATURE

The temperature is extremely variable from day to day, season to season and year to year. The summers are unusually warm for the latitude but the winters are long and cold. The difference in temperature from the mean of the warmest month to the mean of the coldest month is 56°F (31°C) within the city and 60°F (33°C) outside of the city.

Winter in Edmonton usually begins during the first week of November and normally lasts until the first week of April, a duration of five months. During these months the daily mean temperature remains below 32°F (0°C). January is the coldest month having a mean monthly temperature of 6.6°F (-14°C) at the Industrial Airport (Fig. 4) and 1.3°F (-17°C) at the International Airport. Winter has the most variable temperature, as can be seen in figure 5. January's mean monthly temperature over the last forty years varied by 40°F (22°C), from a maximum of 22.3°F (-5.4°C) to a minimum of -18.0°F (-28°C) (Fig. 4). Within the last ten years the record low mean at the International Airport was -20.5°F (-29°C). These fluctuations from year to year are caused by variations in air mass circulation. Warm winters

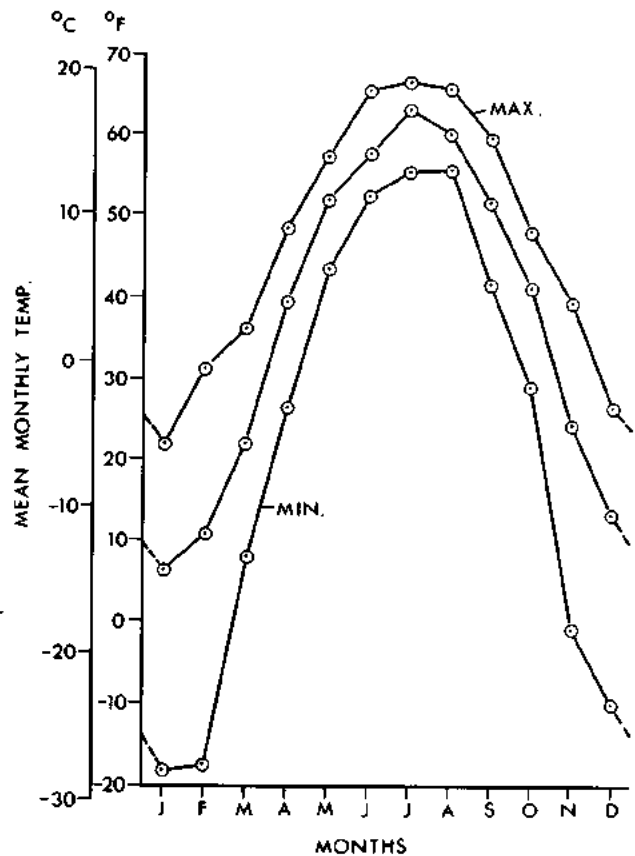


FIGURE 4. Mean monthly temperatures in the Edmonton area.

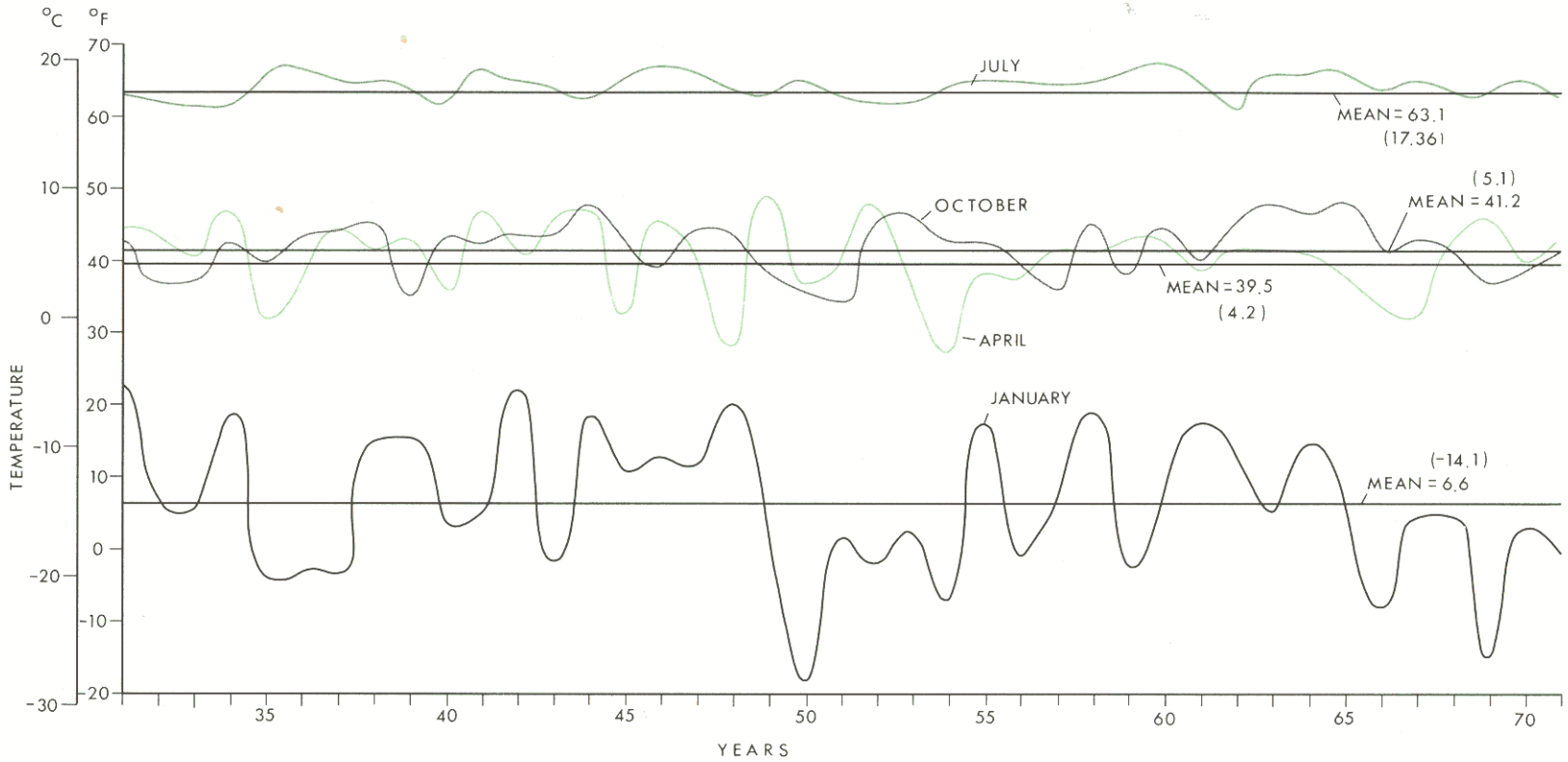


FIGURE 5. Temperature data and mean monthly temperatures for January, April, July and October in the Edmonton area.

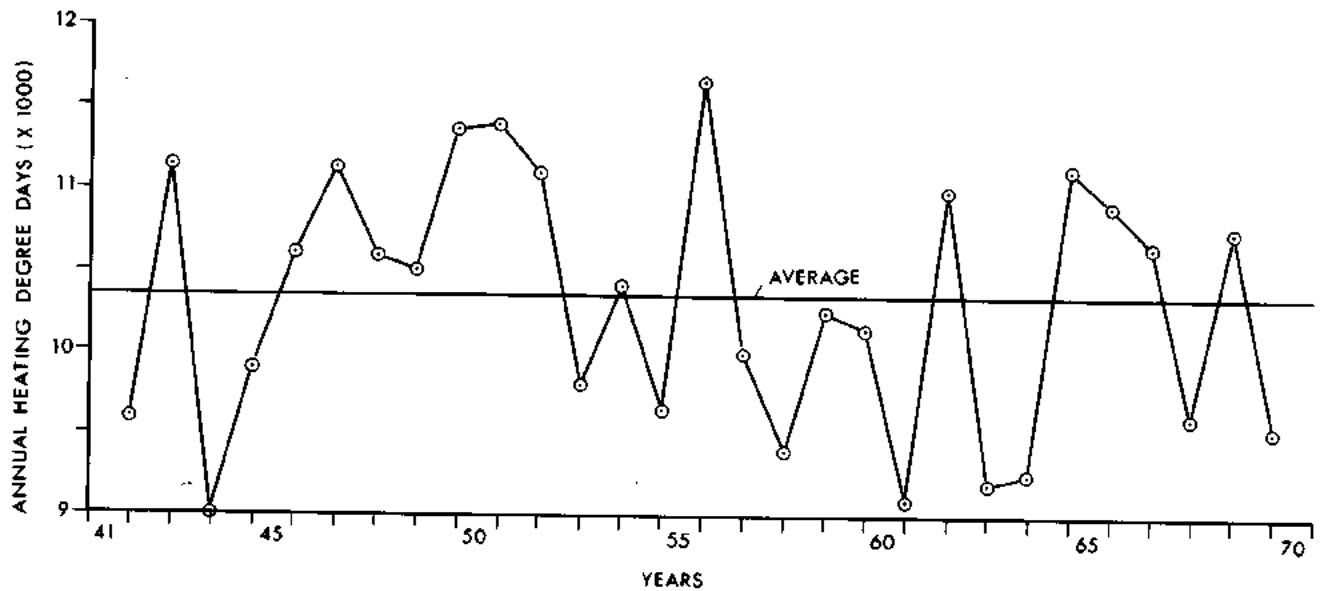


FIGURE 6. Heating degree days in the Edmonton area.

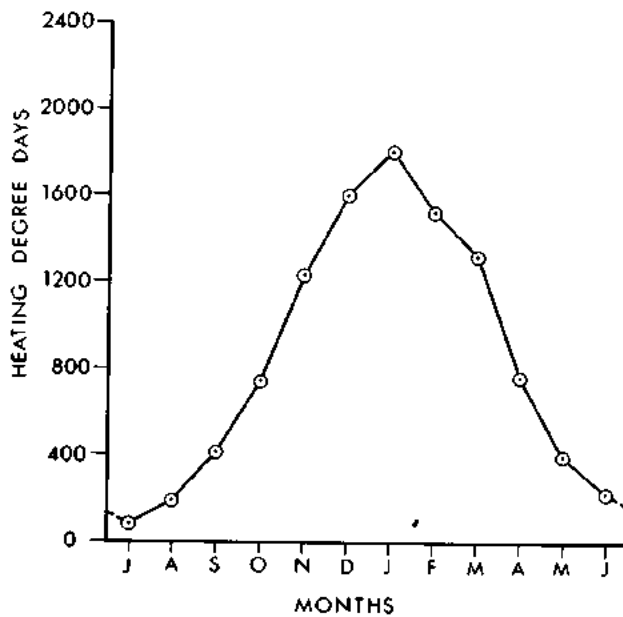


FIGURE 7. Mean monthly heating degree days in the Edmonton area.

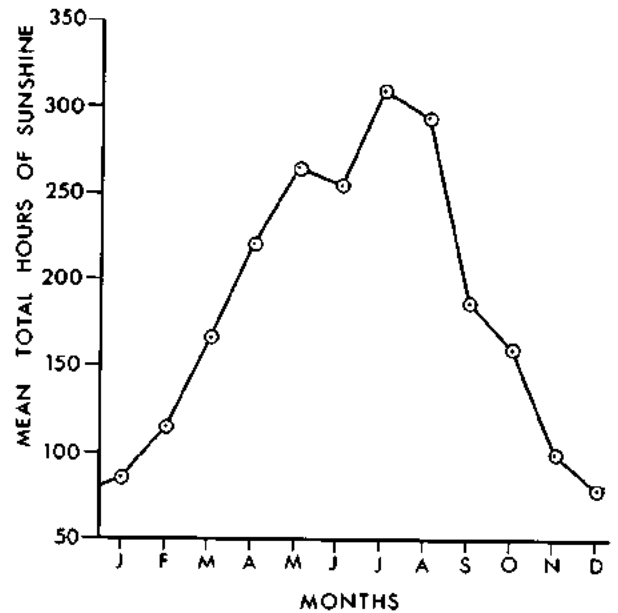


FIGURE 13. Mean monthly total hours of bright sunshine in the Edmonton area.

result from the establishment of a strong easterly flow of Pacific air while continued southerly flow of Arctic air results in cold winters. Chinooks, a common occurrence in southwestern Alberta, are rare in Edmonton but can modify the temperature somewhat.

Spring and autumn in Edmonton, when defined as that period of time with mean daily temperatures between 32°F (0°C) and 42°F (6°C), are short. The temperature rises rapidly during the first three weeks of April and falls rapidly during the last two weeks of October. Mean temperatures for the two periods are 39.5°F (4.2°C) and 41.2°F (5.1°C), respectively (Figs. 4, 5). The average frost-free period is 100 days but can vary from 50 to 150 days. On the average, the last spring frost occurs during the last week of May and the first fall frost during the first week of September.

Summers, technically from late April to mid-October, are pleasant in Edmonton. The temperature has never been over 100°F (38°C) and seldom exceeds 90°F (32°C). The tropical Gulf air which brings heat waves to much of North America does not reach Edmonton, and the effect of the Rockies is to dry the Pacific air and keep humidity low. Temperatures during the five months of summer vary from averages of 52.1°F (11.2°C) in May to 63.1°F (17.2°C) in July to 51.5°F (10.8°C) in September. Temperatures in areas adjacent to the city are quite similar during the summer. The yearly fluctuations of mean monthly summer temperatures are small, varying by only 6°F (3°C) between maximum and minimum in the last forty years (Fig. 5). The mean annual temperature in Edmonton for the period 1931-1971 was 36.8°F (2.7°C).

Figures 6 and 7 give the heating degree days in detail for Edmonton. These figures provide an indication of the amount of energy required to maintain buildings at temperatures of 65°F (18°C) throughout the year.

WIND SPEED AND HUMIDITY

The yearly mean wind speed of 9.1 mph (about 15 km/hr) for Edmonton is one of the lowest on the Canadian Prairies. Mean wind speeds throughout the year remain fairly uniform ranging between a spring maximum of 10 to 11 mph (16 to 18 km/hr) to a winter minimum of 7 to 8 mph (11 to 13 km/hr) (Fig. 8). Predominant wind direction alternates between south and northwest. Northwest winds, although much less common than south winds, usually occur in the summer and are stronger than south winds. Wind speeds can average 40 mph (64 km/hr) for an hour in

any month of the year and gusts of over 80 mph (130 km/hr) occur periodically. Wind chill drops the mean January temperature from +6°F (-14°C) to -23°F (-31°C). During the winter months this effect may be even greater outside the city where temperatures are generally lower and the wind is unimpeded by buildings.

Relative humidity, especially in summer, is quite low in the Edmonton area because of the drying effect the Rocky Mountains have on Pacific air masses. Nighttime values remain fairly constant throughout the year, ranging between 70 and 80 percent (Fig. 9). During the day the humidity is generally lower, especially from April to September when it averages below 50 percent (Fig. 9).

PRECIPITATION

Total precipitation in Edmonton ranges from 12 to 25 inches (30 to 64 cm) and averages 18.6 inches (47.2 cm) per year. Of this, 13.6 inches (35 cm) falls as rain and

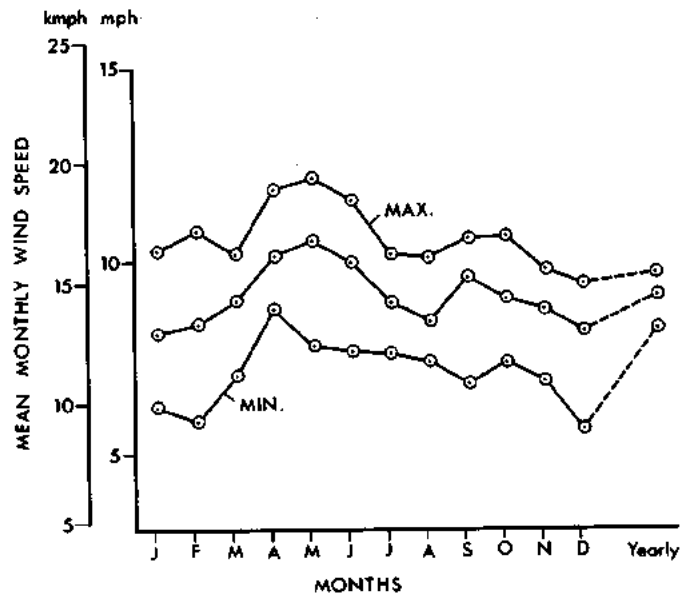


FIGURE 8. Mean monthly wind speed in the Edmonton area.

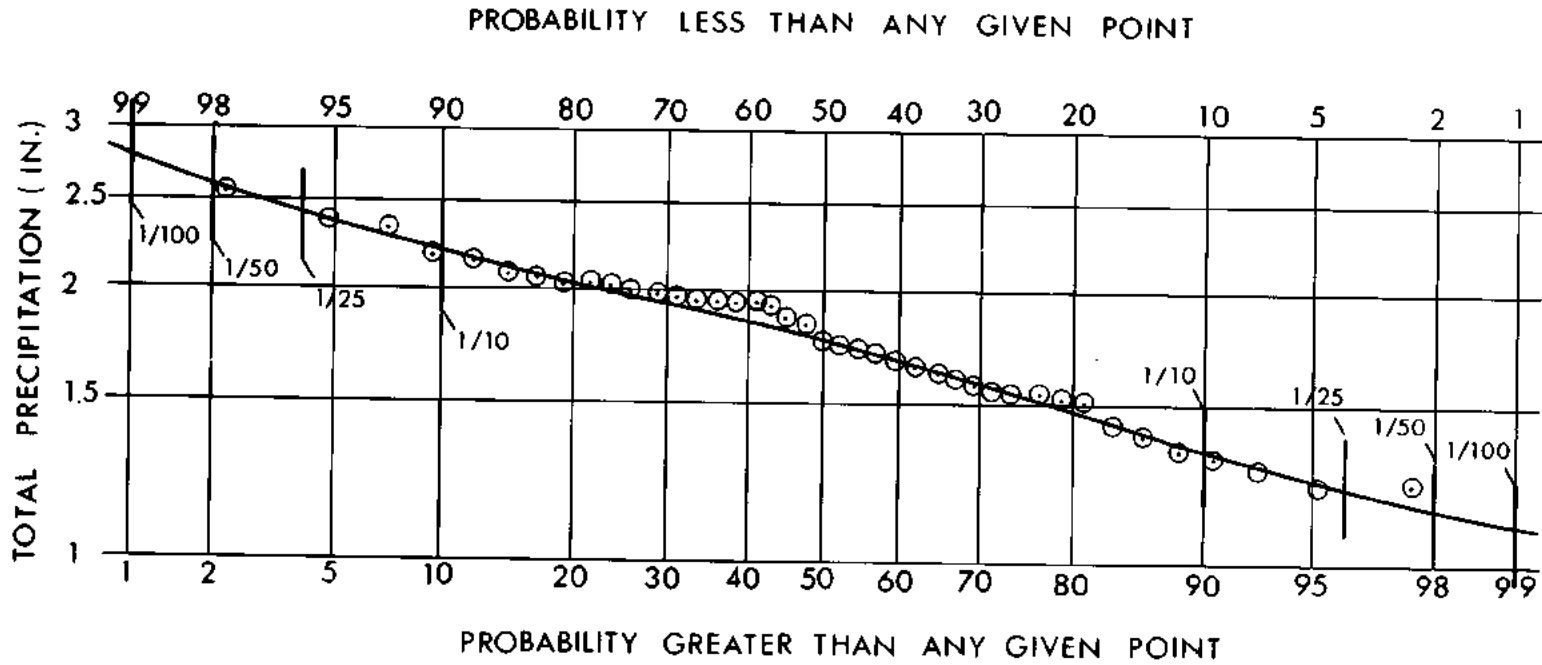


FIGURE 10. Probability of total precipitation exceeding specified ranges.

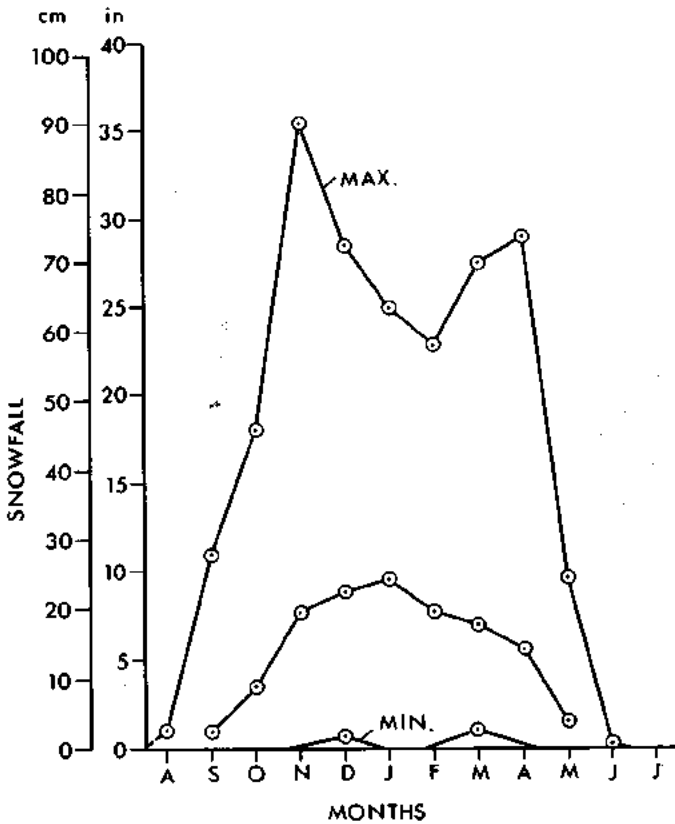


FIGURE 12. Mean monthly snowfall in the Edmonton area.

5 inches (13 cm) as snow. Using yearly precipitation data from Edmonton for the years 1931 to 1971, the probability of precipitation exceeding any value is indicated in figure 10. Similar information for snowfall is presented in figure 11.

Thunderstorms are common and are responsible for much of the rainfall during June, July and August; they are also responsible for hailstorms. Blizzards are infrequent in the Edmonton area and less severe than on the open plains to the south.

Approximately 70 percent of the yearly precipitation falls as rain during the summer growing season from May to September. June and July each receive over 3 inches (8 cm) of rain and constitute the wet months of the year. The snowfall averages 54 inches (137 cm) but ranges from 30 to

90 inches (76 to 230 cm). Snow falls primarily between November and March (Fig. 12).

Summer rains and winter snowfalls are usually gentle. Rainfalls of 5 inches (13 cm) per day or snowfalls of 15 inches (38 cm) per day are unlikely to occur.

CLOUD AND SUNSHINE

Cloud cover is usually about five-tenths, varying little throughout the year. June and November are cloudier than average while February and August are sunnier than average. Mornings tend to have fewer clouds than afternoons. Edmonton, with an average of 2201 hours of sunshine per year (which is 45 percent of possible sunshine), is one of the sunniest of the major western cities. July has over 300 hours of sunlight; December, the dullest month, averages only 75 hours of sunlight (Fig. 13). An overcast day in summer is very rare but in winter as many as 50 percent of the days may be completely overcast.

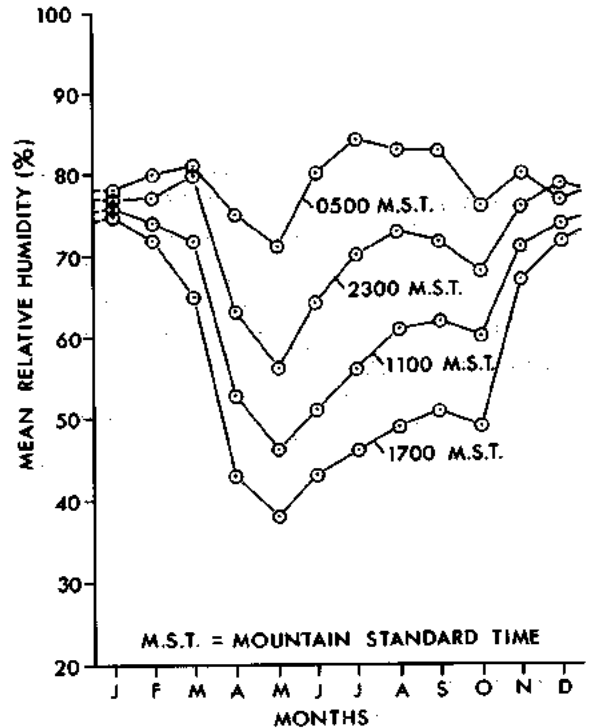


FIGURE 9. Mean relative humidity in the Edmonton area.

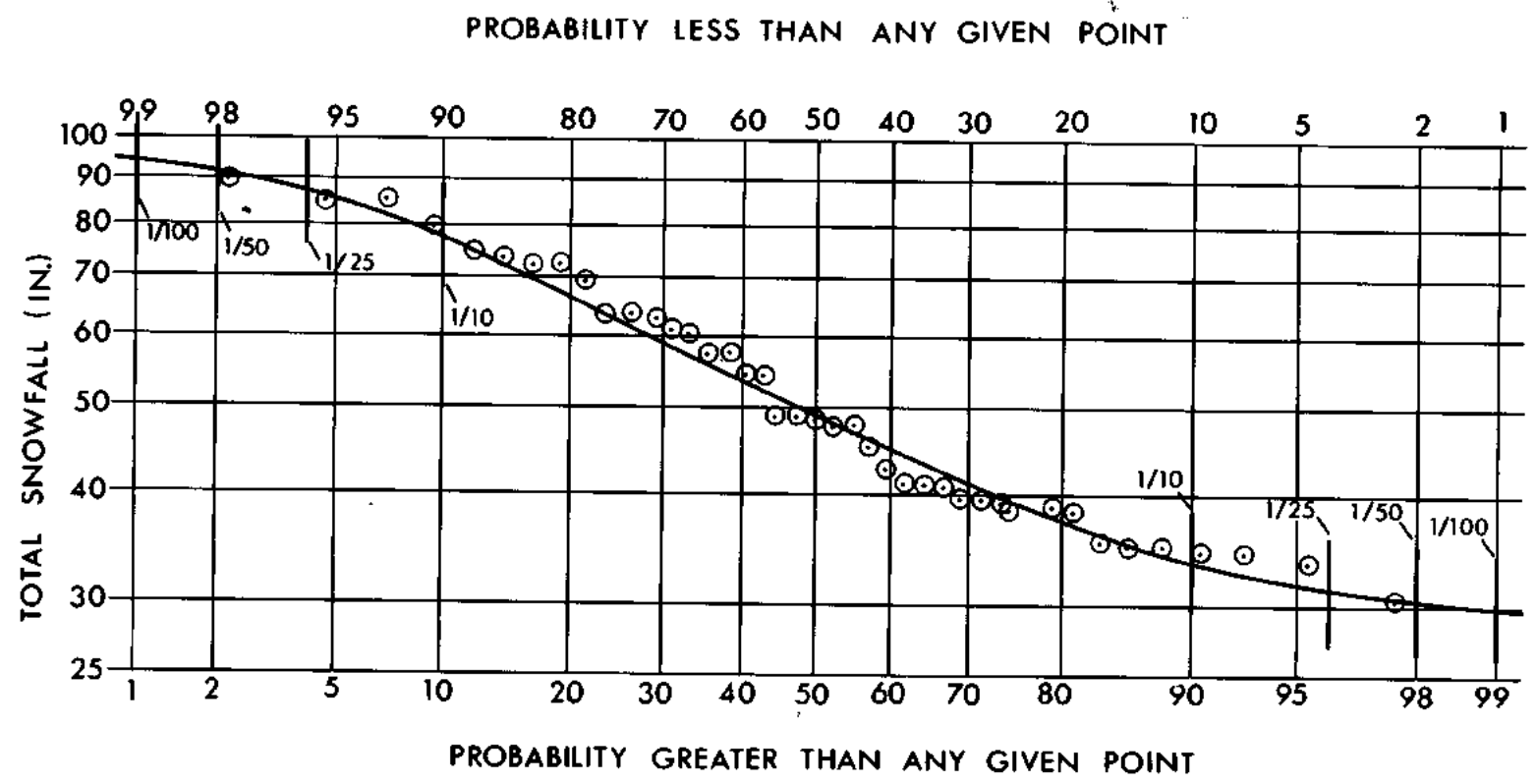


FIGURE 11. Probability of snowfall exceeding specified ranges.

BEDROCK GEOLOGY

GEOLOGIC SETTING

The Alberta Plains, where the study area is located, is an area of low relief underlain at shallow depths by a succession of sandstones and shales — mostly nonmarine — and coal beds of Late Cretaceous and Early Tertiary ages. At greater depths lie Mesozoic strata, a predominantly marine sequence of mainly shales and sandstones. Beneath the Mesozoic beds is a thick sequence of Paleozoic limestone and dolomites, evaporites and to a lesser extent clastic rocks. These Paleozoic rocks rest on the Precambrian basement.

The bedrock structure of the Plains is simple: the strata dip gently westward at a slope of a few feet per mile. Successively younger strata outcrop at the bedrock surface in a westerly direction to the point where they are affected by the structural deformation which formed the Rocky Mountain Foothills.

BEDROCK GEOLOGY OF THE STUDY AREA

In the study area, 138 oil and gas wells have been drilled and several fields are in production. Data from these wells have been incorporated into the following description of the bedrock geology.

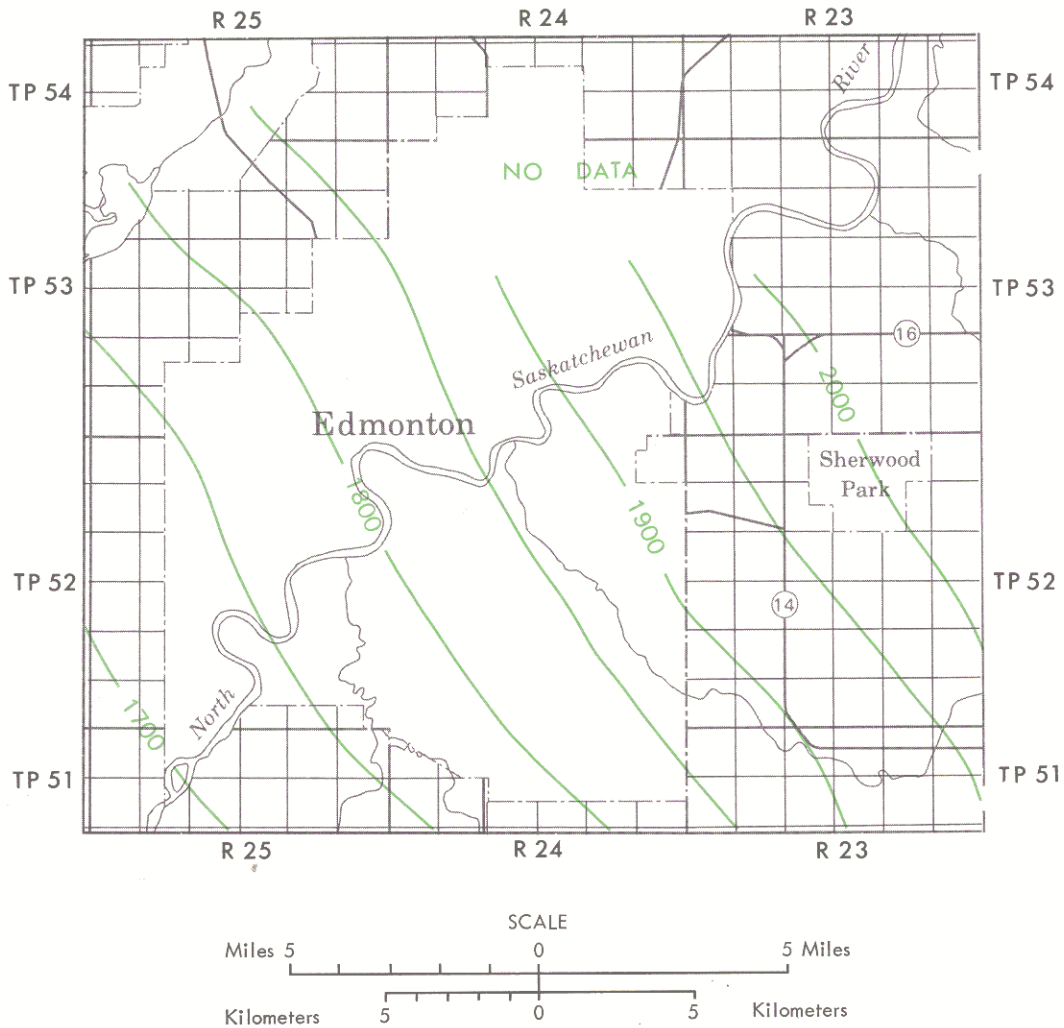


FIGURE 15. Topography of the upper surface of the Bearpaw Formation.

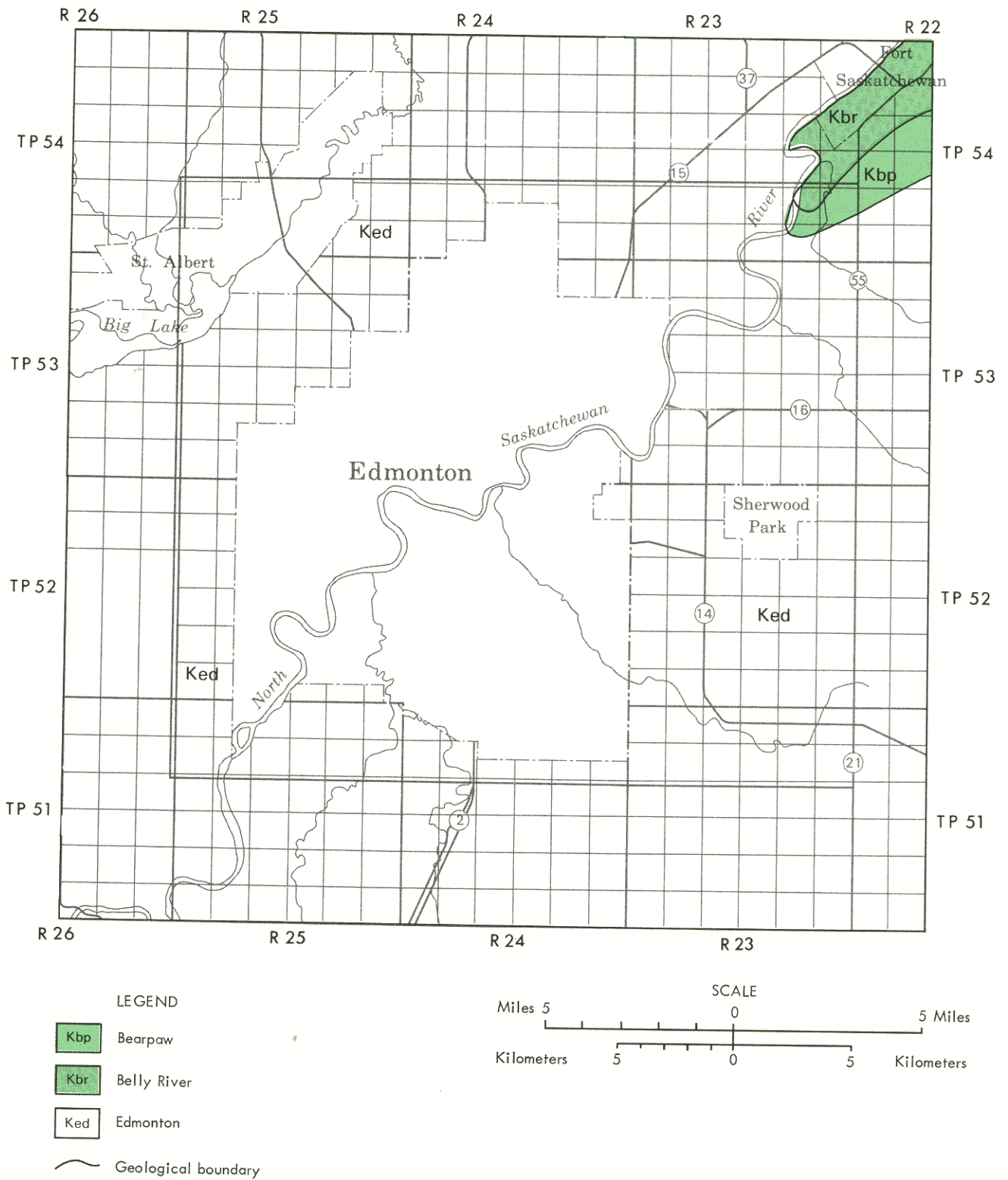


FIGURE 14. Bedrock geology of the Edmonton area.

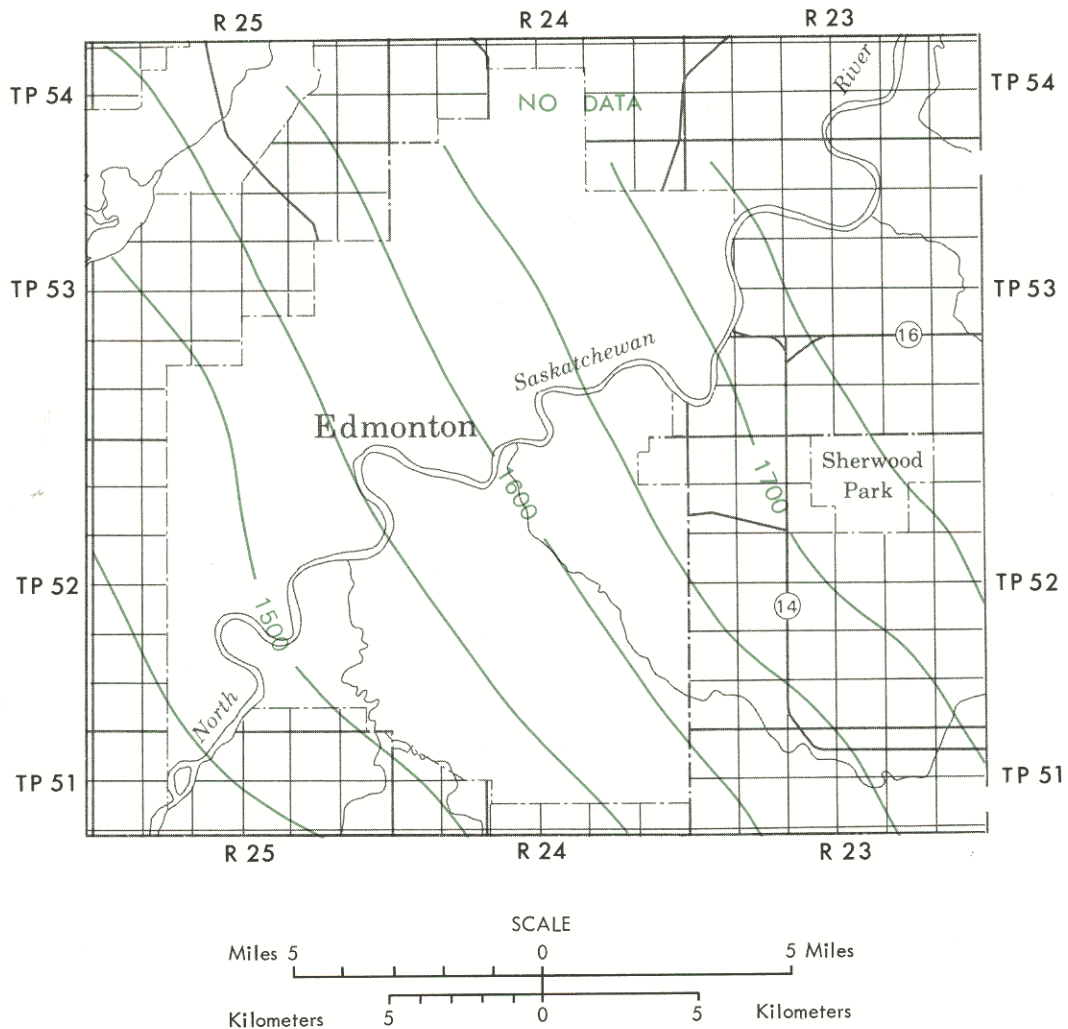


FIGURE 16. Topography of the upper surface of the Belly River Formation.

In the Edmonton area, Mesozoic rocks are overlain by quartzite gravels, sand and glacial and postglacial deposits and are underlain by Paleozoic beds primarily of limestone and dolomite. The thickness of the Mesozoic rocks ranges from 3185 to 4200 feet (971 to 1280 m) and averages 3900 feet (about 1200 m). A generalized stratigraphic column of the bedrock deposits in the map area is provided in table 2.

Throughout most of the Edmonton area, the near-surface bedrock is the Edmonton Formation of Late Cretaceous age (Fig. 14). However, in the northeast the Bearpaw and Belly River Formations form the bedrock surface.

Edmonton Formation

The Edmonton Formation (the Horseshoe Canyon of Irish, 1970) outcrops in many localities along the valley of the North Saskatchewan River and its tributaries, in particular along Whitemud, Blackmud and Mill Creeks.

The upper surface of the Edmonton Formation has been highly dissected by erosion and is discussed in the section of this report that describes the bedrock topography of the study area. The lower boundary of the formation is defined by its contact with underlying Bearpaw shale. Thickness of the Edmonton Formation in the study area is variable

because of the extensive erosion of its upper surface; however, the thickness ranges from about 450 to 620 feet (140 to 190 m) and averages 560 feet (170 m). The formation has a regional northwest-southeast strike and a dip of a few tens of feet per mile to the southwest (Carlson, 1967).

The Edmonton Formation consists primarily of fine-grained bentonitic sandstone and siltstone interbedded with, and grading vertically and laterally into, bentonitic silty claystone. Coal seams and bentonite beds of variable thickness are common throughout the formation together with beds of claystone and sideritic sandstone. Considerable data concerning the distribution and thickness of coal seams are available in a publication by Taylor (1971). Beds in the

Edmonton Formation are lenticular and difficult to trace because of the lateral and vertical variation of lithologies over short distances.

The mineralogy of the Edmonton Formation is characterized by a high percentage of volcanic detritus in the sand and silt fractions: angular quartz, feldspars and finely crystalline volcanic rock fragments (Locker, 1969). Commonly, biotite mica and carbonaceous matter are present, which enhances the fissility of the rocks. Montmorillonite, which is the dominant clay-sized constituent, is present often as a sandstone cement but also as a main component of the claystones (Locker, 1969).

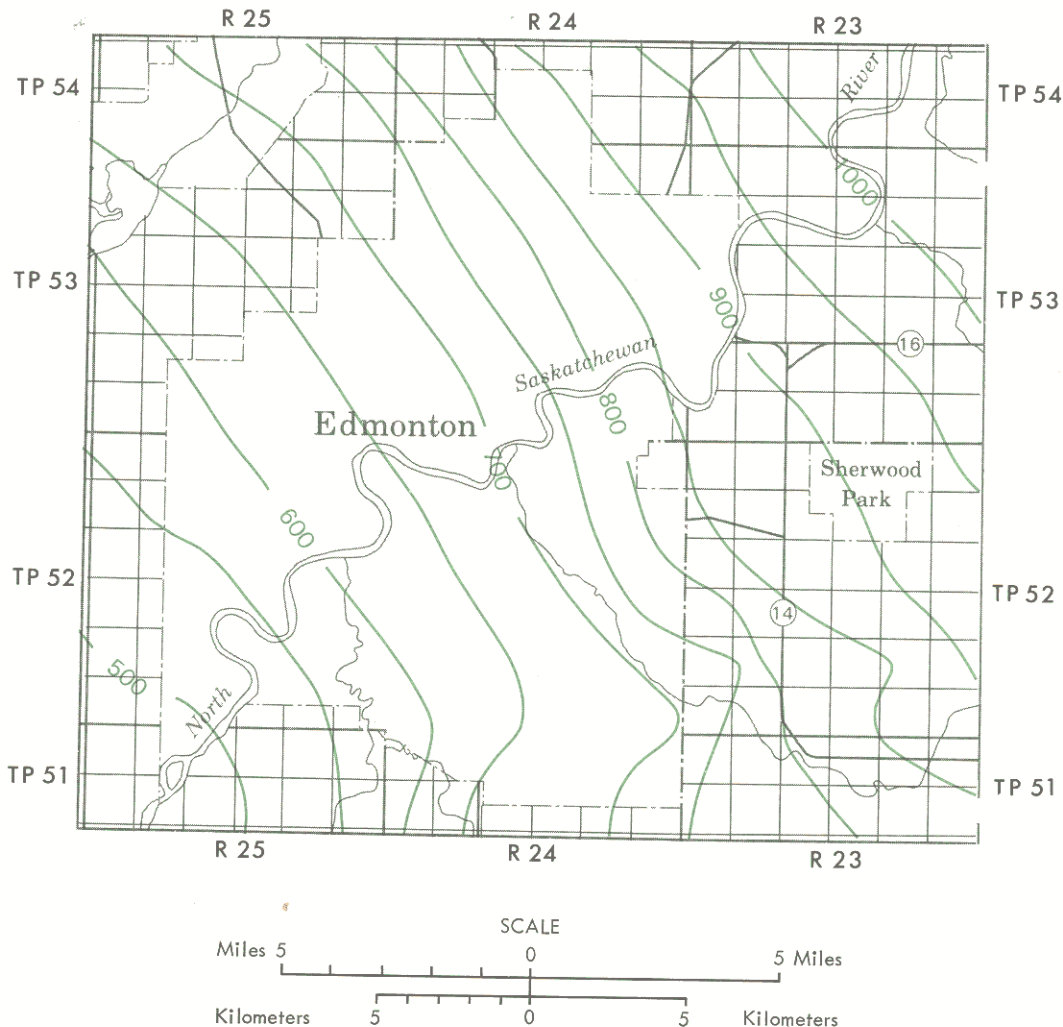


FIGURE 17. Topography of the upper surface of the Lea Peak Formation.

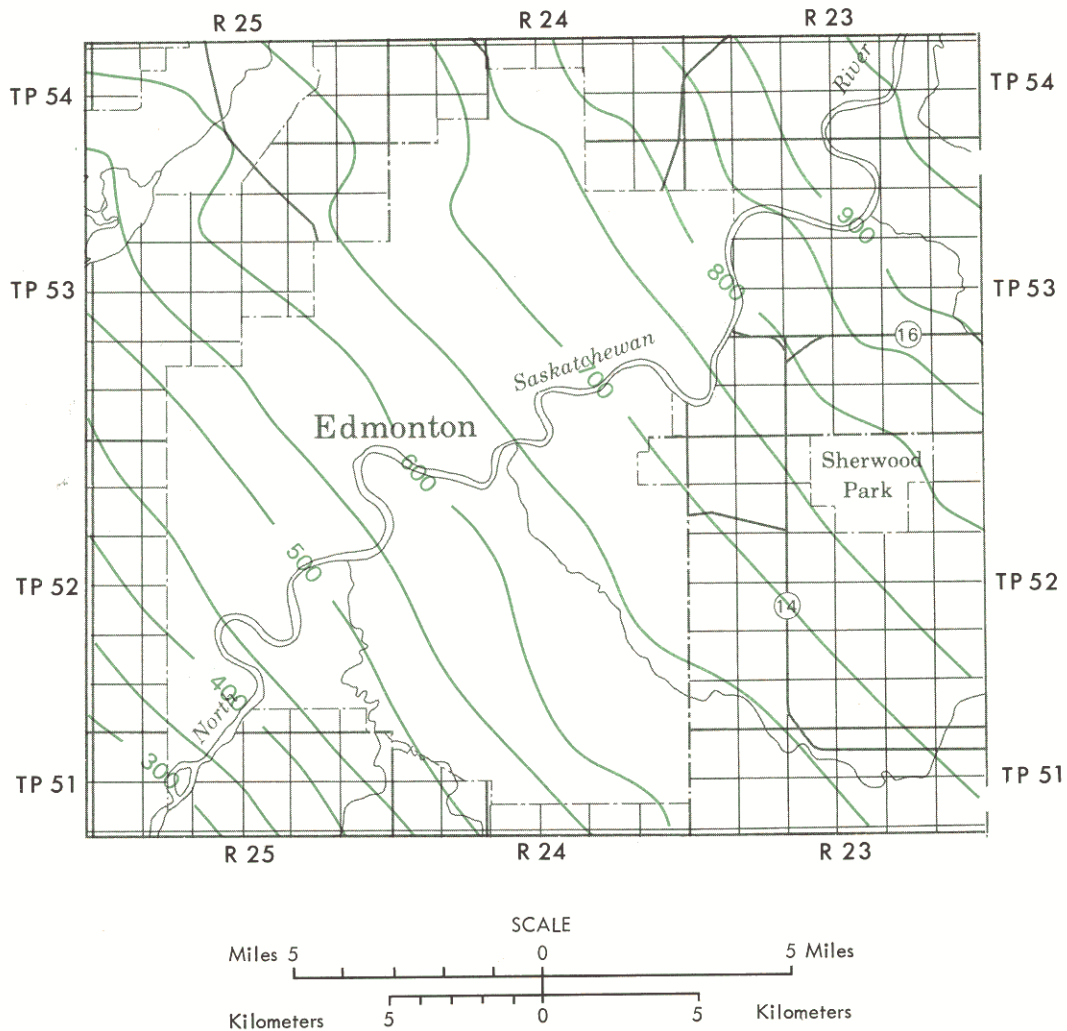


FIGURE 18. Topography of the upper surface of the Fish Scale Zone.

Bearpaw Formation

The Bearpaw Formation, which is mostly dark grey marine shale, glauconitic sandstone and thin bentonite beds, underlies a large area in southern and east-central Alberta (Green, 1972). Its presence in the Edmonton area was questioned by Ower (1958), this location being near the depositional edge of the Bearpaw Sea. However, it was identified beneath the Edmonton Formation in a number of oil and gas wells mainly in the part of the study area south of the North Saskatchewan River. The marine sequence changes character northward and becomes unrecognizable north of the river. The thickness of the Bearpaw Formation ranges from a few feet to 207 feet (<1 to 63 m) but is

generally about 150 feet (about 45 m). The beds slope gently to the southwest (Fig. 15).

Belly River Formation

In the Edmonton area beds of the Belly River Formation underlie the Bearpaw Formation and overlie the Lea Park Formation. Belly River strata are composed of interbedded bentonitic sandstone, silty to sandy shale and carbonaceous claystone. Thin beds of sideritic ironstone and coal seams are also present. The sediments closely resemble the bentonitic rocks of the overlying Edmonton Formation al-

though they appear to be sandier in overall aspect (Locker, 1969). Outcrops are found along the North Saskatchewan River downstream from Edmonton (Fig. 14).

Based on data from 28 oil and gas wells, the Belly River strata range from 690 to 930 feet (210 to 283 m) thick in the Edmonton area and average 840 feet (256 m). The surface of this rock unit slopes gently to the southwest (Fig. 16).

Lower Rock Sequences

The age and lithology of rocks below the Belly River Formation are outlined in table 2. Maps of the surface topography of the Lea Park Formation (Fig. 17) and the base of the Fish Scale Zone (Fig. 18) have been included to

illustrate that the general southwest tilting of the Mesozoic rocks is consistent at depth. The considerably older Wabamun Formation of Devonian age (essentially dolomitic limestone and calcareous dolomite) also exhibits a generally southwest slope; however, these rocks have been subjected to considerable erosion which has caused a somewhat irregular upper surface (Fig. 19).

BEDROCK SURFACE TOPOGRAPHY

The basic configuration of the bedrock surface in the Edmonton area was set in preglacial time; however, the surface was somewhat modified during and since glaciation of the area. Prior to glaciation, rivers and their many short tributaries flowing northeastward from the eastern slopes of

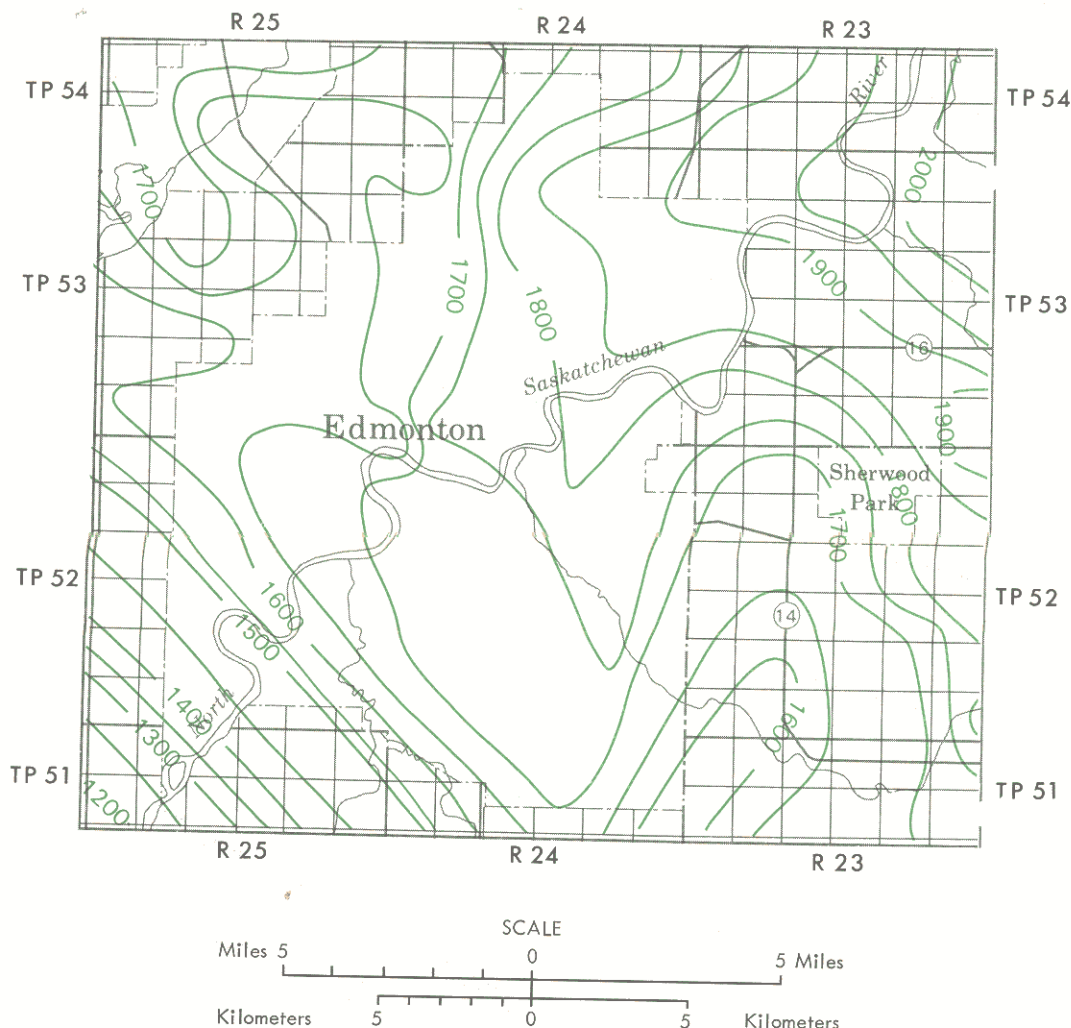


FIGURE 19. Topography of the upper surface of the Wabamun Group.

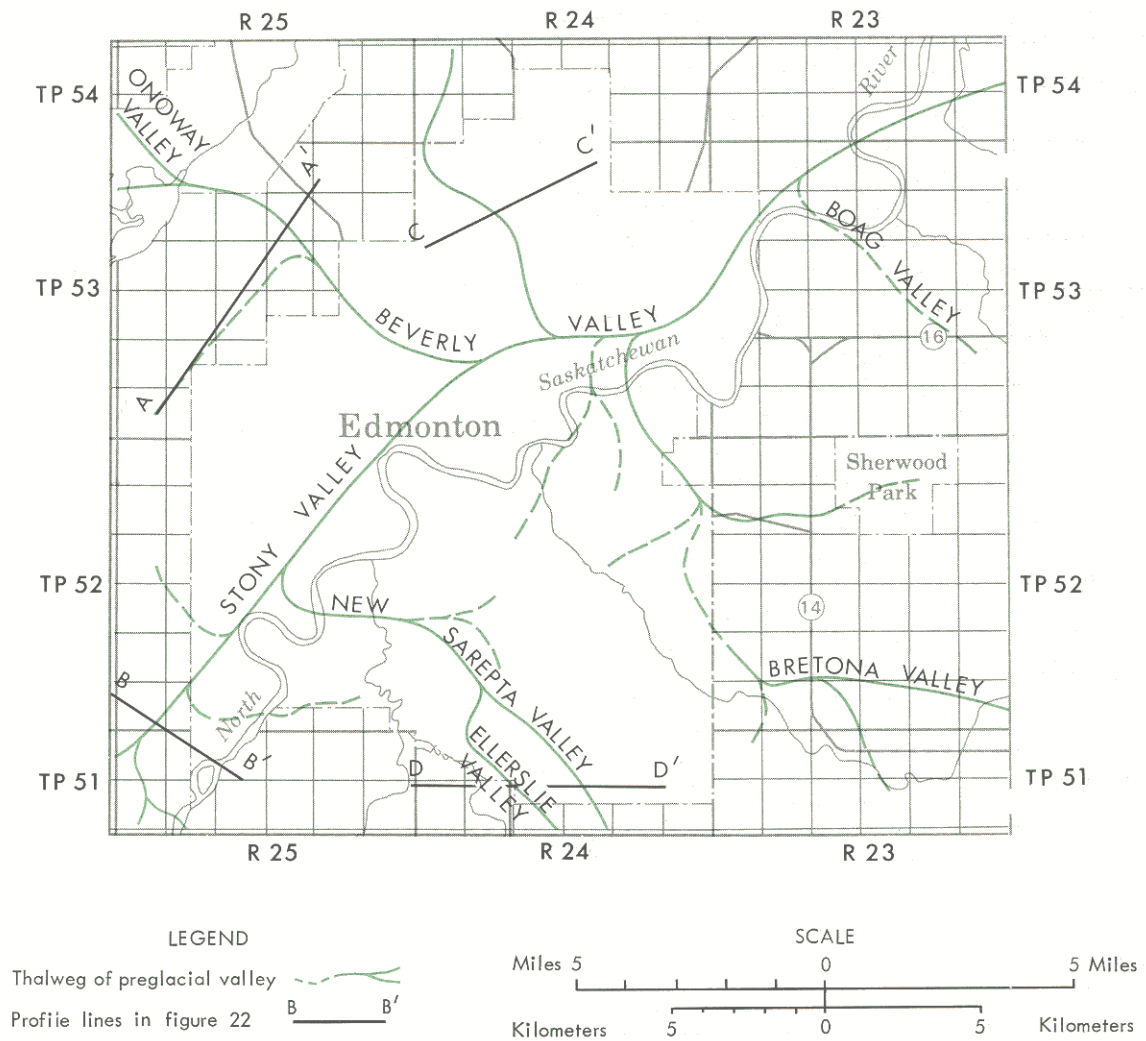


FIGURE 21. Thalwegs of preglacial valley in the Edmonton area.

the Rocky Mountains eroded the soft, relatively flat-lying bedrock to produce a series of dendritic drainage basins separated by low bedrock divides. The dominant topographic feature of the bedrock in the area is the Beverly Valley which passes through the northern portion of the city (Figs. 20, 21). Several flat-topped uplands separated by numerous tributary stream valleys are also present.

During glacial periods the bedrock surface was altered. In some places large pieces of bedrock were excavated and carried away by glacier ice while in other places the bedrock was squeezed and folded but not significantly transported. A section exposing such contorted bedrock can be seen on Highway No. 14 in the east portion of the study

area (Plate 1, Fig. 1). In many of the testholes drilled for this study, blocks of ice-transported bedrock are present in the glacial till deposits which overlie the bedrock. Approximately 20 percent of the testholes intersected slabs of bedrock in the glacial sediments.

Postglacial bedrock erosion has also occurred in the study area. The North Saskatchewan River has excavated its valley since glaciation, and has cut down into bedrock along the river valley from the southwest portion of the area to Clover Bar (Fig. 20). Northeast of Clover Bar, the North Saskatchewan follows the broader preglacial Beverly Valley and extensive postglacial bedrock erosion has not occurred.

Plate 1

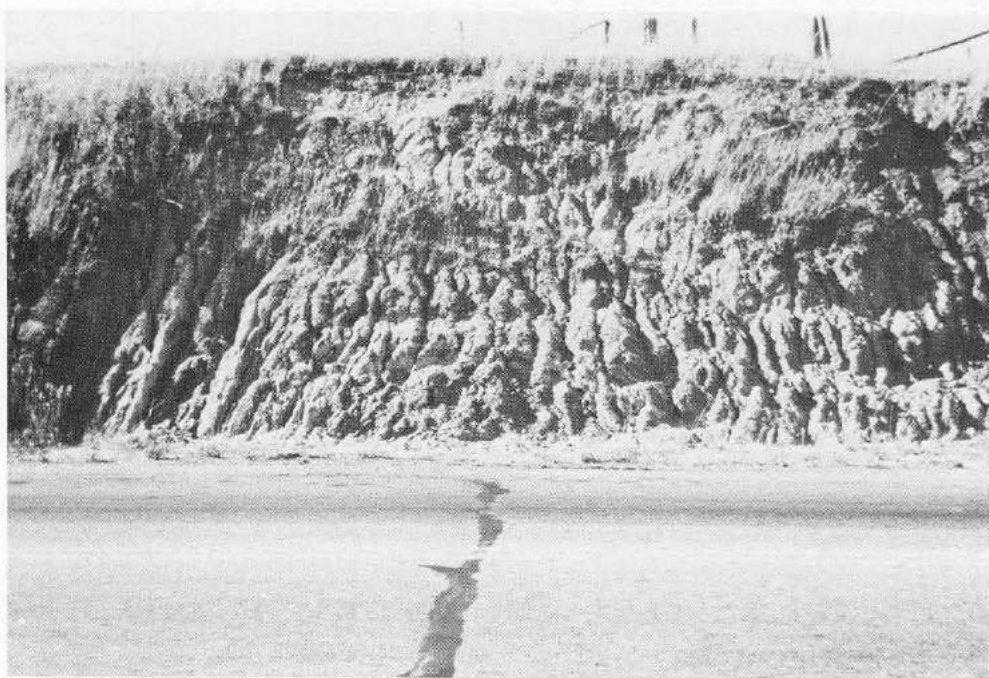


Figure 1. Bedrock (Edmonton Formation) contorted by glacier ice (Lsd. 13, Sec. 27, Tp. 52, R. 23).

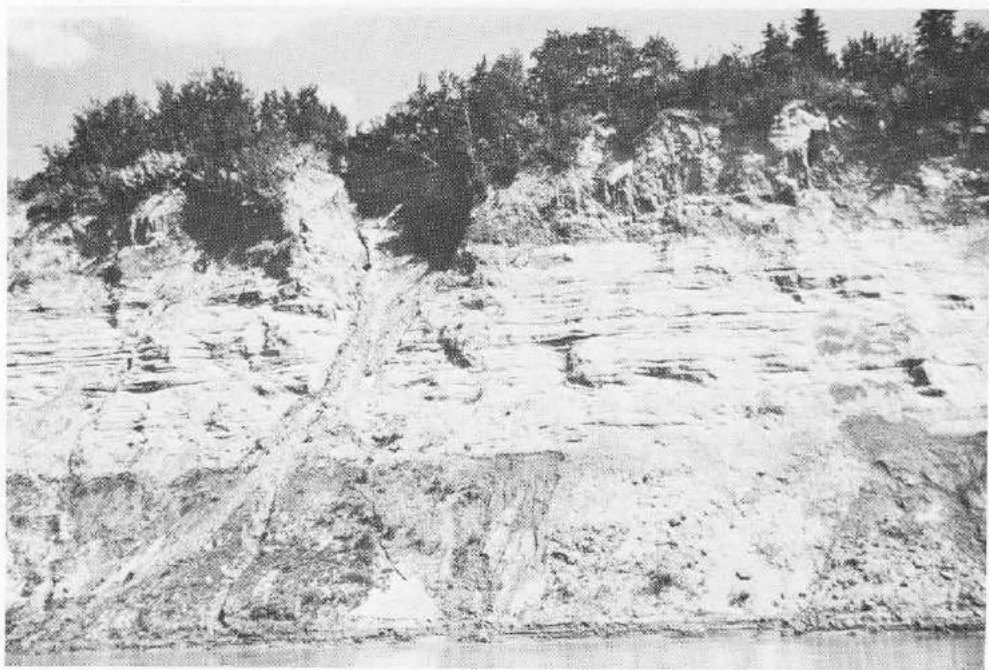


Figure 2. Saskatchewan gravels and sands of the Stony Valley underlain by the Edmonton Formation and overlain by glacial till and glacial Lake Edmonton sediments. Note the springs at the bedrock contact.

Bedrock erosion has also taken place along many of the tributaries of the North Saskatchewan; in particular, White-mud, Blackmud, Mill and Oldman Creeks are characterized by relatively deep narrow valleys (Fig. 20). Minor bedrock erosion may have also occurred along Pointe-aux-Pins and Fulton Creeks.

Data are not sufficient to determine whether the bedrock erosion along the Sturgeon River Valley near St. Albert took place in postglacial times.

Glacial meltwater has eroded the bedrock surface in the Gwynne outlet (an overflow channel of glacial Lake Edmonton) south of the study area and possibly in a minor outwash channel near Clover Bar (Secs. 8 and 17, Tp. 53, R. 23).

Bedrock Uplands

Flat-topped bedrock highs, a prominent aspect of the bedrock surface topography, are found between preglacial stream valleys. The individual uplands vary from less than 5 square miles (less than 13 km²) to over 15 square miles (over 39 km²). Relief on the uplands generally is only about 10 to 20 feet (3 to 6 m). Side slopes 150 to 200 feet (45 to 60 m) high are common with slope angles of 3 to 4 percent.

The two bedrock highs north of the Beverly Valley (Fig. 20) are examples of this type of landform. Both have little surface relief and rapidly drop 150 to 200 feet (45 to 60 m) into the Beverly and Namao Valleys. The North Saskatchewan River has exposed part of a bedrock high in the downtown area at 82 Street and 109 Avenue. At that point the bedrock elevation is 2160 feet (658 m), whereas the bedrock elevation 5 blocks north (82 Street and 114 Avenue) is 2050 feet (624 m).

Near the western boundary of the area a bedrock high in excess of 15 square miles (39 km²) has a surface elevation that varies only by about 10 feet (3 m).

The southeast quarter of the map area is dominated by bedrock highs (Fig. 20). The bedrock elevation in the southeast increases away from the Beverly Valley to a maximum of 2429 feet (740 m) at the extreme southeast corner of the study area.

Two miles farther east, a north-south trending bedrock ridge is present which has been termed the Cooking Lake Divide (Carlson, 1967). The maximum bedrock elevation difference in the Edmonton area is 450 feet (121 m).

Bedrock Valleys

Beverly Valley

The Beverly Valley is the largest preglacial valley present in the study area (Figs. 20, 21). Its position is reflected on the present land surface by the topographic low that extends from north of Spruce Grove to south of Big Lake, through north-central Edmonton and then northeast towards Fort Saskatchewan. It is a broad valley, up to 5 miles (8 km) wide, with gently sloping valley walls. The valley depth is approximately 200 feet (60 m) with side slopes averaging 2 percent. The valley gradient is gentle, approximately 2.5 feet per mile (about 0.5 m per km). A typical cross-section of the Beverly Valley is shown in figure 22.

Stony Valley

The Stony Valley is the main tributary channel of the Beverly Valley in the study area (Figs. 20, 21). It trends northeast from the southwest corner of the map area to its junction with the Beverly Valley near 111 Avenue and 124 Street. Exposures of sediments in Stony Valley are present at the "Big Bend" section on the North Saskatchewan River (Sec. 16, Tp. 52, R. 25) and along the river banks toward Mayfair Park (Plate 1, Fig. 2).

Gradient and side slope values for the Stony Valley are difficult to ascertain because several small preglacial tributaries and the present North Saskatchewan River disrupt the valley. It is, however, narrower than the Beverly Valley, averaging only 2 miles (3 km) across, and the side slopes are estimated to be 2.5 to 3.5 percent. The valley depth is approximately 100 feet (30 m). The gradient is steeper than the Beverly Valley, being on the order of 7 feet per mile (1.3 m per km). A typical cross-section is given in figure 22.

Namao Valley

The Namao Valley, a minor tributary of the Beverly Valley, originates just north of the study area and west of the village of Namao (Figs. 20, 21). It enters the study area in Sec. 7, Tp. 54, R. 24, and joins the Beverly Valley near 118 Avenue and 87 Street. The Namao Valley is typical of the short tributary valleys present in the bedrock surface. Its length is probably not more than 10 miles (16 km); valley width ranges from 1 mile to 2 miles (2 to 3 km); valley side slopes are 1 to 2 percent. The valley depth ranges from 25 feet (8 m) to over 100 feet (30 m); its gradient is approximately 20 feet per mile (about 4 m per km). A representative cross-section is given in figure 22.

New Sarepta and Eilerslie Valleys

The New Sarepta Valley, which originates near the village of New Sarepta in Tp. 49, R. 22 (Carlson, 1967), is the largest of the Stony Valley tributaries (Figs. 20, 21). The valley enters the study area 2 miles (3 km) east of Eilerslie and trends in a northwesterly direction to its junction with the Stony Valley just north of "Big Bend" in Sec. 15, Tp. 52, R. 25. The position of this valley is uncertain in Secs. 13 and 14, Tp. 52, R. 25, because of a lack of deep drillhole information.

The New Sarepta Valley has several small tributaries, the Eilerslie Valley being the largest (Figs. 20, 21). The Eilerslie Valley enters the area 1 mile (2 km) east of Eilerslie and parallels the New Sarepta Valley for 3 miles (5 km). Both valleys become indistinct and close together just outside the study area. It is possible that the Eilerslie Valley is an alternate channel for a stream that also flowed down the New Sarepta Valley.

The New Sarepta Valley is 1 mile (2 km) wide with valley depth ranging from 25 to 50 feet (8 to 15 m). The side slopes vary from 1.5 to 6 percent and the valley gradient is

13 feet per mile (2.4 m per km). The Eilerslie Valley is 1/2 mile (0.8 km) wide with valley depths ranging from 10 feet (3 m) to over 50 feet (15 m). The side slopes vary from approximately 0 to 4 percent and the valley gradient exceeds 25 feet per mile (5 m per km). Cross-sections are shown in figure 22.

Other Preglacial Bedrock Valleys

Several other tributary bedrock valleys are present in the area (Figs. 20, 21).

The Devon Valley, a tributary of the Stony Valley, is present only in the extreme southwest corner of the study area. It is approximately 1 mile (2 km) wide with a depth of 40 feet (12 m).

The Bretona Valley, in the southeastern quarter of the study area, has not been accurately located. The valley depth is quite variable ranging from 20 to 75 feet (6 to 23 m) and its gradient averages 20 feet per mile (4 m per km). The Boag Valley is present in the northeast portion of the study area. The valley is 1 mile (2 km) wide and its depth approaches 50 feet (15 m). Both the Boag and Bretona Valleys originate along the western slope of the Cooking Lake Divide.

SURFICIAL GEOLOGY

Several investigations have been conducted on the surficial geology of the Edmonton area. The Alberta Research Council (Bayrock 1972) published a surficial geology map of the Edmonton map sheet (NTS 83H) at a scale of 1:250,000 (in pocket). Bayrock and Hughes (1962) published a report about the geology of the Edmonton area between longitudes 113°00' and 114°00'W, and latitudes 53°15' and 53°45'N, which was accompanied by surficial geology maps on a scale of 1 inch to 1 mile (1:63,360). A report on the geology of central Edmonton which discussed a small portion of the study area was published by Bayrock and Berg (1966). Westgate (1969) published a summary report on the Quaternary geology of the Edmonton area. In addition, numerous other workers have published papers which include information on the surficial geology of the area.

The following description of the surficial geology of the area is based on data from all previous studies as well as from field mapping and a controlled drilling program conducted by the authors. The surficial geology map (1:50,000 scale) included in this report (Fig. 23) is a modified version of the maps published by Bayrock and Hughes (1962), and incorporates new data obtained during this study.

GEOMORPHOLOGY

The study area, which is part of the Eastern Alberta Plains (Alberta Government and Univ. 1969), ranges in elevation from 2510 feet (765 m) in the southeast to 1985 feet (605 m) in the northeast along the North Saskatchewan River Valley. Regional slope in the vicinity of Edmonton is to the northeast.

Elements of the preglacial landscape are discernible in the sense that present day uplands coincide with preglacial highs, and low areas generally follow preglacial valleys; however, the near-surface sediments were deposited primarily in glacial and postglacial times.

Quaternary Landforms

The landforms shown in figure 23 have been described previously by Bayrock and Hughes (1962).

Ground moraine is present in the southeast portion of the map area and in scattered localities elsewhere. It forms a level to gently undulating till plain with a local relief less than 20 feet (6 m). Small knobs up to 350 feet (about

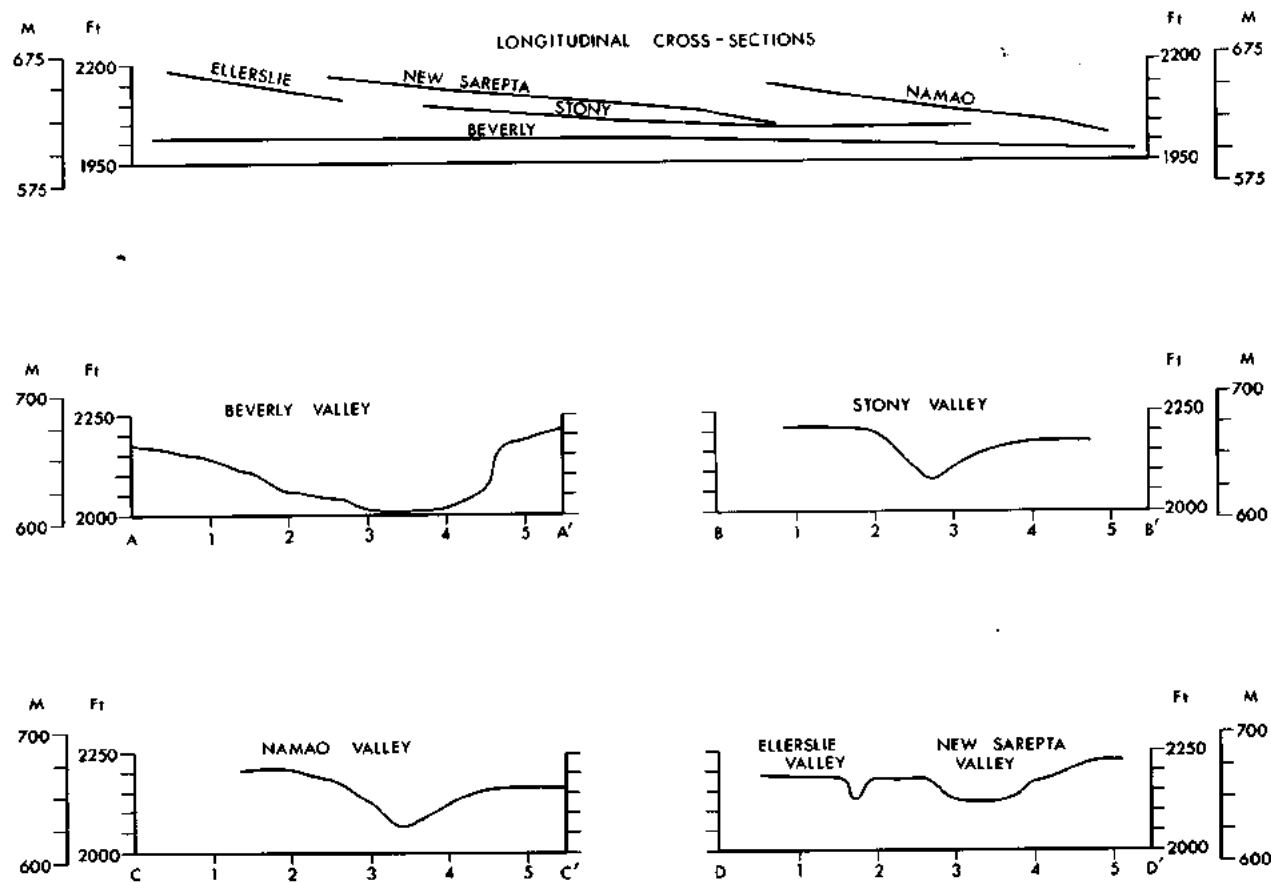


FIGURE 22. *Schematic cross-sections and longitudinal profiles of the major bedrock valleys in the Edmonton area.*

100 m) in diameter and 10 feet (3 m) in height and kettles up to 5 feet (1.5 m) deep and 150 feet (45 m) in diameter are common. The ground moraine grades into hummocky dead-ice moraine in the southeast portion of the area.

Hummocky dead-ice moraine is present only in the southeast portion of the area. Studies of similar deposits in western Canada and Europe indicate that this type of deposit is a product of till deposition from stagnant ice (Bayrock and Hughes, 1962). The main topographic elements of this landform such as knobs, kettles, till ridges, moraine plateaus and stream trenches are all present (Bayrock and Hughes, 1962). Knobs and kettles are the most common features of the hummocky moraine (Plate 2, Fig. 1).

Knobs composed mostly of till range up to several hundred feet in diameter and average 15 to 20 feet (4 to 6 m) in height although they may attain heights up to 50 feet (15 m).

Till ridges found in the hummocky dead-ice moraine form closed or linear ridges. Some of the closed ridges are knobs with central depressions higher than the general ground level, giving them the appearance of large doughnuts. Other closed ridges are circular to irregular in outline and have central depressions that are at approximately the same elevation as the surrounding ground. Several hypotheses have been proposed for the formation of the various types of closed till ridges but most workers agree that they resulted from stagnant ice that separated into individual dead-ice blocks, even though there is no agreement as to the mechanism of deposition (Gravenor and Kupsch, 1959). The closed ridges range up to 20 feet (6 m) in height and up to several hundred feet in diameter.

Linear till ridges are generally between 1/8 and 1/4 mile (0.2 to 0.4 km) long although a few exceed 1 mile (2 km) in length. They vary from straight or sinuous ridges with relatively even crests to elongate rows of hummocks. The ridges are believed to have been formed by debris slumping into crevasses in glacial ice (Gravenor and Ellwood, 1957).

Moraine plateaus are irregularly distributed in the dead-ice moraine. They are irregular in outline with relatively flat surfaces that are usually at the same elevation or slightly higher than the crests of the surrounding knobs. The plateaus are generally composed of till and overlain by a layer of lacustrine sediments which is usually less than 10 feet (3 m) thick. They are believed to be deposits from supraglacial lakes that were surrounded by ice (Bayrock and Hughes, 1962).

Stream trenches occur in the hummocky dead-ice moraine and ground moraine in the southeast portion of the area and are surrounded by lacustrine sediments in the western portion of the area (Fig. 23). They vary from a few hundred feet to several miles in length and are generally less than 1/2 mile wide (0.8 km). They range from a few feet to over 25 feet (<1 m to 8 m) in depth. The channels contain a variety of sediments which may include hummocky dead-ice moraine, glaciofluvial sand and gravel, minor glacio-lacustrine deposits and Recent lacustrine and alluvial deposits. In the southeast portion of the area they are believed to have been formed by meltwater flowing from ice in areas where hummocky dead-ice moraine was being deposited. In the western portion of the area, they were formed by meltwater flowing from the pitted delta located to the west.

Kames present in the southwest corner of the map area are up to 600 feet (183 m) higher than the surrounding ground level. They are generally overlain by a few feet of lacustrine sediments and are composed of sand with minor silt and fine gravel and numerous till inclusions.

Outwash sand and gravel is common in the southeast corner of the area (Fig. 23). The deposits vary in size up to a maximum of approximately 2 square miles (5 km²) and consist of fine- to coarse-grained sand with minor lenses of gravel. The outwash is generally overlain by up to 10 feet (3 m) of lacustrine silt and clay.

Pitted delta deposits occur only in the western portion of the map area (Fig. 23). They have a topographic expression similar to hummocky moraine, and consist mainly of knobs and kettles. These deposits are composed primarily of fine sand and silt, with thin clayey layers which may be pedogenic or geologic in origin, or a combination of the two (Coen, 1965). In some localities the bedding is undisturbed and in others it is highly contorted. Also present are minor pebbles and till inclusions which have probably been deposited by ice rafting. It is believed that the pitted delta was produced by the melting of buried ice blocks in the delta sediments (Bayrock and Hughes, 1962).

Interconnected channels containing fine- to medium-grained sand with minor silt, clay, coarse sand and gravel are present adjacent to the pitted delta. These channels were originally believed to represent a braided channel of the North Saskatchewan River which existed before the North Saskatchewan cut its present valley (Bayrock and Hughes, 1962); however, they are now believed to have been formed by meltwater flowing from the pitted delta (Bayrock, pers. comm.²).

² L. A. Bayrock, Bayrock and Reimchen Surficial Geology Ltd., Vancouver, British Columbia.

Plate 2.



Figure 1 Knob and kettle topography in hummocky dead-ice moraine southeast of Sherwood Park.



Figure 2. Rhythmically bedded glacial Lake Edmonton sediments consisting primarily of silt and clay (sewer excavation in west Edmonton near the junction of 170 St. and Quesnel Freeway).

Glacial Lake Edmonton sediments are the most common surficial deposit, and occur throughout the map area (Fig. 23). The sediments are thickest in the central part of the area where they overlie major preglacial topographic lows. The outer edge of the lake sediments can be only approximately defined because near the old shoreline the sediments are thin and have been altered by soil-forming processes; this makes positive identification difficult. Furthermore, beaches along the boundaries of the lake are poorly developed or absent because of the short lifetime of the lake. Over short distances there are numerous changes in the composition and grain size of the lacustrine sediments. In general, the lower portions of the lake sediments are composed of sand and silt and contain numerous beds of till-like material, till lenses and pebbles. These sediments are believed to have been deposited relatively close to glacier ice margins where mud flows, slumping and ice rafting of glacial debris was common.

The upper portions of the Lake Edmonton sediments consist of silts and clays with only minor till lenses and pebbles (Plate 2, Fig. 2). They are generally rhythmically bedded and may be varved; however, an annual origin has not been proved. It is thought that the ice margin was fairly remote when these sediments were deposited.

Numerous other small deposits of lacustrine silts and clays occur in areas of ground moraine and hummocky dead-ice moraine (Fig. 23).

Glaciolacustrine sand and silty sand is present in scattered localities overlying till and other glaciolacustrine deposits. The sediments are generally less than 5 feet (1.5 m) thick and consist of fine- to medium-grained sand with occasional pockets of gravel and coarse sand as well as silt and clay. These sands are believed to represent deposition from the outflowing waters of Lake Edmonton (Bayrock and Hughes, 1962).

Aeolian sand is common in the southwest portion of the map area and in scattered localities elsewhere. It occurs as fine- to medium-grained sheet sand, as poorly developed sand dunes, and as well developed parabolic and longitudinal dunes up to 40 feet (12 m) in height. Sources of sediment for the sand dunes were lacustrine sands and melt-water channel sediments near the pitted delta deposits.

Bottomland sediments consisting of Recent clay, silt, sand, peat, muck and marl are present in many topographic lows throughout the area.

Slumps, landslides and colluvium are present along the banks of the North Saskatchewan River as well as the banks of many of the tributary valleys (Fig. 23).

Alluvium has been deposited along the valley of the North Saskatchewan River, carved since retreat of the glaciers from the area. Upstream from Edmonton, the valley is relatively narrow with steep banks and has been eroded through both preglacial uplands and buried channels. Downstream the valley widens abruptly and the banks are much lower and more gentle because the river approximately follows the course of the broad preglacial Beverly Valley. Four terrace levels were mapped along the North Saskatchewan River Valley in the study area; however, a fifth level has been observed southwest of Edmonton near Devon. All the terraces consist of sand, gravel, silt and clay. The lowermost or youngest terrace occurs approximately 30 feet (9 m) above the present river level (Plate 3, Fig. 1). This terrace generally has a sand and gravel layer up to 20 feet (6 m) thick which overlies bedrock (Plate 3, Fig. 2). The sand and gravel layer is usually overlain by a layer of silt, clay and fine sand attaining thicknesses up to 30 feet (9 m).

The older terrace levels are developed discontinuously along the course of the North Saskatchewan River Valley. The sediments vary significantly over short distances but appear to contain coarser sand and gravel than the lowermost terrace.

STRATIGRAPHY AND DISTRIBUTION OF SURFICIAL DEPOSITS

In this portion of the report, data from surface exposures and drillhole logs has been synthesized to provide information on the stratigraphy and distribution of surficial deposits in the study area. The succession and character of rock stratigraphic units in the Edmonton area is shown in table 3. Various names have been used by different investigators in the Quaternary sediments, but no formal nomenclature has been proposed. The names used in this report should be considered informal.

Distribution of Surficial Deposits

For the purposes of this report, surficial deposits are referred to as any sediments above the bedrock surface. The thickness of surficial deposits in the study area is shown in figure 24. The various types of sediments have been described in a previous section of this report.

Plate 3.



Figure 1. Terraces along the North Saskatchewan River valley south of the Beverly Bridge. The lowermost terrace (i.e., the "30 foot terrace") is on the right side of the photograph.



Figure 2. Sands and gravels of the lowermost terrace on the North Saskatchewan River. Pit is located north of Clover Bar on the south side of the river.

Table 3. Succession and characteristics of near-surface geologic deposits in the Edmonton area

Era	Period	Lithology
CENOZOIC	Quaternary	colluvium
		lacustrine sand, silt and clay, organic deposits and marl
		aeolian sand in sheets and dunes
		alluvium
		glaciolacustrine sand, silt and clay
CENOZOIC	Tertiary	glaciofluvial sand and gravel
		till with lenses of sand and gravel
		Saskatchewan gravels and sands; primarily quartzite with minor chert, ironstone, coal fragments and clay lumps
MESOZOIC	Cretaceous	bentonitic shales and sandstones, coal seams and bentonite beds

Most areas where surficial deposits are thin are found along the valleys of the North Saskatchewan River and its tributaries such as Whitemud Creek, Blackmud Creek, Mill Creek, Oldman Creek and other minor streams. Numerous bedrock outcrops occur in these areas where degradation of the stream valleys has resulted in erosion of the surficial deposits.

In areas where the lowermost terrace in the North Saskatchewan River Valley is well developed, the bedrock is usually overlain by a maximum of 30 to 35 feet (9 to 11 m) of river alluvium composed of silts, sands and gravels. Depth to bedrock below the terraces is greater only if Saskatchewan gravels and sands are present below river alluvium as, for example, in Sec. 34, Tp. 53, R. 23 (Fig. 24).

Surficial deposits are also relatively thin on several of the preglacial bedrock highs. North of the Beverly Valley two broad uplands are present: one, located west of the Namao Valley, has an area of approximately 5 square miles (13 km²) and has less than 50 feet (15 m) of sediment above bedrock; the other, east of the Namao Valley, is covered by less than 25 feet (7 m) of sediments over an area exceeding 8 square miles (21 km²). On a broad upland existing south of the Beverly Valley and west of the Stony Valley, an area of approximately 1 square mile (3 km²) has overburden less than 50 feet (15 m) thick. An estimated

3 square miles (8 km²) west of Blackmud Creek and east of Whitemud Creek covers a bedrock high on which surficial deposits are less than 50 feet (15 m) thick. A large bedrock high between the New Sarepta and Bretona Valleys has numerous localities where the drift is less than 50 feet (15 m) thick, especially along Mill Creek. Approximately 2 miles (3 km) southwest of Sherwood Park, a bedrock high occurs with less than 50 feet (15 m) of surficial deposits over an area of about 3 square miles (8 km²). Several other small areas throughout the study area are overlain by 25 to 50 feet (7 to 15 m) of drift as is shown in figure 24. Also, bedrock that has been shoved by glacier ice and redeposited is present throughout the area. Approximately 1 mile (2 km) northwest of Sherwood Park, an east-west trending ridge of shoved bedrock with dimensions 1/4 mile (2.5 km) wide by 2 miles (3 km) long is covered by less than 25 feet (7 m) of overburden.

The Beverly Valley which attains widths in excess of 4 miles (6 km) contains a thick sequence of deposits above bedrock. A large area along the trend of the valley where sediments exceed 100 feet (30 m) in thickness is outlined in figure 24. Drillhole data are insufficient to provide a detailed picture of the sediments where they exceed 100 feet (30 m); however, limited data indicate that the deepest part of the channel contains fill approximately 225 to 250 feet (69 to 76 m) thick. The Namao and Stony Valleys also contain sediments greater than 100 feet (30 m) in thickness over most of their lengths. The deepest drillhole in the Namao Valley, located in Sec. 32, Tp. 53, R. 24, recorded fill in excess of 158 feet (48 m) thick. The deepest well penetrating the Stony Valley indicated sediments greater than 171 feet (52 m) thick.

In the Ellerslie Valley 79 feet (24 m) of fill is recorded and in the New Sarepta Valley fill is 118 feet (36 m) thick. The thickest fill in the Bretona Valley is found approximately 1-1/2 miles (2.4 km) northwest of Bretona where the drift is greater than 150 feet (46 m). The fill in the Boag Valley is more than 100 feet (30 m) thick in its upper reaches and on the east side of the study area it exceeds 115 feet (35 m).

The only other area where thick sediments occur above bedrock is in the vicinity of the pitted delta deposits as is shown at the western margin of figure 24; sediments in this area can be more than 100 feet (30 m) thick. The thickness of the surficial deposits and their stratigraphic relationships are illustrated by a series of north-south and east-west geologic cross-sections of the study area (Fig. 26).

Saskatchewan Gravels and Sands

Oligocene and younger gravels and sands found throughout Alberta were deposited by streams flowing northeastward or eastward from the Rocky Mountains. Deposition of this preglacial alluvium continued intermittently from the last half of the Tertiary Period well into the Quaternary Period. During this time, gradual uplift of the Plains caused the streams to incise deep valleys. These streams also migrated laterally during their history. The downcutting and lateral migration often resulted in remnant bedrock uplands being left between the streams.

The preglacial gravels deposited by these streams can be divided into three types:

- (1) high-level sediments, which commonly form protective caps which retard erosion on bedrock uplands; these preglacial gravels and sands are the oldest and represent early stages of lowering of the land surface;
- (2) intermediate-level sediments which typically form benches and terraces in proximity to major preglacial stream valleys;
- (3) low-level sediments deposited by streams prior to glaciation and which are found as channel fill at the base of preglacial valleys.

The name used for alluvium belonging to this third group is Saskatchewan gravels and sands (Stalker, 1968). Although the term Saskatchewan Sands and Gravels has been used by many workers (Bayrock and Hughes, 1962; Westgate, 1969; McPherson and Kathol, 1973), the term Saskatchewan gravels and sands as used in this report conforms with that of Stalker (1968).

In discussing these deposits Stalker (1968) states:

"Advent of the first Laurentide ice-sheet ended deposition of Saskatchewan gravels and sands. However, this ice-sheet did not overrun all areas at the same time. Its effects were felt progressively westward, as the advancing ice raised base levels of the rivers, caused their currents to slow, and forced each stream to deposit part of its load. In many buried valleys on the plains much sand and silt overlies the coarser elements of the Saskatchewan deposits, and most of this apparently was deposited in proglacial lakes formed during advance of that first glacier (Stalker, 1963; p. 4; Westgate, 1965, pp. 91-93). As a rule those deposits are included with the Saskatchewan gravels and sands."

Saskatchewan gravels are generally quite similar in lithology throughout the Plains and are composed mainly of quart-

zite rock fragments. Minor amounts of chert, arkose, petrified wood, coal and clay ironstone are present. Large quartzite boulders mixed with clay ironstone and bedrock fragments are often found at the contact with bedrock. The Saskatchewan sands are similar in lithology to the gravels, but generally contain a higher percentage of local bedrock material. The sands are usually fine- to medium-grained and poorly sorted. Both the sands and gravels are rounded and contain minor silt and clay beds.

Saskatchewan gravels and sands are present in the study area primarily as channel fill deposits in the numerous stream valleys that formed part of the preglacial drainage system of the North Saskatchewan River. Intermediate-level terrace deposits occur along some of the valleys and may be older than Saskatchewan gravels and sands as defined by Stalker (1968).

The Beverly Valley contains the largest quantity of Saskatchewan gravels and sands (Figs. 20, 27). Grain size and sediment thickness vary over short distances but generally the valley contains 50 to 75 feet (15 to 23 m) of fine-grained sand over 10 to 15 feet (3 to 5 m) of gravel. The thickness of sediments overlying the Saskatchewan deposits ranges from over 150 feet (over 45 m) in the northwest to approximately 75 feet (23 m) in the northeast (Fig. 27). In the northeast where the North Saskatchewan River follows the preglacial Beverly Valley the river has partially removed the overburden. Several sand and gravel pits are located in that area.

The Beverly Valley has two intermediate-level terraces: one on its south flank in the northwest part of the study area and another on its south flank in the east-central portion of the area (Fig. 27). The terrace to the northwest is approximately 25 feet (8 m) thick and is composed mainly of fine-grained sand. It occurs approximately 50 feet (15 m) above the thalweg and is overlain by about 75 feet (23 m) of sediments (Fig. 27). The terrace deposit in the east-central portion of the area varies from 0 to 25 feet (0 to 8 m) in thickness, ranges from fine sand to coarse gravel, and is usually overlain by more than 25 feet (8 m) of sediments.

The Stony Valley, although not as large as the Beverly Valley, contains significant quantities of sand and minor gravel (Fig. 27). Thicknesses of 75 feet (23 m) are common, overlain by 50 to 75 feet (15 to 23 m) of glacial and postglacial deposits (Fig. 27). The New Sarepta, Ellerslie and Namao Valleys contain up to 50 feet (15 m) of channel

fill consisting mainly of sand (Fig. 27). Overlying sediments generally exceed 50 feet (15 m) in thickness. The other buried valleys contain thin layers of Saskatchewan sand overlain by thick glacial drift (Fig. 27).

Glacial Till

The possibility of two distinct till sheets existing in the study area has been debated. Warren (1954) described a grey till near Edmonton separated from an overlying brown till in numerous localities by stratified quartzose sands which he called the Tofield sand. Bayrock and Berg (1966) confirmed the presence of two colors of till but did not acknowledge the presence of separate till sheets. They stated:

"The till is brown where oxidized, grey where unoxidized; the color change from brown to grey occurs about 20 feet below the surface and is not a reflection of a change in composition. Lenses of stratified sand and gravel are commonly present in the till; the lenses are usually less than 1 foot thick and represent minor washing of glacial debris by running water."

Westgate (1969) indicated the presence of a greyish brown lower till separated from a yellowish brown upper till by the Tofield sand.

The authors observed the differently colored tills discontinuously separated by lenses of sand and gravel but, in spite of data from numerous outcrop sections and a detailed drilling program, could not establish the presence of two tills with any degree of certainty or confirm the continuity of the Tofield sand. So, in this report, the till deposits are considered a single unit which often contains lenses of glaciofluvial sediments.

Throughout much of the study area, the till is between 25 and 50 feet (8 to 15 m) thick (Fig. 28). Areas of relatively thin till occur on two bedrock uplands located on the west and east sides of the Namao Valley, where the till is less than 10 feet (3 m) thick over areas of about 2 square miles (5 km²) and 7 square miles (18 km²) respectively. Although surficial deposits are relatively thick in the vicinity of the pitted delta deposits along the western boundary of the area, the till is quite thin—less than 10 feet (3 m) thick wherever drillhole data is available. An area of approximately 5 square miles (13 km²) near Blackmud and Whitemud Creeks also is underlain by till less than 10 feet (3 m) thick. Other small areas where till is thin occur throughout the area as shown in figure 28.

The till is generally thickest along the buried valleys. In excess of 50 feet (15 m) of till occurs along the entire length of the Beverly Valley. It may actually exceed 75 feet (23 m) in thickness in many places, but additional deep drilling would be required to confirm this. Similarly the till is greater than 50 feet (15 m) thick along the Stony Valley and could be considerably thicker.

Approximately 1 mile (1.6 km) northwest of Bretona, the till is greater than 100 feet (30 m) thick along the Bretona Valley. Elsewhere along the valley it generally exceeds 50 feet (15 m) and often is more than 75 feet (23 m) thick. The upper reaches of the Boag Valley, along the east boundary of the study area, contain over 75 feet (23 m) of till. Other areas where the till exceeds 50 feet (15 m) in thickness occur in the southeast portion of the area where ground moraine and hummocky dead-ice moraine are present on the surface (Fig. 28).

Glaciolacustrine Sediments

The distribution and thickness of glaciolacustrine sediments (hereafter referred to as lacustrine sediments) in the study area are outlined in figure 29.

Lacustrine sediments are generally absent from most of the southeast portion of the area where ground moraine and hummocky dead-ice moraine are present on the surface. In this area only a few small lacustrine deposits occur, with sediments being less than 10 feet (3 m) thick.

The thickest deposits of lacustrine sediments occur in the western portion and the extreme southwest corner of the area, where thicknesses usually exceed 30 feet (9 m) and often exceed 70 feet (21 m).

Elsewhere in the map area, lacustrine sediments averaging 10 to 30 feet (3 to 9 m) thick occur in a broad northeast-southwest trending belt which approximately follows the present course of the North Saskatchewan River; however, the sediments have been completely removed by erosion within the river valley itself. Within this broad belt there are numerous small areas, too many to describe individually, in which the lacustrine deposits are either greater than 30 feet (9 m) or less than 10 feet (3 m) thick. These are outlined in figure 29. Small areas where lacustrine sediments are thickest are believed to have resulted from sediment deposition in depressions in the underlying till surface.

Other Sediments

Other Pleistocene sediments such as glaciofluvial sand and gravel and pitted delta sediments are present in the study area; however, these are not sufficiently extensive to warrant construction of separate isopach maps. This is also true

for the Recent sediments which occur in the Edmonton area.

Data concerning the distribution of these sediments are provided on the surficial geology maps and on the geological cross-sections.

NATURAL RESOURCES OF THE EDMONTON AREA

In this section of the report, natural resources in the study area are reviewed. Emphasis is placed on groundwater and on sand and gravel; because these are considered to be the most important resources in the Edmonton area. However, other potential mineral resources are also discussed.

GROUNDWATER

As population and industrial growth continue in Edmonton, the importance of groundwater as a primary resource becomes increasingly apparent. Intelligent management of groundwater supplies depends upon extensive knowledge of the interrelationships between this resource and the geologic environment.

The Groundwater Division of the Alberta Research Council is currently preparing detailed hydrogeological reports on the Edmonton area. These reports will also be of assistance to planners and developers because the nature and distribution of groundwater also affects the engineering behavior of geologic materials. The following brief description, which is based on the work of Carlson (1967), recent work by Groundwater Division staff and data collected for this study, is meant only as an introduction to the groundwater resources of the Edmonton area. Table 4 indicates the potential groundwater production from various geologic deposits.

Aquifers

The Edmonton Formation, essentially poorly consolidated bentonitic sandstone layers and coal beds, constitutes a widely used source of groundwater in the study area. Wells used for domestic water supply commonly are not greater than 300 feet (90 m) deep and are usually much shallower. Although bedrock well yields calculated from short-term pumping tests often vary greatly over short distances, the actual longer-term (for example, 20-year) safe yields may typically be lower and may vary less widely. Wells completed in thick, fractured coal seams provide the highest long-term yields, perhaps in the order of 25 to 50 imperial

gallons per minute (igpm) [100 to 230 litres per minute (l/min)]. Yields of up to 10 igpm (45 l/min) can be obtained from zones with sandstone beds, while thick shaly zones may yield less than 1 igpm (5 l/min). The chemical quality of water from bedrock is reasonably good, although usually not acceptable in terms of federal standards set for municipal water supplies. Total dissolved solids contents are usually in the range of 1000 to 1500 parts per million, and the water is typically of the sodium bicarbonate (NaHCO_3) type (with minor sulfate and chloride contents). Undesirable chemical constituents cause problems only locally and not frequently.

The buried valley sands and gravels are the best aquifers among the surficial deposits (Fig. 30). These deposits are highly permeable and are usually partially or completely saturated because they occur in low-lying areas on the bedrock. Water in these deposits is usually hard and may have a high iron content. The coarser-grained basal layers of the buried valley deposits have the highest potential for groundwater supplies because of their high permeability and lower topographic position.

The Beverly Valley (Fig. 21) contains the most extensive of the buried valley aquifers. It has considerable potential as a source of industrial water supply with yields up to 100 igpm (450 l/min) known. The Stony Valley (Fig. 21) also contains a high-potential aquifer although these deposits are generally less permeable than those in the Beverly Valley and are at a higher elevation. The remainder of the buried valleys in the area contain fine- to medium-grained sand and have considerable potential for domestic supply (Fig. 30).

The potential for groundwater production from glacial and postglacial deposits is outlined in figure 31. Lacustrine clay has the lowest potential; although clays can be saturated, low permeability prevents adequate flow rates. The pitted delta deposits along the western border of the study area consist of fine- to medium-grained sand usually in excess of 50 feet (15 m) thick. Grain size generally increases with

Table 4. General hydrogeologic features of the near-surface sediments in the Edmonton area

Material	Type	Usual Depth from Surface in feet (m)	Permeability	Estimated Yield in igpm (l/min)	Water Quality	Aquifer Potential	
						Domestic	Industrial
Bedrock	unfractured shale	>100 (> 30)	very low	<1 (< 5)	good	low	very low
	fractured coals	>100 (> 30)	medium	25 - 50 (100 - 220)	good	very high	medium
	sandstone zones	>100 (> 30)	low - medium	2 - 10 (9 - 45)	good	medium - high	low
Sand and Gravel	buried valley terraces and beds	50 - 150 (15 - 45)	medium - very high	25 - 100 (100 - 450)	good	very high	low
	North Saskatchewan River alluvium	surficial	medium - very high	25 - 100 (100 - 450)	good	variable	low - medium
	Outwash and kame gravels	surficial - 100 (0 - 30)	medium - very high	5 - 25 (25 - 100)	good	medium - high	low - medium
Pitted Delta	predominantly sands and silts	surficial	medium - high	5 - 25 (25 - 100)	variable	medium	very low
Lacustrine	predominantly clays and silts	surficial	very low	0 - 5 (0 - 25)	variable	very low	very low
Till	mixed	surficial - 100 (0 - 30)	low	0 - 5 (0 - 25)	variable	low	very low
Aeolian	sand	surficial	medium - high	0 - 5 (0 - 25)	poor	low	very low

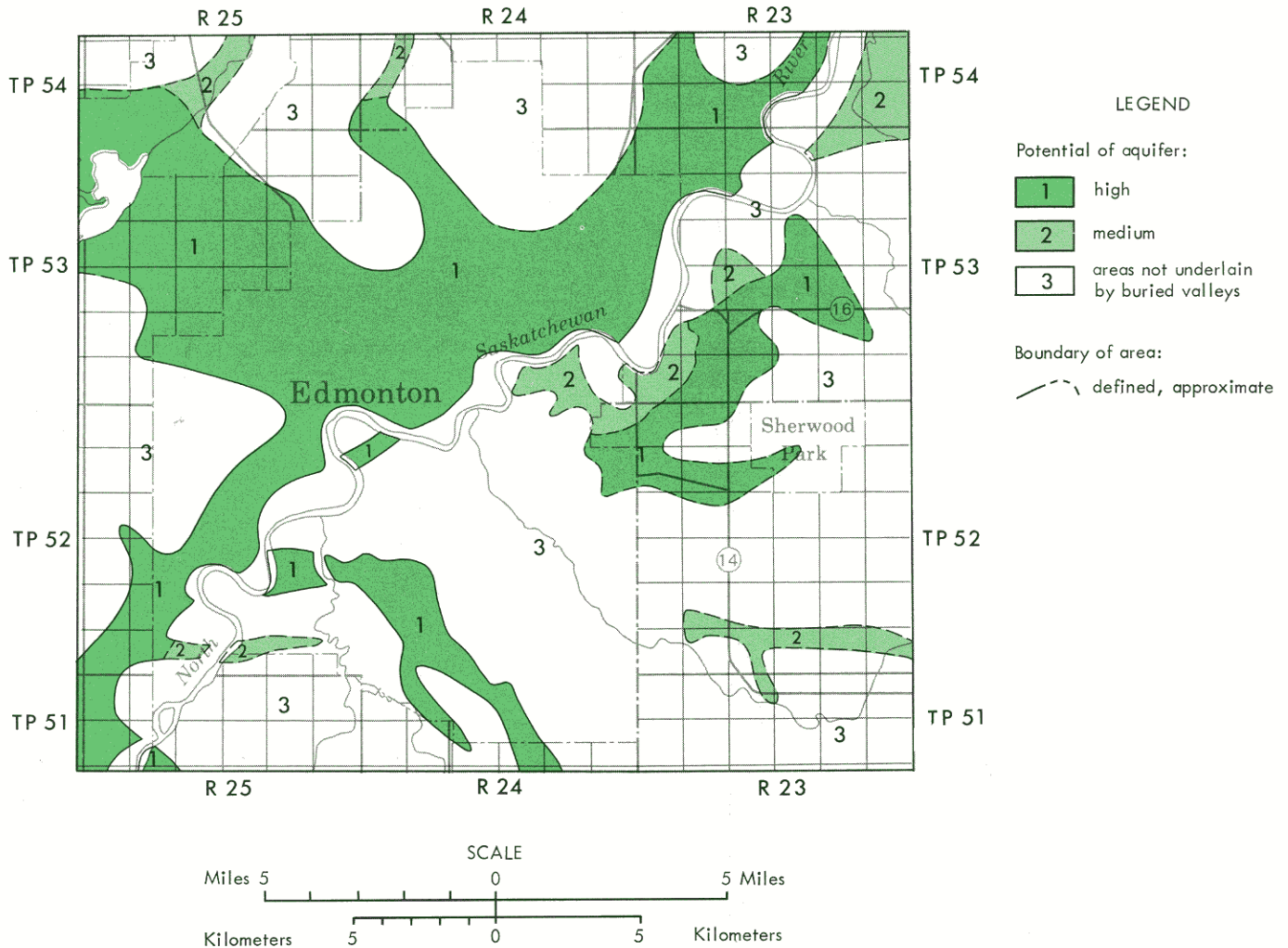


FIGURE 30. Groundwater potential of buried valley aquifers in the study area.

depth and ranges from silt to fine sand to medium-grained sand with fine pebbles. Properly designed wells in the pitted delta deposits have considerable potential for domestic water supply. Aeolian sands composed of fine- to medium-grained sand occur in the southwest portion of the area. When in topographic lows, these sands may have limited potential for domestic water supply depending upon the nature of the underlying material.

The best prospects for water supply from the till are in glaciofluvial sand and gravel lenses. Long term yield will depend upon the availability of recharge to these lenses. Closed lenses in an unfractured till will be of little value but lenses receiving recharge through joints in the till may provide domestic water supplies. Water quality and seasonal

fluctuations in supply could be problems. Wells in till deposits often require screens at several levels in order to obtain adequate production.

North Saskatchewan River alluvium has some potential for water supply. The high-level terraces are usually unsaturated but the low-level terraces that are directly connected to the river will contain water. Infiltration galleries utilizing the alluvium are the source of municipal water supply in some communities but this has not yet been attempted in the Edmonton area.

The Beverly Valley (Fig. 21) contains the most extensive of the buried valley aquifers. It has considerable potential as a source of industrial water supply with yields up to

100 igpm (450 l/min) known. The Stony Valley (Fig. 21) also contains a high-potential aquifer although these deposits are generally less permeable than those in the Beverly Valley and are at a higher elevation. The remainder of the buried valleys in the area contain fine- to medium-grained sand and have considerable potential for domestic supply (Fig. 30).

The potential for groundwater production from glacial and postglacial deposits is outlined in figure 31. Lacustrine clay has the lowest potential; although clays can be saturated, low permeability prevents adequate flow rates. The pitted delta deposits along the western border of the study area consist of fine- to medium-grained sand usually in excess of

50 feet (15 m) thick. Grain size generally increases with depth and ranges from silt to fine sand to medium-grained sand with fine pebbles. Properly designed wells in the pitted delta deposits have considerable potential for domestic water supply. Aeolian sands composed of fine- to medium-grained sand occur in the southwest portion of the area. When in topographic lows, these sands may have limited potential for domestic water supply depending upon the nature of the underlying material.

The best prospects for water supply from the till are in glaciofluvial sand and gravel lenses. Long term yield will depend upon the availability of recharge to these lenses. Closed lenses in an unfractured till will be of little value

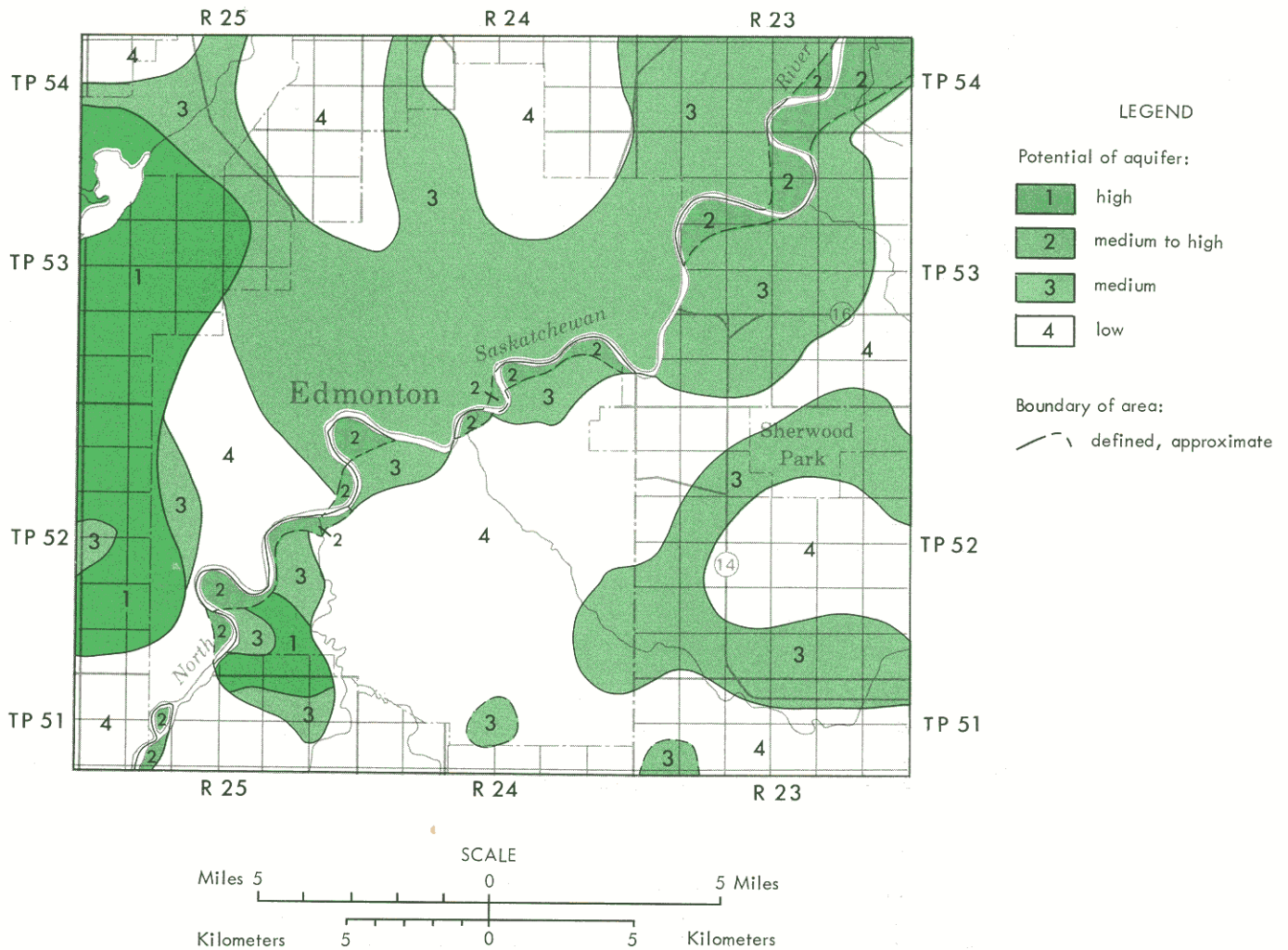


FIGURE 31. Groundwater potential of glacial and postglacial deposits in the study area.

but lenses receiving recharge through joints in the till may provide domestic water supplies. Water quality and seasonal fluctuations in supply could be problems. Wells in till deposits often require screens at several levels in order to obtain adequate production.

North Saskatchewan River alluvium has some potential for water supply. The high-level terraces are usually unsaturated but the low-level terraces that are directly connected to the river will contain water. Infiltration galleries utilizing the alluvium are the source of municipal water supply in some communities but this has not yet been attempted in the Edmonton area.

The growing number of small, closely spaced acreages and new large industrial developments in the Edmonton vicinity has created new problems for users of subsurface aquifers. Many areas of lower yield which adequately serve a few widely separated users, may not support prolonged use by many contiguous domestic or industrial users. Septic fields may not have the capacity for satisfactory disposal of waste in areas of many closely spaced homes. A few, localized groundwater pollution problems are presently evident but the addition of an ever-increasing number of small quantities of pollutants to the saturated zone may result in serious aquifer pollution. It is apparent, therefore, that proper groundwater management is of prime importance in the Edmonton area and the effect of any development on the groundwater regime should be properly assessed to permit maximum use of this valuable resource.

SAND AND GRAVEL RESOURCES

The section on aggregate resources is based upon data obtained from mapping and auger drilling of surficial and shallow subsurface deposits within an area of 35 townships surrounding and including the City of Edmonton (Figs. 32, 33, 34). The general distribution and types of potentially economic sand and gravel deposits have been determined with two objectives in mind:

- (1) to provide geological background for those involved in exploring for sand and gravel;
- (2) to aid planners in avoiding possible land use conflicts.

It should be stressed that detailed investigations of specific deposits have not been conducted; rather, emphasis has been placed on determining those areas — especially in the subsurface — with some *potential* for containing aggregate deposits. Thus, companies and individuals involved in locating supplies of sand and gravel should be able to use this report as a guide in their exploration programs. Similarly, planners concerned with the orderly development and zon-

ing of the greater Edmonton area will be able to evaluate the relative merits of mineral resource (aggregate) exploitation versus those of alternative land uses for the regions surrounding the city, as well as gauge the possible effects of resource development on the environment.

Previous Work

As mentioned before, considerable information has been published concerning the surficial geology of the Edmonton area. Bayrock and Hughes (1962) discussed the surficial geology of the Edmonton district and described near-surface deposits of sand and gravel. Carlson (1967) outlined the thalwegs of buried valleys in the Edmonton area. More recently, a surficial geology map of the Edmonton area (map sheet 83H) was published on a scale of 1:250,000 (Bayrock, 1972). McPherson and Kathol (1973) published a report outlining potential aggregate sources in the Edmonton area. Information from this report is included in the following description of sand and gravel deposits.

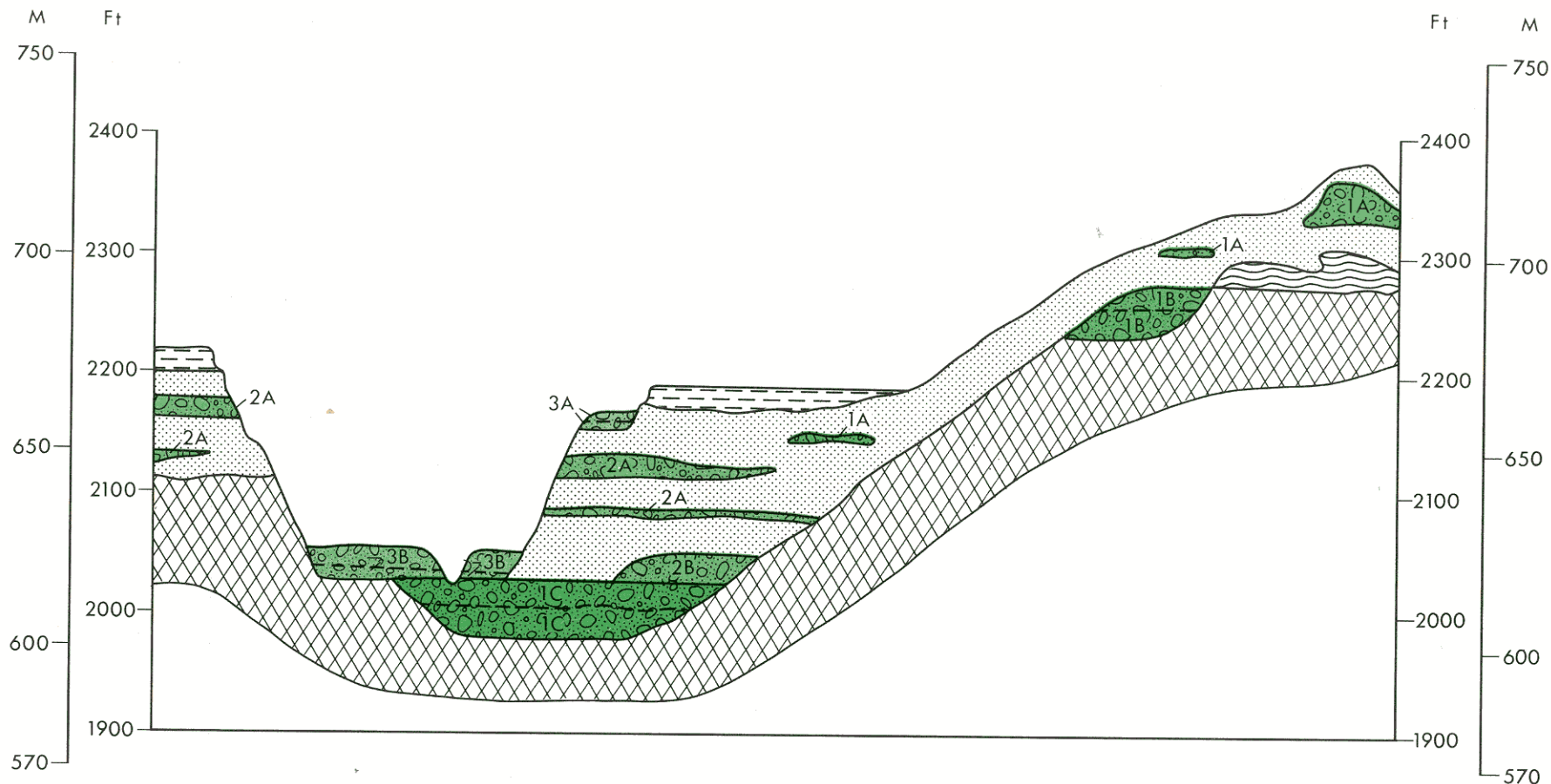
Classification of Sand and Gravel Deposits

Commercial deposits of sand and gravel in the area can be classified into three major groups, distinguishable on the basis of time and mode of deposition. The stratigraphic relationships of these deposits as might be observed in an ideal cross-section of the North Saskatchewan River Valley are shown schematically in figure 32.

Preglacial sands and gravels (Saskatchewan gravels and sands) are found in the bedrock valleys buried by glacial (Pleistocene) and postglacial (Recent) deposits. Older preglacial quartzite gravels occur on bedrock uplands in the area. Glacial sands and gravels are also present throughout the area; some deposits are buried within the drift, but many are exposed at the present land surface. Recent alluvial deposits in the form of bars and terraces lie along existing streams but those of economic significance are confined to the valley of the present-day North Saskatchewan River.

Preglacial Gravels and Sands

Virtually all of the concrete aggregate used in the Edmonton area is manufactured from preglacial Saskatchewan deposits. Most of this material is now supplied by gravel-processing operations near Villeneuve, northwest of St. Albert, and near Heatherdown, just west of the map area as shown in figure 33. In addition, Saskatchewan gravels and sands are utilized for the manufacture of asphalt gravel and for road-base aggregate.



LEGEND

- | | | | |
|----------|----------------------------------|--------------------------|--------------------------------|
| Deposit: | | Types of Sand and Gravel | |
| | Lacustrine (clay, silt) | 1. Preglacial | |
| | Till | | A. Reworked |
| | Sand and Gravel | | A. Beds and Lenses Within Till |
| | Disturbed Bedrock | | B. Outwash |
| | Bedrock (sandstone, shale, coal) | 3. Recent (Post-Glacial) | |
| | | | A. High Level Terrace |
| | | | B. Present River Terrace |
| | | | B. High Level Terrace |
| | | | C. Preglacial Valley Fill |

FIGURE 32. Schematic cross-section showing stratigraphic relationships of sand and gravel deposits, Edmonton area.

Preglacial gravels and sands are found as gravel cappings on the uplands north of Spruce Grove or along the buried preglacial valleys. However, only two of the valleys appear to contain commercial gravel deposits in terms of quantity, quality, depth of overburden and distance from markets. These two are the Onoway Valley northwest of Edmonton and the Beverly Valley, which crosses the map area from west to east.

Onoway Valley

The thalweg of the buried Onoway Valley trends east from Calahoo on the western margin of the map area along the course of the Sturgeon River Valley, and then turns southward towards the Beverly Valley which it joins west of the town of St. Albert (Fig. 21). The valley is generally broad with a gently sloping southwest side and steeper northeast bank.

Data from auger drilling, rotary drilling, and seismic shot-holes show that a broad belt of buried sands and gravels extends along the south bank of the Onoway Valley. Test-holes that revealed considerable thicknesses of sand and gravel are shown in figure 33. Their lithologic logs are included in Appendix 1.³

It is probable that the deposit is not continuous over the entire length of the valley but likely is concentrated in certain localities within area "A" outlined in figure 33. Extensive test drilling will be required to define the best aggregate deposits in this area.

The sands and gravels, which directly overlie Cretaceous bedrock, are overlain in turn by glacial till and lacustrine clay. Thickness of overburden may vary considerably over short distances but is generally 20 to 50 feet (6 to 15 m). The sands and gravels themselves are expected to range from 0 to 50 feet (0 to 15 m) or more in thickness. In many areas, fine-grained sand overlies or is interbedded with the gravel.

Lithologically, the gravels are composed of quartzite and chert, but a small percentage of sandstone and local bedrock material is present. The deposits contain only minor amounts of deleterious materials, such as coal, clay lumps, ironstone and iron-stained sandstone. Although chert is generally considered to be a troublesome substance, the chert in the Saskatchewan gravels and sands in the

Edmonton area has been found to have little detrimental affect on the manufacture of Portland cement concrete.

It is thought that most of the deposits will be water-saturated, as the base of the Onoway Valley is at a lower elevation than the present Sturgeon River.

Currently, Consolidated Concrete Ltd. and Alberta Concrete Products Ltd. are utilizing sand and gravel from the Onoway Valley in the vicinity of Villeneuve⁴ (Fig. 33) for the manufacture of concrete aggregate used in the Edmonton area. The deposits within this valley are the only known gravels in the map area that have the necessary physical properties and are sufficiently low in harmful materials to be suitable for this purpose.

Other large deposits, similar to those described above, are likely present along the Onoway Valley and within the area outlined.

Beverly Valley

The thalweg of the Beverly Valley enters the map area in township 53, range 28, and trends east beneath the City of Edmonton, then turns north and parallels the course of the North Saskatchewan River northeast of Edmonton (Fig. 21). The valley is several miles wide with gently sloping sides, particularly along the south bank.

Within the map area preglacial sands and gravels are present along the entire length of the valley, either as channel fill in the bottom of the valley or as terraces on the sides of the valley. However, only in certain areas will gravel be present in sufficient quantities and the overburden thin enough for the deposits to be of potential commercial significance.

West of Edmonton and north of Spruce Grove sand and gravel is found in hilly terrain within the area "B1" shown in figure 33. The gravels on the south side of the hills are interpreted as being a high-level terrace deposit developed on the north side of the Beverly Valley. In the vicinity of Gladu Lake the deposits are highly contorted and may have been shoved up by glacial ice from the floor of the Onoway Valley or may be material slumped off the gravel-capped bedrock plateau to the west. As observed in quarries, the gravels as well as the overburden — which consists of glacial lake clay or till or both — vary considerably in thickness.

Lithologically, the gravels are composed of quartzite and chert with minor amounts of sandstone and bedrock frag-

³ Additional drillhole data has been published (McPherson and Kathol, 1972) or is on open file at the Alberta Research Council.

⁴ Consolidated Concrete's operation is located in NW1/4, Sec. 20, Tp. 54, R. 26 W. 4th Mer. Alberta Concrete Products' operation is located in NW1/4, Sec. 16, Tp. 54, R. 26 W. 4th Mer.

ments. Experience by aggregate companies has shown that deleterious materials, such as clay lumps, coal, ironstone and iron-stained sandstone, are present in sufficient quantities to prevent the sands and gravels from being economically utilized for the manufacture of concrete aggregate; however, the gravels have been found to be suitable for asphalt or road-base aggregate. Grain size analyses of samples from some of these pits are included in table 5. Several pits have been opened in this area, but it is assumed that additional deposits can be located by test drilling within the boundaries indicated in figure 33.

East of Edmonton the thalweg of the Beverly Valley trends northeast, parallel to the North Saskatchewan River. Borehole data have confirmed the geological interpretation that a high-level terrace extends along the southeast bank of the valley, approximately parallel to the Canadian Pacific rail line (area "B2", Fig. 33). Drillhole data are shown in figure 33 and lithologic logs are included in Appendix 1. As is the case in the Onoway Valley, it is expected that potentially economic deposits are not continuous over the entire valley side but are concentrated in certain areas. The overburden, which consists of lacustrine clay and till, is estimated to be in the order of 20 to 70 feet (6 to 21 m) or more thick while sand and gravel thickness may vary between 0 and 50 feet (0 and 15 m).

The gravels are similar in lithology to those found in the Beverly Valley west of Edmonton. The presence of detrimental materials prevents them from being used for concrete aggregate; however, they may be suitable for the manufacture of asphalt and road-base aggregate. Grain size analyses are provided in table 5. There are no pits developed in these terrace deposits except at Clover Bar near the eastern boundary of Edmonton, and the authors feel there is considerable potential for developing commercial gravel deposits within the boundaries outlined in figure 33.

There is also potential for asphalt or road-base aggregate deposits along the floor of the Beverly Valley between the terrace deposits described above and the present valley of the North Saskatchewan River (Area "C", Fig. 33). Borehole data have confirmed the presence of sand and gravel overlying bedrock and overlain by lacustrine clay and till in this area. However, the deposits are generally thin and the overburden relatively thick. Detailed drilling within this area may reveal commercial aggregate deposits, but the potential for development is certainly not as high as the potential along the high-level terrace (area "B2", Fig. 33).

Glacial Deposits

Glacial sands and gravels are those materials deposited during the retreat of the glacier; they occur as outwash plains,

outwash deltas, meltwater channel sediments, kames and crevasse fillings. These deposits occur to some extent within or below other glacial sediments (till, lacustrine deposits) but are present at or just below the surface in many areas. The larger deposits have been mapped and classified by Bayrock (1972) as is shown in figure 34 and are described in table 6.

Recent Alluvial Deposits

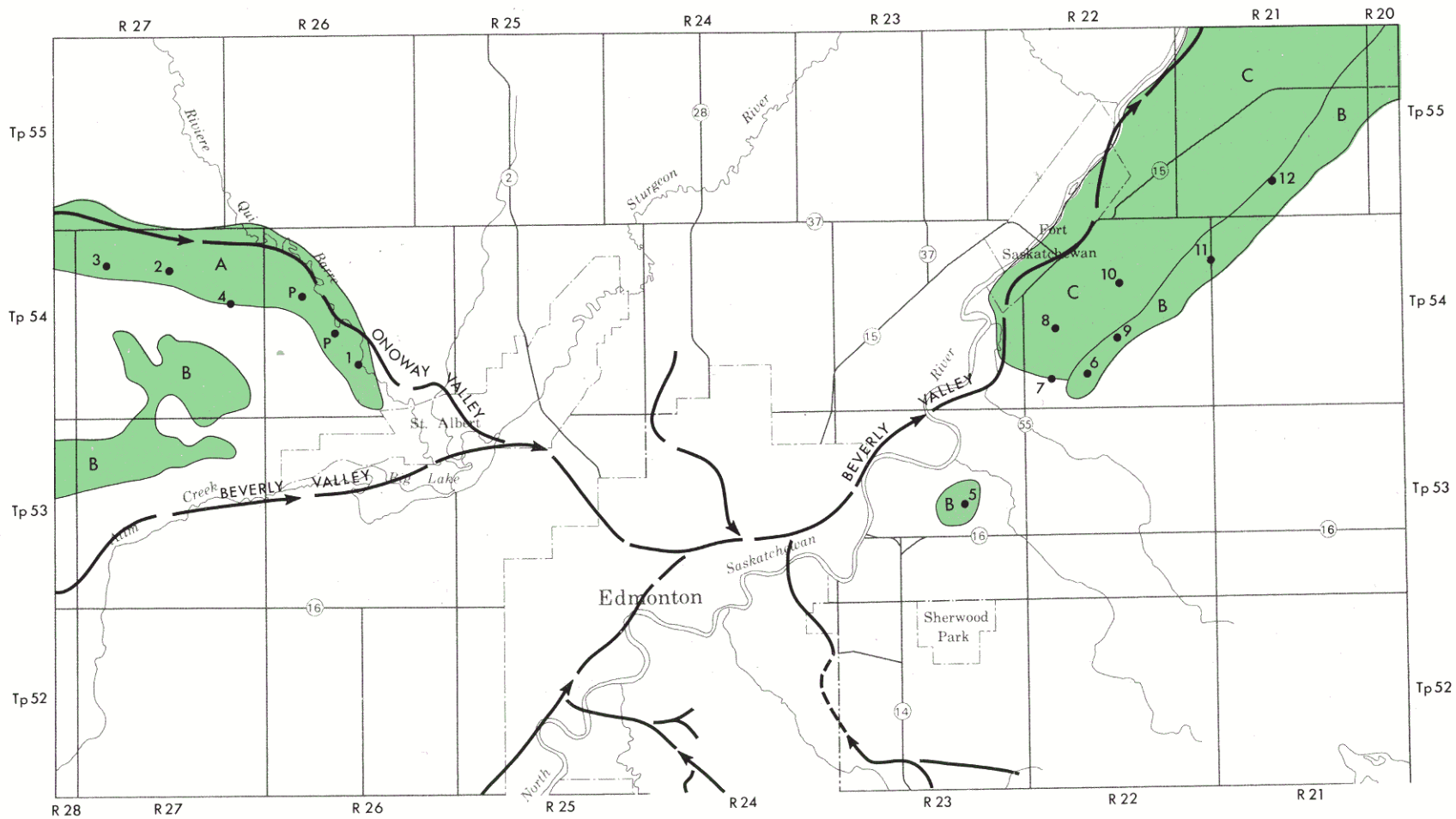
Recent alluvial deposits of economic importance are confined to the valley of the present North Saskatchewan River, where they are found in the form of terraces or bars. However, as current legislation prohibits exploitation of river bars as aggregate sources, the ensuing discussion is directed towards terrace deposits.

At least four terrace levels have been observed along the North Saskatchewan River Valley within the map area, but only the lowermost terrace (generally referred to as the "30-foot terrace") is sufficiently extensive to be utilized as a sand and gravel source. These deposits have been mapped by Bayrock and Hughes (1962) and Bayrock (1972) as shown in figure 23.

The sands and gravels range from 0 to 30 feet (0 to 9 m) thick and are overlain by 10 to 30 feet (3 to 9 m) of alluvial silt and clay. They usually overlie bedrock but in isolated instances have been deposited on Saskatchewan gravels and sands in the Beverly Valley.

In addition to "surficial" glacial sand and gravel deposits, irregularly distributed beds and lenses of similar deposits are found at the base of the till (overlying bedrock or Saskatchewan gravels and sands) or, more commonly, interstratified with till (Fig. 34). The locations and extent of these buried deposits are difficult to predict, but some data on their distribution in the greater Edmonton area are contained in a report by McPherson and Kathol (1972) as well as in the descriptive geology section of this report.

All glacial deposits, whether at the surface or buried, are of limited extent and are characterized by the presence of rock fragments derived from the Canadian Shield as well as variable amounts of coal, shale, clay lumps and petrified wood. The sands and gravels vary greatly in grain size over short distances and many have a high clay content (Table 5). These characteristics have prevented these deposits from being used as either concrete or asphalt gravel, but they may be suitable as local supplies of road-base and fill aggregate. Many of the deposits have been and are presently being used as aggregate sources, but some potentially economic deposits remain undeveloped or uncovered.



URBAN GEOLOGY OF EDMONTON

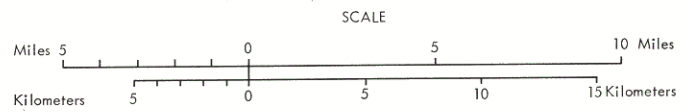
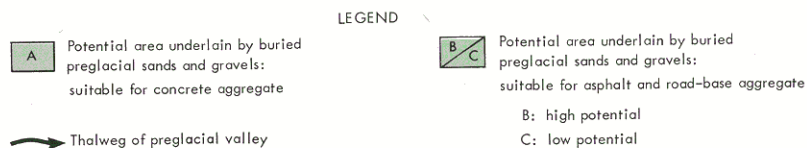


FIGURE 34. Distribution of potential preglacial sand and gravel deposits, Edmonton area.

Table 5. Grain size analyses of sand and gravel samples from the Edmonton region

Sample Location (W4th)				Description of Deposit	Weight Percent Retained by Mesh Size											
Lsd	Sec	Tp	R		2 1/2	1 1/4	5/8	5/16	4	9	14	28	48	100	200	<200
SE 1/4	9	54	27	preglacial gravel and sand on bedrock upland	-	10.52	20.77	20.87	8.77	5.12	1.57	3.01	12.78	7.33	3.40	5.84
NE 1/4	9	54	27	preglacial gravel and sand	5.09	8.09	14.18	14.30	7.97	4.36	1.43	2.85	14.23	11.72	5.86	10.00
SE 1/4	16	54	27	preglacial gravel and sand on bedrock upland	9.59	12.68	19.27	14.47	5.26	3.09	1.15	2.62	15.95	9.15	2.94	3.80
NE 1/4	28	53	27	preglacial sand, terrace deposit, Beverly channel	-	-	-	-	-	0.31	0.12	3.13	52.50	38.35	4.65	3.99
NE 1/4	28	53	27	preglacial sand and gravel, terrace deposit, Beverly channel	-	16.46	23.15	15.68	6.44	4.42	1.75	4.51	15.34	6.18	2.42	3.68
NW 1/4	27	53	27	preglacial sand and gravel, terrace deposit, Beverly channel	4.64	14.16	16.32	16.74	8.26	5.21	2.01	2.76	10.71	7.31	3.77	6.70
SE 1/4	36	55	22	Saskatchewan sand, Beverly channel	-	-	-	0.51	0.20	0.50	0.29	0.91	16.10	51.44	18.28	11.87
NW 1/4	8	53	23	preglacial sand, terrace deposit, Beverly channel	-	16.74	16.90	8.54	2.42	2.27	1.27	4.11	26.29	16.54	2.55	2.41
NE 1/4	33	53	23	Saskatchewan sand and gravel, Beverly channel	2.99	19.97	29.21	20.89	8.97	8.40	1.92	1.79	2.23	0.89	0.93	1.82
NW 1/4	32	51	21	crevasse filling	-	-	1.71	1.64	2.59	6.09	6.68	20.42	30.45	24.38	3.75	2.34
SE 1/4	3	54	27	outwash gravel	-	14.45	23.88	18.23	9.27	5.85	2.90	5.07	7.19	3.70	2.59	6.86
NW 1/4	26	51	24	outwash sand	-	-	-	-	-	0.03	0.09	3.03	54.82	35.30	3.50	3.24
NW 1/4	3	51	25	outwash sand	-	-	-	-	0.41	0.02	0.28	4.88	44.91	33.65	2.81	13.04
NW 1/4	34	53	23	North Saskatchewan River lowermost terrace alluvium	-	11.02	11.21	6.38	2.32	2.01	1.40	4.35	21.48	22.30	13.11	4.45
NW 1/4	20	53	23	North Saskatchewan River lowermost terrace alluvium	22.64	23.12	13.71	8.04	4.88	5.60	4.29	3.68	2.59	2.78	2.50	6.23
NW 1/4	20	53	23	North Saskatchewan River lowermost terrace alluvium	-	10.95	7.21	9.67	7.48	6.96	5.08	9.77	13.55	16.84	6.68	5.89
NE 1/4	20	53	23	North Saskatchewan River upper terrace alluvium	-	-	-	-	0.41	1.73	2.61	8.41	39.78	44.14	2.29	0.68
NW 1/4	21	53	23	North Saskatchewan River lowermost terrace alluvium	-	16.62	12.27	6.59	2.73	2.50	2.37	4.88	24.39	21.33	3.34	3.01

The gravels contain materials from several sources such as fragments from both the Canadian Shield and preglacial sediments. Detrimental materials such as coal, local bedrock fragments, ironstone, petrified wood and bone fragments also are common. These characteristics make terrace sands and gravels unsuitable for concrete aggregate, but they have proven suitable for asphalt, road-base and fill aggregate. Grain size analyses from selected localities are provided in table 5.

Terrace deposits have been used extensively as sand and gravel sources in the area because of their proximity to Edmonton as well as their relatively thin overburden cover. Large reserves, both developed and undeveloped, are pre-

sent within the areas outlined by Bayrock and Hughes (1962), and Bayrock (1972) and it is anticipated that they will continue to serve as aggregate sources for many years.

OTHER RESOURCES

Oil and Gas

Numerous wells have been drilled in the Edmonton area and several oil and gas pools discovered as outlined in figure 35. Although potential for further discoveries exists, exploration is likely to be limited within the boundaries of the study area because of possible land use conflicts that may occur between oil and gas exploration and urban development.

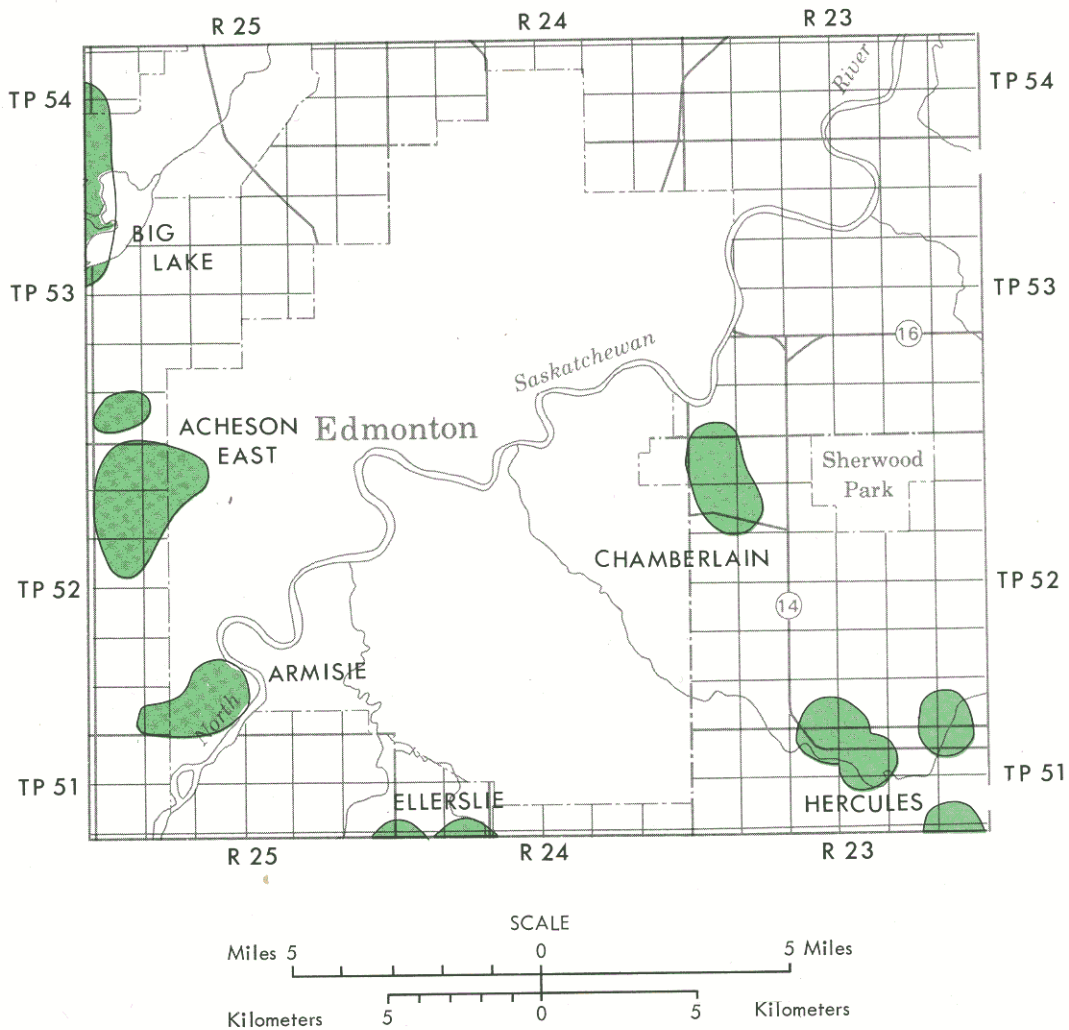


FIGURE 35. Oil and gas pools in the Edmonton area.

Coal

Coal seams are common in the Edmonton Formation. They were mined extensively in the past as a source of heating fuel but have since been replaced by alternate sources of energy. Considerable information about the extent and distribution of the coal deposits as well as old mine workings is available in a report by Taylor (1971). It is unlikely that coal will be extensively mined in the subsurface of the Edmonton area in the near future.

Bentonite

Bentonite is common in the Edmonton Formation; however, no deposits of commercial significance have been found locally. Because detailed drilling information already available for the study area has failed to reveal the presence of a commercial deposit, it is unlikely that any will be found in the future.

Marl

Marl deposits are common near the surface in Recent lacustrine sediments in the study area: the largest occur in Big Lake near St. Albert (Fig. 23). These deposits are generally of limited extent and poor quality and are unlikely to be commercially significant.

Ceramic and Brick Clay

Clays are being mined from glaciolacustrine sediments in the northeast portion of the study area. Other glaciolacustrine deposits outlined in figures 23 and 24 may also be suitable for development, although detailed site investigations are necessary to assess this possibility.

Peat

Peat deposits are common in surface depressions in the study area (Fig. 23). However, these are generally thin and not of sufficient extent for large-scale mining operations.

Silica Sand

Extensive sand dune deposits are present in the southwest portion of the study area (Fig. 23) and elsewhere within a 30-mile radius of Edmonton (Bayrock, 1972). Carrigy (1970) indicated that these deposits can be beneficiated and used to manufacture fiberglass, green and amber glass containers, and low quality window glass. However, the high iron content in the sands precludes their use in good quality plate and sheet glass manufacture (Carrigy, 1970).

Salt

A high-quality salt (sodium chloride) bed, the Lotsberg Salt of Devonian age, lies at a depth of about 6500 feet (1980 m) in the northeast quarter of the study area; its thickness is 50 to 100 feet (15 to 30 m), increasing toward the northeast. Another bed, the Prairie Evaporite Salt, is present at a depth of about 6000 feet (1830 m) under the eastern one-third of the area, and thickens to 50 feet (15 m) along the east boundary.

These beds serve as a source of raw material for chemical plants at Fort Saskatchewan and also as reservoirs for underground storage of petroleum products (in artificially created caverns). Considerable potential exists for further development.

GEOLOGY FOR LAND USE PLANNING

As popular concern for the environment develops, land use planners are faced with the problem of comprehensively assessing environmental conditions. The result is that the demand for geologic information concerning the natural capabilities and limitations of the area is growing. In this chapter, data concerning the engineering properties of the deposits in the study area are synthesized with previously discussed information about the nature and distribution of the sediments. This synthesis is the basis for a series of land use maps in which the Edmonton area is rated in terms of the following factors:

- (1) general construction conditions
- (2) suitability for solid waste disposal
- (3) susceptibility to erosion

- (4) slope stability
- (5) deep sewer construction.

These are by no means all the factors that may have a bearing on development; however, they are felt to be of considerable importance in the Edmonton area. It is hoped that these maps will help satisfy the increasing demand for information.

The maps are intended to serve only as general guidelines for regional development or further studies, and when using them two facts should be kept in mind. Firstly, the maps rate the suitability of various areas for development in terms of the geologic and geotechnical characteristics of the sediments. Because numerous disciplines interrelate in land

use planning, as outlined previously in table 1, final development decisions would require input from other fields of study. In some cases, geologic and geotechnical factors may have a controlling influence on development decisions, in other instances these factors may be of limited importance to final development plans. Secondly, the maps are based on currently known geologic data and, although considerable data are available, it will certainly be necessary to conduct detailed site investigations prior to development because of the extreme variability of the geologic deposits over short distances.

GEOTECHNICAL CHARACTERISTICS OF THE GEOLOGIC DEPOSITS

Considerable data on the geotechnical properties of geologic deposits in the Edmonton area are available from both published and unpublished reports. Also, many samples collected during the field surveys and drilling program were analyzed for general material properties and indices. This information has not been included in this report because, in spite of a large volume of data, it is still not sufficiently detailed to replace site investigations.⁵ In place of specific information, a chart has been prepared which outlines material properties and indices of geologic deposits in the Edmonton area (Table 7). Ranges of values for the different properties and indices for the various sediments should fall within the ranges indicated. Nonetheless, departures from these ranges are possible because of local lithologic variations as well as changes in environmental setting (for example, topographic position, water tables and so on).

The information presented (Table 7) has been utilized in conjunction with the geologic and hydrologic data to construct the land use maps for the study area.

LAND USE CAPABILITIES AND LIMITATIONS IN THE EDMONTON AREA

In table 8, the various geologic deposits in the Edmonton area, both on surface and in the subsurface, are described in terms of their capabilities and limitations for a variety of land uses. In order to exploit this information fully, table 8 should be used in conjunction with data concerning the distribution of the geologic materials provided on the surficial and bedrock geology maps, stratigraphic cross-sections and subsurface contour maps.

⁵ This data is on open file at the Alberta Research Council and is available upon request.

The information about the various deposits has been synthesized in subsequent sections of the report and maps have been prepared which outline the capabilities for and limitations to development of various parts of the study area.

General Construction Conditions

General construction as used in this report refers to any construction activities that occur as a result of development of the Edmonton area. In figure 36 the study area is rated in terms of its suitability for general construction. The geologic materials present in the various areas as well as their development capabilities and limitations are outlined in the legend accompanying the map. It should be noted that with proper engineering design virtually all of the Edmonton area could be developed. Therefore the maps tend to rate the various areas in terms of natural geologic capacities and problems.

Areas near stream valleys have been classified as having the most geologic limitations for development because extensive investigation and design is often required to ensure bank stability. Areas where Recent lacustrine, glacio-lacustrine, pitted delta and mixed lacustrine-till deposits occur are suitable only for construction of light structures because of the moderate to high compressibility; however, if foundation loads can be transmitted to more competent underlying layers, these areas are generally suitable for heavier structures. Other factors that may be detrimental to construction in these areas include sulfate contents, potential swell, susceptibility to frost action and susceptibility to erosion and slumping on steep banks and cuts.

Those areas characterized by other geologic sediments were rated as generally suitable for most types of construction; in particular, till and bedrock are generally more than adequate foundation materials for most types of structures. Again, specific localized problems that may be encountered in these areas are outlined in figure 36.

In developing the rating system for the general construction conditions map, sulfate content of the geologic materials was considered because of the potential for sulfate attack on concrete. In order to determine the areas where sulfate attack is most likely, sulfate content was determined in 542 samples collected in the study area. The results are summarized in figure 37 which shows the sulfate content of the deposits at various localities and depths. Figure 38 is a synthesis of this information. The potential for sulfate attack on concrete is based on the rating system of the United States Bureau of Reclamation (1966) which is as follows:

Table 7. Geotechnical characteristics of geologic deposits in the Edmonton area

Material	Liquid Limit ¹	Plasticity Index ¹	Soil Density ²	Compressibility	Shear Strength ³	Potential Swell	Permeability ⁴ (cm/sec)	Frost Action	
Recent Lacustrine	silt	30 - 50	low - medium	medium - high	low - medium	low - medium	$10^{-4} - 10^{-5}$	high	
	clay	45 - 75	low	high	low - medium	high	$10^{-6} - \dagger$	low	
	organic clay	60 - 75	20 - 30	low	high	low	$10^{-6} - \dagger$	low - medium	
Stream Alluvium	gravel		high	very low	high	very low	$1.0 - \dagger$	low	
	sand		medium - high	low	high	very low	$1.0 - 10^{-2}$	low - medium	
	silt	30 - 50	medium	medium - high	low - medium	low	$10^{-4} - 10^{-5}$	high	
River Terrace	clay	45 - 75	25 - 40	low - medium	high	low - medium	medium - high	$10^{-6} - \dagger$	low
	gravel		high	very low	high	very low	$1.0 - \dagger$	low	
	sand		medium - high	low	high	very low	$1.0 - 10^{-2}$	low - medium	
Aeolian	silt	30 - 50	medium	medium - high	low - medium	low	$10^{-4} - 10^{-5}$	high	
	sand		low - medium	low	medium - high	very low	$10^{-1} - 10^{-2}$	high	
Glaciolacustrine	sand		medium	low	medium - high	low	$10^{-1} - 10^{-2}$	medium - high	
	silt	30 - 50	low - medium	medium - high	low - medium	low - medium	$10^{-4} - 10^{-5}$	high	
	clay	45 - 75	25 - 40	low	high	low - medium	high	$10^{-6} - \dagger$	low
Pitted Delta	sand		medium - high	low	medium - high	low	$1.0 - 10^{-2}$	medium - high	
	silt	30 - 50	low - medium	medium - high	low - medium	low	$10^{-3} - 10^{-5}$	high	
Lacustro-till		30 - 35	15 - 30	medium	medium	medium	$10^{-3} - 10^{-6}$	low - medium	
Outwash	gravel		high	very low	high	very low	$1.0 - \dagger$	low	
	sand		medium - high	low	high	very low	$1.0 - 10^{-2}$	low - medium	
Kame and Crevasse Filling	gravel		high	very low	high	very low	$1.0 - \dagger$	low	
	sand		medium - high	low	medium - high	low	$1.0 - 10^{-2}$	variable	
	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	$10^{-4} - \dagger$	low - medium
Hummocky Moraine	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	$10^{-4} - \dagger$	low
Ground Moraine	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	$10^{-4} - \dagger$	low
Saskatchewan Gravels and Sands	gravel		high	very low	high	very low	$1.0 - \dagger$	low	
	sand		medium - high	low	high	very low	$1.0 - 10^{-2}$	low - medium	
Bedrock	sandstone			low	medium	high	$10^{-3} - 10^{-6}$		
	siltstone			low	medium	high	$10^{-4} - \dagger$		
	shale			low	medium	high	$10^{-5} - \dagger$		
	bentonite	>100	>50		low	very high	$10^{-6} - \dagger$		
	coal			low	low	low	variable		

¹Atterberg limits (see glossary)²low < 100 lbs./ft³medium 100-115 lbs./ft³high > 100 lbs./ft³³Assuming confined conditions⁴† higher permeability likely

‡ lower permeability likely

<u>Rating</u>	<u>% Water Soluble Sulfate Content</u>
Negligible attack	< 0.10
Mild but positive attack	0.10 to 0.20
Considerable attack	0.20 to 0.50
Severe attack	> 0.50

It was observed that sands are generally lowest in sulfate content; lacustrine clays and silts are generally highest. In addition, areas of high sulfate content correspond quite closely to areas of Solonchic soils as indicated on the soils map of the Edmonton area (Fig. 39).

Solid Waste Disposal

As population increases and industry expands (especially in urban areas) the quantity and type of solid wastes also increases rapidly and disposal becomes a major task. The ultimate solution is to recycle wastes to generate useful products; however, since the technology of recycling has not been adequately developed and costs for recycling may be prohibitive, another form of disposal is required. One of the most widespread methods of disposal is the sanitary landfill site. If a site is properly selected and maintained, it can be an acceptable method of disposal.

Criteria for Selection of Sites for Solid Waste Disposal

Much research has been conducted on sanitary landfill sites and several important facts have been demonstrated (as summarized by Hughes *et al.* 1971):

- (1) A polluting leachate can be produced by refuse in contact with groundwater or surface water. In Britain, Illinois and Wisconsin, it has been demonstrated that precipitation can infiltrate refuse and produce leachate. This may also be the case in the Edmonton area although the authors are not aware of any research that has been conducted locally to demonstrate that this is the case.
- (2) In fine-grained materials with relatively low permeability such as fine sand, silt and clay, dissolved solids in refuse leachate travel relatively short distances; however, in fractured deposits and permeable sands and gravels, the solids may travel considerable distances.

- (3) Gases are produced by decomposition of refuse; these gases are predominantly methane and carbon dioxide and to a lesser extent hydrogen sulfide.
- (4) The length of time required for refuse to stabilize and cease production of contaminants is difficult to predict because it is dependent on factors such as available moisture, temperature, materials present in the landfill, and conditions of burial and compaction.
- (5) The design of protective measures for otherwise unsuitable sites appears feasible and is being studied in California and Illinois.

The well designed landfill site has characteristics which minimize the pollution of water and air and, in addition, is aesthetically pleasing. Location of sites in relatively uninhabited areas, construction of fences, planting of trees and regular burial of garbage with fill material make the site more acceptable.

Landfill gases can be handled by venting the landfill to the atmosphere followed by burning the gas at the vent (Elissen *et al.* 1957, Dunn, 1960).

Criteria for selection of refuse disposal sites to minimize water pollution — both surface water and groundwater — have been developed for Illinois by Cartwright and Sherman (1969) and for the Edmonton area by Green and Currie (1970).

In establishing the criteria for the Edmonton area, Green and Currie discussed several important interrelationships between refuse disposal sites and the hydrologic environment:

- (1) **Climate:** Because the ground is frozen in the Edmonton area in the winter, no percolation of water into the ground occurs from November to March. Most recharge occurs in spring when the ground is generally saturated, but may also occur in the summer and fall during periods of heavy or prolonged rainfall. Precipitation in the Edmonton area averages 18.6 inches (47.2 cm) annually of which 10 to 20 percent (1.9 to 3.7 in or 3.8 to 9.4 cm) may penetrate into the ground to reach the water table.
- (2) **Topographic Position:** Precipitation may run off on the surface, penetrate into the soil to be used by plants, evaporate to the atmosphere, or penetrate into the ground and form part of the groundwater system. Groundwater moves through geologic deposits from topographically high areas (called recharge areas) to topographically low areas (called discharge areas). Re-

charge areas are generally unsuitable for waste disposal sites because pollutants may migrate downward and become part of the groundwater system. Similarly areas of high groundwater discharge such as springs along stream banks are unsuitable because of the danger of polluting surface waters. Areas where either low recharge or discharge is occurring are the most favorable for the location of waste disposal sites.

- (3) **Geologic Materials:** In fine-grained materials with relatively low permeability such as fine sand, silt and clay, dissolved solids in refuse leachate travel relatively short distances minimizing the potential for pollution. However, in fractured deposits and permeable sands and gravels, the leachates may travel considerable distances, thus enhancing the possibility of pollution. Another important factor is the capacity of the material for ion exchange: fine-grained materials such as silts and clays are particularly effective in removing dissolved solids from refuse leachate by ion exchange, but coarse granular materials are less effective, allowing pollutants to remain in the leachate longer.

Based on research by Cartwright and Sherman (1969) in Illinois, and on the factors discussed previously, Green and Currie (1970) compiled a set of criteria for solid waste disposal site selection in the Edmonton area, as follows:

- (1) Type of unconsolidated material:
- Favorable: glacial lake silts and clays, till, windblown silts
 - Unfavorable: sand, gravel
 - Questionable: fissured till, fissured lacustrine sediments
- (2) Thickness of unconsolidated material:
- Favorable: 50 feet or more (>15 m)
 - Unfavorable: less than 50 feet (<15 m)
- (3) Type of bedrock:
- Favorable: shale, siltstone
 - Unfavorable: sandstones, coal seams
- (4) Site topography:
- Favorable: flat plains (prairie) areas
 - Unfavorable: depressions where water accumulates; ravines and gullies; stream or river terraces and flood plains; other sites where leachate might discharge into surface water bodies
 - Questionable: dry valley bottom sites (require specific evaluation)

- (5) Groundwater situation:

- Favorable: limited groundwater discharge (areas of saline soils, phreatophytic plant growth)
- Unfavorable: groundwater recharge areas; active groundwater discharge areas (springs, seepages, bogs, standing water on the surface)
- Questionable: groundwater situation undefined (specific evaluation required)

- (6) Relations to nearby water wells and aquifers:

- Favorable: all nearby wells are deep; all aquifers covered by 50 feet (15 m) or more favorable materials; no domestic wells within 1000 feet (300 m); no municipal or industrial wells in the area
- Unfavorable: shallow wells within 1000 feet (300 m); aquifer covered by less than 50 feet (15 m) of favorable materials; municipal or industrial wells or both in the area (wells as distant as several miles may induce groundwater pollution because of pumping effects).

By utilizing these criteria, the various types of geologic materials in the study area have been rated in terms of their suitability for solid waste disposal in table 8.

It should be noted that little if any research on the distance of travel of pollutants in the groundwater has been conducted in the Edmonton area, so the values for aquifer overburden thickness and distance of sites from existing wells have been chosen somewhat arbitrarily in an attempt to provide an adequate margin of safety. Future studies may reveal that these values should be modified.

A map has been prepared which outlines the expected suitability of the study area for solid waste disposal in terms of geologic, hydrologic, and hydrogeologic conditions (Fig. 40). Because of the expected variations of conditions affecting waste disposal over short distances, site investigations will be necessary to confirm the suitability, or otherwise, of any particular area for solid waste disposal.

Susceptibility of Geologic Deposits to Erosion

Many interrelated factors affect the susceptibility of geologic deposits to erosion; some of the more important include:

- (1) type of geologic materials

- (2) material properties (in particular grain size and density)
- (3) slope
- (4) vegetative cover
- (5) soil type
- (6) groundwater
- (7) time
- (8) climate.

At any specific site, all factors have a bearing on the erodibility of the deposits; however, the relative importance of each factor will vary at different localities.

During the field investigations, it was observed that there was some degree of consistency in the nature of the erosion of different geologic materials. Based on these observations, it is possible to rate the geologic deposits in terms of their susceptibility to erosion as shown in table 8. The complexity of the interrelated factors affecting the erodibility of the deposits at any given location is indeed a problem; however, the rating system represents (in a general manner) conditions likely to be encountered in the field. The grouping of slopes into those less than 10° and those greater than 30° is a simplification because changes in erodibility are gradational with slope changes; slopes less than 10° are not expected to be susceptible to significant erosion whereas slopes greater than 30° will generally be susceptible to erosion.

Erosion problems are not likely to be severe in the Edmonton area; but localized areas of steep slopes, especially along the North Saskatchewan River and its tributaries, may exhibit significant erosion. Erosion will generally be greatest in bedrock sandstone, pitted delta silts, fine lacustrine sands and silts, fine aeolian sands and fine alluvial sands and silts (Table 8).

In figure 41, various portions of the study area have been rated in terms of their susceptibility to erosion. The legend accompanying the map outlines the materials found within each map segment, indicates the factors which contribute to erodibility of the materials and outlines preventive measures that may be undertaken to control erosion.

Slope Stability

In attempting to assess the stability of slopes in various materials or combinations of materials, a great deal of information can be obtained from observations of both previously excavated slopes and natural slopes.

Utilizing this information, plus hydrogeologic data and the previously outlined information on geologic and geotechnical properties of the materials, the authors rated the various geologic materials in terms of slope stability. This rating system as well as factors contributing to the rating are outlined in table 8. The rating indicates the general conditions to be expected in various materials. However, only site investigations could produce the necessary specific information.

A map has been prepared in which the study area has been rated in terms of slope stability (Fig. 42). The legend accompanying the map describes the various types of geologic materials that occur and also outlines the factors contributing to slope stability in different parts of the study area. In using this map, slope stability refers to both the stability of natural slopes and to the stability of any man-made slopes that may be created during development. In many instances, slope stability will not be a problem as long as cuts are adequately designed. The least stable natural slopes generally occur along the valley of the North Saskatchewan River and its tributaries where natural slopes are steep. Most bank failures originate in lacustrine clays and in shales. The most stable natural slopes are found where glacial till or bedrock sandstone forms the banks. The least stable cut slopes would also likely exist in lacustrine clays and shale; the most stable slopes would probably occur in glacial till and bedrock sandstone. It follows then, that careful slope design is more critical in areas where clays and shales are present.

Deep Sewer Construction

Edmonton has an extensive network of deep storm sewers which allows surface runoff to drain rapidly to the North Saskatchewan River.

The sewers are constructed using a rotary augering machine (generally referred to as a "mole") which is capable of boring tunnels larger than 20 feet (6 m) in diameter. Problems in tunnel construction have been encountered in certain types of geologic materials. Most of the problems have occurred in noncohesive sands and silts which tend to cave and flow, particularly when saturated. Such situations are most often encountered in buried channels containing Saskatchewan gravels and sand. Saturated sand and gravel lenses in till may also cause localized difficulties. Lacustrine clay, dense till and bedrock are generally suitable for sewer construction. In table 8, the various geologic materials have been rated in terms of their suitability for deep sewer construction.

Three maps (Figs. 43, 44, 45) have been prepared outlining the suitability of various portions of the study area for deep sewer construction. The maps assess the Edmonton area in the following depth intervals:

- (1) 0 to 50 feet (0 to 15 m) below surface (Fig. 43)
- (2) 50 to 100 feet (15 to 30 m) below surface (Fig. 44)
- (3) greater than 100 feet (30 m) below surface (Fig. 45).

Additional information is provided by the legends accompanying the maps. Because of the variability of deposits over short distances, more detailed data would be needed prior to actual construction of sewers in any given area. It should be emphasized that the rating system is designed for the present method of sewer construction. Should different methods of sewer construction be used in the future (such as those employed in certain other cities), the rating system would not necessarily be applicable.

SUMMARY AND RECOMMENDATIONS

SUMMARY

This study was carried out to satisfy increasing demands for the geologic information necessary for formulating development and land use plans.

Information about the geologic framework was compiled from existing data, field surveys and a controlled drilling program, and is presented as a report accompanied by a series of maps, figures, tables and stratigraphic cross-sections. Descriptions of climate, natural resources and geo-technical characteristics of the geologic deposits have also been included.

Land use capabilities and limitations of the various geologic deposits have been outlined and a series of land use maps prepared in which the study area is rated in terms of the following factors:

- (1) general construction conditions
- (2) suitability for solid waste disposal
- (3) susceptibility to erosion
- (4) slope stability
- (5) deep sewer construction conditions.

The main intent of these maps is that they be used as general guidelines for regional development or as a basis for conducting more detailed studies in specific areas.

RECOMMENDATIONS

The authors feel that this report provides basic background information for further investigation into the spectrum of environmental sensitivities and capabilities of the Edmonton area. Recommendations for additional investigations include the following:

- (1) development of a data bank for storing new geologic and engineering data as it becomes available, so that it is accessible to people needing the information;
- (2) updating and reinterpreting of the land use maps on a regular basis as technological developments occur and as additional data become available;
- (3) undertaking of projects by other disciplines — in particular the biological and social sciences — in order that other factors affecting the environmental sensitivities and capabilities of the Edmonton area be assessed.

REFERENCES

- ALBERTA, GOVERNMENT and UNIVERSITY (1969): Atlas of Alberta; Univ. Alberta Press in association with Univ. Toronto Press.
- ATMOSPHERIC ENVIRONMENT SERVICE (1971): Annual meteorological summary, Edmonton, Alberta; Weather Office, Edmonton, Alberta, 24 pages.
- BAYROCK, L. A. (1972): Surficial geology of the Edmonton map sheet (83H); Alberta Res. Map.
- BAYROCK, L. A. and T. E. BERG (1966): Geology of the City of Edmonton, Part I: Central Edmonton; Res. Coun. Alberta Rept. 66-1, 30 pages.
- BAYROCK, L. A. and G. M. HUGHES (1962): Surficial geology of the Edmonton district; Res. Coun. Alberta Prelim. Rept. 62-6, 40 pages.
- BOWSER, W. E., A. A. KJEARSGAARD, T. W. PETERS and R. E. WELLS (1962): Soil survey of Edmonton sheet (83H); Alberta Soil Surv. Rept. 21, 66 pages.
- CARLSON, V. A. (1967): Bedrock topography and surficial aquifers of the Edmonton district, Alberta; Res. Coun. Alberta Rept. 66-3, 21 pages.
- CARRIGY, M. A. (1970): Silica sand in the vicinity of Edmonton, Alberta; Res. Coun. Alberta Rept. 70-1, 30 pages.
- CARTWRIGHT, K. and F. B. SHERMAN (1969): Evaluating sanitary landfill sites in Illinois; Geol. Surv. Illinois, Environmental Geol. Notes, No. 27, 15 pages.
- COEN, G. M. (1965): Origin of bands in sandy soils of the Stony Plain area; unpublished M.Sc. thesis, Dept. Soil Sci., Univ. Alberta, 132 pages.
- DOMENICO, P. A. (1963): Geology and groundwater hydrology of the Edmonton Formation in central Alberta, Canada; unpublished M.Sc. thesis in geology, Graduate School of Syracuse Univ.
- DOMINION BUREAU OF STATISTICS (1961): The Climate of Canada [reprinted from the Canada Year Book (1959 and 1960)]; Queen's Printer, Ottawa, 74 pages.
- DOWLING, D. B. (1909): The coal fields of Manitoba, Saskatchewan, Alberta and eastern British Columbia; Can. Dept. Mines, Geol. Surv. Branch Rept. 1035, 106 pages.
- DUFF, D. E. (1951): Some analyses of Pleistocene deposits in the Edmonton area; unpublished M.Sc. thesis, Dept. Geol., Univ. Alberta, 47 pages.
- DUNN, W. L. (1960): Storm drainage and gas burning at a refuse disposal site, Civil Eng., Vol. 30, p. 8-68.
- ELISSEN, R., *et al.* (1957): Sanitary landfill gas control; American City, Vol. 72, No. 12, p. 115-117.
- GRAVENOR, C. P. and R. B. ELLWOOD (1957): Glacial geology of the Sedgewick district, Alberta; Res. Coun. Alberta Prelim. Rept. 57-1, 43 pages.
- GRAVENOR, C. P. and W. O. KUPSCH (1959): Ice disintegration features in western Canada; Jour. Geol., Vol. 67, p. 48-64.
- GREEN, R. (1972): Geological map of Alberta; Res. Coun. Alberta Map 35.
- GREEN, R. and D. V. CURRIE (1970): Criteria for selection of sites for solid waste disposal, unpublished report, Res. Coun. Alberta, 16 pages.
- HUGHES, G. M. (1958): A study of Pleistocene Lake Edmonton and associated deposits, unpublished M.Sc. thesis, Dept. Geol., Univ. Alberta, 60 pages.
- HUGHES, G. M., J. J. TREMBLAY, H. ANGER and J. D'CRUZ (1971): Pollution of groundwater due to municipal dumps; Inland Waters Branch, Dept. of Energy, Mines and Resources Tech. Bull., No. 42, 98 pages.
- IRISH, E. J. W. (1970): The Edmonton Group of south central Alberta; Bull. Can. Petroleum Geol., Vol. 18, No. 18, p. 125-156.
- LOCKER, J. G. (1969): The petrographic and engineering properties of fine-grained sedimentary rocks of central Alberta; Res. Coun. Alberta Bull. 30, 144 pages.
- McPHERSON, R. A. and C. P. KATHOL (1972): Stratigraphic sections and drillhole logs, Edmonton area, Alberta; Res. Coun. Alberta Rept. 72-6, 78 pages.
- (1973): Sand and gravel resources of the Edmonton area, Alberta; Alberta Res. Rept. 73-2, 11 pages.
- OWER, J. R. (1958): The Edmonton Formation; Edmonton Geol. Soc. Quart., Vol. 2, p. 3-11.
- ROED, M. A. (1966a): River bank stability study, University of Alberta, Edmonton, Alberta; unpublished manuscript, Dept. Geol., Univ. Alberta, 42 pages.
- (1966b): Report on the geology of the north Garneau district, Edmonton; unpublished manuscript, Dept. Geol., Univ. Alberta, 18 pages.
- RUTHERFORD, R. L. (1937): Saskatchewan gravels and sands in central Alberta; Trans. Roy. Soc. Can., Vol. 31, No. 3 p. 81-95.

- SELWYN, A. (1874): Observations on the Northwest Territory on a journey across the plains to Rocky Mountain House, returning by the Saskatchewan River; Can. Dept. Mines Geol. Surv. Rept.
- STALKER, A. MacS. (1963): Quaternary stratigraphy in southern Alberta; Geol. Surv. Can. Paper 62-34, 52 pages.
- (1968): Identification of Saskatchewan gravels and sands; Can. Jour. Earth Sci., Vol. 5, p. 155-163.
- TAYLOR, D. A. (1934): Detailed stratigraphy of the Edmonton district; unpublished M.Sc. thesis, Univ. Alberta, 68 pages.
- TAYLOR, R. S. (1971): Atlas: coal mine workings of the Edmonton area; Spence Taylor and Associates Ltd., 33 pages.
- THOMPSON, S. (1969): A summary of laboratory results on Lake Edmonton clay; Internal Note SM2, Dept. Civil Eng., Univ. Alberta, Edmonton, Alberta, 29 pages.
- TURNER, A. K. and D. M. COFFMAN (1973): Geology for planning: a review of environmental geology; Quart. Colorado School of Mines, Vol. 68, No. 3, p. 1-127.
- TYRRELL, J. B. (1887): Report on a part of northern Alberta and portions of adjacent districts of Assiniboia and Saskatchewan; Geol. and Nat. Hist. Surv. Can. Ann. Rept. 1886, New series 2(E), 176 pages.
- UNITED STATES BUREAU OF RECLAMATION (1966): Concrete Manual; United States Dept. of Interior, Bureau of Reclamation, 7th ed., 642 pages.
- WARREN, P. S. (1954): Some glacial features of central Alberta; Trans. Roy. Soc. Can., Vol. 48, No. 3, p. 75-86.
- WESTGATE, J. A. (1969): The Quaternary geology of the Edmonton area, Alberta; *in* S. Pawluk, ed., Pedology and Quaternary Research symposium, Edmonton, Alberta; Univ. Alberta Printing Dept., p. 129-151.
- WESTGATE, J. A. and L. A. BAYROCK (1964): Periglacial structures in the Saskatchewan gravels and sands of central Alberta, Canada; Jour. Geol., Vol. 72, p. 641-648.
- WESTGATE, J. A., D. G. W. SMITH and H. NICHOLS (1969): Late Quaternary pyroclastic layers in the Edmonton area, Alberta; *in* S. Pawluk, ed., Pedology and Quaternary Research symposium, Edmonton, Alberta; Univ. Alberta Printing Dept., p. 170-186.

APPENDIX

SAND AND GRAVEL SURVEY - DRILLHOLE LOGS

Locations of the holes are shown in figure 34

Hole No. 1

<u>Depth (ft)</u>	<u>Lithology</u>
0-9	Lacustrine till, clayey
9-24	Till, grey-brown
24-35	Saskatchewan gravels, coarse, minor sand layers
35-48	Sand, fine with a few pebbles
48-50	Gravel, medium to coarse
50-55	Sand, fine with a few pebbles
55-65	Sand and gravel interbedded
65-68	Gravel, coarse
68-70	Shale (bedrock)

Hole No. 5

<u>Depth (ft)</u>	<u>Lithology</u>
0-1	Lacustrine clay
1-20	Lacustrine clay, brownish-grey
25-40	Till, brownish-grey
40-44	Lacustrine clay, dark grey
44-55	Till, silty
55-95	Saskatchewan gravels and sands interbedded
95-103	Sandstone (bedrock)

Hole No. 2

<u>Depth (ft)</u>	<u>Lithology</u>
0-6	Lacustrine clay
6-25	Till, grey and clayey
25-35	Saskatchewan sand, fine with a few pebbles
35-50	Gravel, coarse
50-56	Gravel, coarse with minor interbedded sand
56-62	Shale (bedrock)

Hole No. 6

<u>Depth (ft)</u>	<u>Lithology</u>
0-7	Lacustrine silty clay
7-14	Till, minor clay layers
14-23	Lacustrine clay, silty with minor stones
23-30	Till, sandy
30-50	Saskatchewan gravels, minor interbedded sand
50-52	Silty shale (bedrock)

Hole No. 3

<u>Depth (ft)</u>	<u>Lithology</u>
0-15	Lacustrine clay, minor pebbles
15-26	Lacustrine silt
26-31	Saskatchewan sand, minor pebbles
31-57	Gravel, coarse with minor interbedded sand layers
57-60	Gravel and bedrock shale mixed
60-62	Shale (bedrock)

Hole No. 7

<u>Depth (ft)</u>	<u>Lithology</u>
0-3	Lacustrine clay, grey brown
3-12	Till, rocks common
12-15	Sand and gravel, glacial
15-41	Till, silty
41-43	Saskatchewan sand, fine-grained
43-60	Shale (bedrock)

Hole No. 4

<u>Depth (ft)</u>	<u>Lithology</u>
0-17	Lacustrine silty clay, light brown
17-33	Till, brown
33-48	Saskatchewan sand, minor pebbles
48-61	Gravel, coarse
61-65	Shale (bedrock)

Hole No. 8

<u>Depth (ft)</u>	<u>Lithology</u>
0-17	Lacustrine clay, silty
17-22	Till, grey-brown
22-57	Saskatchewan sand, minor pebbles
57-60	Shale (bedrock)

Hole No. 9

<u>Depth (ft)</u>	<u>Lithology</u>
0-33	Till, brown
33-34	Saskatchewan sand (ice-pushed)
34-38	Till, rocky
38-53	Saskatchewan sand, minor pebbles
53-66	Gravel, coarse
66-70	Shale (bedrock)

Hole No. 10

<u>Depth (ft)</u>	<u>Lithology</u>
0-22	Lacustrine silty clay
22-38	Till, rocky
38-53	Saskatchewan sand, minor pebbles
53-66	Gravel, coarse
66-70	Shale (bedrock)

Hole No. 11

<u>Depth (ft)</u>	<u>Lithology</u>
0-33	Till, grey brown
33-50	Saskatchewan sand, numerous pebbles
50-60	Gravel, medium
60-70	Gravel, medium to fine
70-78	Gravel, coarse
78-80	Shale (bedrock)

Hole No. 12

<u>Depth (ft)</u>	<u>Lithology</u>
0-31	Outwash sand, fine with minor pebbles
31-35	Saskatchewan gravel, fine
35-37	Gravel, coarse
37-48	Silt, no pebbles
48-60	Shale (bedrock)

GLOSSARY OF TERMS*

- aeolian** Eroded, transported or deposited by wind action.
- alluvium** Unconsolidated sand, silt and gravel deposits laid down by streams; includes sediments deposited in river beds, flood plains and deltas, and fans at the base of a mountain slope.
- anhydrite** Anhydrous calcium sulfate: CaSO_4 ; common mineral in evaporite deposits.
- arkose** A feldspar-rich pink to buff sandstone composed of coarse angular grains and usually derived from rapid erosion of granitic rocks.
- Atterberg Limits** Unconsolidated sediment contains a certain amount of water in addition to particulate matter; this water content determines whether the sediment behaves as a liquid, a plastic or a solid. The water content boundary between the liquid and plastic states is the *liquid limit* and that between the plastic and solid states is called the *plastic limit*. The *plasticity index* is defined as the liquid limit minus the plastic limit.
- Bearpaw Sea** The northwest arm of an inland sea that covered parts of the interior of North America in Late Cretaceous times; the Bearpaw sea covered the southeast section of Alberta. The Bearpaw Formation is the deposit from this sea.
- bedrock** In-place pre-Quaternary material underlying the soil mantle.
- bentonite** A soft, plastic porous rock composed largely of colloidal silica and clay minerals (often montmorillonite) and produced by devitrification of glassy volcanic material.
- biotite** A common black to brown rock-forming mineral of the mica group: $\text{K}(\text{Mg}, \text{Fe}^{+2})^3(\text{Al}, \text{Fe}^{+3})\text{Si}_3\text{O}_{10}(\text{OH})_2$.
- bituminous** Said of a sedimentary rock containing any of the inflammable hydrocarbons collectively called bitumen.
- carbonaceous** Containing organic matter (if discussing unconsolidated sediments) or coal (if discussing rocks).
- calcareous** Containing calcium carbonate: CaCO_3 .
- Canadian Shield** Geologic region of Canada within which Precambrian crystalline and sedimentary complexes are exposed.
- Cenozoic** An era of geologic time from the end of the Tertiary to the present; paleontologically characterized by the widespread distribution of mammals and birds and angiosperms (see Geological Time Scale).

*The definitions included in this glossary are based on definitions from: 1) Gary, M., R. McAfee, Jr. and C. L. Wolf (1972): Glossary of Geology; American Geological Institute, Washington, 805 pages.

2) Mollard, J. D. (1973): Landforms and Surface Materials of Canada, A Stereoscopic Airphoto Atlas and Glossary, 3rd edition, Regina.

- chert** A hard flint-like rock composed of cryptocrystalline silica.
- clastic sediments** Accumulated particles of broken rocks, for example sands and clays.
- clay** Fine-grained sediment (grains 0.002 mm in diameter) having plasticity and containing a considerable amount of the clay minerals.
- clay minerals** Complex and loosely defined group of finely crystalline to amorphous hydrous silicates of aluminium which may have exchangeable cations on silicate surfaces in the crystal lattice; the most common clay minerals are kaolin, montmorillonite and illite.
- claystone** Consolidated clay sediment having the texture and composition of a shale but lacking lamination.
- colluvium** Heterogeneous, loose sediment deposited at the base of steep slopes by mass-wasting processes (e.g. soil creep, rockslides) or nonchannel water flow.
- Cretaceous** The final period of the Mesozoic Era (see Geological Time Scale).
- crevasse filling** A short, straight ridge of stratified sand and gravel deposited in a glacial crevasse and left standing when the ice melted.
- dendritic** Said of a drainage pattern in which the streams branch out in an irregular tree-like manner.
- Devonian** A period of the Paleozoic Era, (see Geological Time Scale).
- dip** The angle of inclination a bed makes with the horizontal measured perpendicular to the direction of strike.
- discharge area** An area where subsurface water emerges from underground.
- dolomite** A carbonate sedimentary rock composed mainly of the mineral dolomite: $\text{CaMg}(\text{CO}_3)_2$.
- drift** Material of any sort moved by glaciers or meltwater streams and deposited by processes associated with glaciation.
- dune** A low mound or ridge of loose sand formed by wind or water action. Aeolian dunes are commonly formed in desert or semi-desert conditions such as margins of glacial lakes or on flood plains and outwash plains. The most common shapes for aeolian dunes are *parabolic* and *longitudinal*. Parabolic dunes are scoop-shaped and from the air look like crescents; the horns of the crescent point upwind. Longitudinal dunes are long and narrow and are aligned parallel to the prevailing wind direction.
- epoch** A geologic time unit smaller than a period (see Geological Time Scale).
- era** A geologic time unit including two or more periods (see Geological Time Scale).
- esker** A long, low, narrow ridge of sand, silt and gravel deposited by a stream flowing between ice walls or in an ice tunnel in a retreating glacier and left behind when the glacier melted.
- evaporites** Nonclastic sedimentary rocks composed of minerals precipitated from saline waters that became increasingly concentrated as evaporation proceeded.

feldspars A group of abundant rock-forming minerals with a general formula: $R Al(Al,Si)_3O_8$ where R = K, Na, Ca, Ba, Rb, Sr, Fe; feldspars constitute 60 percent of the earth's crust and occur in all kinds of rocks.

Geological Time Scale

ERA	PERIOD	EPOCH	APPROXIMATE TIME BEFORE PRESENT (IN MILLIONS OF YEARS)	EON	
CENOZOIC Recent Life	Quaternary	Recent	0.01	Age of man	
		Pleistocene			
	Tertiary	Pliocene	1.5	Age of mammals	
		Miocene	7		
		Oligocene	26		
		Eocene	38		
		Paleocene	54		
	MESOZOIC Middle Life	Cretaceous	Upper	65	Age of reptiles (including dinosaurs)
			Lower	100	
		Jurassic	Upper	136	
Middle			162		
Triassic		Lower	172		
		Upper	192		
		Middle	205		
PALEOZOIC Ancient Life	Permian	Lower	215	Age of amphibians	
		Upper	220		
	Carboniferous	Lower	240		
		Pennsylvanian	280		
		Mississippian	325		
	Devonian	Upper	345		Age of fishes
		Middle	359		
	Silurian	Lower	370		
		Upper	395		
		Lower	430		Age of marine invertebrates
Ordovician	Upper	445			
	Lower	500			
Cambrian	Upper	515			
	Middle	540			
	Lower	570			
PRECAMBRIAN			4500	Earliest life forms known (all soft bodied)	

Dates from R. K. Wanless et al., Age Determinations and Geological Studies K-Ar Isotopic Ages, Report 12; Geol. Surv. Can. Paper 74-2, 1974.

- geology** The study of the planet Earth.
- geotechnics** The study and evaluation of earth materials for the purpose of solving civil engineering problems.
- glacial lake** A lake that derives most of its water from the melting of glacier ice.
- glacier** A large mass of ice formed, at least in part, on land by the compaction and recrystallization of snow, moving by creep outward due to the stress of its own weight.
- glaciofluvial** Refers to glacial meltwater streams or deposits produced by such streams.
- glaciolacustrine** Refers to sediments deposited in glacial lakes.
- glaucinite** A general name applied to green-colored hydrous silicates of potassium and iron, commonly formed in a marine environment.
- granite** A general name applied to quartz-bearing, coarse-grained rocks formed at great depths in the earth.
- groundwater** The part of subsurface water which is below the water table, that is, in the saturated zone.
- ground moraine** The rock debris dragged along beneath a glacier and deposited as a thin extensive till layer when the glacier retreated or wasted.
- hummocky moraine** Moraine characterized by a knob and kettle topography.
- hydrogeology** The branch of geology that deals with subsurface waters.
- hydrology** The science of water (both as liquid and as ice) including the study of its properties, circulation and distribution on or in the surface of the earth.
- incised** Said of a stream that has deepened its valley by downcutting due to a relative upward movement of the earth's surface.
- infiltration gallery** A horizontal conduit built to intercept groundwater; galleries often parallel rivers which provide a perennial water supply.
- ion** An atom or group of atoms carrying a positive or negative charge due to loss or gain of electrons.
- ion exchange** The reversible replacement of certain ions by others without a change in the crystal structure of the exchanging medium.
- ironstone** An iron-rich sedimentary rock.
- isopach** A line on a map connecting points of equal thickness of a designated unit.
- kame** A long, narrow steep-sided hill or ridge of sand and gravel deposited in contact with glacier ice by meltwater.

- kettle** A sharply defined closed depression in glacial drift created by the melting out of a mass of underlying ice that was wholly or partially buried.
- knob and kettle topography** Undulating morainal landscape marked by a disordered assemblage of mounds or ridges and kettles.
- lacustrine** Refers to lakes and to sediments formed in lakes.
- lacustro-till** Unsorted, unstratified glacial drift deposited in lake environments.
- laminated** Said of sediments exhibiting visible layers less than 1 cm thick.
- liquid limit** See Atterberg Limits.
- limestone** A sedimentary rock whose composition is more than 50 percent by weight of CaCO_3 (calcium carbonate) and less than 5 percent by weight of $\text{CaMg}(\text{CO}_3)_2$ (dolomite).
- liquefaction** The sudden temporary transformation of loose soil or sediments into a fluid mass when shock or strain causes the internal structure to collapse.
- lithology** The description of rocks on the basis of characteristics such as color, structures, mineralogical components and grain size.
- log** A detailed, sequential record of the progress made in drilling a well or testhole. It may include notes on thicknesses, lithologies, fossil content, water conditions and so forth. It is obtained by examining cuttings and cores and by using geophysical devices which record such properties as electrical resistivity, spontaneous potential, gamma ray intensity, density, and acoustic velocity as the geophysical tool passes through different layers.
- marl** A general term usually applied to soft, crumbling unconsolidated mixtures of clay and calcium carbonate formed in freshwater environments.
- meltwater channel** A channel developed by waters flowing from melting glaciers.
- Mesozoic** An era of geologic time from the end of the Paleozoic to the beginning of the Cenozoic and characterized by the dominance of reptiles (dinosaurs) and gymnosperms (see Geological Time Scale).
- methane** The principal constituent hydrocarbon of natural gas with a general formula CH_4 .
- montmorillonite** A hydrous aluminosilicate clay mineral with a crystal lattice that can expand when water molecules move into the interlayer spaces.
- moraine** An accumulation of glacial drift formed by direct action of a glacier along its margin or surfaces. Various morainal types are classified on the basis of topographic characteristics and inferred position relative to the glacier.
- moraine plateau** A subcircular, flat-topped, mesa-like mound of till and stratified drift.
- Oligocene** An epoch of the Tertiary period (see Geological Time Scale).

- outwash** Stratified detritus removed from a glacier by meltwater and deposited beyond the active margin of the glacier.
- overburden** Rock material of any nature that overlies useful deposits of minerals, gravel or coal and which must be removed if these deposits are to be mined from the surface.
- Paleozoic** An era of geologic time after the Precambrian and before the Mesozoic (see Geological Time Scale).
- plasticity index** See Atterberg Limits.
- plastic limit** See Atterberg Limits.
- period** A geologic time unit during which a clearly defined type sequence of rocks were deposited (see Geological Time Scale).
- permeability** The capacity of a material to transmit a fluid.
- phreatophytic** A plant that depends on groundwater for its water supply.
- pipng** Erosion of a subsoil layer by percolating waters and resulting in the development of subsurface channels and possibly caving of overlying materials.
- pitted delta** A delta composed of glacial drift with a surface marked by kettles, pits and potholes.
- Pleistocene** The earlier of two epochs of the Quaternary period of geologic time, usually considered to end with the recession of the last glacier (see Geological Time Scale).
- Precambrian** All geologic time before the Paleozoic and characterized by the absence of hard-bodied life forms (see Geological Time Scale).
- proglacial lake** A lake formed just beyond the front margin of a retreating glacier and usually in direct contact with the ice.
- quartz** The most common crystalline form of silica.
- quartzite** A strong, hard, granulose metamorphic rock consisting chiefly of quartz.
- Quaternary** The second period of the Cenozoic Era, covering the last two to three million years (see Geological Time Scale).
- Recent** The epoch of the Quaternary from the end of the Pleistocene to the present (see Geological Time Scale).
- recharge** The processes involved in replenishing the groundwater.
- runoff** The part of precipitation appearing in surface streams.
- sandstone** Any elastic sedimentary rock formed from the compaction and cementation of sand-sized particles (0.06 to 2 mm in diameter).

shale Any clastic sedimentary rock formed from compaction and cementation of particles less than 0.06 mm in diameter and having a laminated structure.

siderite A blackish-brown mineral with a formula FeCO_3 and commonly found in impure forms in clays and shales.

silica The dioxide of silicon (SiO_2). Silica occurs in crystalline form (quartz), cryptocrystalline form (chert), amorphous form (opal) and impure forms (quartz sands).

soil The uppermost portion of the weathered layer on the earth's surface that contains organic matter and is capable of supporting plant life.

strata Layers of sedimentary rocks, each of which is internally approximately uniform in composition.

stream trench A narrow steep-sided canyon, gully, or other depression eroded by a stream.

strike The compass direction of a horizontal line on an inclined plane.

terrace A relatively flat-lying step-like surface bounded by a steep descending slope on one side and a rise to higher surfaces on the other.

Tertiary The first period of the Cenozoic Era (see Geological Time Scale).

thalweg The line on a map connecting the deepest points along a stream bed or valley.

till Unsorted, unstratified glacial drift deposited directly by the glacier.

tuff A compacted deposit of volcanic ash and dust that may contain up to 50 percent sediments such as sand and clay.

varve A thin pair of glaciolacustrine layers seasonally deposited in still water; normally the lowest "summer" layer consists of coarse-grained, light-colored sediments and the "winter" layer consists of dark clayey, often organically rich material.

water content The ratio of the weight of water contained in a sediment sample to the dry weight of that sample multiplied by 100.

water table The surface in the ground along which hydrostatic pressure equals atmospheric pressure. The zone of saturation is below and the zone of aeration is above the water table.

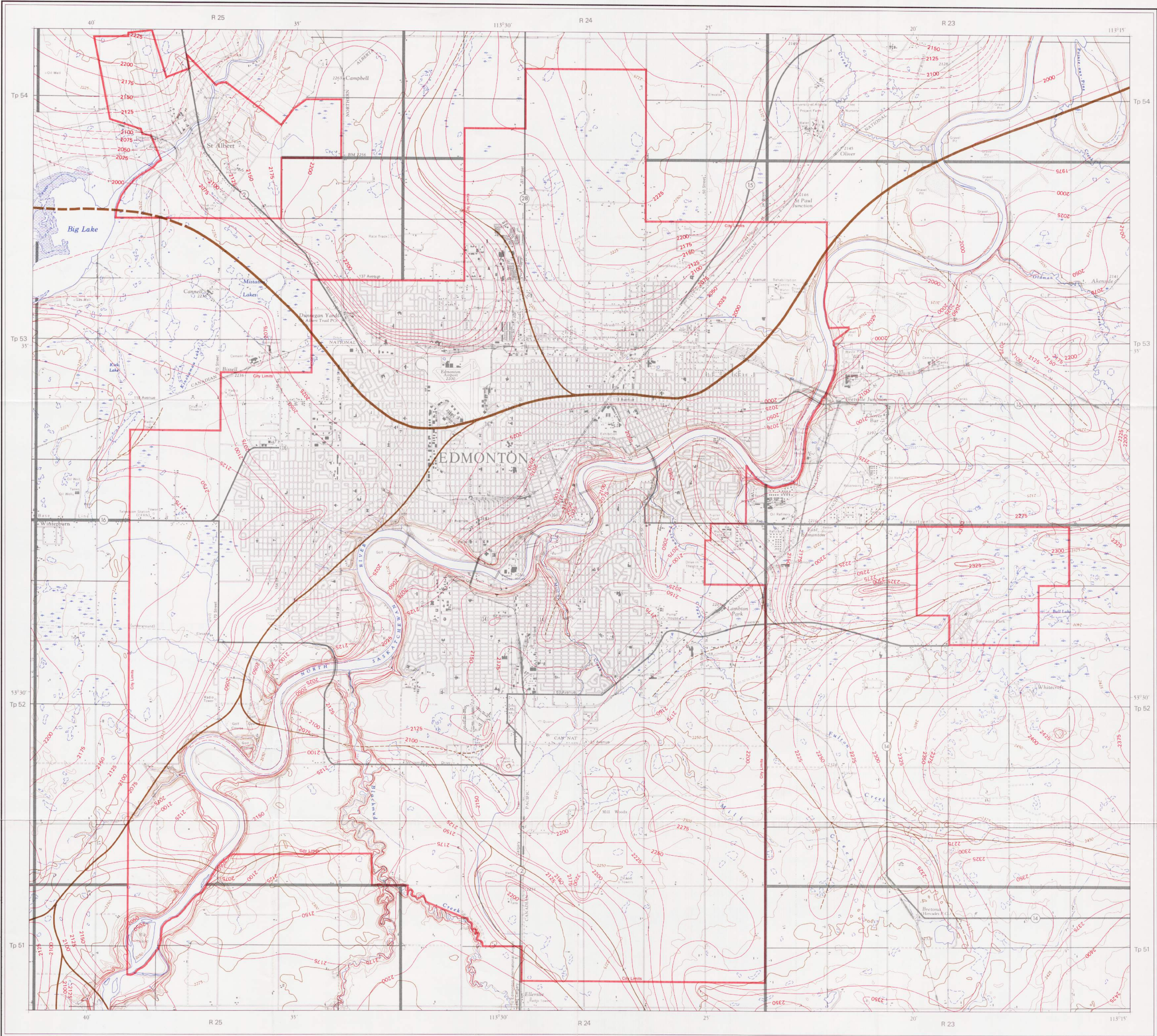


FIGURE 20. BEDROCK TOPOGRAPHY AND PREGLACIAL THALWEGS IN THE EDMONTON AREA.

Bedrock surface contour (in feet) defined, approximate
 Thalweg* of preglacial valley: defined, approximate
 *Variations in thickness indicate only qualitative relationships between valleys.

LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft)

Miles 1 2 3 4
 Kilometers 1 2 3 4 5 6
 SCALE 1:50 000



To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson

LEGEND

RECENT

EROSIONAL FEATURES

- 16 Gully, creek valley, scar: thin colluvial cover on valley slopes, thin alluvial materials along streams, mixed glacial and bedrock material in slump areas
- 15 Lake and slough deposits: silt, clay, organic muck and marl
- 14 River terrace: alluvial gravel, sand and silt along North Saskatchewan River
- 13 Stream alluvium: gravel, sand, silt and clay along small streams
- 12 Sand: medium- to fine-grained in sheet form, generally thin
- 11 Sand: medium- to fine-grained in dune form; 10 to 50 ft thick

PLEISTOCENE

GLACIOLACUSTRINE DEPOSITS

- 10 Silt and clay: bedded silt and clay, with minor sand; varved in places
- 9 Sand, silty sand: mainly sand, with minor silt and clay; minor pockets of coarse sand and gravel
- 8 Silt, clay and sand: bedded silt and clay; minor sand; overlying kame
- 7 Sand and silt: fine- to medium-grained sand, minor silt and gravel; overlying till
- 6 Mixed: bedded silt, sand and clay with pebbles, till pockets and till-like layers

GLACIOFLUVIAL DEPOSITS AND FEATURES

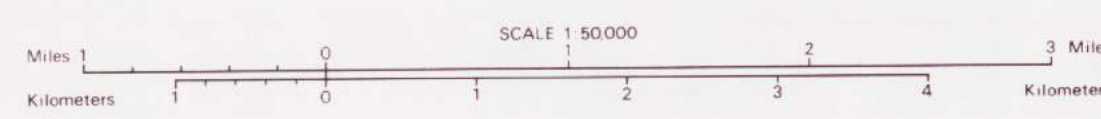
- 5 Pitted delta: fluvial sand, silt and sand, minor clay with occasional till pockets; topography hummocky to gently rolling
- 4 Outwash sand and gravel: mainly sand, minor gravel pockets; thickness variable (2 ft to 20 ft); topography level to gently undulating
- 3 Kame, crevasse filling: mainly sand, minor gravel and silt with inclusions of till; locally forms hills and ridges

GLACIAL DEPOSITS

- 2 Hummocky moraine: till composed of mixed clay, silt and sand with pebbles and boulders; lenses of sand, gravel and local bedrock; generally more than 40 ft thick; topography undulating to gently rolling
- 1 Ground moraine: till composed of clay, silt and sand with pebbles and boulders; variable in thickness but generally less than 40 ft thick; topography level to undulating

Geological boundary: defined, approximate
 Stream trench and channel

NOTE: The geologic contacts on the Surficial Geology Map (Fig 23) do not always correspond to the contacts on the geologic cross-sections (Fig 26). The scale of the cross-sections does not permit as detailed a subdivision of the geologic sediments as can be made on the Surficial Geology Map.



Alberta
 RESEARCH COUNCIL
 To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson

LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line

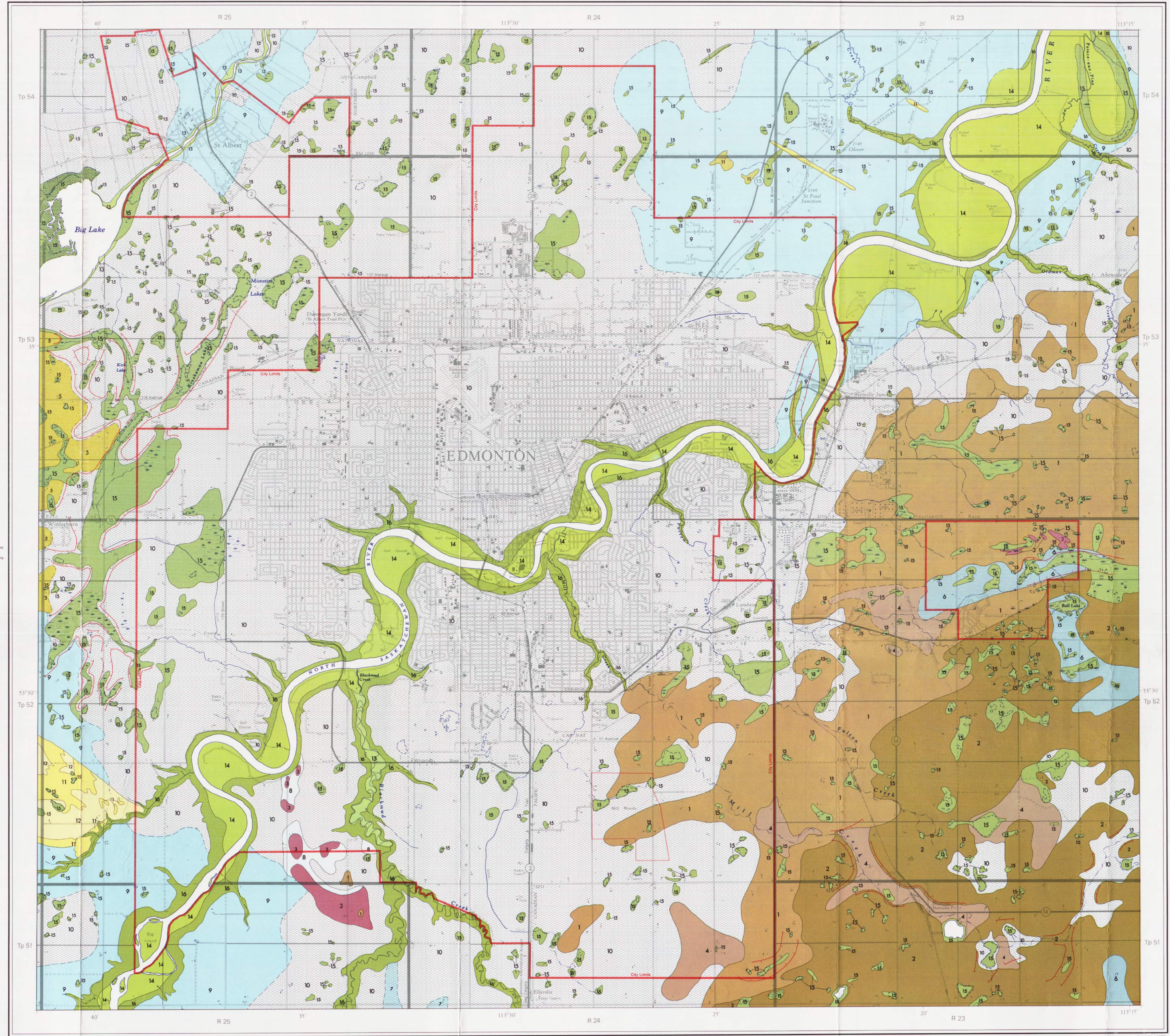


FIGURE 23. SURFICIAL GEOLOGY OF THE EDMONTON AREA.

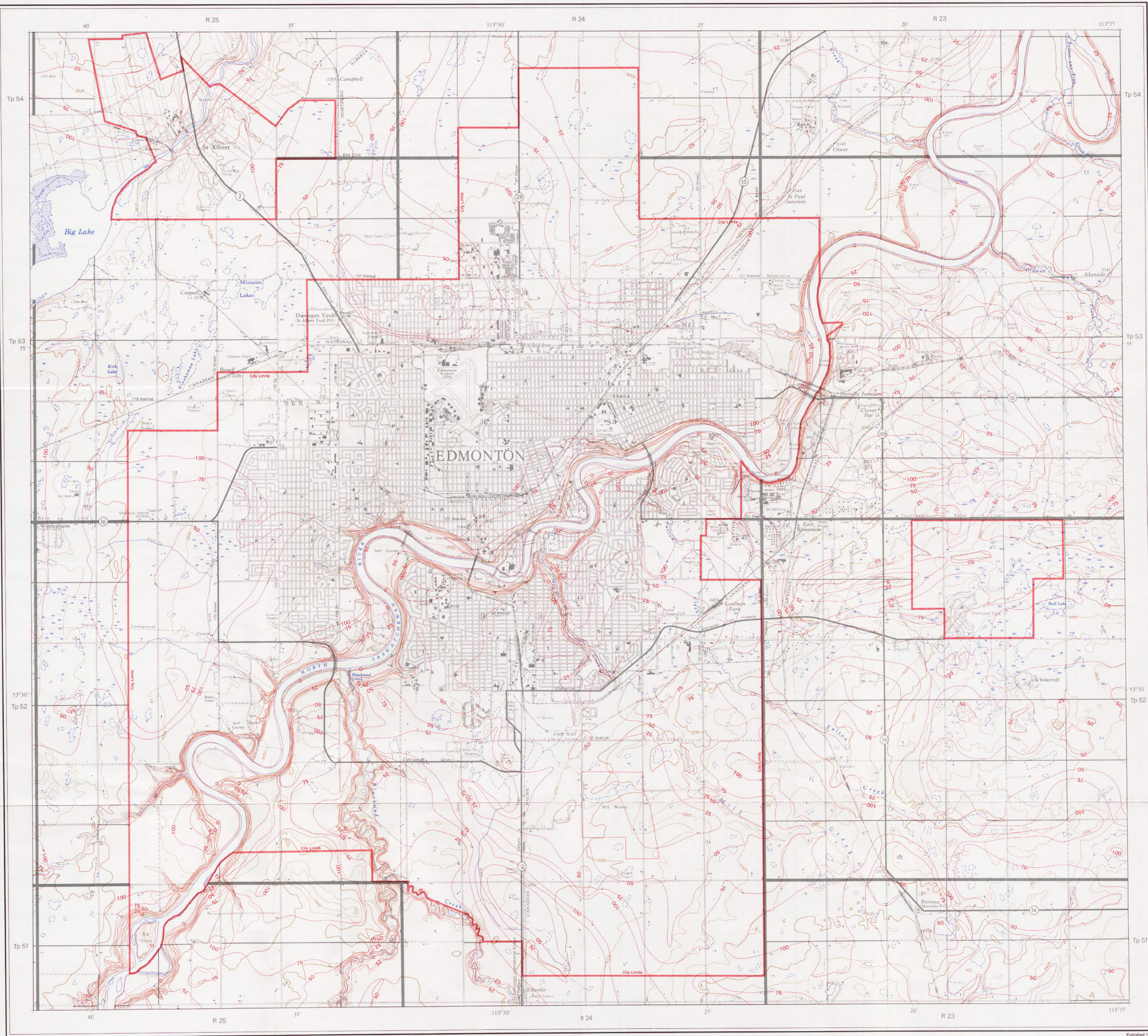
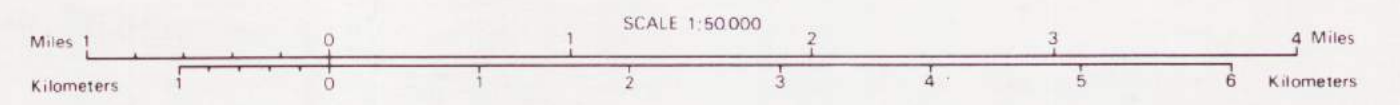


FIGURE 24. THICKNESS OF SURFICIAL DEPOSITS IN THE EDMONTON AREA.

LEGEND

- | | | | |
|---------------------------------|-------|---|-------|
| River or stream | ..... | Highway | ..... |
| Intermittent river or stream | ..... | Railway | ..... |
| Lake | ..... | Township boundary | ..... |
| Intermittent lake | ..... | Section line | ..... |
| Road, hard surface, all weather | ..... | Topographic contour (contour interval 25 ft.) | ..... |



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

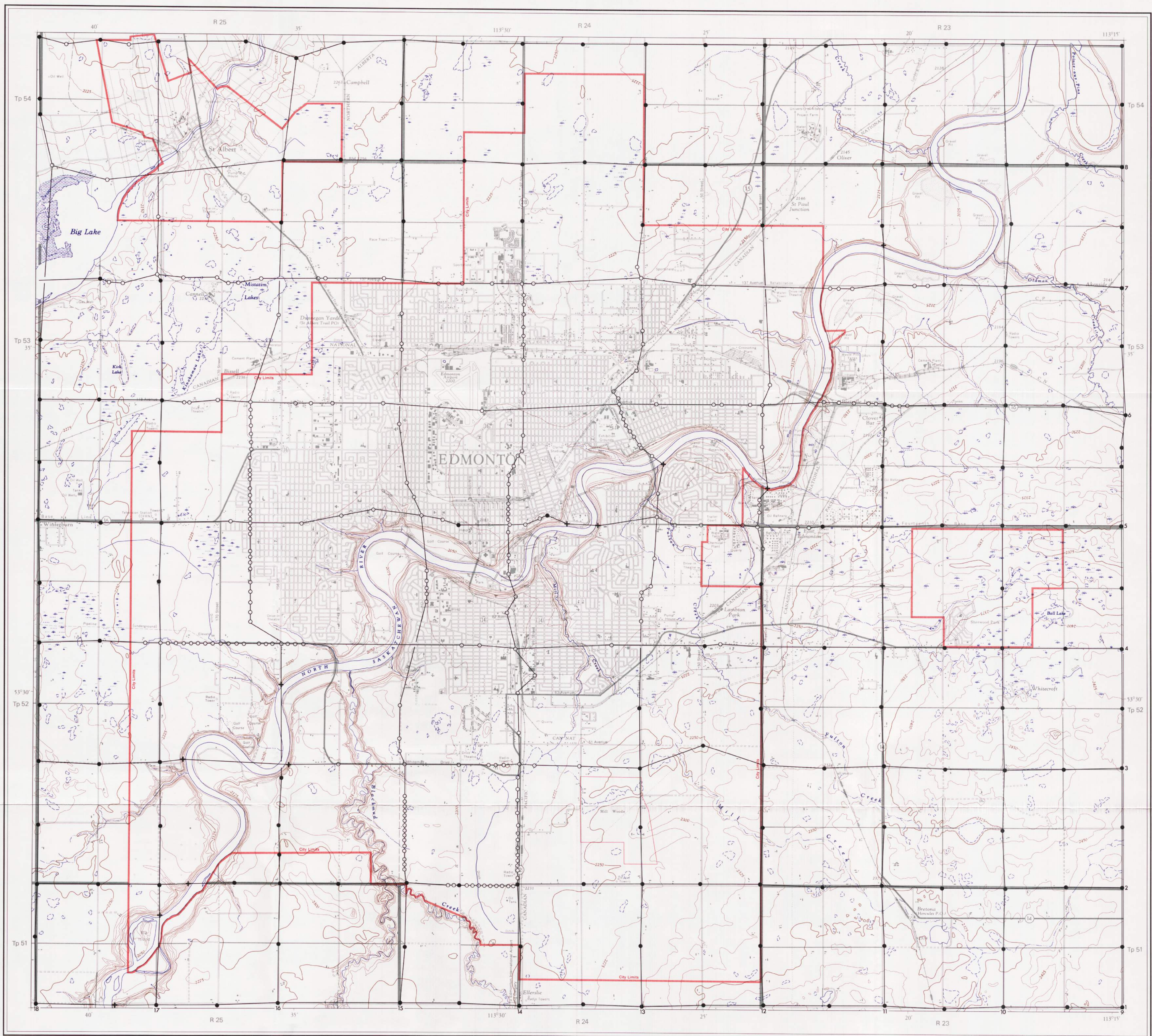


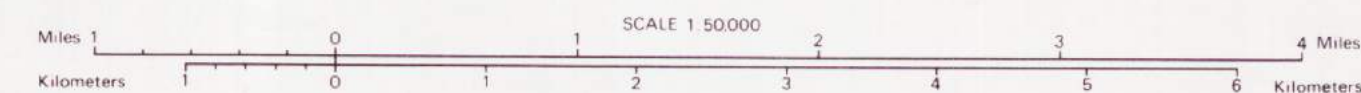
FIGURE 25. INDEX MAP SHOWING LINES OF GEOLOGICAL CROSS-SECTIONS.

- Line of geologic section 2
- Section number 3
- Alberta Research Council drill hole sites ●
- Other drill hole sites ○
- Exposed section along North Saskatchewan River +

LEGEND

- River or stream ————
- Intermittent river or stream - - - - -
- Lake [Symbol]
- Intermittent lake [Symbol]
- Road, hard surface, all weather [Symbol]

- Highway [Symbol]
- Railway [Symbol]
- Township boundary [Symbol]
- Section line [Symbol]
- Topographic contour (contour interval 25 ft.) [Symbol]



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

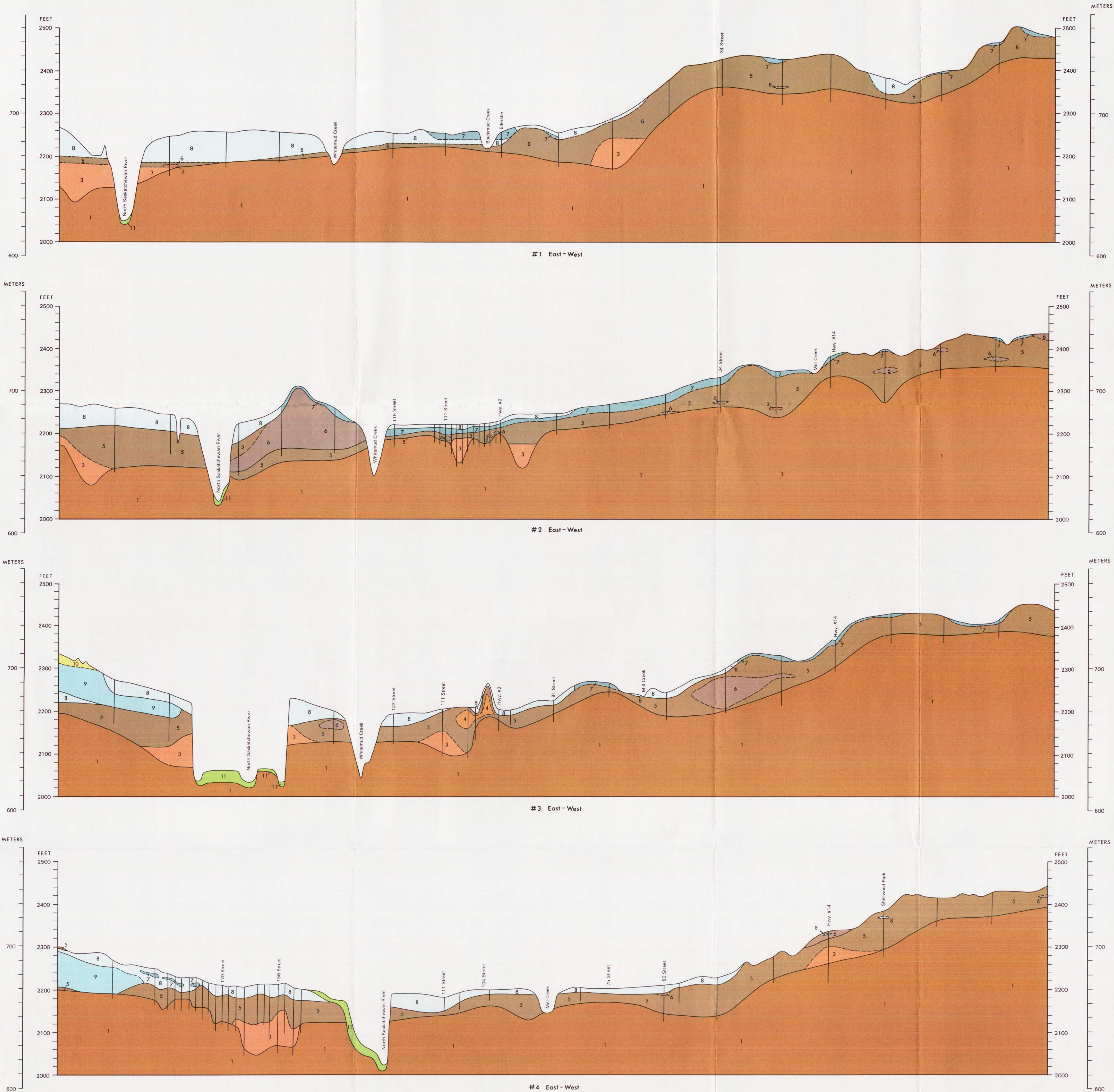


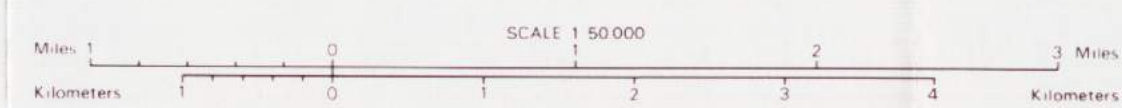
FIGURE 26. GEOLOGICAL CROSS-SECTIONS IN THE EDMONTON AREA

- 11** Alluvium: recent river terrace and floodplain deposits consisting of clay, silt and gravel
- 10** Aeolian deposits: sand, medium- to fine-grained in sheet or dune form, thin to 50 feet thick
- 9** Glaciolacustrine deposits: mainly fine sand and silt deposited in a large delta in Glacial Lake Edmonton
- 8** Glaciolacustrine deposits: bedded sands, silts and clays deposited in a large preglacial lake called Glacial Lake Edmonton
- 7** Lacustrine-till glaciolacustrine sediments mixed with pebbles and till-like layers, deposited by mud-flows into a glacial lake or by ice rafting or by both
- 6** Glacial sand and gravel: mainly sand and gravel deposited by glacial melt-water
- 5** Glacial till: unsorted, unstratified sediment deposited by a glacier, composed of clay, silt and sand with pebbles and boulders; lenses of outwash sand or gravel or disturbed bedrock are common

- 4** Saskatchewan gravels and sands: quartzose sediments varying from fine sand to coarse gravel; fluvialite in origin and deposited prior to glaciation in the area
- 3** Disturbed Saskatchewan gravels and sands: Saskatchewan gravels and sands that have been reworked by glacier ice
- 2** Bedrock (ice-shoved): bedrock material underlain by glacial deposits; these blocks of bedrock have been moved by glacier ice and are referred to as ice-shoved
- 1** Bedrock: Edmonton Formation composed of interbedded bentonitic shales and sandstones with numerous coal seams

NOTE: The geologic contacts on the Surficial Geology Map (Fig 23) do not always correspond to the contacts on the geologic cross-sections (Fig 26). The scale of the cross-sections does not permit as detailed a subdivision of the geologic sediments as can be made on the Surficial Geology Map.

All elevations in feet above mean sea level



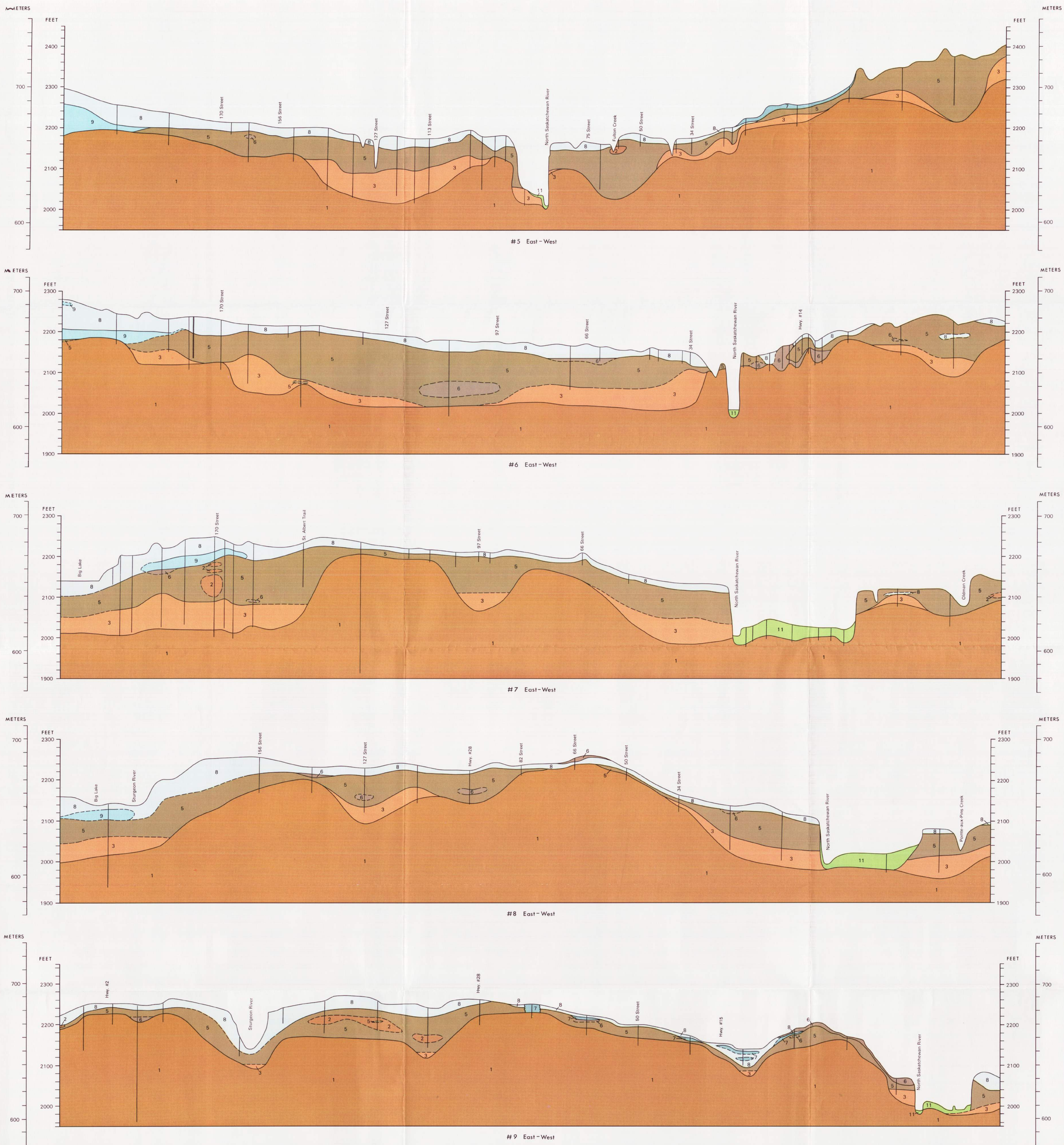


FIGURE 26. GEOLOGICAL CROSS-SECTIONS IN THE EDMONTON AREA

- LEGEND**
- 11 Alluvium: recent river terrace and floodplain deposits consisting of clay, silt and gravel
 - 10 Aeolian deposits: sand, medium to fine grained in sheet or dune form, thin to 50 feet thick
 - 9 Glaciolacustrine deposits: mainly fine sand and silt deposited in a large delta in Glacial Lake Edmonton
 - 8 Glaciolacustrine deposits: bedded sands, silts and clays deposited in a large preglacial lake called Glacial Lake Edmonton
 - 7 Lacustrine till: glaciolacustrine sediments mixed with pebbles and till-like layers, deposited by mud flows into a glacial lake or by ice rafting or by both
 - 6 Glacial sand and gravel: mainly sand and gravel deposited by glacial melt water
 - 5 Glacial till: unsorted, unstratified sediment deposited by a glacier, composed of clay, silt and sand with pebbles and boulders, lenses of outwash sand or gravel or disturbed bedrock are common
 - 4 Saskatchewan gravels and sands: quartzose sediments varying from fine sand to coarse gravel; fluviatile in origin and deposited prior to glaciation in the area
 - 3 Disturbed Saskatchewan gravels and sands: Saskatchewan gravels and sands that have been reworked by glacier ice
 - 2 Bedrock (ice-shoved): bedrock material underlain by glacial deposits; these blocks of bedrock have been moved by glacier ice and are referred to as ice shovels
 - 1 Bedrock: Edmonton Formation composed of interbedded bentonitic shales and sandstones with numerous coal seams

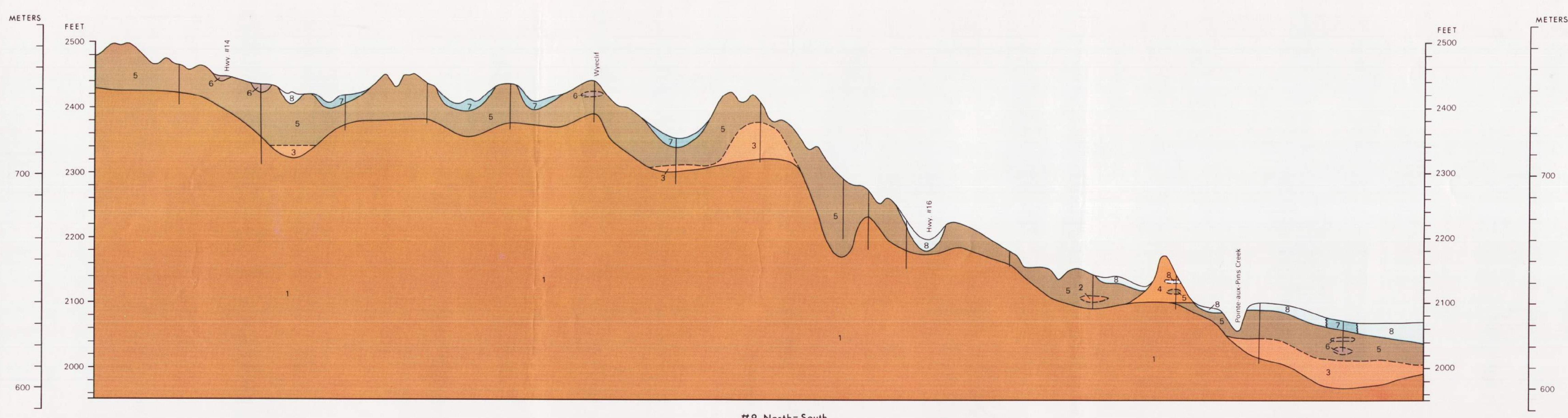
NOTE: The geologic contacts on the Surficial Geology Map (Fig 23) do not always correspond to the contacts on the geologic cross-sections (Fig 26). The scale of the cross-sections does not permit as detailed a subdivision of the geologic sediments as can be made on the Surficial Geology Map.

All elevations in feet above mean sea level.

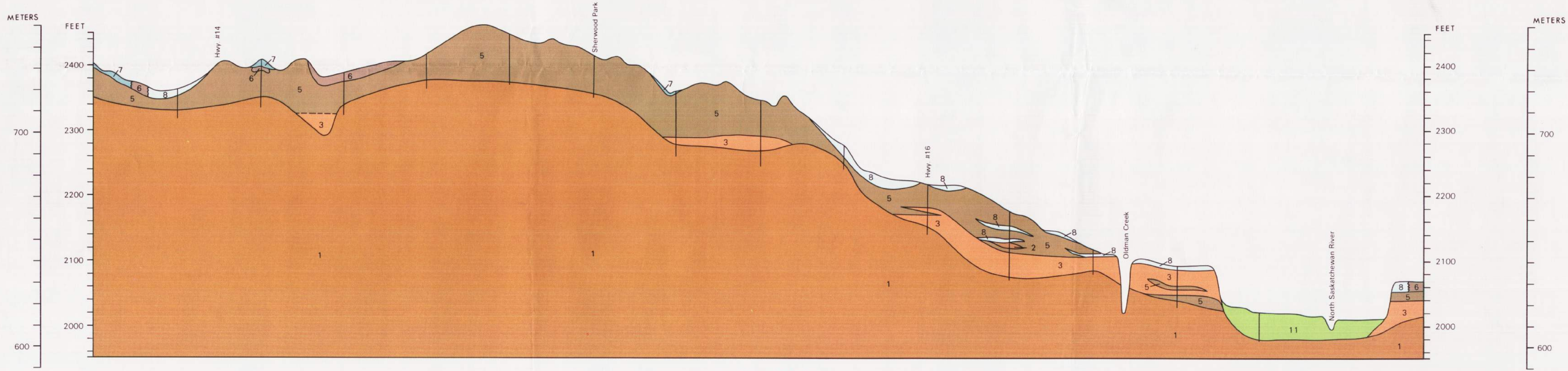
Scale: 1:50,000
 Miles: 0 1 2 3
 Kilometers: 0 1 2 3



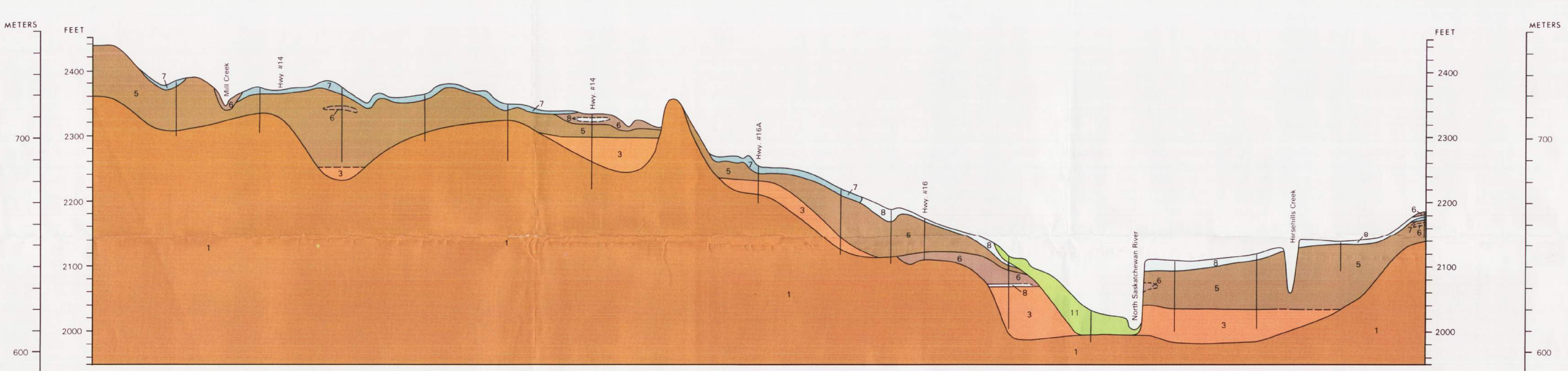
To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson



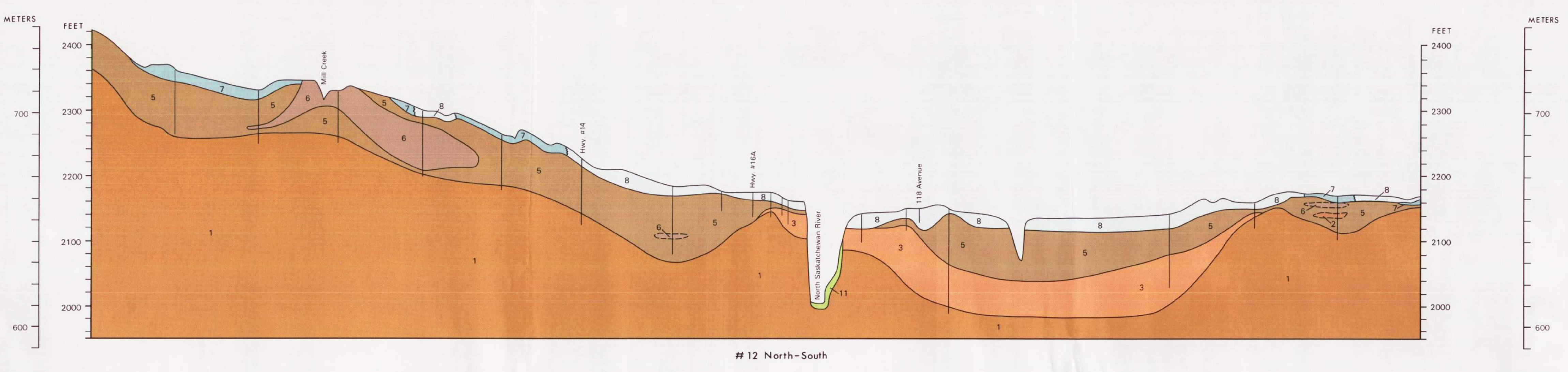
#9 North-South



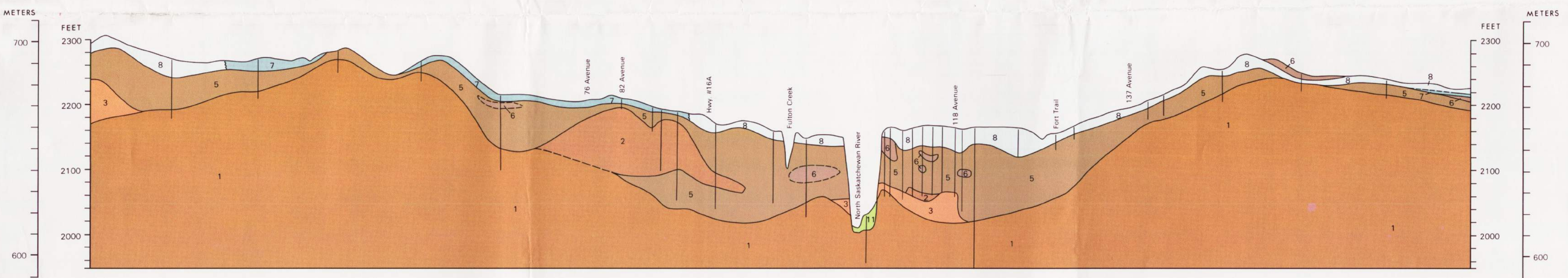
#10 North-South



#11 North-South



#12 North-South

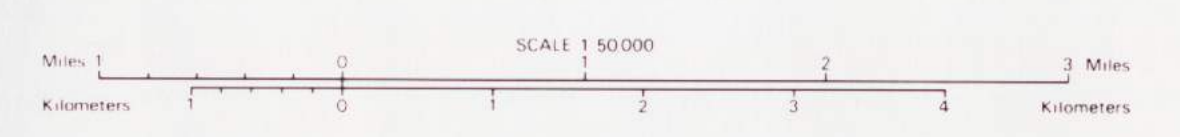


#13 North-South

FIGURE 26. GEOLOGICAL CROSS-SECTIONS IN THE EDMONTON AREA

- 11 Alluvium: recent river terrace and floodplain deposits consisting of clay, silt and gravel
- 10 Aeolian deposits: sand, medium to fine-grained in sheet or dune form, thin to 50 feet thick
- 9 Glaciolacustrine deposits: mainly fine sand and silt deposited in a large delta in Glacial Lake Edmonton
- 8 Glaciolacustrine deposits: bedded sands, silts and clays deposited in a large preglacial lake called Glacial Lake Edmonton
- 7 Lacustrine till: glaciolacustrine sediments mixed with pebbles and till like layers; deposited by mud-flows into a glacial lake or by ice rafting or by both
- 6 Glacial sand and gravel: mainly sand and gravel deposited by glacial melt-water
- 5 Glacial till: unsorted, unstratified sediment deposited by a glacier, composed of clay, silt and sand with pebbles and boulders; lenses of outwash sand or gravel or disturbed bedrock are common

- LEGEND**
- 4 Saskatchewan gravels and sands: quartzose sediments varying from fine sand to coarse gravel; fluvial in origin and deposited prior to glaciation in the area
 - 3 Disturbed Saskatchewan gravels and sands: Saskatchewan gravels and sands that have been reworked by glacier ice
 - 2 Bedrock (ice-shoved): bedrock material underlain by glacial deposits; these blocks of bedrock have been moved by glacier ice and are referred to as ice-shoved
 - 1 Bedrock: Edmonton Formation composed of interbedded bentonitic shales and sandstones with numerous coal seams
- NOTE: The geologic contacts on the Surficial Geology Map (Fig 23) do not always correspond to the contacts on the geologic cross-sections (Fig 26). The scale of the cross-sections does not permit as detailed a subdivision of the geologic sediments as can be made on the Surficial Geology Map.
- All elevations in feet above mean sea level.



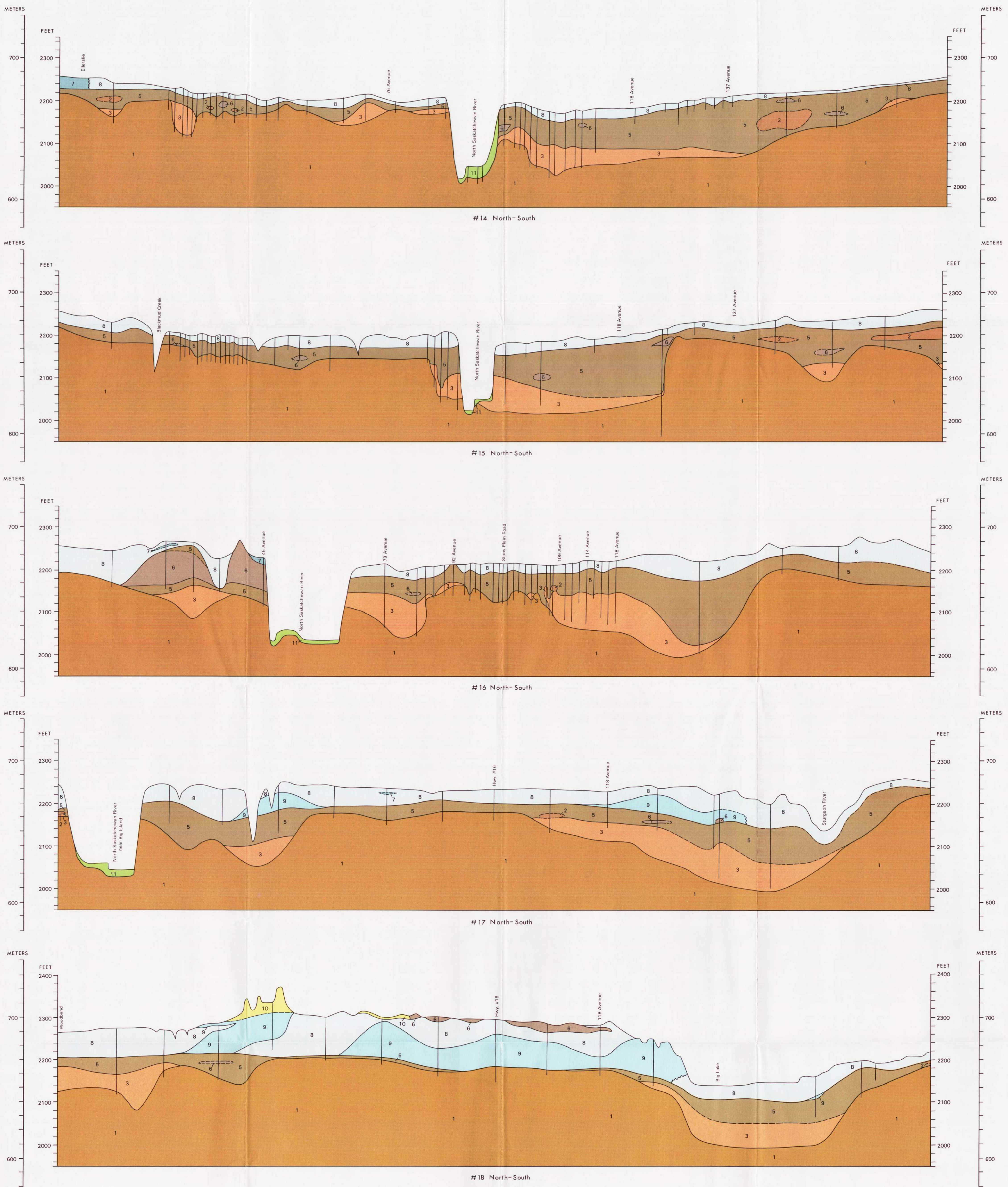
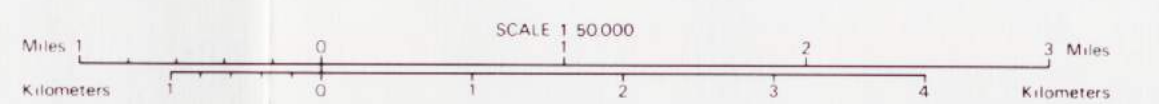


FIGURE 26. GEOLOGICAL CROSS-SECTIONS IN THE EDMONTON AREA

LEGEND

- | | |
|--|---|
| <ul style="list-style-type: none"> 11 Alluvium: recent river terrace and floodplain deposits consisting of clay, silt and gravel 10 Aeolian deposits: sand, medium-to fine-grained in sheet or dune form, thin to 50 feet thick 9 Glaciolacustrine deposits: mainly fine sand and silt deposited in a large delta in Glacial Lake Edmonton 8 Glaciolacustrine deposits: bedded sands, silts and clays deposited in a large proglacial lake called Glacial Lake Edmonton 7 Lacustrine-till: glaciolacustrine sediments mixed with pebbles and till-like layers, deposited by mud-flows into a glacial lake or by ice rafting or by both 6 Glacial sand and gravel: mainly sand and gravel deposited by glacial melt-water 5 Glacial till: unsorted, unstratified sediment deposited by a glacier, composed of clay, silt and sand with pebbles and boulders; lenses of outwash sand or gravel or disturbed bedrock are common | <ul style="list-style-type: none"> 4 Saskatchewan gravels and sands: quartzose sediments varying from fine sand to coarse gravel; fluvialite in origin and deposited prior to glaciation in the area 3 Disturbed Saskatchewan gravels and sands. Saskatchewan gravels and sands that have been reworked by glacier ice 2 Bedrock (ice-shoved): bedrock material underlain by glacial deposits, these blocks of bedrock have been moved by glacier ice and are referred to as ice-shoved 1 Bedrock: Edmonton Formation composed of interbedded bentonitic shales and sandstones with numerous coal seams |
|--|---|

All elevations in feet above mean sea level.



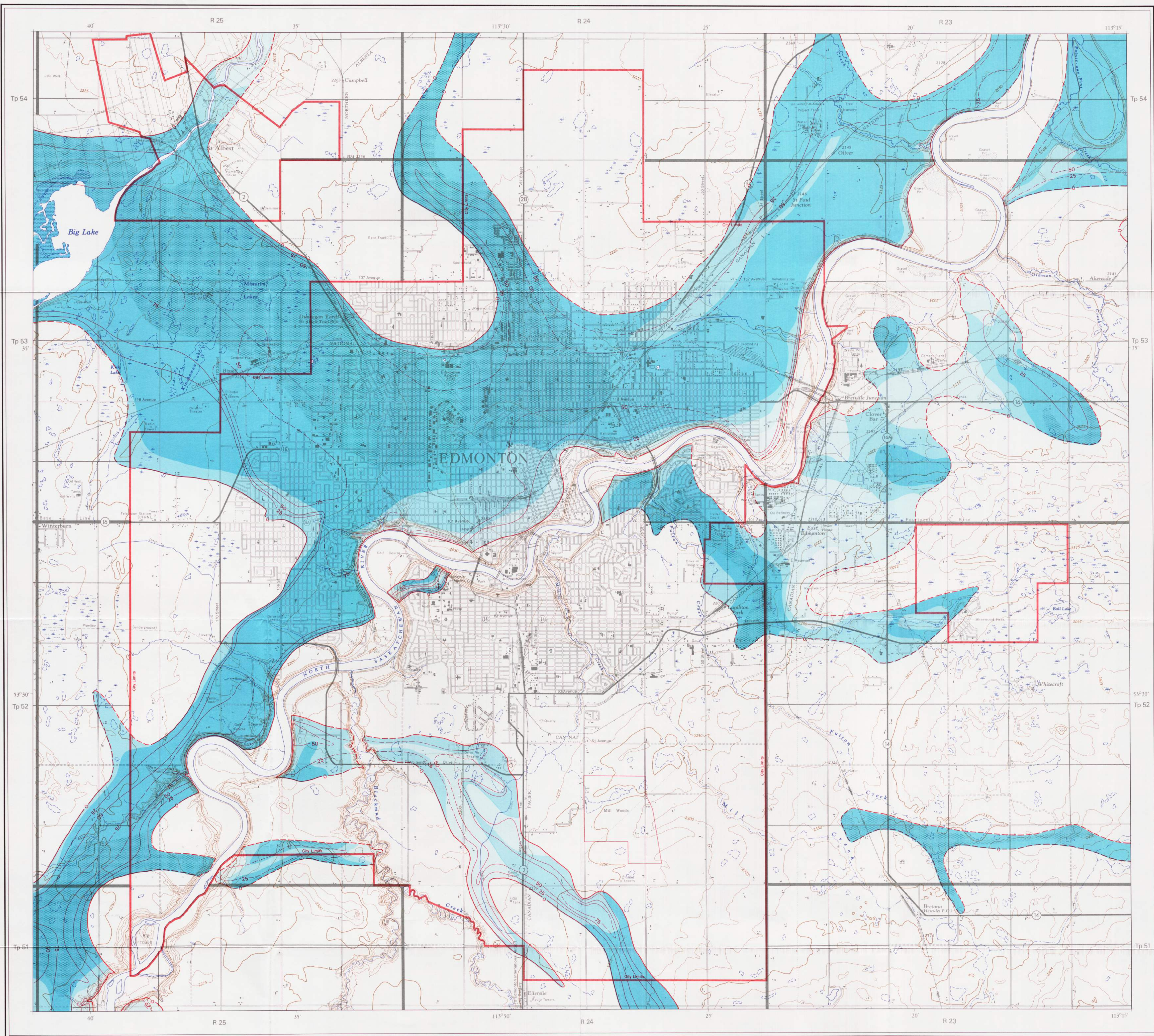


FIGURE 27. THICKNESSES OF SASKATCHEWAN GRAVELS AND SANDS AND OVERBURDEN IN THE EDMONTON AREA.

Thickness of overburden (in feet)

- 0-25
- 25-50
- 50-75
- 75-100
- >100
- Unmapped

Sub-crop of Saskatchewan gravels and sands
 defined, approximate
 Isopach (in feet) defined, approximate

LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft.)

Scale 1:50,000
 Miles 0 1 2 3 4
 Kilometers 0 1 2 3 4 5 6



To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson

Published 1975

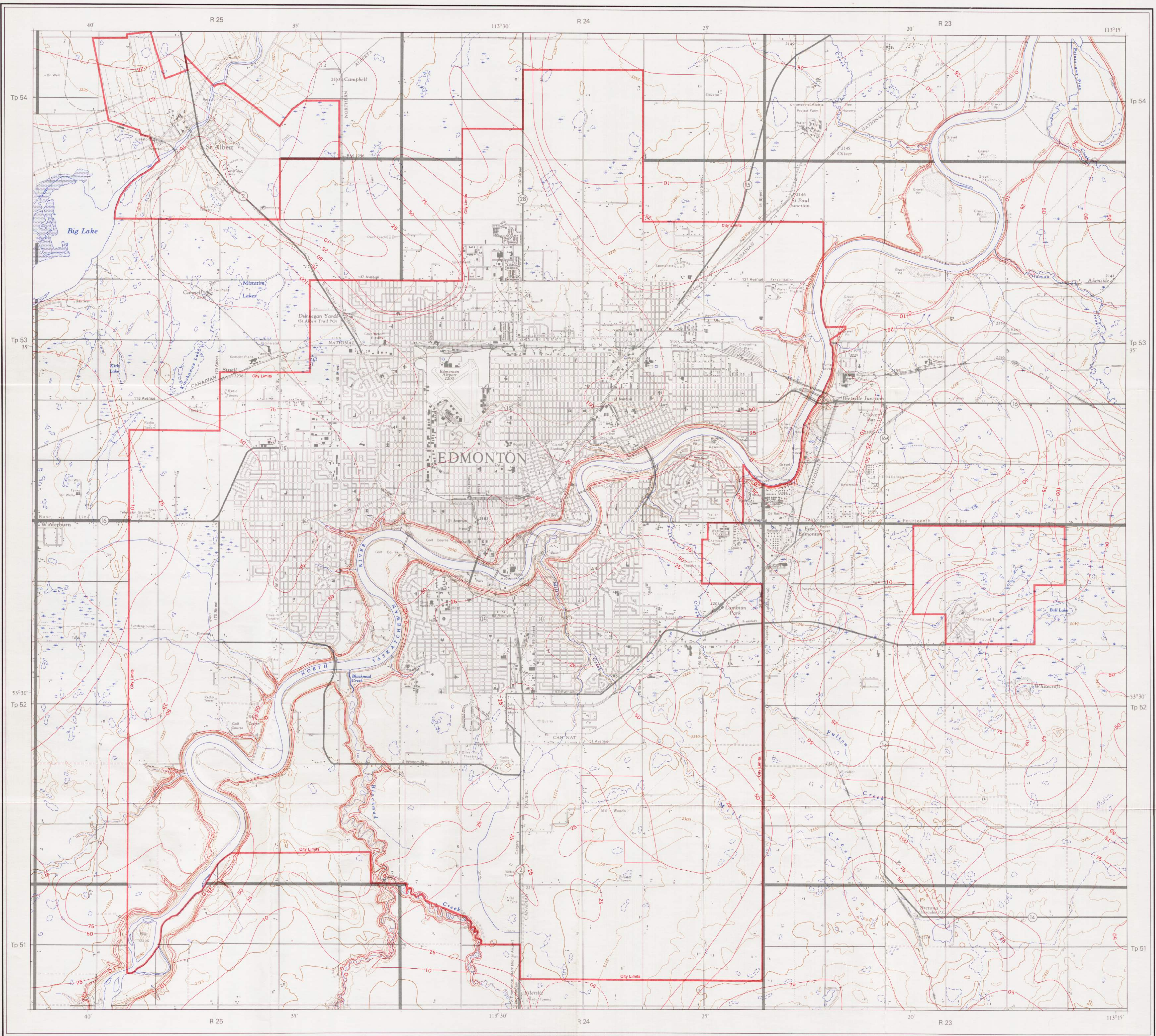


FIGURE 28. THICKNESS OF GLACIAL TILL IN THE EDMONTON AREA.

LEGEND

- | | | | |
|---------------------------------|-------|---|---------------|
| River or stream | ..... | Highway | ————— 2 ————— |
| Intermittent river or stream | ..... | Railway | ————— |
| Lake | ..... | Township boundary | ————— |
| Intermittent lake | ..... | Section line | ————— |
| Road, hard surface, all weather | ..... | Topographic contour (contour interval 25 ft.) | ————— |

Miles 1 0 1 2 3 4
Kilometers 1 0 1 2 3 4 5 6

SCALE 1:50,000



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

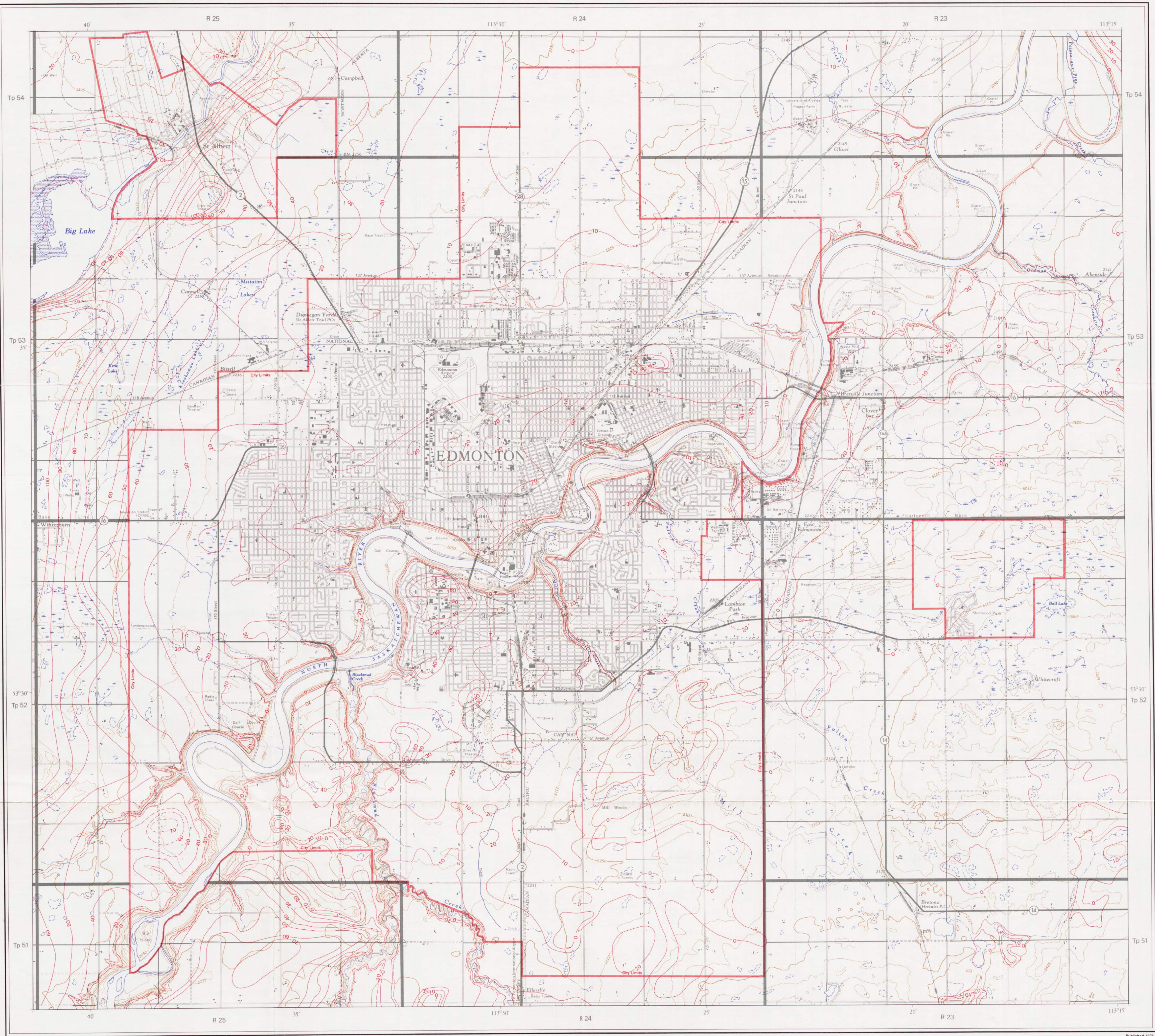
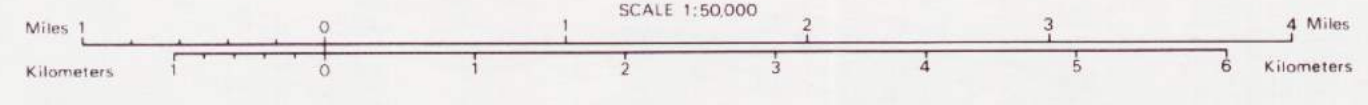


FIGURE 29. THICKNESS OF GLACIOLACUSTRINE SEDIMENTS IN THE EDMONTON AREA.

LEGEND

- | | | | |
|---------------------------------|-------|---|-------|
| River or stream | ..... | Highway | ..... |
| Intermittent river or stream | ..... | Railway | ..... |
| Lake | ..... | Township boundary | ..... |
| Intermittent lake | ..... | Section line | ..... |
| Road, hard surface, all weather | ..... | Topographic contour (contour interval 25 ft.) | ..... |



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

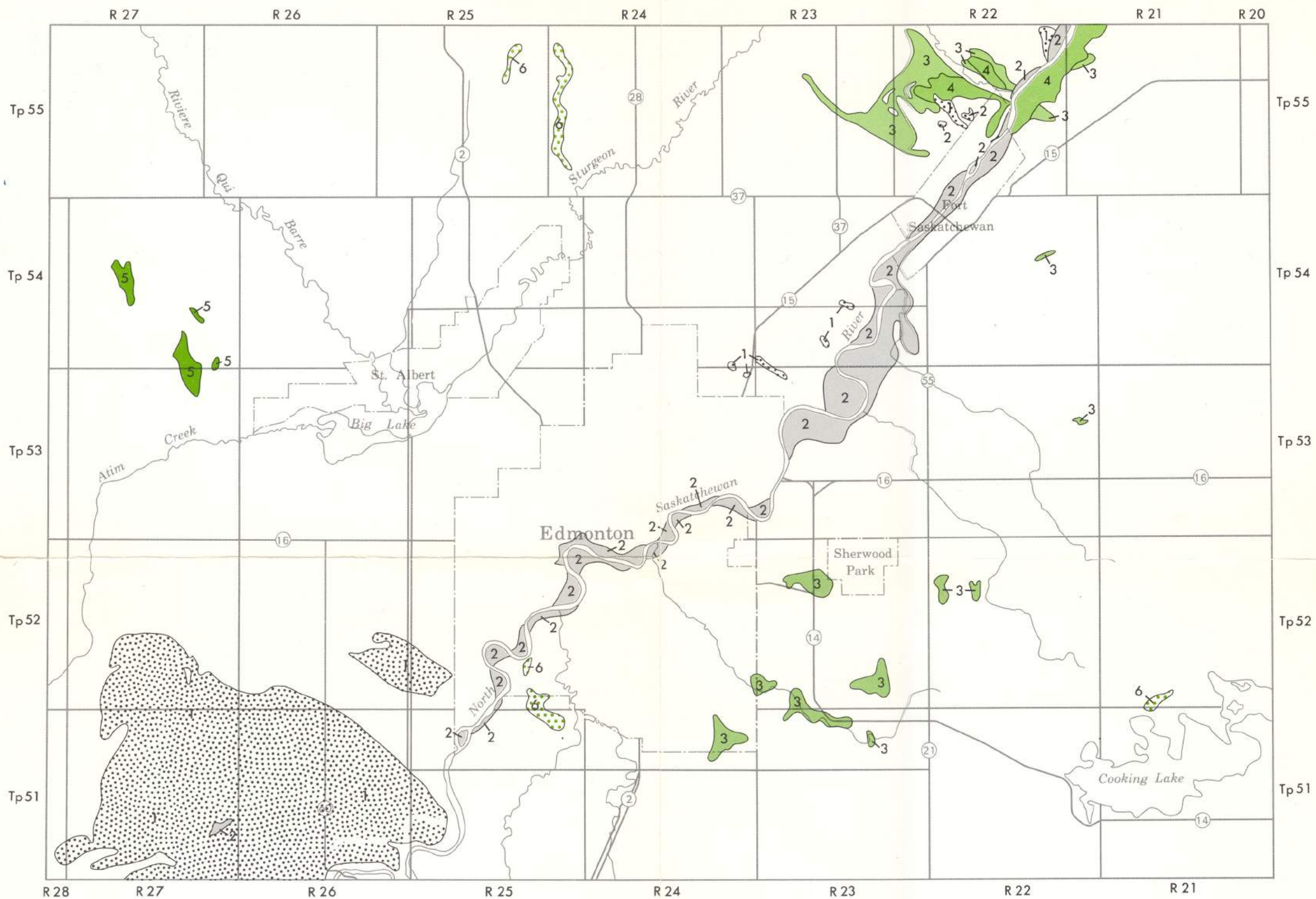
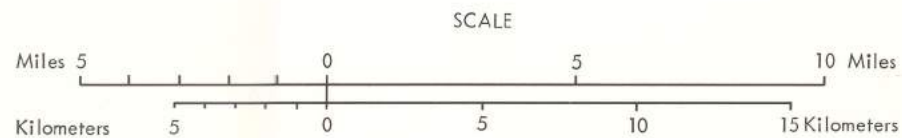


FIGURE 33. Surficial deposits of sand and gravel in the Edmonton region.

LEGEND

- | | | | |
|---|---------------|---|-------------------------|
|  | Sand dunes |  | Outwash sand and gravel |
|  | River terrace |  | Outwash gravel |
|  | Outwash sand |  | Kame |



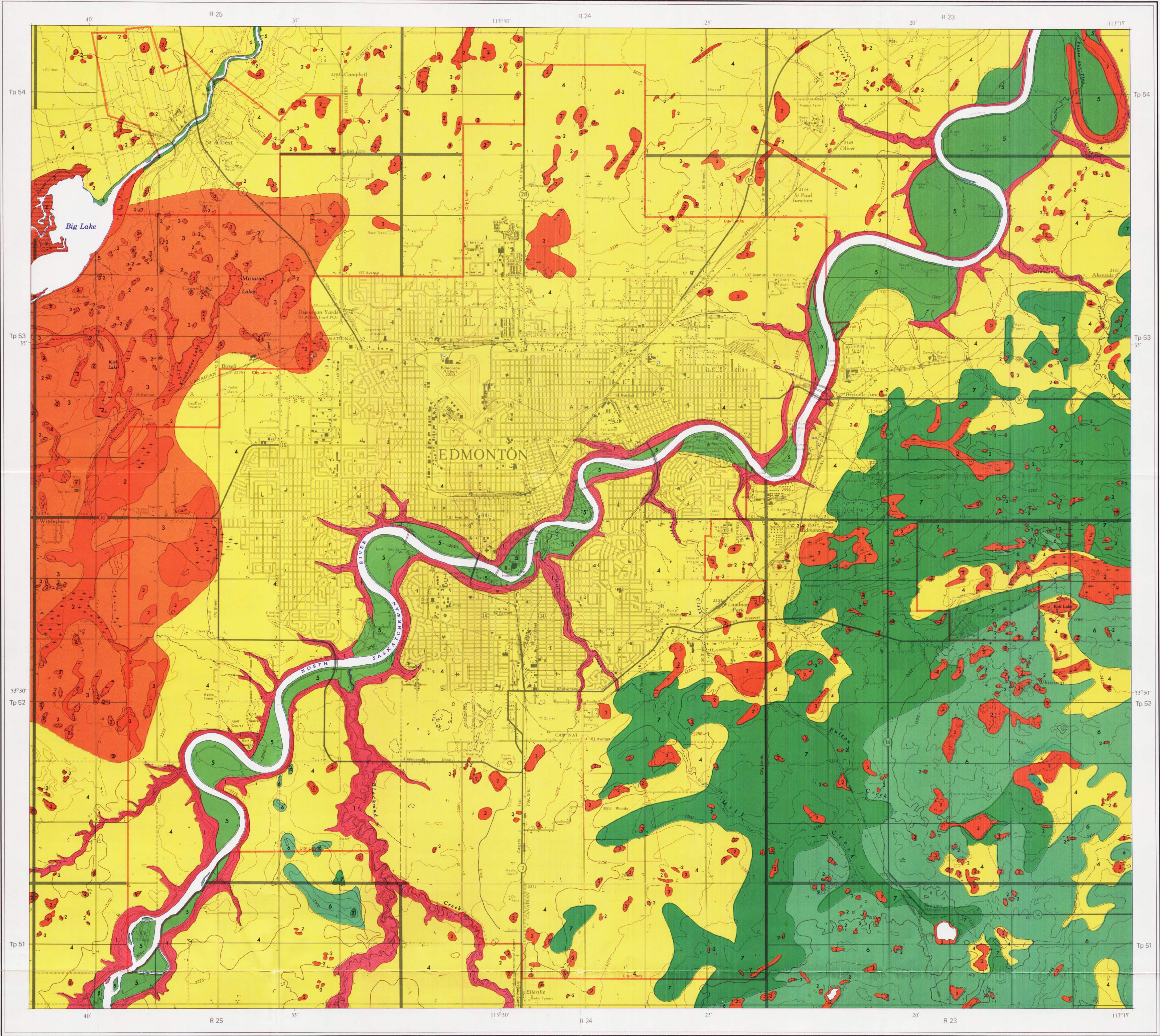


FIGURE 36. GENERAL CONSTRUCTION CONDITIONS IN THE EDMONTON AREA.

LEGEND

AREA	SUITABILITY	MATERIALS	POTENTIAL HAZARDS
1	Unsuitable	gully, creek valley, scarp	groundwater discharge areas, springs; subject to intense erosion and weathering; steep unstable slopes; difficult working location
2		Recent lacustrine and organic	high groundwater table, poor drainage; low strength, high compressibility; poor compaction characteristics; high sulfate content
3		pitted delta; glaciolacustrine silt and clay; (areas with high groundwater table)	generally high groundwater table, poor drainage; low to medium strength; moderate to high compressibility; susceptibility to frost action, swelling and erosion; poor to moderate compaction characteristics; potentially high sulfate content
4	Suitable	glaciolacustrine silt and clay; glaciolacustrine sand and silt; mixed lacustrine and till; aeolian	potentially high groundwater table; generally medium strength; moderate to high compressibility; susceptible to frost action, swelling and erosion; potentially high sulfate content
5		river terraces	seasonal fluctuations in groundwater table; weak and compressible silt and clay lenses; susceptible to frost action; erosion and undercutting
6		hummocky moraine, kames and crevasse fillings	properties vary horizontally and vertically over short distances; sand and gravel lenses often saturated; susceptible to frost action in kames and crevasse fillings
7		ground moraine; outwash	properties vary horizontally and vertically over short distances

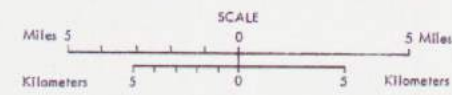
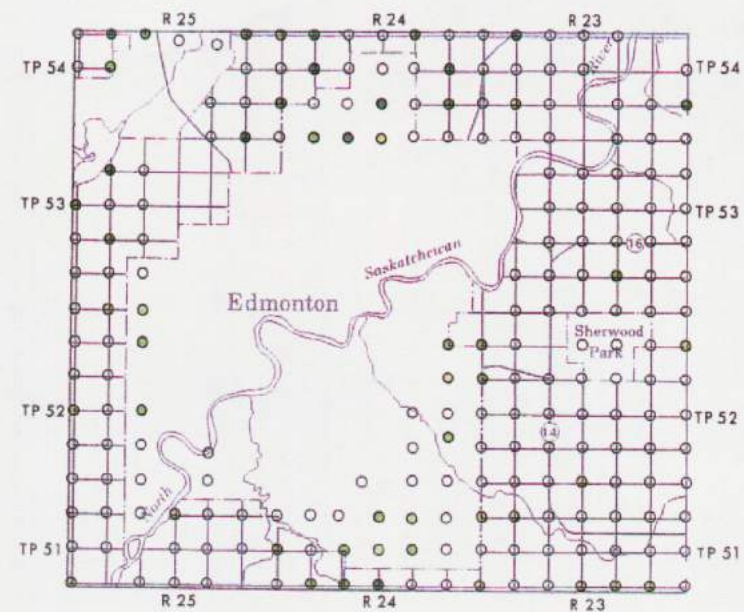
LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft.)

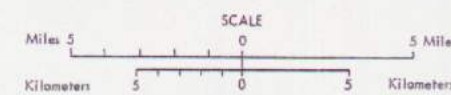
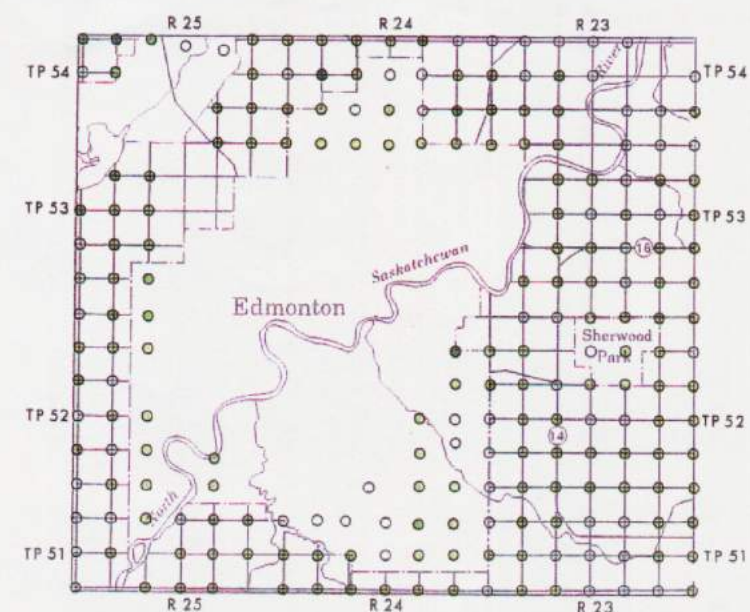


To accompany Alberta Research Council Bulletin 32 by C. P. Kathol and R. A. McPherson

DEPTH 0-5



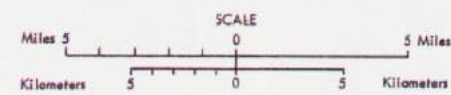
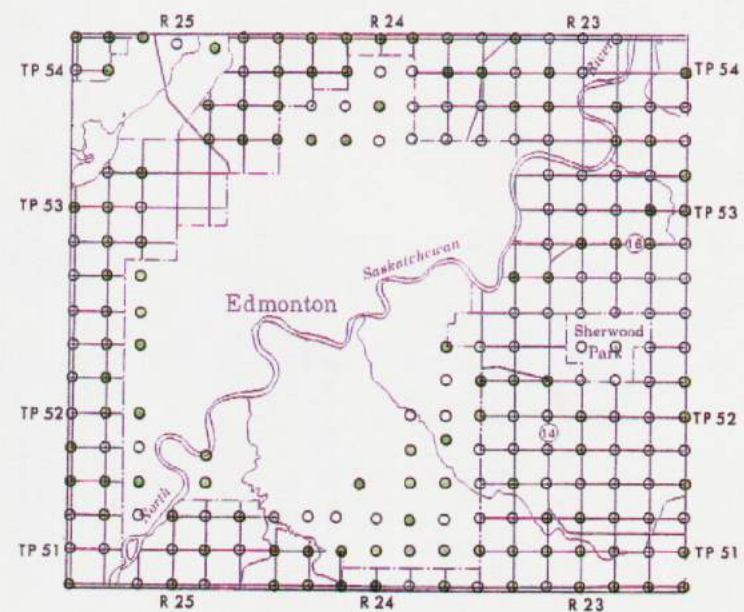
DEPTH 5-10



Potential for sulfate attack at data point:

- negligible
- mild, but positive
- considerable
- severe

DEPTH 10-20



DEPTH 20-30

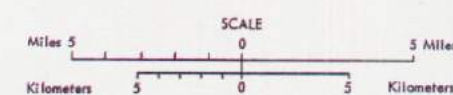
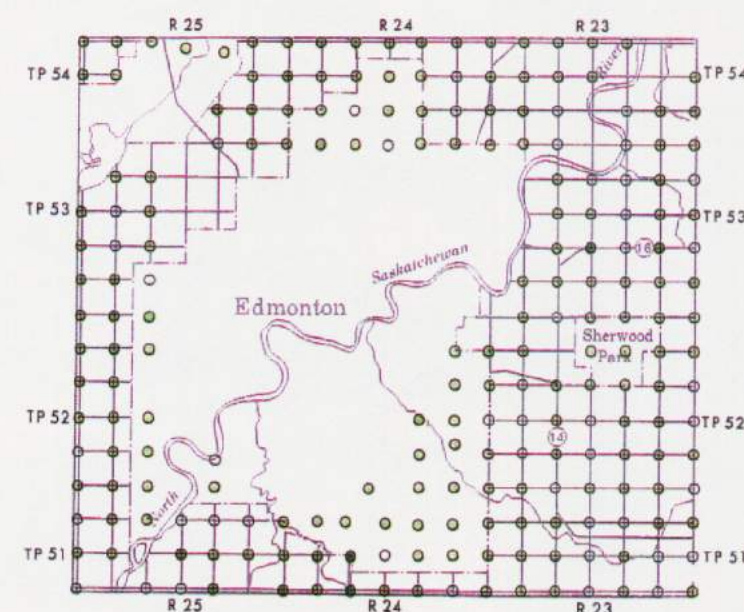


FIGURE 37. Potential for sulfate attack on concrete in the Edmonton area at various depths below the surface.

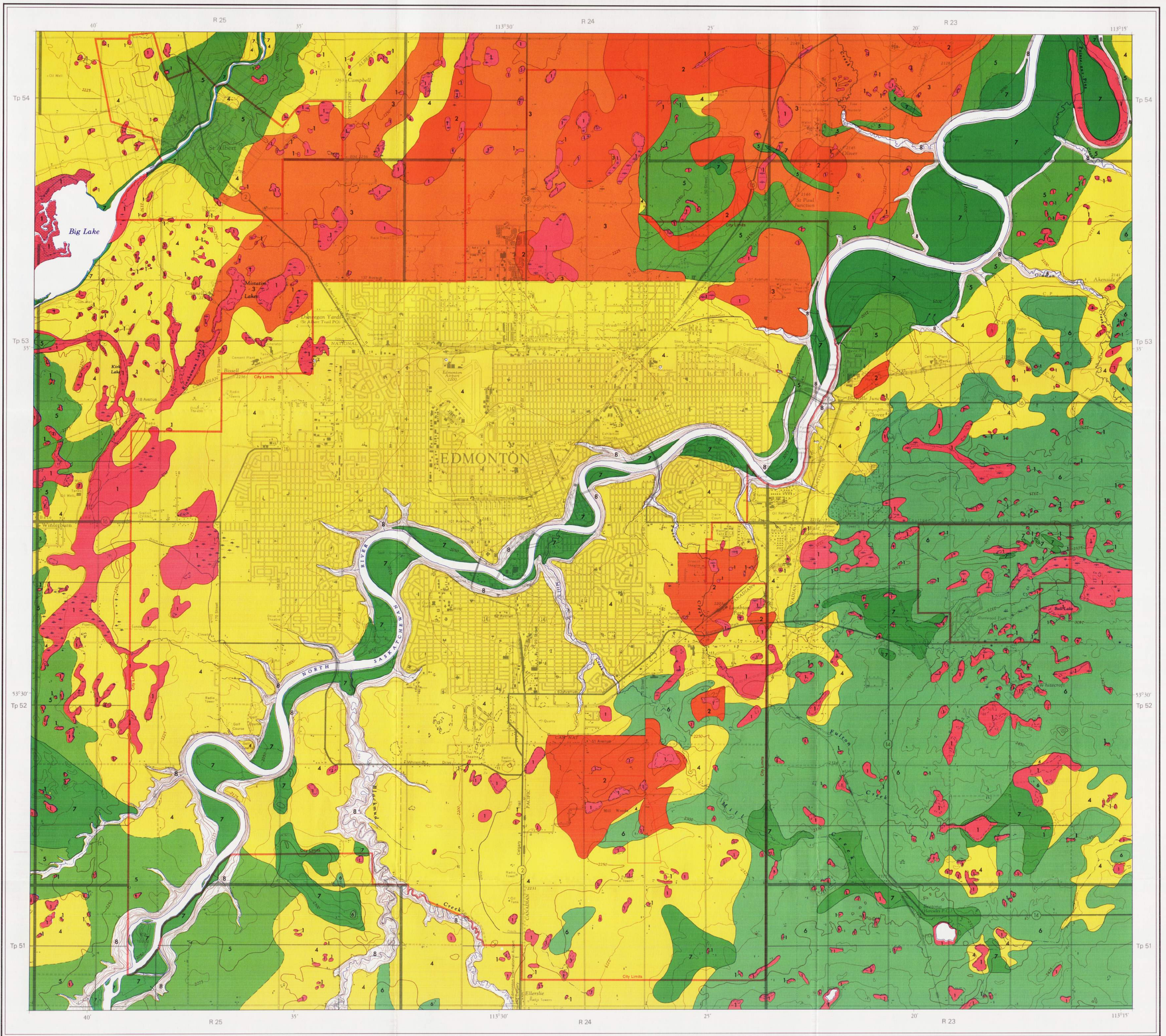


FIGURE 38. POTENTIAL SULFATE HAZARD IN THE EDMONTON AREA.

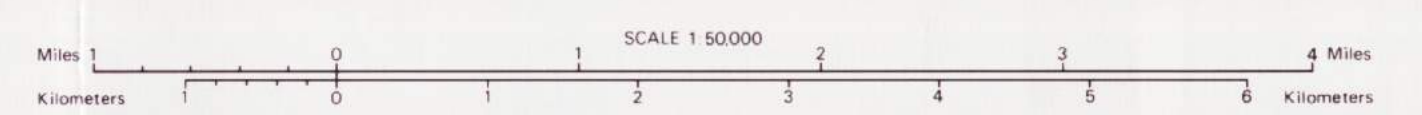
LEGEND

AREA	POTENTIAL	MATERIALS
1	High	Recent lacustrine and organic
2		Solonchetsic soils — > 50%
3		Solonchetsic soils — < 50%
4	Low	glaciolacustrine silt and clay
5		glaciolacustrine sand and silt; pitted delta
6		mixed lacustrine and till; hummocky moraine; ground moraine
7		aeolian, outwash; river terrace; kames and crevasse fillings
8		gully, creek valley, scarp

Boundary of area: defined, approximate

LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft.)



To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson

LEGEND
CHEROZEMIC SOILS

Pe L	Penhold Loam	Orthic Black developed on calcareous alluvial lacustrine material
Ph FSL	Peace Hills Fine Sandy Loam	Orthic Black developed on alluvial aeolian material
Ph SL	Peace Hills Sandy Loam	
Ph CSL	Peace Hills Coarse Sandy Loam	
Fth SL	Ferintosh Sandy Loam	Orthic Black developed on outwash material
Ar L	Angus Ridge Loam	Eluviated Black developed on glacial till
Mo SIL	Maimo Silt Loam	Eluviated Black developed on lacustrine material
Mo SICL	Maimo Silty Clay Loam	
Pk L	Ponoka Loam	Eluviated Black to Orthic Black developed on alluvial lacustrine material
Pk SL	Ponoka Silt Loam	
Fn L	Falun Loam	Orthic Dark Grey developed on glacial till
Wb L	Winterburn Loam	Orthic Dark Grey developed on pitted deltaic material
Wb SL	Winterburn Sandy Loam	
Mc SIL	Mico Silt Loam	Orthic Dark Grey developed on lacustrine material
Mc SICL	Mico Silty Clay Loam	

SOLOMETZIC SOILS

Cam L	Camrose Loam	Black Solodized Solonetz developed on glacial till
Wkn Sil	Wetaskiwin Silt Loam	Black Solodized Solonetz developed on lacustrine material
Wkn SICL	Wetaskiwin Silty Clay Loam	
Kv L	Kavanagh Loam	Black and Dark Grey Solodized Solonetz and Solonetz developed on residual material

PODZOLIC SOILS

Ck L	Cooking Lake Loam	Orthic Grey Wooded developed on glacial till of Edmonton Formation origin
To L	Toimam Loam	Orthic Grey Wooded developed on alluvial lacustrine material
Cu SL	Culp Sandy Loam	Orthic Grey Wooded developed on alluvial aeolian material
Un L	Uncas Loam	Dark Grey Wooded developed on glacial till
Cv SL	Carvel Sandy Loam	Dark Grey Wooded developed on pitted deltaic material
Le LS	Leith Loamy Sand	Dark Grey Wooded developed on aeolian material

GLEYSOLIC SOILS

Pr SIL	Prestville Silt Loam	Peaty Meadow developed on lacustrine material
Pr SICL	Prestville Silty Clay Loam	

REGOSOLIC SOILS

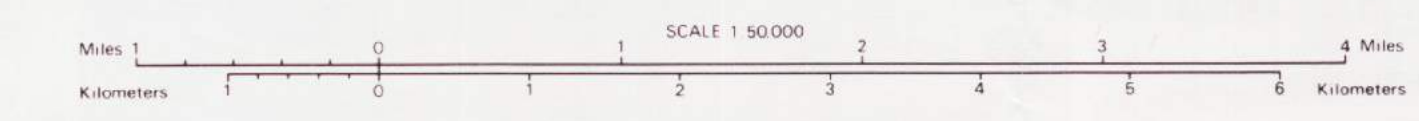
Av	Alluvium	Orthic Regosal on recently deposited river material
----	----------	---

ORGANIC SOILS

O	Organic soils	Sedge and Moss Peats
---	---------------	----------------------

SOIL COMPLEXES

U.R.	Unclassified soils on rough broken land adjacent to stream courses	
------	--	--



Alberta
RESEARCH COUNCIL

To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

LEGEND

	River or stream
	Intermittent river or stream
	Lake
	Intermittent lake
	Road, hard surface, all weather
	Highway
	Railway
	Township boundary
	Section line

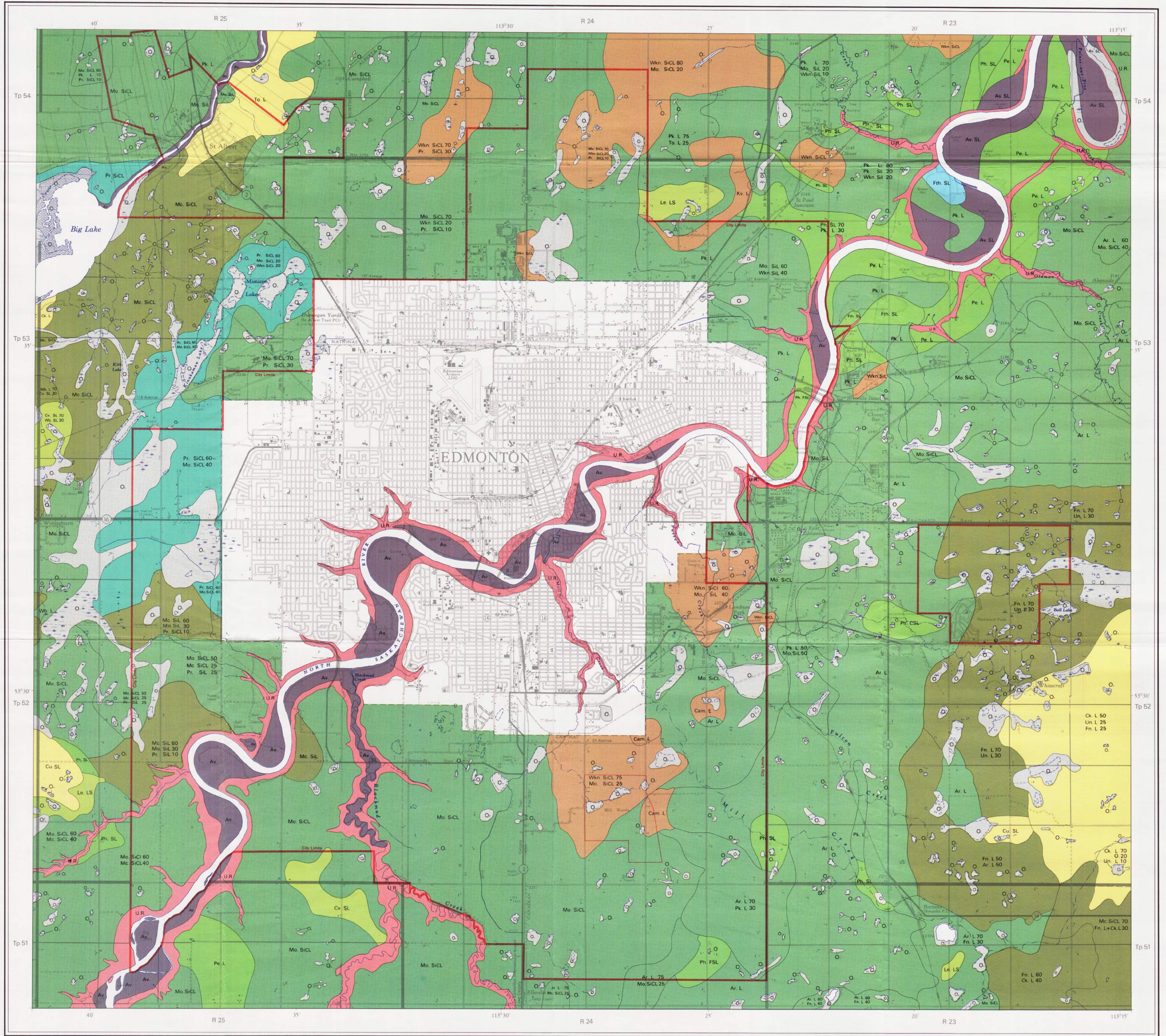


FIGURE 39. SOILS MAP OF THE EDMONTON AREA.

AREA SUITABILITY	MATERIALS	CONTROLLING FACTORS
1	areas adjacent to surficial waters (lakes, rivers, creeks), 1/2 m safety margin used; includes all alluvial deposits and gullies, creek valleys and scarps	potential pollution of surface waters by run-off and by groundwater flow, unstable slopes
2	areas underlain by Saskatchewan gravels and sands	potential contamination of major aquifer
3	pitted delta	medium to high permeability may allow pollution of surface and subsurface waters; generally high groundwater table; areas of fine silt and clay may be suitable
4	Unsuitable	medium to high permeability may allow pollution of surface and subsurface waters; locally high groundwater table
5	Recent lacustrine and organic	local groundwater discharge areas
6	kames, crevasse fillings	high permeability may allow pollution of surface and subsurface waters; may be suitable if permeable materials are removed and underlying deposits and controlling factors are favorable
7	outwash	high permeability may allow pollution of surface and subsurface waters; deposits are generally thin and may be suitable if permeable materials are removed and underlying deposits and controlling factors are favorable
8	glaciolacustrine silt and clay and till, less than 50 ft. thick, over bedrock	may be suitable if bedrock is impermeable
9	glaciolacustrine sandy silt and fine sand and till, less than 50 ft. thick, over bedrock	may be suitable if permeable materials are thin or discontinuous, and if local groundwater conditions are favorable
10	Questionable	glaciolacustrine deposits greater than 50 ft. thick over till and bedrock, sandy silt and fine sand on surface and if local groundwater conditions are favorable
11	glaciolacustrine sandy silt and fine sand and till, greater than 50 ft. thick, over bedrock	may be suitable if permeable lacustrine deposits are thin or discontinuous and if local groundwater conditions are favorable
12	outwash sand and gravel lenses occurring in the subsurface	may be suitable if thin and discontinuous
13	glaciolacustrine silt and clay and till, greater than 50 ft. thick, over bedrock	avoid areas with high groundwater table
14	glaciolacustrine silt and clay, greater than 50 ft. thick, over bedrock	avoid areas with high groundwater table
15	hummocky moraine, less than 50 ft. thick, over bedrock; mixed lacustrine and till over till, less than 50 ft. thick, over bedrock	highly permeable sand and gravel lenses, or areas of high groundwater table, or areas of permeable bedrock, may be present and should be avoided
16	Suitable	highly permeable sand and gravel lenses, or areas of high groundwater table, or areas of permeable bedrock, may be present and should be avoided
17	ground moraine, less than 50 ft. thick, over bedrock	areas of permeable bedrock may be present and should be avoided
18	ground moraine, greater than 50 ft. thick, over bedrock	sand and gravel lenses may be present and should be avoided

Boundary of area defined, approximate

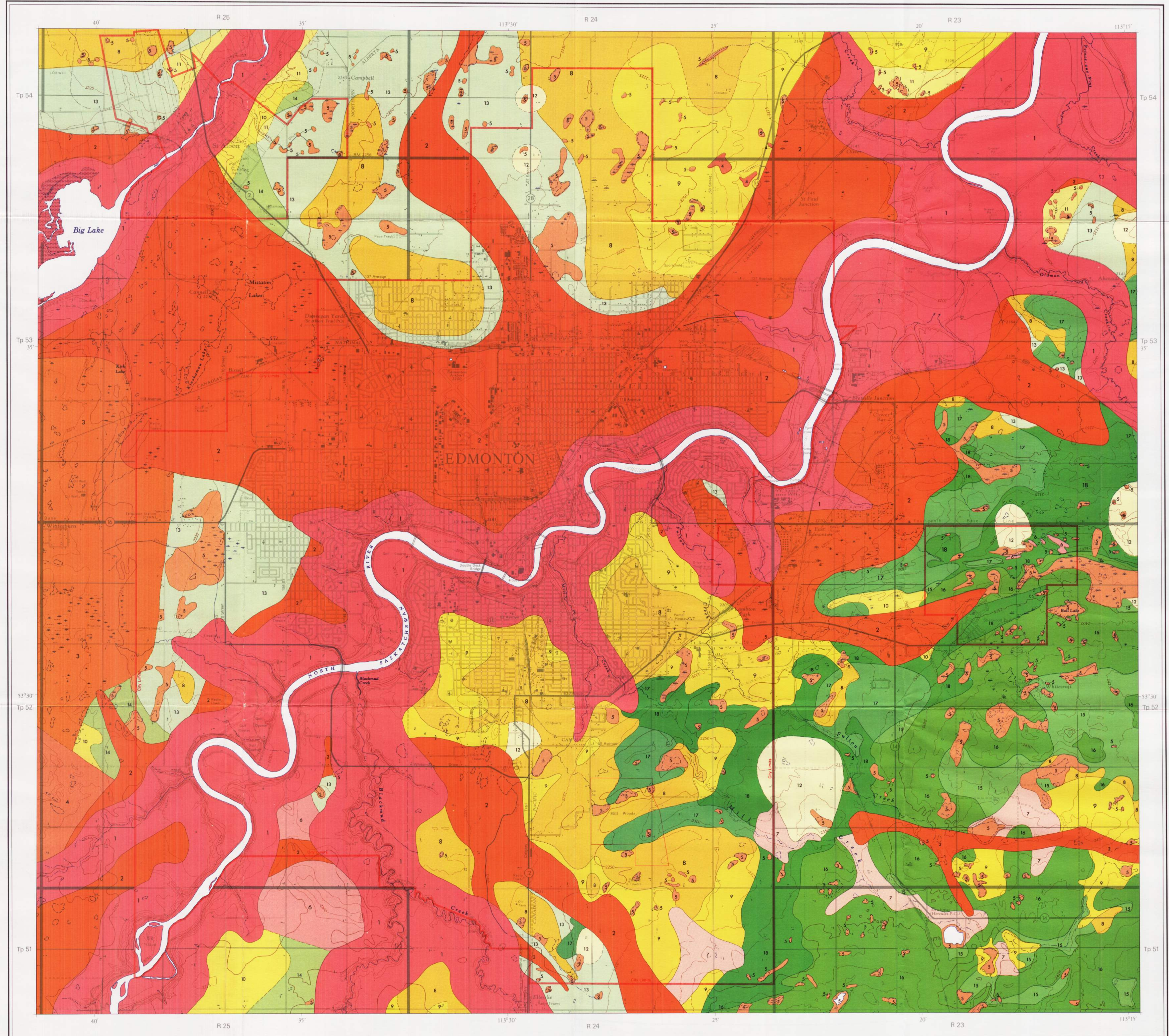


FIGURE 40. SUITABILITY OF THE EDMONTON AREA FOR SOLID WASTE DISPOSAL.

LEGEND	
River or stream	
Intermittent river or stream	
Lake	
Intermittent lake	
Road, hard surface, all weather	
Highway	
Railway	
Township boundary	
Section line	
Topographic contour (contour interval 25 ft.)	

Scale 1:50,000
 Miles 0 1 2 3 4
 Kilometers 0 1 2 3 4



To accompany Alberta Research Council Bulletin 32
 by C. P. Kathol and R. A. McPherson

Published 1975

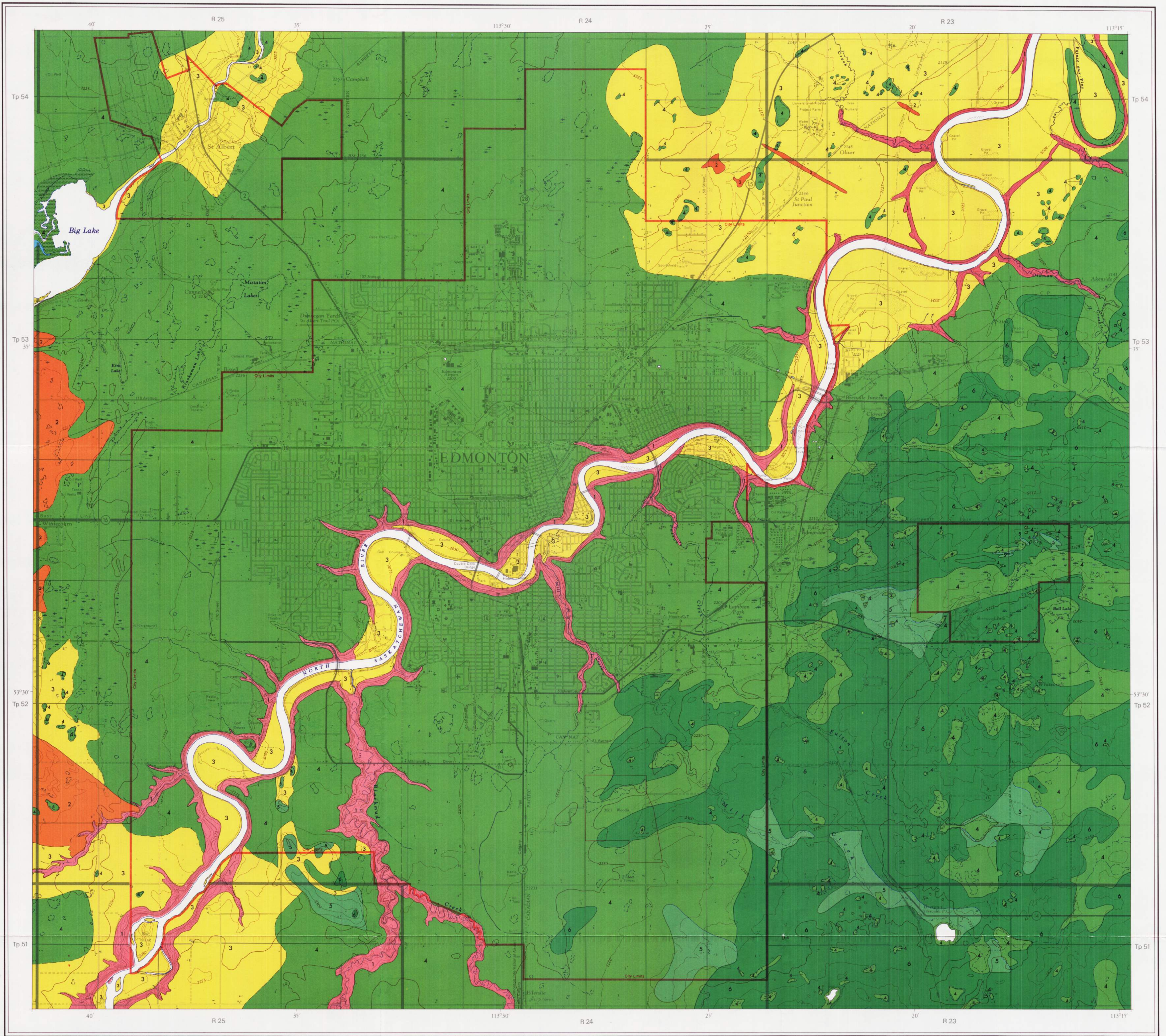


FIGURE 41. SUSCEPTIBILITY OF DEPOSITS IN THE EDMONTON AREA TO EROSION.

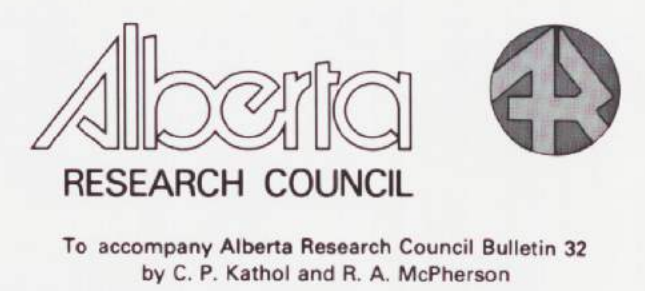
LEGEND

AREA	SUSCEPTIBILITY TO EROSION	GEOLOGIC MATERIALS	FAVORABLE PROPERTIES	DETRIMENTAL PROPERTIES	COUNTERACTIVE MEASURES
1	High	gully, creek valley, scarp, slump area; bedrock and glacial deposits exposed		groundwater discharge areas (springs, piping); little or no vegetation; revegetates slowly; generally steep slopes; banks unstable and susceptible to undercutting, weathering; highly erodible materials may be present (silt, sandstone, fine sand)	avoid disturbance
2		pitted delta, aeolian	naturally moderately to well vegetated; aeolian material generally dry; moderate permeability reduces surface run-off	generally high groundwater table in pitted delta; moderate to high relief; no cohesion or cementation; susceptible to wind erosion; revegetates slowly to moderately	avoid disturbance; provide drainage; protect slopes with organic debris; cut to gentle slopes; terrace slopes
3	Medium	glaciolacustrine sand and silty sand; glaciolacustrine silt and clay; river terraces (sands, silt and clay)	naturally flat lying; naturally well vegetated; revegetates moderately to rapidly; moderate permeability reduces surface run-off	some materials lack cohesion or cementation; susceptible to wind erosion; generally present in topographic lows with high groundwater table	protect slopes with organic debris litter; provide drainage; cut to gentle slopes; terrace slopes
4		Recent lacustrine and organic deposits; lacustrine till	naturally flat lying to low relief; naturally moderately to well vegetated; generally composed of cohesive materials	low permeability causes high surface run-off; generally present in topographic lows with high groundwater table	protect slopes with organic debris litter; cut to gentle slopes; terrace slopes
5	Low	outwash; kames; crevasse fillings; river terraces (sands and gravels)	often low relief; gravel lag prevents further erosion; naturally moderately to well vegetated; high permeability reduces surface run-off	may be saturated; revegetates slowly	encourage revegetation with organic debris litter
6		hummocky moraine, ground moraine	low to moderate relief; usually cohesive material; partially self-arresting due to gravel lag; naturally moderately to well vegetated; revegetates rapidly	low permeability causes high surface run-off; high groundwater table may occur in lows	encourage revegetation with organic litter



LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft)



To accompany Alberta Research Council Bulletin 32
by G. P. Kathol and R. A. McPherson

Boundary of area defined, approximate

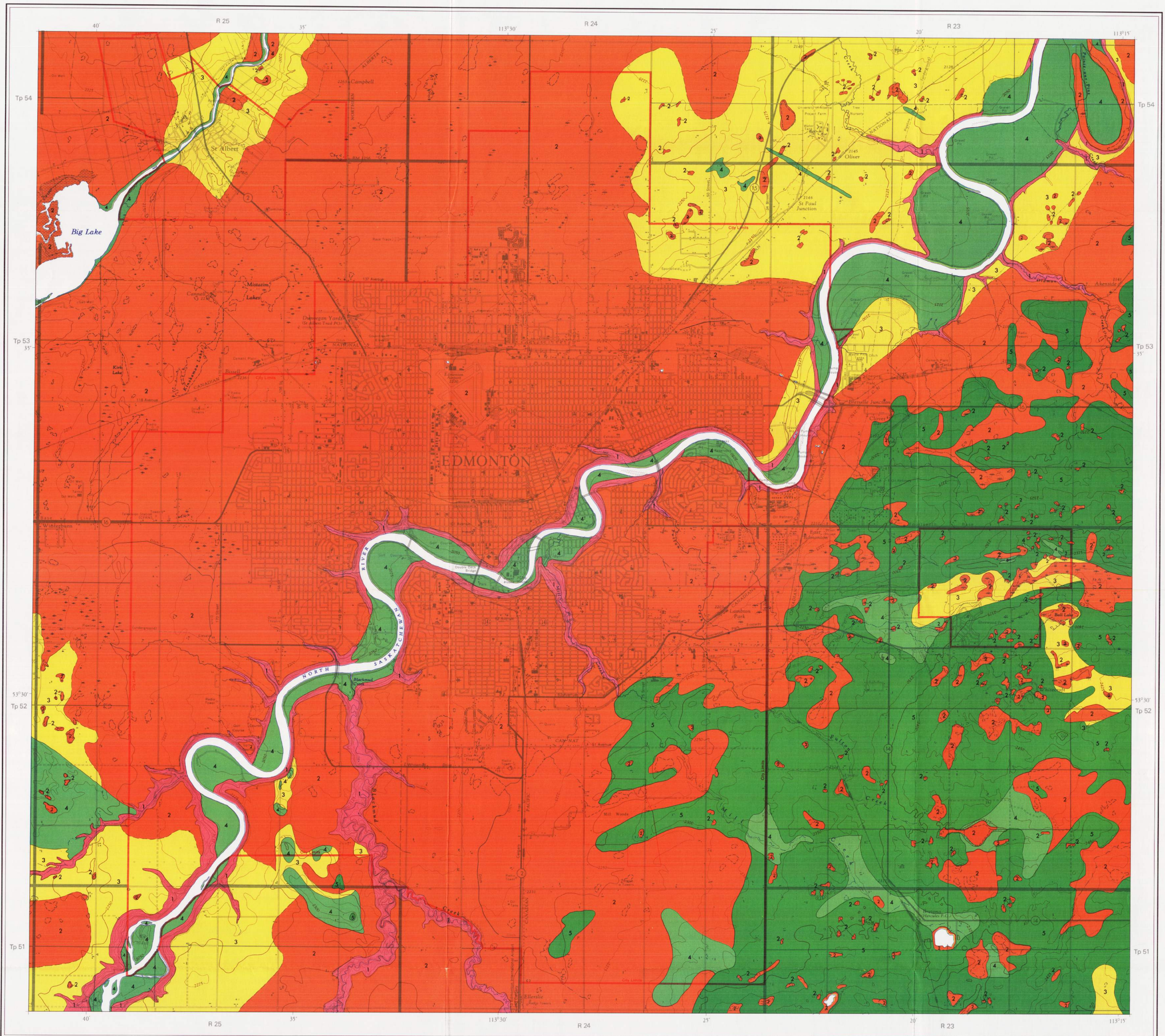
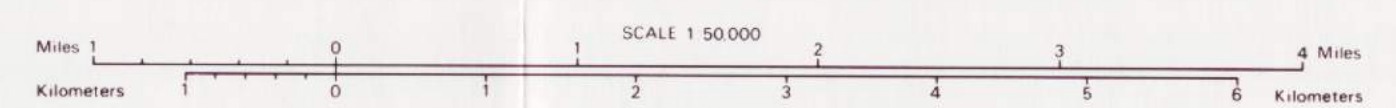


FIGURE 42. SUSCEPTIBILITY OF DEPOSITS TO SLUMPING IN THE EDMONTON AREA.

LEGEND			
AREA	SUSCEPTIBILITY TO SLUMPING	MATERIALS	PROBLEMS
1	Highest	gully, creek valley, scarp and slump areas, bedrock and glacial deposits exposed	over-steepened banks susceptible to being undercut, jointed, groundwater discharge areas, bentonite layers present, high in montmorillonite
2		Recent lacustrine, glaciolacustrine silt and clay, pitted delta	significant percentage of montmorillonite present, liquification of saturated silts is possible, organic deposits occur, low topographic position causes high groundwater table
3	Medium	glaciolacustrine sand and silty sand, lacustro-till	moderate clay content
4		outwash, kames and crevasse fillings, aeolian, North Saskatchewan River terrace	possible liquification when saturated, silt and clay lenses may impede drainage
5	Lowest	ground moraine; hummocky moraine	sand and silt lenses present, prone to jointing, moderate montmorillonite content in clay tills

Boundary of area defined, approximate

LEGEND	
River or stream	
Intermittent river or stream	
Lake	
Intermittent lake	
Road, hard surface, all weather	
Highway	
Railway	
Township boundary	
Section line	
Topographic contour (contour interval 25 ft)	



Alberta
RESEARCH COUNCIL

To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

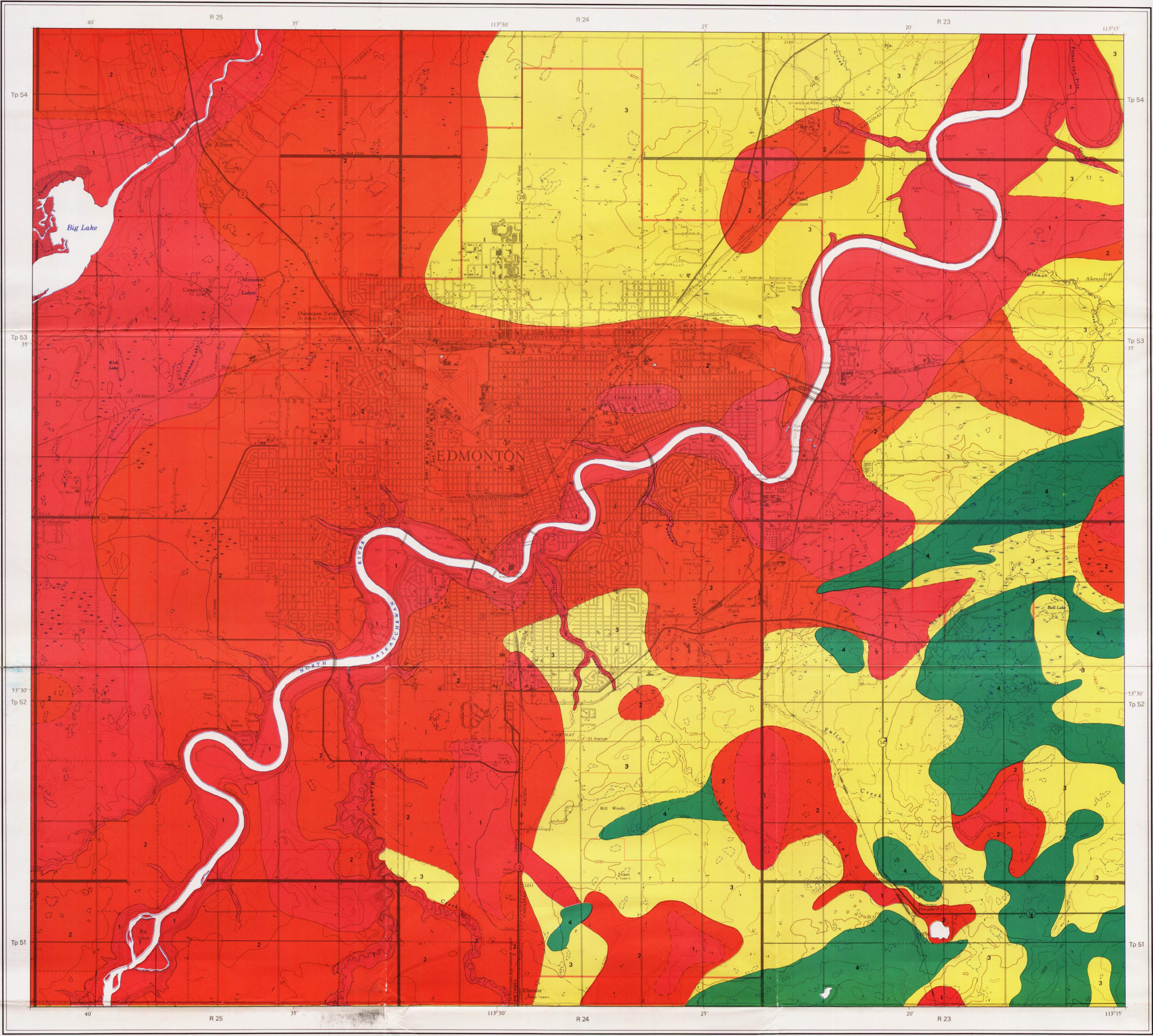
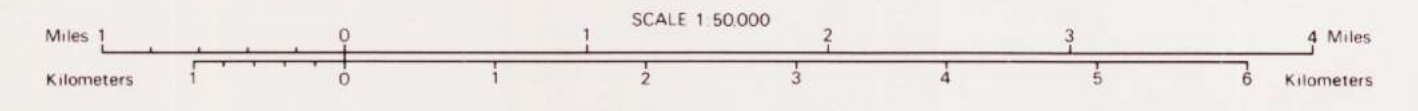


FIGURE 43. SUITABILITY OF THE EDMONTON AREA FOR DEEP SEWER CONSTRUCTION 0 TO 50 FEET (0 TO 15 M) BELOW THE SURFACE.

LEGEND		
AREA	SUITABILITY	MATERIALS
1	Unsuitable	Saskatchewan gravels and sands; pitted delta; aeolian; outwash; kames and crevasse fillings; gully, creek valley, scarp; North Saskatchewan River terrace
2		glaciolacustrine silt and clay; glaciolacustrine sand and silty sand; localized occurrences of Unit 1
3	Suitable	areas of thin glaciolacustrine, thin mixed lacustrine and till; or thin outwash over till (often less than 15 ft. thick); areas of till with minor sand and gravel lenses
4		bedrock; hummocky moraine and ground moraine over bedrock

Boundary of area: defined, approximate

LEGEND	
river or stream	
intermittent river or stream	
lake	
intermittent lake	
road, hard surface, all weather	
highway	
railway	
ownership boundary	
section line	
topographic contour (contour interval 25 ft.)	



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

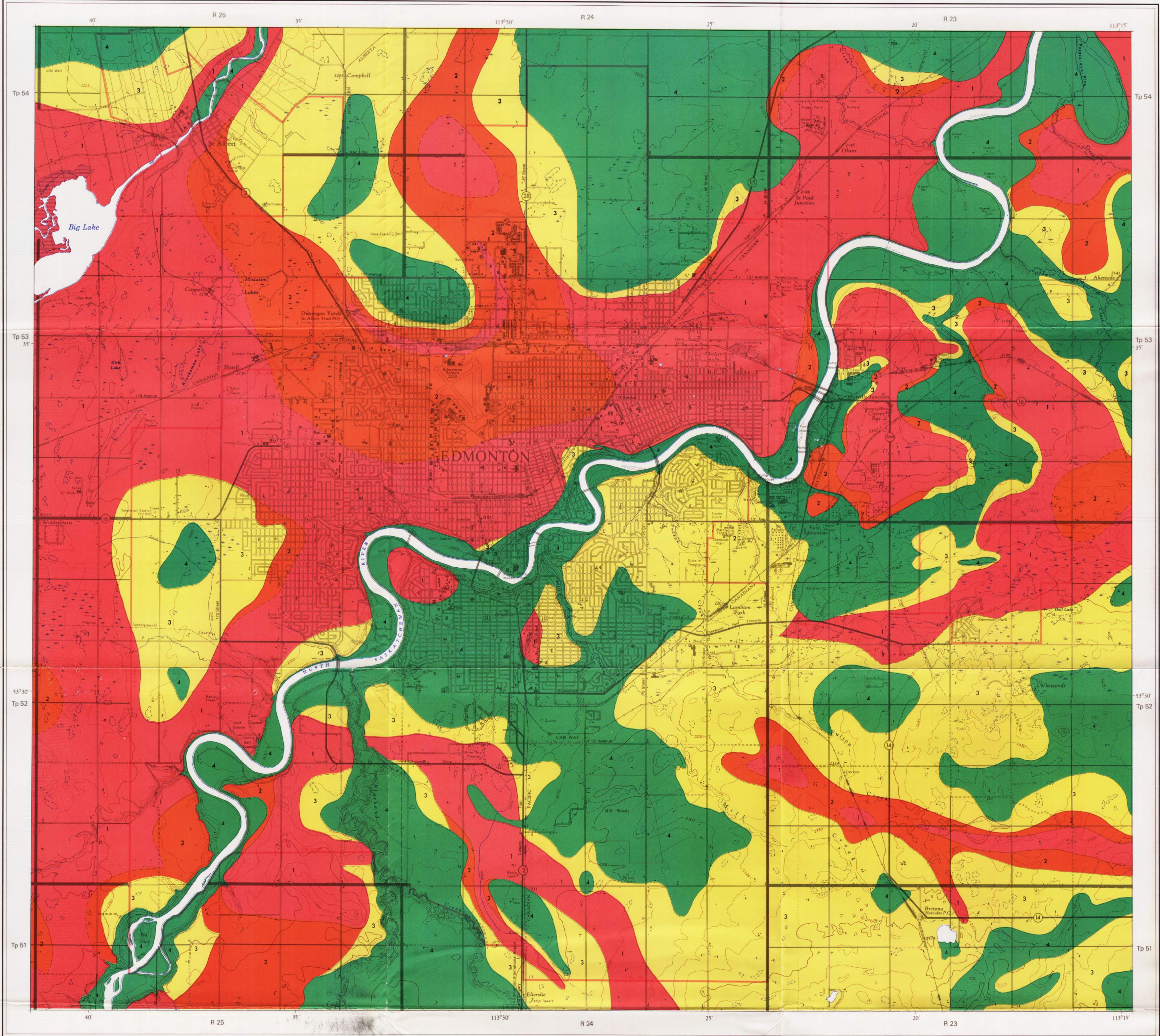


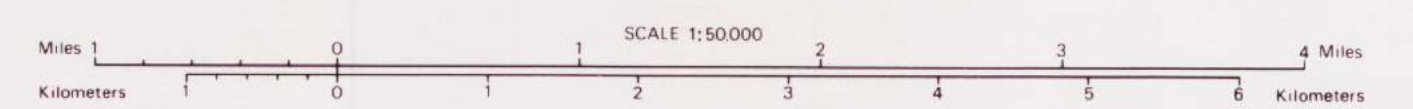
FIGURE 44. SUITABILITY OF THE EDMONTON AREA FOR DEEP SEWER CONSTRUCTION 50 TO 100 FEET (15 TO 30 M) BELOW THE SURFACE.

LEGEND

AREA	SUITABILITY	MATERIALS
1	Unsuitable	Saskatchewan gravels and sands, pitted delta, aeolian, outwash, kames and crevasse fillings
2		glaciolacustrine silt and clay glaciolacustrine sand and silty sand
3	Suitable	hummocky moraine, ground moraine
4		bedrock

LEGEND

- River or stream
- Intermittent river or stream
- Lake
- Intermittent lake
- Road, hard surface, all weather
- Highway
- Railway
- Township boundary
- Section line
- Topographic contour (contour interval 25 ft.)



To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

Boundary of area: defined, approximate



FIGURE 45. SUITABILITY OF THE EDMONTON AREA FOR DEEP SEWER CONSTRUCTION AT DEPTHS GREATER THAN 100 FEET (30 M) BELOW THE SURFACE.

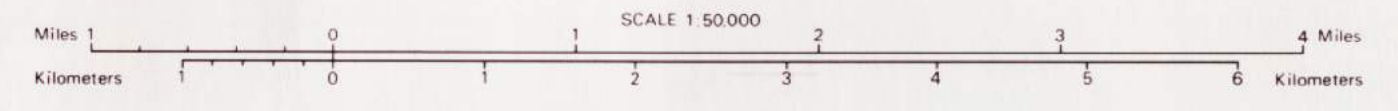
LEGEND

AREA	SUITABILITY	MATERIALS
1	Unsuitable	Saskatchewan gravels and sands, pitted delta, outwash, kames
2		areas where unsuitable materials possibly present, mainly outwash and Saskatchewan Sands and Gravels
3	Suitable	till over bedrock
4		bedrock

Boundary of area: defined, approximate

LEGEND

River or stream	
Intermittent river or stream	
Lake	
Intermittent lake	
Road, hard surface, all weather	
Highway	
Railway	
Township boundary	
Section line	
Topographic contour (contour interval 25 ft.)	



Alberta
RESEARCH COUNCIL

To accompany Alberta Research Council Bulletin 32
by C. P. Kathol and R. A. McPherson

Table 2. Generalized stratigraphic column of bedrock deposits in the Edmonton area.

Era	Period	Group	Formation	Thickness in feet (meters)	Depth in feet (meters)	Lithology		
MESOZOIC	Cretaceous	Upper	Edmonton	560 (170)	0 200 (61) 400 (122)	Fine-grained calcareous and bentonitic sandstones; sandy, bentonitic and carbonaceous shales; mudstone; volcanic tuff, bentonite, ironstone bands and nodules, coal seams.		
			Bearpaw	150 (45)	600 (183)	Dark grey to brownish grey shale and siltstone containing ironstone concretions and thin bentonite beds.		
			Belly River	875 (267)	800 (244) 1000 (305) 1200 (366) 1400 (427)	Light grey shales with carbonaceous shale layers and minor green, brown and red shales; light grey sandstones; thin siltstone, bentonite and coal beds.		
				Lea Park	425 (130)	1600 (488) 1800 (550)	Brown and yellow shale underlain by dark grey marine shale.	
					Colorado	630 (192)	2000 (610) 2200 (671) 2400 (732) 2600 (792)	Dark grey marine shale with abundant calcareous white specks and minor amounts of red-speckled shale; sandstone, chert pebble conglomerate, bentonite, thin limestone bands and ironstone concretions.
				Second White Specks		300 (91)	2800 (853)	a zone of medium to dark grey marine shale containing white to buff calcareous specks
			Base Fish Scale Zone	130 (40)		3000 (914)	a marker horizon of light sandstone containing easily recognized fish scales	
			Viking	90 (27)		Coarse- to fine-grained sand, silt; dark grey to black silty shale.		
			Joli Fou	50 (15)	3200 (975)	Dark grey, non-calcareous marine shale with lenses of medium- to fine-grained sandstone.		
			Lower	Mannville	840 (256)	3400 (1036) 3600 (1097) 3800 (1158) 4000 (1219)	Interbedded layers of quartz and mixed sandstones, marine and nonmarine shales and coal seams.	
		Wabamun			250 (76)	4200 (1280)	Dolomitic limestone overlying calcareous dolomite	
		Winterburn			Graninia	80 (24)		Buff silty dolomite with minor dolomite and anhydrite.
					Calmar	50 (15)	4400 (1341)	Mottled red and green quartz siltstone containing dolomite and anhydrite.
			Nisku	200 (61)	4600 (1402)	Light brown beds of silty anhydritic dolomite with greenish grey shale partings.		
Upper	Ireton	140 (43)		Grey, green and brown calcareous or dolomitic shale with limestone bands and quartz silt stringers.				
		Leduc	530 (162)	4800 (1463) 5000 (1524) 5200 (1585)	Light grey to dark brown limestone or dolomite.			
	Duvernay		330 (101)	5400 (1646) 5600 (1707)	Brown bituminous shales associated with brown, black and grey green calcareous shales and silty limestones.			
		Cooking Lake	210 (64)	5800 (1768)	Buff fossiliferous limestone associated with beds or zones of limestone; interbedded with black shale in the upper portion.			
		Beaverhill Lake	710 (216)	6000 (1828) 6200 (1890) 6400 (1951)	Fragmental limestone grading to silty limestone repeated cyclically.			
	Elk Point			6600 (2012)	Red and green dolomitic shales containing anhydritic dolomites, magnesian and silty limestones and four thick salt beds.			

Table 6. Description of surficial sand and gravel deposits in the Edmonton area

Material	Location	Approximate Area Extent	Description	Present and Potential Use
River Terrace	areas bordering the North Saskatchewan River	variable but may cover several sections	deposit varies from coarse gravels to silt, but usually consists of medium gravels overlain by medium- to fine-grained sand with a layer silt on top	mined extensively in Edmonton area for asphalt aggregate, road gravel and fill material; many terraces have not yet been used
Aeolian	extensive areas southwest of Edmonton and smaller isolated dunes to the northeast of the city	variable: from 10 acres (4 hectares) to 1 1/2 townships	fine- to medium-grained sand in sheet or dune form; dune deposits are 10 to 50 ft (3 to 15 m) thick while sheet deposits are thin	utilized only as fill sand but may also be usable for making low quality glass (Carrigy, 1970)
Outwash Sand	Secs 31, 32, 33, 34, Tp 51, R 23 Sec 5, Tp 52, R 23	1 sq mi (2.6 km ²)	fairly clean sand with lenses of gravel and thin beds of silt and clay; overburden 0 to 2 ft (0 to 0.6 m) thick, deposit occurs along old meltwater channel	currently partially exploited for fill material
	Secs 26, 27, 34, 35, Tp 51, R 23	80 acres (32 hectares)	medium- to coarse-grained sand with numerous silt and clay beds	has been partially utilized as fill material
	Secs 25, 26, 35, 36, Tp 51, R 24	1 1/4 sq mi (3.2 km ²)	fairly clean sand with pebbles and occasional gravel lenses; 5 to 10 ft (1.5 to 3 m) thick with less than 5 ft (1.5 m) of overburden	some mining of this deposit occurred in recent years but deposit not presently exploited; suitable as fill material
	Secs 1, 12, Tp 52, R 24 Secs 6, 7, Tp 52, R 23	1/2 sq mi (1.3 km ²)	clean, medium- to coarse-grained sand with lenses of silt and gravel; about 10 ft (3 m) thick with little or no overburden	has been partially exploited for fill
	Secs 2, 3, 10, 11, Tp 52, R 23	1 sq mi (2.6 km ²)	dirty, medium- to coarse-grained sand; 2 to 3 ft (0.6 to 1 m) thick, very little overburden	one small abandoned pit; low potential as source of fill sand
	Secs 21, 28, 29, 30, Tp 52, R 23	1 sq mi (2.6 km ²)	dirty, fine-grained sand; very thin	little potential for development
	Secs 19, 30, Tp 52, R 22	1/2 sq mi (1.3 km ²)	extremely dirty, medium- to coarse-grained sand, with numerous coal fragments; silt and clay lenses; thin and irregular	little potential for development but may be good fill material
	Secs 20, 29, Tp 52, R 22	1/4 sq mi (0.6 km ²)	minor pockets of sand mixed with silt and clay	little or no potential for development
	Secs 24, 25, Tp 53, R 22	70 acres (28 hectares)	dirty sand with minor gravel and numerous silt and clay lenses; 2 to 4 ft (0.6 to 1.2 m) thick with up to 5 ft (1.5 m) overburden	little potential for development
	Secs 22, 23, 26, Tp 54, R 22	80 acres (32 hectares)	poorly sorted, medium-grained sand with minor gravel; relatively thin	low potential for development
	Secs 13, 14, 23, 24, Tp 55, R 22	1/4 sq mi (0.6 km ²)	poorly sorted sand with minor gravel; thin	currently one pit open; can be used for fill aggregate
	Sec 15, Tp 55, R 22	50 acres (20 hectares)	poorly sorted sand with minor gravel; relatively thin	no current development but suitable for use as fill aggregate
	Sec 30, Tp 55, R 21	80 acres (32 hectares)	poorly sorted sand with minor gravel and till pockets; relatively thin	no development currently but suitable for use as fill aggregate
	Outwash Sand and Gravel	Secs 22, 23, 27, 28, 33, 34, Tp 55, R 22	1 sq mi (2.6 km ²)	poorly sorted, fine-grained sand with common gravel and till pockets; relatively thin	partially developed; suitable for use as fill aggregate
large irregular area in Tp 55, Rs 22 and 23, as shown in figure 33		6 sq mi (15.54 km ²)	large sheet deposit consisting of medium-grained poorly sorted sand with numerous gravel pockets and till lenses; relatively thin	partially developed; suitable for use as fill gravel
Outwash Sand and Gravel	Secs 30, 31, 32, Tp 55, R 21 Secs 14, 23, 24, 25, Tp 55, R 22	3 1/2 sq mi (9.1 km ²)	poorly sorted sand and gravel; variable grain size over short distances	partially developed; suitable for use as fill aggregate
	Secs 22, 27, 28, Tp 55, R 22	3/4 sq mi (1.9 km ²)	poorly sorted sand and gravel with variable grain size over short distances	partially developed; suitable for use as fill aggregate
	Secs 15, 19, 20, 21, 22, 28, 29, Tp 55, R 22	1 3/4 sq mi (4.5 km ²)	poorly sorted sand and gravel with variable grain size over short distances	partially developed suitable for use as fill aggregate
Outwash Gravel	Secs 16, 17, 20, 21, Tp 54, R 27	1/2 sq mi (1.3 km ²)	poorly sorted gravel with coal fragments, sand and silt; 2 to 8 ft (0.6 to 2.4 m) thick with overburden up to 3 ft (1 m) thick	exploration of this deposit is needed to determine its commercial potential
	Secs 2, 3, 10, Tp 54, R 27	2 sq mi (5.2 km ²)	flat-lying gravels with many sand and silt lenses; 5 to 8 ft (1.5 to 2.4 m) thick with no overburden	three pits presently exploit this material; suitable for road and fill gravel; further development is probable
	Secs 11, 14, Tp 54, R 27	100 acres (40 hectares)	poorly sorted gravels with sand, silt and till pockets; 6 ft (1.8 m) thick with very little overburden	presently only a small test pit in the deposit; little potential for development but may be used for fill material
	Secs 1, 2, Tp 54, R 27	50 acres (20 hectares)	poorly sorted gravel with numerous sand lenses; 5 ft (1.5 m) thick with very little overburden	some potential for use as fill or road gravel
Kames, Eskers, and Crevasse Fillings	Secs 6, 7, 18, 19, 30, 31, Tp 55, R 24	1 1/2 sq mi (3.9 km ²)	poorly sorted gravel with numerous till and sand pockets; 5 to 10 ft (1.5 to 3 m) thick and 400 ft (122 m) wide; variable overburden	currently one small excavation into deposit; exploration needed to determine the potential of this deposit
	Secs 26, 35, Tp 55, R 25	1/4 section (57 hectares)	poor quality sand and gravel with numerous till pockets	may have potential as fill sand or gravel
	Secs 2, 10, Tp 52, R 25 Secs 35, 36, Tp 51, R 25	1 sq mi (2.6 km ²)	uniform fine- to medium-grained sand with a few gravel and till lenses; over 50 ft (15 m) thick with no overburden	presently exploited by three pits; sand used for fill; possibilities for further development especially in northern portion of deposit
	Secs 4, 5, Tp 52, R 21 Sec 32, Tp 51, R 21	100 acres (40 hectares)	relatively clean, cross-bedded sand; some gravel and till pockets	one small abandoned pit at present; low potential but exploration may reveal other small similar deposits
	Secs 13, 14, Tp 51, R 24	10 acres (4 hectares)	poor quality sand and gravel with numerous till inclusions	little potential for development

Table 8. Capabilities and limitations for development of the geologic deposits in the study area

Material	Lithology	Topography	Suitability for General Construction	Suitability for Solid Waste Disposal	Susceptibility to Erosion on Fresh Exposed Slopes	Slope Stability	Suitability for Deep Sewer Construction	Mineral Resources	Groundwater Conditions
Gully, creek valley, scarp	variable; exposed bedrock and surficial deposits; thin colluvium on valley slopes; thin alluvial materials along streams; mixed glacial and bedrock materials in slump areas	steep to moderate slopes; irregular	unsuitable due to presence of steep unstable slopes and areas of groundwater discharge	unsuitable due to pollution hazard to surface and groundwater and to instability of slopes	slope angle generally greater than 30° so moderate to severe erosion possible depending upon material exposed; sandstone, silts and sands are most susceptible	unstable generally; varies according to material exposed; bedrock shale is the least stable material	unsuitable due to instability of slopes	minor aggregate deposits in stream alluvium; exposed coal seams	numerous springs; high water table common in stream valley bottoms
Recent lacustrine and organic deposits	thin deposits of sand, silt, clay, muck, marl and organic deposits	flat surface; found in topographic lows	unsuitable due to presence of high groundwater table and high sulfate content of material; also material has low strength, high compressibility and very poor compaction characteristics	unsuitable due to presence of high groundwater table and areas of groundwater discharge	slopes <10°: slight to moderate susceptibility; revegetates rapidly slopes >30°: moderate to considerable danger; revegetates slowly	stable naturally; unstable when exposed	not applicable as deposits are thin	low potential as source of peat or marl	high water table; potential springs; near-surface aquifers; high total dissolved solids
North Saskatchewan River terrace and stream alluvium	alluvial gravel, sand, silt and clay	flat lying; found in valley bottom and as terraces on valley sides	generally suitable but the seasonally fluctuating groundwater table, the weak and compressible clay lenses and the potential erosion due to frost and undercutting may cause difficulties	unsuitable because the fairly high permeability of the deposits may allow pollution of surface waters including the North Saskatchewan River	slopes <10°: only slight susceptibility in sand and gravels but considerable in silts and clays; sand and gravel revegetate slowly while silts and clays revegetate rapidly slopes >30°: slight danger for gravels; moderate to considerable for sands; considerable to severe for clays and silts	relatively stable	unsuitable; deposits prone to caving and liquefaction when saturated; generally not applicable due to topographic position	deposits contain significant sand and gravel reserves	high groundwater table; near-surface aquifers in sand and gravels; infiltration galleries present
Aeolian sand	medium- to fine-grained sand	moderate relief in dunes; flat lying in sheet form	generally suitable but subject to wind and water erosion and piping	unsuitable because the high permeability of the material may allow pollution of local groundwater supplies	slopes <10°: moderate susceptibility; revegetates slowly; deep gullies form slopes >30°: severe tendency; revegetates very slowly and deep gullies form	stable naturally when unexposed	unsuitable; material prone to caving and liquefaction when saturated	potential source of fine fill sand and sand for low quality glass (see Carrigy, 1970)	low potential for domestic supplies
Glaciolacustrine silt and clay	bedded silt and clay with minor sand lenses; varved in places	flat lying	unsuitable due to potentially high groundwater table and susceptibility to erosion processes	suitable if thick and underlain by impermeable material	slopes <10°: slight to moderate susceptibility depending upon silt content; revegetates rapidly slopes >30°: medium to severe; depends upon silt content; revegetates slowly and gullies form	long term instability of oversteepened slopes; good drainage necessary	generally suitable but noncohesive silts may cause problems	low potential as source of brick clay	negligible potential for domestic supplies due to low permeability of materials
Glaciolacustrine sand and silty sand	sand and silty sand with minor silt and clay lenses and gravel pockets	flat lying	unsuitable due to potentially high groundwater table and susceptibility to erosion process	generally unsuitable due to medium permeability; areas of fine silt and clay may be suitable	slopes <10°: slight to considerable susceptibility depending on grain size; revegetates rapidly slopes >30°: considerable to severe susceptibility; revegetates slowly; forms deep gullies	generally stable if good drainage provided	generally unsuitable as materials prone to caving and liquefaction	negligible	low potential as domestic supplies source
Pitted delta	bedded silt with sand, clay and till pockets	rolling to hummocky	unsuitable; materials have low to medium strength, poor compaction characteristics and moderate to high compressibility and are susceptible to erosion processes	generally unsuitable but areas of fine silt and clay may be suitable	slopes <10°: moderate to severe; revegetates slowly and forms gullies slopes >30°: severe susceptibility; revegetates slowly and forms extensive deep gullies	generally stable if good drainage provided	generally unsuitable; materials prone to caving and liquefaction	negligible	sandy areas suitable as domestic supplies source
Mixed lacustrine and till deposits	bedded silt, sand and clay; usually overlying till	relatively flat to gently rolling	unsuitable due to potentially high groundwater table and potentially high sulfate content; materials also have high compressibility and medium strength	unsuitable due to relatively high groundwater table and the presence of lenses of highly permeable material	slopes <10°: slight to moderate susceptibility depending upon silt and sand content; revegetates rapidly slopes >30°: moderate to considerable susceptibility depending upon silt and sand content; revegetates slowly to rapidly	variable stability; generally stable in low slopes but clays and silts may be unstable in undrained exposures	not applicable as deposits are thin	negligible	sandy areas suitable as domestic supplies source
Outwash	mainly sand with minor gravel lenses, often quite thin	flat to gently rolling	generally suitable but some areas may be saturated	unsuitable because the high permeability of the material may allow pollution of surface and groundwater, also potentially high groundwater table	slopes <10°: slight susceptibility; revegetates slowly depending upon dominant grain size and grading slopes >30°: slight to considerable susceptibility depending upon grain size and grading; revegetates slowly	generally stable	unsuitable; prone to caving and liquefaction when saturated as is usually the case	source of road and fill aggregate	potential source of domestic supplies
Kames and crevasse fillings	sand and silt with minor gravel and till lenses	form local ridges and hills	generally suitable but some areas may be prone to frost action or may be saturated	unsuitable because the high permeability of the material may allow pollution of ground and surface waters; also potentially high groundwater table	slopes <10°: slight to moderate susceptibility depending upon fine sand and silt content; revegetates slowly to rapidly slopes >30°: moderate to considerable susceptibility depending upon silt content; revegetates slowly	relatively stable but subject to surface erosion if exposed	not applicable as deposits are thin	source of fill sand and gravel	low potential as domestic supplies source
Hummocky moraine	mainly till composed of mixed clays, silt and sand with pebbles and boulders; lenses of stratified sand and gravel common; occasional layers of disturbed bedrock	undulating to gently rolling	generally suitable but sand and gravel lenses may be saturated and material properties vary considerably over short distances; jointing is common and results in loss of strength	suitable if material is not severely fractured and if sand and gravel lenses are not continuous	slopes <10°: slight susceptibility; forms shallow self-arresting gullies slopes >30°: slight to considerable susceptibility; revegetates slowly; forms deep gullies which are only partially self-arresting	generally stable	generally suitable but sand and gravel lenses may be saturated and fracturing may result in caving in some places	negligible	sand and gravel lenses have low potential as a source of domestic supplies
Ground moraine	till composed of mixed clay, silt and sand with pebbles and boulders; minor stratified sand and gravel lenses and layers of disturbed bedrock	level to undulating	suitable but material properties vary over short distances and jointing may reduce material strength	suitable if material is not severely fractured	slopes <10°: slight susceptibility; forms shallow self-arresting gullies slopes >30°: slight to considerable susceptibility; revegetates slowly; forms deep gullies which are only partially self-arresting	generally stable	suitable but material is severely fractured in places and may cave in large blocks	negligible	low to negligible potential as source of domestic supplies
Saskatchewan gravels and sands	mainly sorted, rounded quartz sand with minor silt and clay; gravel lenses common especially near base of the formation	(subsurface)	suitable if not saturated	unsuitable because material has high permeability and is a major source of domestic and industrial water supplies	slopes >30°: generally only exposed on steep unstable slopes where moderate to severe erosion is likely; revegetates negligibly to slowly	generally stable	unsuitable; prone to caving and liquefaction when saturated as is usually the case	high potential as source of concrete and other aggregate; exploitation restricted by thickness of overburden	high potential as source for domestic and industrial supplies
Bedrock - shale	shale; minor siltstone, coal seams, bentonite layers	(subsurface)	suitable but jointing may reduce material strength and material may contain weak bentonite and coal layers	suitable if material is not severely fractured and if groundwater table is low	slopes >30°: generally only exposed on steep unstable slopes where moderate to severe erosion is likely; revegetates negligibly to slowly	generally unstable especially where bentonite layers are present	suitable although material may be fractured in some places	low potential as source for soft coal and bentonite	low potential as source for domestic supplies
Bedrock - sandstone	sandstone; minor siltstone	(subsurface)	suitable but jointing may reduce material strength and deposits may be saturated in places	unsuitable because material is moderately permeable and is a major source of domestic and industrial supplies	slopes >30°: generally exposed only on steep unstable slopes where moderate to severe erosion is likely; revegetates negligibly to slowly	relatively stable	suitable although material may be fractured in some places	negligible	high potential as source for domestic and industrial supplies