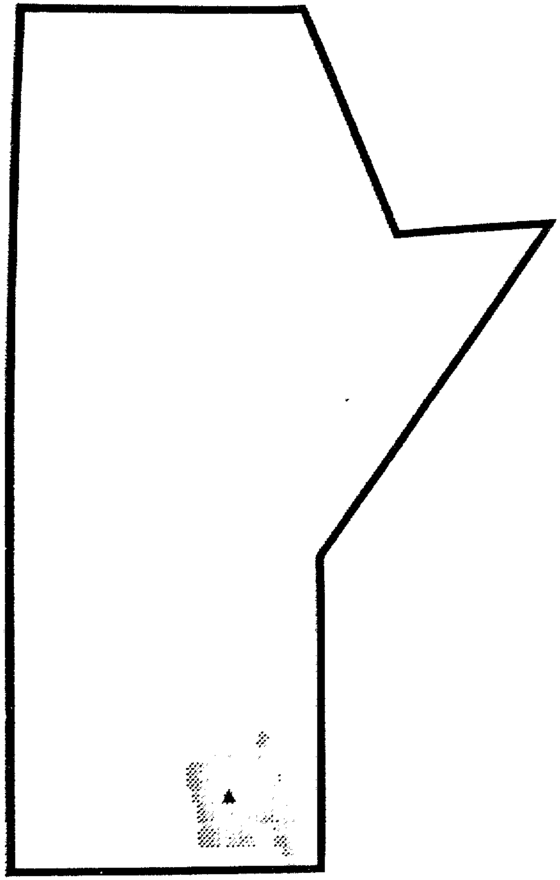

AGGREGATE RESOURCES OF THE WINNIPEG REGION

prepared for

MINERAL RESOURCES DIVISION
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
PROVINCE OF MANITOBA

prepared by

The UMA Group

June 1976

Underwood McLellan & Associates Limited
1479 Buffalo Place, Winnipeg, Manitoba R3T 1L7 Telephone (204) 284-0580

June 30, 1976

Dr. F. J. Elbers,
Director
Mineral Evaluation and Administration Branch,
Mineral Resources Division,
Department of Mines, Resources
and Environmental Management
993 Century Street
Winnipeg, Manitoba
R3H 0W4

Dear Sir:

We are pleased to submit our report "Aggregate Resources of the Winnipeg Region".

Supplementary to this report is a technical file which will provide you with more detail on sand and gravel occurrences than what is presented in the report. This file is based on a township-range system.

We trust that the findings of this report will provide a useful document to assist in future land use planning and aggregate management.

We have found this study most challenging and we have appreciated the co-operation extended to us by the Mineral Resources Division.

Yours truly,

UNDERWOOD MCLELLAN & ASSOCIATES LIMITED

R. Hood, P. Eng.
Vice President and Manager
Manitoba & Northwestern Ontario

C. E. Anderson, P. Eng.
Director
Resource Planning & Development

CEA/la

AGGREGATE RESOURCES OF THE WINNIPEG REGION

PREPARED FOR

MANITOBA
DEPARTMENT OF MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT

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JUNE 1976

ACKNOWLEDGEMENT

We wish to express our sincere appreciation to the many individuals who co-operated with the study team and without whose assistance and guidance this report would not have been possible.

Special appreciation is due to Ms. Susan Ringrose and Mr. B.B. Bannatyne, of the Mineral Resources Division, who acted as study co-ordinators on behalf of the Division.

SUMMARY

The purpose of the study was to provide qualitative and quantitative estimates of aggregate potentially available to support construction requirements in the Winnipeg Region over the long term.

The Winnipeg Region comprised an area of some 6500 square miles (1,700,000 hectares) around the City of Winnipeg, including the Belair, Agassiz and Sandilands Forest Reserves.

The study components were:

— to forecast aggregate demand in the Region to the year 1996 and extrapolate that forcast to the year 2026;
— to provide an estimate of the quality and quantity of sand and gravel potentially available within the Region based on existing data and selective field testing;
— to carry out an Airborne E-Phase Resistivity Survey in an area east of Bird's Hill to locate potential granular deposits buried beneath non-granular overburden.
— to identify, using seismic surveys, in and adjacent to the R.M. of Rockwood, areas with thin overburden over the limestone bedrock for potential future limestone quarry locations;

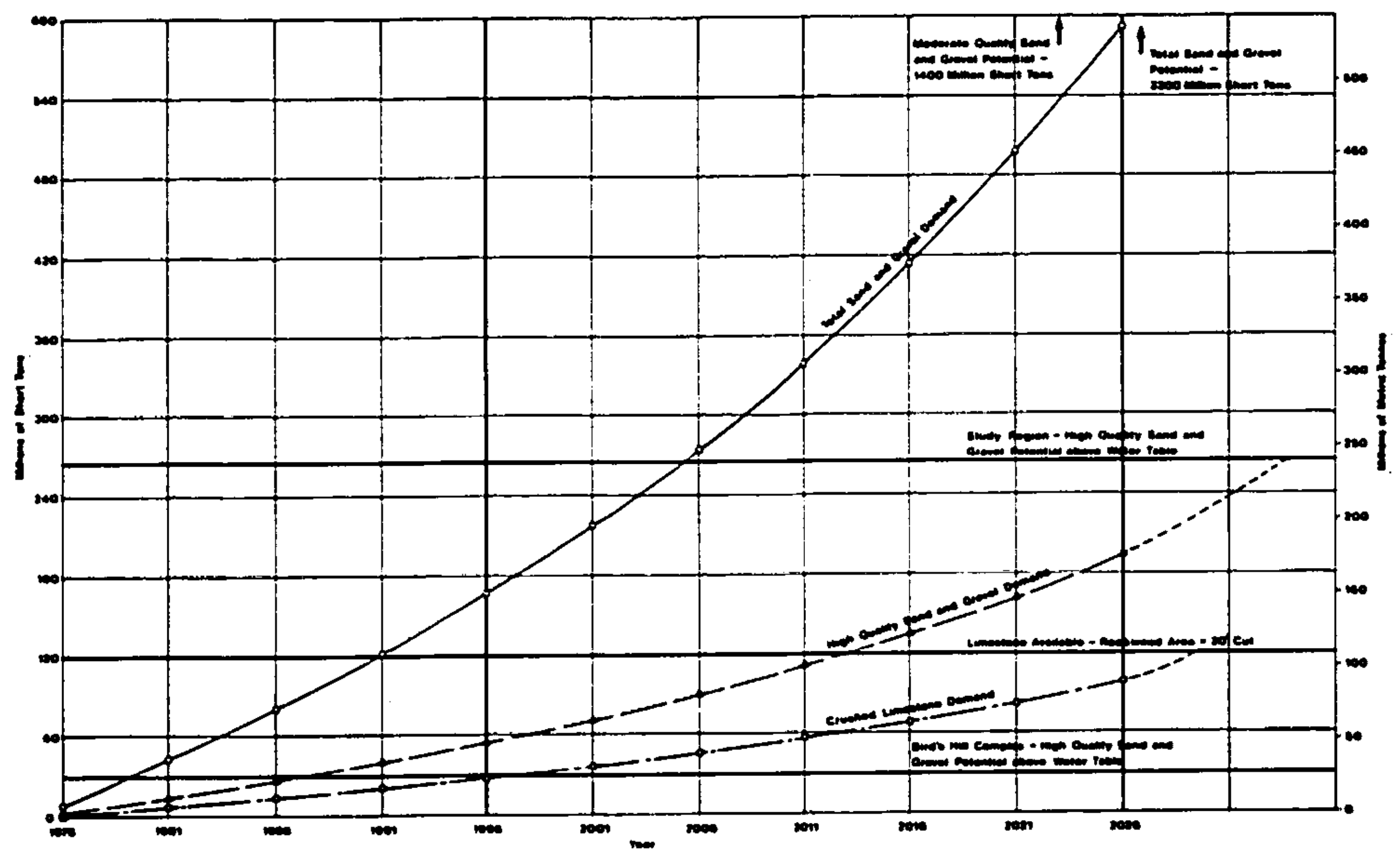
The expected demands were projected to be:

	Cumulative to 1996 Millions of		Cumulative to 2026 Millions of	
	Short Tons	Metric Tonnes	Short Tons	Metric Tonnes
Total Sand and Gravel	167	151	591	536
High Quality Sand & Gravel	54	49	193	175
Crushed Limestone	27	24	98	89

The sand and gravel potential for the Region is summarized as follows:

	Millions of	
	Short Tons	Metric Tonnes
Total Sand and Gravel	3300	3000
Moderate Quality Sand and Gravel	1400	1300
High Quality Sand and Gravel	265	240
High Quality Sand and Gravel remaining in Bird's Hill	30	27

The following graph illustrates the relationship between supply and demand:



The E-phase survey defined anomalies that could represent significant quantities of sand and gravel being buried beneath non-granular overburden. Test drilling will be required to verify their existence and total potential.

The seismic surveys identified 12 selected sites where the limestone bedrock was expected to be within 10 feet (3 metres) of ground surface. Five of the sites were test drilled by the Mineral Resources Division prior to the completion of this report. Further test drilling and possibly detailed seismic surveys will be required to define each of the sites in detail. A conservative estimate indicates that some 120 million short tons (108 million metric tonnes) of limestone are available in the area at shallow depth.

The conclusions that were derived based on the scope of this study are:

- High quality sand and gravel available above water table in the Bird's Hill area is expected to be depleted during the mid 1980's.
- There appears to be sufficient high quality sand and gravel within the Region (including the Forest Reserves) to meet demands until 2026 but probably not more than 5 to 10 years beyond that time.
- There appears to be sufficient moderate quality sand and gravel to meet the regional demands to well beyond the year 2026.
- Once the Bird's Hill supplies are depleted, the next significant source area for high quality sand and gravel will be the Belair-Agassiz-Sandilands Forest Reserves and adjacent areas.
- The availability of limestone within the R.M. of Rockwood and adjacent areas, should be sufficient to meet the crushed limestone requirements to beyond the year 2026.

It is suggested that alternatives to sand and gravel, such as light weight aggregates and soil cement may have to be considered in the future.

Land use planning and pit rehabilitation will have to be given more consideration as the sand and gravel deposits from existing sources are depleted and the pressure increases on other areas, particularly in the Belair, Agassiz and Sandilands Forest Reserves. Priorities will have to be established to avoid land use conflicts between forestry and aggregate requirements. Urban, recreational and industrial development over potential sources of aggregate that could in effect 'sterilize' their economic recovery will have to be avoided.

TABLE OF CONTENTS

Acknowledgement
Summary
Table of Contents
List of Plates
List of Tables

List of Plates

List of Tables

SECTION A
INTRODUCTION

SECTION A
INTRODUCTION

1. TERMS OF REFERENCE

The terms of reference for the Study were generally outlined in the request for proposals by the Department of Mines, Resources and Environmental Management dated April 10, 1975 and subsequently in the agreement dated July 24, 1975 between the Mineral Resources Division, Department of Mines, Resources and Environmental Management, Province of Manitoba and Underwood McLellan and Associates Ltd. These terms of reference are summarized as follows:

1.1 Purpose

The purpose of the study was to provide qualitative and quantitative estimates of aggregate potentially available to support construction requirements in the Winnipeg Region over the long term.

1.2 The Winnipeg Region

The Winnipeg Region was defined as Southern Manitoba, comprising the Municipalities of Brokenhead, Cartier, De Salaberry, Hanover, McDonald, Morris, Ritchot, Rockwood, Rosser, Springfield, St. Andrews, Ste. Anne, St. Clement, St. Francois Xavier, East St. Paul, West St. Paul, Tache, Woodlands and the City of Winnipeg.

In a letter dated August 8, 1975 from the Mineral Resources Division, it was requested that the following additional areas be included within the terms of reference of the Winnipeg Region Aggregate Resources Study:

— the Bel Air Provincial Forest
— the Agassiz Provincial Forest
— the Sandilands Provincial Forest, to the northern boundary of Township 6.

It was appreciated that in order to consider this additional area and to remain within the original budget, that field investigative emphasis would have to be decreased in selected areas as the study advanced and priorities were established. However, every attempt would be made to give consideration to all areas.

The resultant Winnipeg Region Study area comprising 6,500 square miles is defined on Plate A-1.

1.3 Study Components

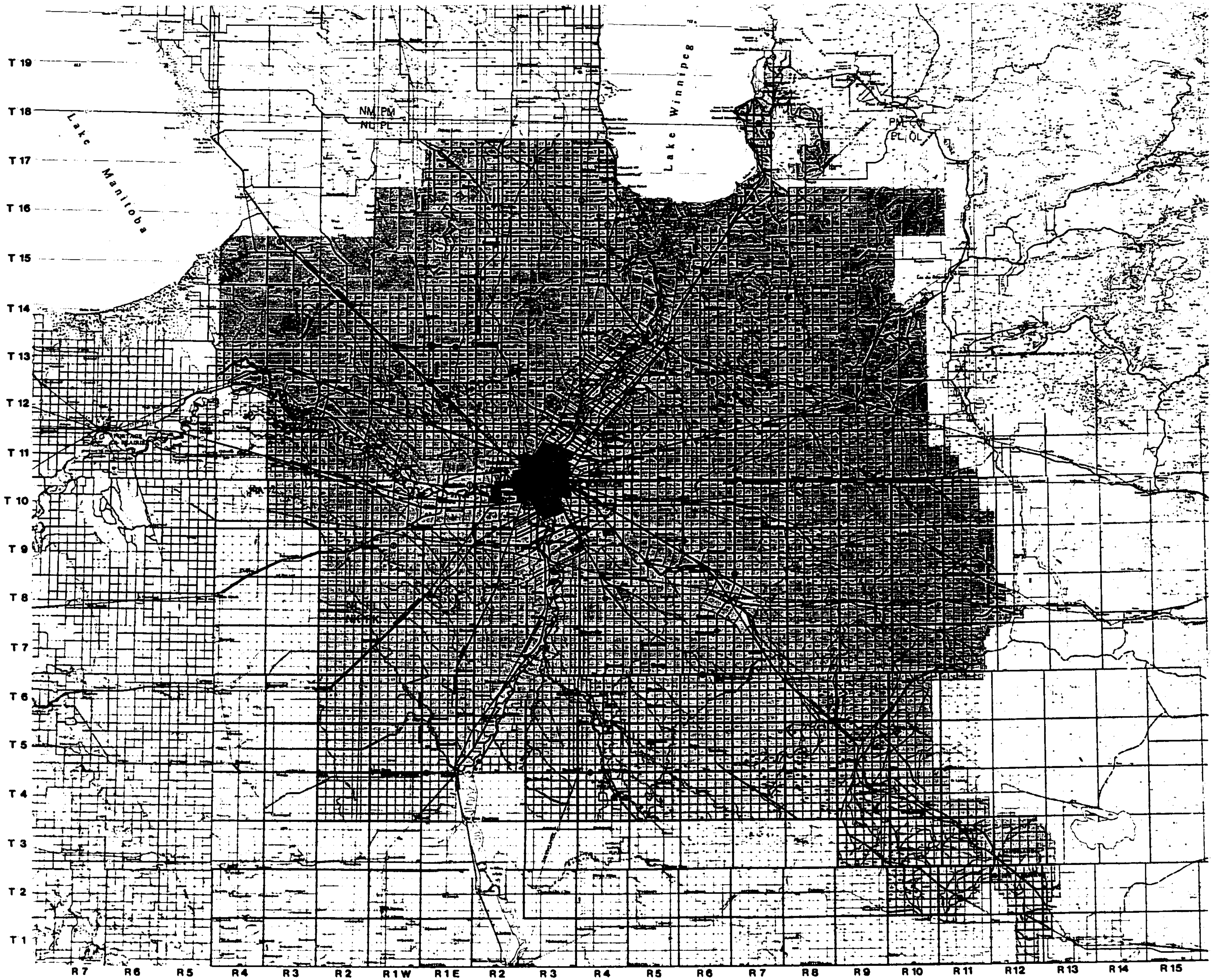
a) Forecast aggregate demand in the Region to the year 1996 and extrapolate that forecast to the year 2026.

b) Provide an estimate of the quality and quantity of sand and gravel aggregate potentially available within the Region based on existing data and selective field exploration.

c) In, and adjacent to, the R.M. of Rockwood, identify, using seismic surveys, areas with shallow overburden cover over the limestone bedrock for potential future limestone quarry locations and estimate the quantities of limestone potentially available.

d) Consider the use of the Airborne E-Phase Resistivity Survey method in a selected area to locate potential granular deposits buried beneath non-granular overburden.

It was mutually accepted early in the program that flexibility to adjust the terms of reference, as priorities identified themselves, was a necessity.



Legend

Study Area

Aggregate Resources of the Winnipeg Region

The Winnipeg Region Study Area

0 5 10 15 Miles

0 10 20 30 Kilometres

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Plate A-1

SECTION B

CLASSIFICATION AND PRODUCTION OF AGGREGATES

SECTION B
CLASSIFICATION AND PRODUCTION OF AGGREGATES

1. INTRODUCTION

Within the Winnipeg Region aggregates are obtained from two sources:

- sand and gravel deposits
- limestone and dolomite bedrock

Typical uses for aggregates are:

- concrete
- bituminous paving mixtures
- granular road surfacing
- railway ballast and sub-ballast
- concrete blocks
- other masonry products
- backfill
- culvert bedding and backfill
- rip-rap and filters

In order to meet the many specifications demanded by the end use, aggregates must be processed and the basic material should consist of sound, tough and durable pebble and rock fragments and sand, with which may be included a quantity of fine particles and which must be free from roots, sod and other deleterious substances.

2. CLASSIFICATION OF AGGREGATES

Gradation specifications for aggregates can be found in the American Society for Testing and Materials and Canadian Standards Association manuals. These specifications are too numerous to identify within the context of this report but some discussion on general specification considerations is warranted.

Aggregates are generally classified by silt content (percent by weight less than No. 200 sieve size); sand content (percent by weight greater than No. 200 sieve size but less than No. 4 sieve size); and gravel content (percent by weight greater than No. 4 sieve size); and by the uniformity of gradation of various mixtures of these material sizes. Most specifications call for well-graded granular material to ensure the void ratio of placed material is at a minimum.

The usage of aggregates will depend upon required gradations. An aggregate with less than 5 percent passing the No. 200 sieve is considered "clean" and one with greater than 15% passing the No. 200 sieve is considered "dirty". The following examples assist in clarifying these definitions:

- for an aggregate to be free draining, as in the case of a filter material, the percent passing the No. 200 sieve content should be in the range of 0 to 5 percent.
- for an aggregate to be relatively well-draining, readily compactable, and of high strength, as in the case of roadway fills or base coarse under pavements, the percent passing the No. 200 sieve should be in the range of 5 to 15 percent.
- if the percent passing the No. 200 sieve content is greater than 15 percent, the aggregate will be poor draining and may be frost susceptible.

Four ranges of sand and gravel content, based on percent passing the No. 4 sieve size, can be used in the classification of aggregates:

a) 90 to 100 percent
b) 70 to 90 percent
c) 40 to 70 percent
d) less than 40 percent

These classifications must take into account the limitations mentioned above relative to the percent passing the No. 200 sieve size.

Examples of aggregate usage based on sand and gravel content are:

— aggregates with 90 to 100 percent passing the No. 4 sieve are required for use in fine concrete, seal coat paving, plaster and masonry mortar.

— specifications for concrete blocks, concrete culverts, railway sub-ballast, roadway base coarse and granular backfill generally call for gravel content in three broad ranges: 40 - 90 percent, 70 - 90 percent or 40 - 70 percent passing the No. 4 sieve.

— aggregates with less than 40% passing the No. 4 sieve could be crushed and blended with other aggregates to give required gradations or used for coarse masonry grout, coarse culvert subdrain filter and for coarse concrete aggregate.

A poor quality sand and gravel deposit is usually lacking in coarse material, with only 15 to 20 percent being retained on the No. 4 sieve. A high quality material will have 40 to 70 percent retained on the No. 4 sieve. The poor material can be modified to produce a high quality aggregate. This is done by screening the pit run material and separating the coarse material from the fine; crushing the coarse material to the desired sieve size; and then blending the coarse with the fine to comply with the required gradation specifications.

3. EXTRACTION METHODS AND PROCESSING

In general, obtaining mineral aggregates from naturally occurring sources is described by the term "Surface Mining".

In the Winnipeg Region, this technique includes the following: open pit mining for sand and gravel and quarrying for crushed stone. Because a significant percentage of granular material is believed to lie below the water table, recovery of this material will likely be given more consideration in the future in the Winnipeg Region.

Every extraction method and processing operation and production site is unique in its own operation. Many basic individual production steps are common to all plants and are used in various sequences to ensure the required product.

The following basic steps are common to most aggregate production operations:

Clearing - involves the removal and disposal of trees, shrubs, and other surface litter.

Stripping - involves the removal of topsoil and subsoil.

Excavation - raw material may be removed with many types of equipment depending on the type of aggregate or rock being handled.

Stockpiling - unprocessed and processed materials are stockpiled to ensure a wide variation of production demands.

Processing - aggregate production, in general, involves the use of various types of equipment. The processing steps include screening, crushing and washing. Fill material in general needs no processing.

Aggregate produced for today's construction needs are more superior than in the past. This is mainly due to new technology in the production field. Crushing techniques have improved, with the present day capability to crush boulders as large as 30 inches in diameter. Portable conveyors and automated equipment can produce aggregates that can be accurately proportioned to produce any type of construction materials needed within the industry.

The flow diagrams on Plates B-1 and B-2 depict typical sand and gravel and crushed limestone aggregate operations, respectively, which are common to the Winnipeg Region.

PLATE B-1
FLOW DIAGRAM FOR SAND AND GRAVEL OPERATION

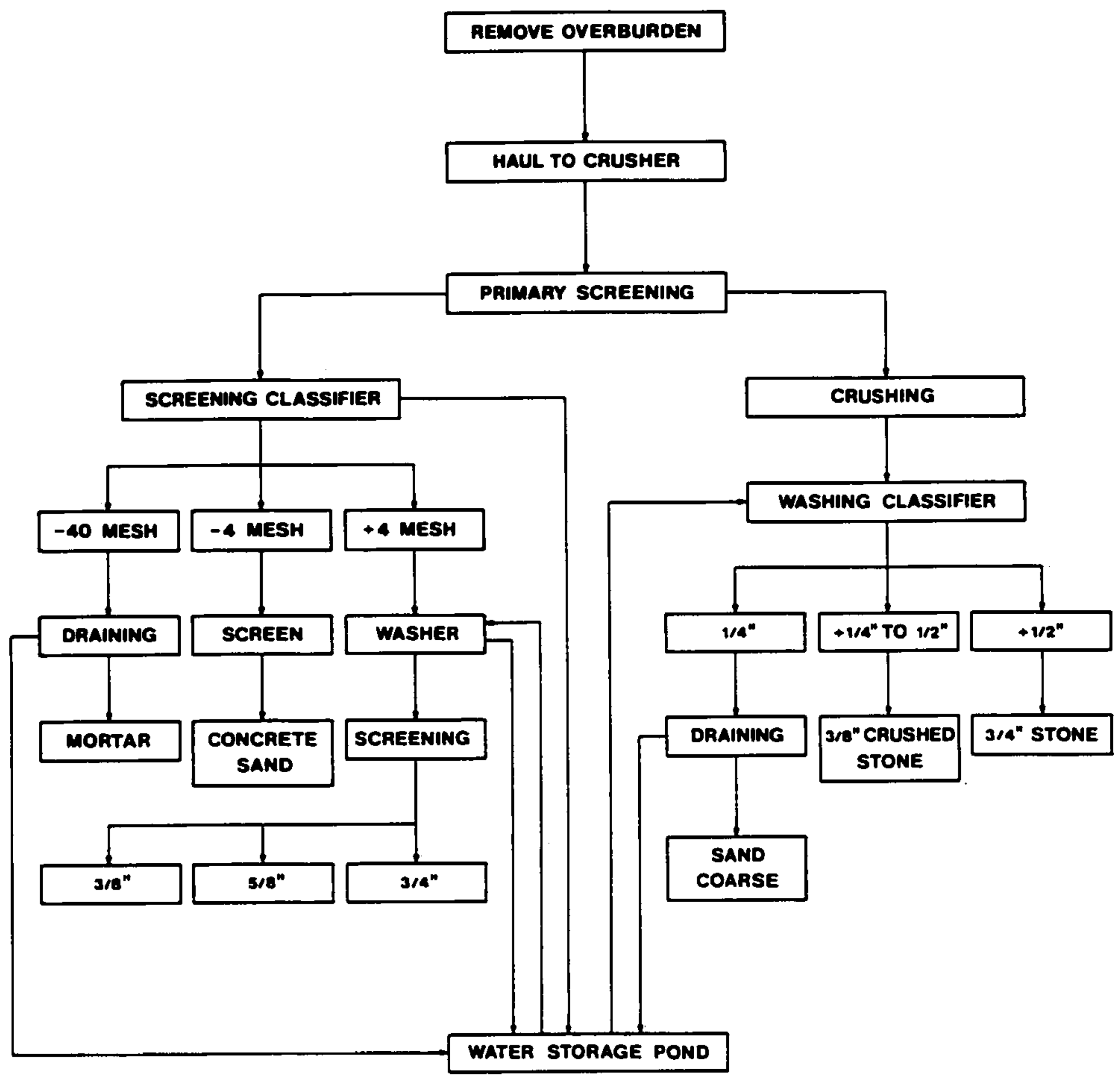
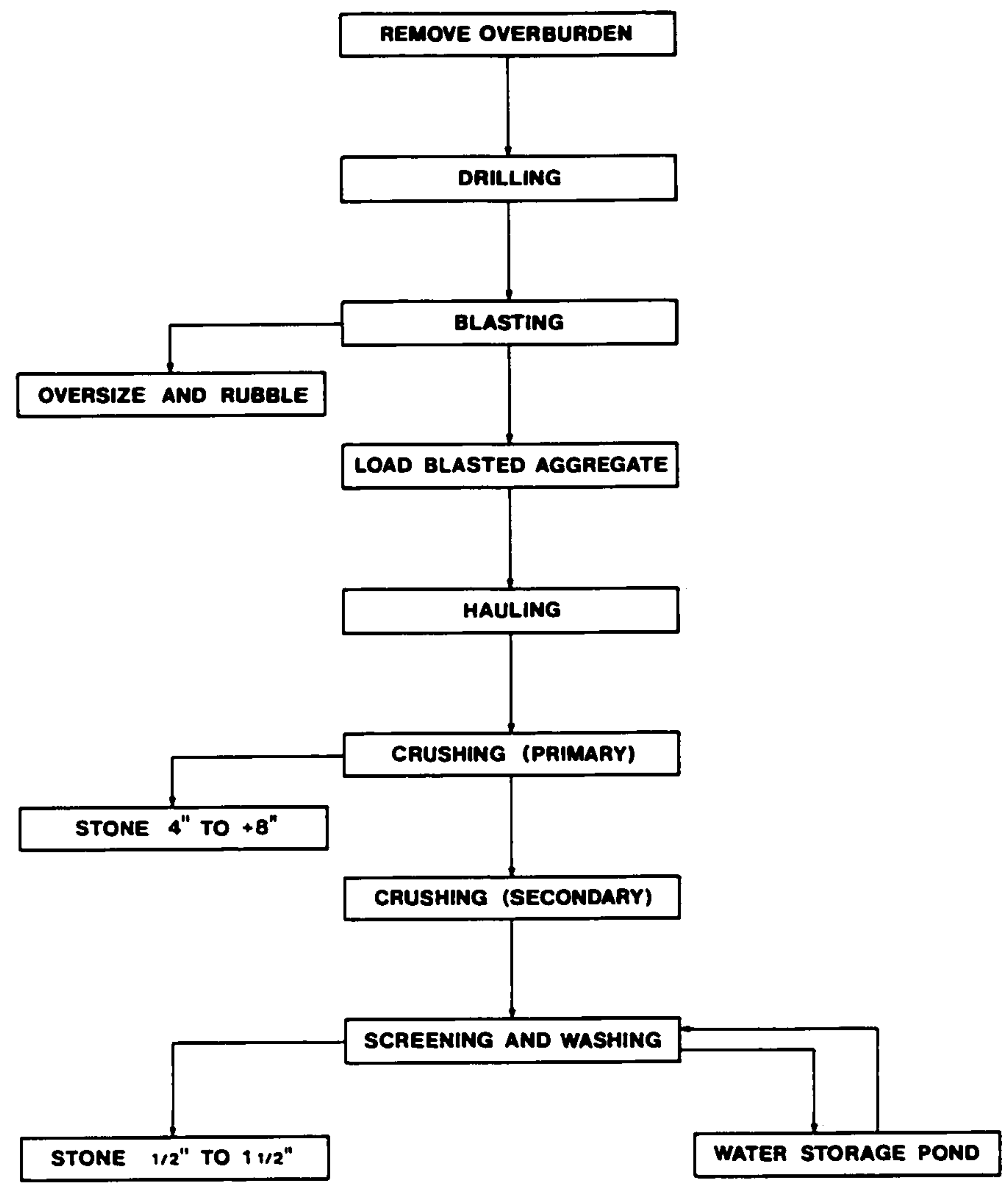


PLATE B-2
FLOW DIAGRAM FOR CRUSHED STONE OPERATION



SECTION C

AGGREGATE REQUIREMENTS IN THE WINNIPEG REGION

SECTION C
AGGREGATE REQUIREMENTS IN THE WINNIPEG REGION

1. INTRODUCTION

1.1 Abstract

This section of the report contains an analysis and projection of future mineral aggregate demand in the Winnipeg Region to 1996 based on projected population growth, anticipated construction activity and derived coefficients of aggregate usage in each construction sector, as determined through analysis of historical data. The detailed forecast covers a 20-year period from 1976 to 1996. Estimates are provided through to the year 2026 by means of extrapolation of forecast results.

1.2 Study Region

For purposes of the demand analysis contained in this section of the report, the Winnipeg Region is defined as Southern Manitoba, comprising the municipalities of De Salaberry, Hanover, Ritchot, Ste. Anne, Tache, Dufferin, Morris, Roland, Brokenhead, St. Andrews, St. Clement, Springfield, Indian Reserves, Cartier, Grey, MacDonald, Portage la Prairie, Rockwood, Rosser, St. Francois Xavier, Woodlands, East St. Paul, West St. Paul and the City of Winnipeg. It is to be noted that portions of these boundaries fall outside the Winnipeg Region defined in Sub-Section A.1.2 and do not include the Provincial Forest Reserve areas. The boundaries were expanded to include all of the significant urban centres around Winnipeg, because such growth centres are centres of construction activity and thereby will have an impact on the future demand for aggregate in the general area.

As a means of isolating relative growth levels and variations in supply and demand factors within the Winnipeg Region, the Region was sub-divided into East, West, Interlake and Greater Winnipeg subregions. This subregional classification was selected because it follows the boundaries of the Manitoba Economic Regions 1, 2, 5 and 7, as designated by Statistics Canada, and thereby conforms to the data base used in some statistical summaries published by Statistics Canada.

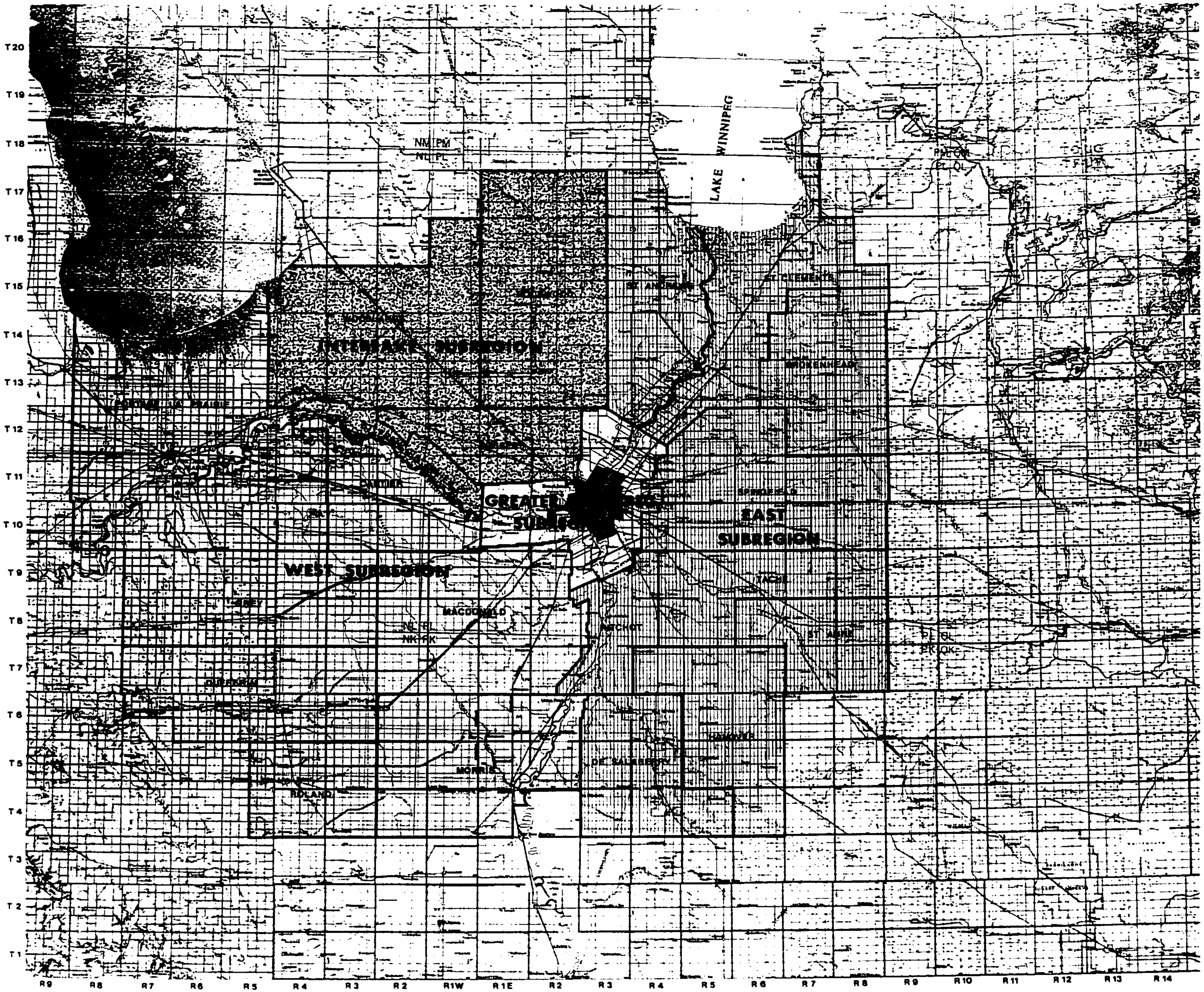
The East subregion comprises those municipalities east of the Red River including St. Andrews and excluding the City of Winnipeg. The West subregion includes all the municipalities west of the Red River and west of St. Francois Xavier and Woodlands municipalities. The Interlake subregion consists of the municipalities of Woodlands, Rosser, St. Francois Xavier and Rockwood. The Greater Winnipeg subregion comprises Unicity and the municipalities of East and West St. Paul. These subregions are indicated on Plate C-1.

1.3 Information Sources

Information and statistical data were gathered from all sources and agencies who compile data relevant to the construction industry and the production and consumption of aggregate. These sources included the Manitoba Department of Industry and Commerce, Department of Mines, Resources and Environmental Management, Department of Highways, Department of Municipal Affairs, Statistics Canada, as well as municipalities and private companies engaged in the production and distribution of sand and gravel and limestone and the manufacture of concrete products.

As the municipalities and private companies do not document or publish their consumption and usage data in a form suitable for this study, a questionnaire was directed to aggregate producers, intermediate users and basic users. These questionnaires were distributed by mail and were followed up by telephone and personal interviews. Over 100 different private firms and government departments involved in the production and use of sand, gravel, crushed stone, cement and limestone, in the Winnipeg Region, were contacted in this manner to provide information to augment the published statistics.

This direct solicitation was necessary to obtain consumption figures relative to unit measures of construction activity, and to provide a level of detail for subsequent subregional analyses which the published statistics did not contain. As well, careful inspection of published data on the sand, gravel and crushed stone industry in Manitoba, and particularly in the Winnipeg Region, revealed the necessity for an in-depth study of the producer-user relationship, to develop an accurate accounting of the industrial flow of sand, gravel and crushed stone as it progresses from the producer through the direct and indirect channels prior to final consumption.



Aggregate Resources of the Winnipeg Region

Subregions of the Winnipeg Region

0 5 10 20 Miles

0 10 20 30 Kilometres

The UMA Group

Plate C-1

1.4 Construction Sectors

The analytical approach adopted for this study utilizes a series of projections by construction sector within each subregion. The construction categories or sectors into which construction activity is categorized are:

a) Residential — single family, multi-family dwellings and apartments.
b) Non-Residential — commercial, institutional and industrial building construction except mine and mine mill buildings.
c) Road Construction — includes roads, highways, bridges, trestles and related structures.
d) Other Engineering — includes sewer and water and related engineering.
e) Residual — includes power stations, power lines, gas wells, mine shafts, parks, pools, tunnels, telegraph lines, signals, street lighting, fences and snowsheds.

The last category (residual) has been identified in order to separate out construction activities unlikely to occur in the Winnipeg Region, e.g., mine shafts, and to eliminate essentially minor uses of construction aggregate, e.g., pools.

1.5 Limitations on Published Data

While there are many sources of published data on the construction industry, there are problems in attempting to apply this data within the constraints of this study. Data problems are often encountered in any complex analysis of the type undertaken here, because of the many factors to be analysed, the many sources of data available, and the necessity to perform the analysis at a level of detail beyond that of conventional data sources.

In this study, the problems with published data included conflicting information, errors, ommissions, failure of respondents to submit information for publication and, of major consequence, the lack of data at the sub-provincial level. The problems associated with the data, and the provisions introduced to overcome data problems, are discussed below according to major subjects and topics of data research.

1.5.1 Residential and Non-Residential Construction

The most comprehensive and detailed summary of construction activity in Canada is that published by Statistics Canada in *Construction in Canada,* Cat. 64 - 201, which reports activity at a provincial level. However, Statistics Canada does not publish such comprehensive data at the sub-provincial level. Consequently, it is not possible to use this series to determine the value of construction by sector for the four subregions identified within the Winnipeg Region (East, West, Interlake and Greater Winnipeg).

For residential and non-residential building construction, the only sub-provincial data available from Statistics Canada in regular form is the value of building permits issued by municipality (Cat. 64 - 203). Here, building permit data is broken down into residential, industrial, commercial and institutional government categories. Rather than being an accurate reflection of building construction in each municipality or economic region, the data provides only a general indication of levels of activity in each area for the following reasons:

— Building permits reflect budgets, rather than actual construction values.
— Delays in timing of construction after a building permit is issued may lead to data inconsistencies on an annual basis, e.g., housing starts and completions.
— Building permit by-laws in certain municipalities may not require licensing/reporting of all building construction.
— Most important of all, not all municipalities regularly report building permit data to Statistics Canada; in 1973, for example, such important centres as Portage, Beausejour, Steinbach, St. Anne and Selkirk all failed to report monthly building permits at least once during the year. It is understood that due to limited resources, Statistics Canada does not follow up on delinquent municipalities and therefore reports only data received. Such procedures tend to cause the data to overstate the activity in major urban centres such as Winnipeg, relative to the rest of the province.

Another source of building permit data is reported annually in *Trade and Commerce* magazine, based upon surveys conducted by the magazine. This data source, however is restricted to major municipalities excluding most rural municipalities and some urban municipalities.

Of the two sources, Statistics Canada building permit data was chosen as being the most representative.

1.5.2 Road Construction

Once again, information on road construction is published at the provincial level only and contains insufficient detail to accommodate a comprehensive analysis of the type undertaken in this study. It was necessary to rely totally on a survey of provincial and municipal governments in the Winnipeg Region, to determine the activity in this sector.

1.5.3 Other Engineering Construction

Other engineering construction in the Winnipeg Region essentially encompasses construction expenditures by municipalities. These are covered under municipal local improvements in the financial statements of the municipal corporations, but this account includes municipal road construction as well. Consequently, a survey of municipal users was necessary to carry out the analysis of this sector.

1.5.4 Statistics Canada Commodity Surveys

The commodity surveys on sand, gravel and limestone published by Statistics Canada, are incomplete and inaccurate. For this reason, our survey of aggregate producers and users in the Winnipeg Region resulted in major alterations to the published data. Statistics Canada commodity surveys could not be entirely relied upon for the following reasons:

a) While the commodity surveys for sand, gravel and crushed stone (limestone) are intended to cover all producers, Statistics Canada in fact does not reach all major (let alone minor) producers.

b) Resources available to this particular division of Statistics Canada prohibit follow up of those returns which are received and there is evidence that the survey itself is subject to considerable misinterpretation by producers, particularly in the allocation of their production to various end-use categories.

c) There appears to be some evidence of double counting of production, e.g., Department of Highways return shows sand and gravel used by the Department rather than sand and gravel actually produced by the Department (net of contractors.)

d) Limestone production used in Canadian cement and lime plants is not reported in crushed stone production; ignored, therefore, in the published data are the limestone quarry operations of Canada Cement Lafarge and Inland Cement, as well as limestone production of Steel Brothers.

e) Construction aggregate allocated to the concrete aggregate category is not identified by construction sector.

For these reasons, published data had to be supplemented by interviews and telephone conversations with the major producers and users in the Winnipeg Region. These discussions yielded revised data with respect to both total production and end-use allocation.

1.6 Producer and User Survey

1.6.1 Method

A comprehensive survey of all producers and users of sand, gravel and limestone was carried out to obtain data on the Winnipeg Region and to augment the published statistics at the provincial level. For the most part, respondents included in the survey are located in the Winnipeg Region, although it was necessary to contact certain other producers elsewhere in the province, in order to document complete information on the total sand, gravel and crushed stone industry in Manitoba.

The survey was concerned with the volume of aggregate produced, its disposition or consumption for construction purposes, the location of pits or quarries and certain cost information. A questionnaire form was used for purposes of gathering this information. Because of the extensive scope and depth of the survey, many of the respondents were not able to provide the information directly from summaries of operating data, and faced the laborious task of assembling information from basic documents. Consequently, only 1973 information was requested.[1] This resulted in a complete in-

[1] Other years' data were requested from certain large users such as the Manitoba Department of Highways.

dustry profile for 1973, which is the basic reference year used throughout the study.

Three types of respondents were surveyed — producers, intermediate users and end users. Producers are companies engaged in extracting and processing sand, gravel and crushed stone. Intermediate users are companies who convert aggregate to products used in the construction industry such as ready mix, asphalt and precast concrete products. End users are the companies and government departments and agencies that use sand, gravel, crushed stone, cement, limestone and concrete products in their construction projects. A list of the respondents is contained in Appendix 1. Appendix 2 contains copies of questionnaire forms used in the survey.

1.6.2 Survey Results

The results of the survey have been incorporated into the study and into the various data summaries and statistical tables presented in this report. The survey revealed the volume of aggregate production in the Winnipeg Region to be 6.3 million tons in 1973 with 42% of this flowing through intermediate processors. The reported quantities extracted and consumed in various sectors of the industry were compared to Statistics Canada and Manitoba Department of Industry and Commerce data, and were confirmed or adjusted as necessary in follow-up interviews and by telephone. Individual questionnaire results are confidential and are not available for circulation.

It is the general consensus of the companies and agencies surveyed, that future requirements will follow current trends of slow growth and that there are no signs of new technology that will change industry practises or lead to new types of demand for aggregate. There is concern that new land use legislation will seriously reduce the supply of this already limited resource in the Winnipeg Region. Transportation costs now represent 50% of the total cost of aggregate and any developments which may contribute to increased hauling distances and costs are of concern to everyone in the industry.

1.6.3 Implications of Using Survey Results for Forecasting

It was absolutely essential that this survey be conducted to obtain the information necessary to prepare the forecast of aggregate demand presented in this report. The published industry statistics are not sufficiently complete or detailed to allow a comprehensive analysis of the type undertaken here.

While the data thoroughly profiles the commodity flow in 1973, the use of this single data base to forecast future requirements has obvious implications on forecast reliability, since it reflects only one year's profile of activity. Nevertheless, 1973 activity was considered to be representative of conditions in the industry and a reliable basis for forecasting.

Time and budget restrictions, as well as the lack of documentation at the producer and user level, prohibited the preparation of similar profiles for earlier years. Thus it has not been possible to analyse year-to-year trends and variations in aggregate usage and flows. However, trends and averages have been analysed for various other forecast components, including construction spending and population, for which published statistics are available. Consequently, the forecasts do contain relative growth parameters which are based on historical relationships and trends in the construction industry.

2. AGGREGATE STATISTICS

2.1 Sand and Gravel

Table C-1 presents standard end-use allocation data for sand and gravel construction aggregate, as originally tabulated for 1973 by Statistics Canada and as revised through discussions with major producers in the Winnipeg Region and beyond.[1]

The net effect of these adjustments resulted in a figure for sand and gravel production which is approximately 5% higher than the figures reported by Statistics Canada. The major increases are in road construction, concrete aggregate and railroad ballast. In contrast, allocations reported under all other categories declined.

Approximately 7% of the revised production figures could not be allocated to any of the nine major categories; in all instances, these discrepancies were due to lack of data for smaller operators.

TABLE C-1

SAND AND GRAVEL ALLOCATION DATA, 1973
(000 tons)
MANITOBA

Use	Statistics Canada	Revised	Percent Adjustment	Winnipeg Region
Road construction	6,747	8,669	28.5	2,025
Ice control	79	14	(82.2)	13
Concrete aggregate	1,843	2,241	21.6	1,952
Asphalt aggregate	550	535	(2.7)	242
Railroad ballast	776	928	19.6	66
Mortar sand	153	26	(83.0)	15
Mine fill	67	—	—	—
Other fill	1,618	1,113	(31.2)	952
Other uses	13	2	(84.6)	1
Total allocated	11,846	13,528	14.0	5,266
Total production	13,700	14,449	5.5	5,353
Percent allocated	86.5	93.6	—	98.4

Sources: 1. Statistics Canada Cat. 26-215
2. Producer and user survey

2.2 Limestone

Similarly, Table C-2 documents standard end-use allocations for limestone (crushed stone) for 1973.[1] In the revised figures, limestone has been allocated to cement plants on the basis of 1.12 tons of limestone for every ton of cement produced in Manitoba in 1973.

With reference to Table C-2 the end-use allocation has been substantially revised not only for cement plants but also for road metal. In total, it is estimated that 1.38 million tons of limestone were produced in Manitoba in 1973[2], and that over 52% of this was used by the two cement plants in Winnipeg.

TABLE C-2

LIMESTONE ALLOCATION DATA, 1973
(000 tons)
MANITOBA

Use	Statistics Canada*	Revised	Percent Adjustment
Rubble & riprap	2.8	—	—
Concrete aggregate	35.0	35.0	nil
Asphalt aggregate	75.0	75.0	nil
Road metal	239.9	518.6	116.2
Railroad ballast	—	24.7	—
Canadian cement & lime plants	—	724.3	—
Other uses	237.6	—	—
Total	590.3*	1,377.6	133.3

* Total excludes 34,979 tons used in pulverized stone and other uses. It also excludes limestone production at Mafeking, Manitoba which is all shipped to Regina.

Sources: 1. Statistics Canada Cat. 26 - 217
2. Producer and user survey.

[1] See Appendix 3 for Statistics Canada data for earlier years.

[2] Discussions with producers indicated that distinctions between limestone, sand and gravel are not always observed by operators in reporting production.

With reference to Table C-2, it is to be noted that the limestone allocation data encompasses the total province. It was not possible to allocate usage within the Winnipeg Region from the survey information, as was done in the case of sand and gravel. Limestone is extracted from quarries outside the Region for use in cement production in Winnipeg. Cement production represents over 50% of the total usage of limestone. As this major use of limestone in the form of cement could not be traced geographically, no attempt was made to allocate any of the cement or non-cement uses of limestone on a geographical basis, from commodity and industry flow data. An estimate of limestone usage within the Winnipeg Region, based on shares of total construction activity, is presented in sub-section 4.2.2 (c).

2.3 Allocation by Construction Sector

2.3.1 Sand and Gravel

Tables C-1 and C-2 by themselves do not provide sufficient data to identify the proportion of sand, gravel and limestone being directed into each construction sector. These estimates were derived from the major users participating in the survey. Survey data concerning the allocation of concrete aggregate made it possible to determine the final end-use allocation for sand and gravel production in 1973. This is shown in Table C-3 by construction sector.

2.3.2 Limestone

The allocation of end-use quantities for limestone involved an intermediate step of identifying the amount of limestone used in cement, which in turn is used in concrete, redi-mix and in other applications. This process involved discussions with representatives of the two cement plants to identify all end-use sectors for cement.

Table C-4 provides all end-use estimates for limestone in Manitoba in 1973, including a category labelled exports and unallocated. This latter category accounts for a substantial portion of the total, and represents cement used in hydro construction and mining (not likely to occur in the Winnipeg Region) and cement exported from the province.

TABLE C-3

SAND & GRAVEL

FINAL END USE ALLOCATION, MANITOBA 1973

(000 tons)

	Concrete Aggregate	Other Sand & Gravel	Total	Percent Allocated to Each Sector
Residential	922.9	51.8	974.7	6.7
Non-Residential Building	669.1	294.0	963.1	6.7
Road Construction	) 733.8	) 10,830.9	9,218.0	63.8
Other Engineering	)	)	2,346.7	16.2
Not Allocated	—	946.5	946.5	6.6
Total Production	2,325.8	12,123.2	14,449.0	100.0

Sources: 1. Statistics Canada
2. Producer and user survey

TABLE C-4

LIMESTONE

FINAL END USE ALLOCATION, MANITOBA 1973

Use	Tons	Percent Allocated to Each Sector
Residential	191,253	13.9
Non-Residential Building	100,895	7.3
Road Construction	599,101	43.5
Other Engineering	138,308	10.0
Exported & Unallocated	349,165*	25.3
Total	1,378,722	100.0

* Limestone used in cement exported from province or otherwise used in mining and hydro construction (not likely to occur in the Winnipeg Region).

Sources: 1. Statistics Canada
2. Producer and user survey

2.4 Aggregate Usage in the Winnipeg Region

Based upon interviews conducted with users and producers, it was possible to undertake the same type of allocation for sand and gravel in the Winnipeg Region as was performed for the province, i.e., allocation of consumption in the four major construction sectors. As indicated earlier, limestone usage in the Winnipeg Region could not be allocated from survey information. However, by combining 1973 construction spending in the Region and subregions with the aggregated usage coefficients for limestone, derived in Sub-Section 3, it was possible to allocate limestone consumption by construction sector in the Region. The results of this analysis are included in Table C-5[1].

Table C-5 indicates that the Winnipeg Region consumes the majority of total provincial aggregate requirements in the residential and non-residential building construction categories, but far less in the road construction and other engineering categories. In itself, this result is not particularly surprising, given the high rate of building construction activity known to be occurring in the Winnipeg Region, plus the stated priorities of the Manitoba Government with respect to increased road construction in the rural and northern areas. As local improvement expenditures by municipalities in the Winnipeg Region are known to be relatively high[2], the low share of other engineering construction (58%), is explained by the existence of other users outside the Region who obviously require aggregate for backfill and other purposes.

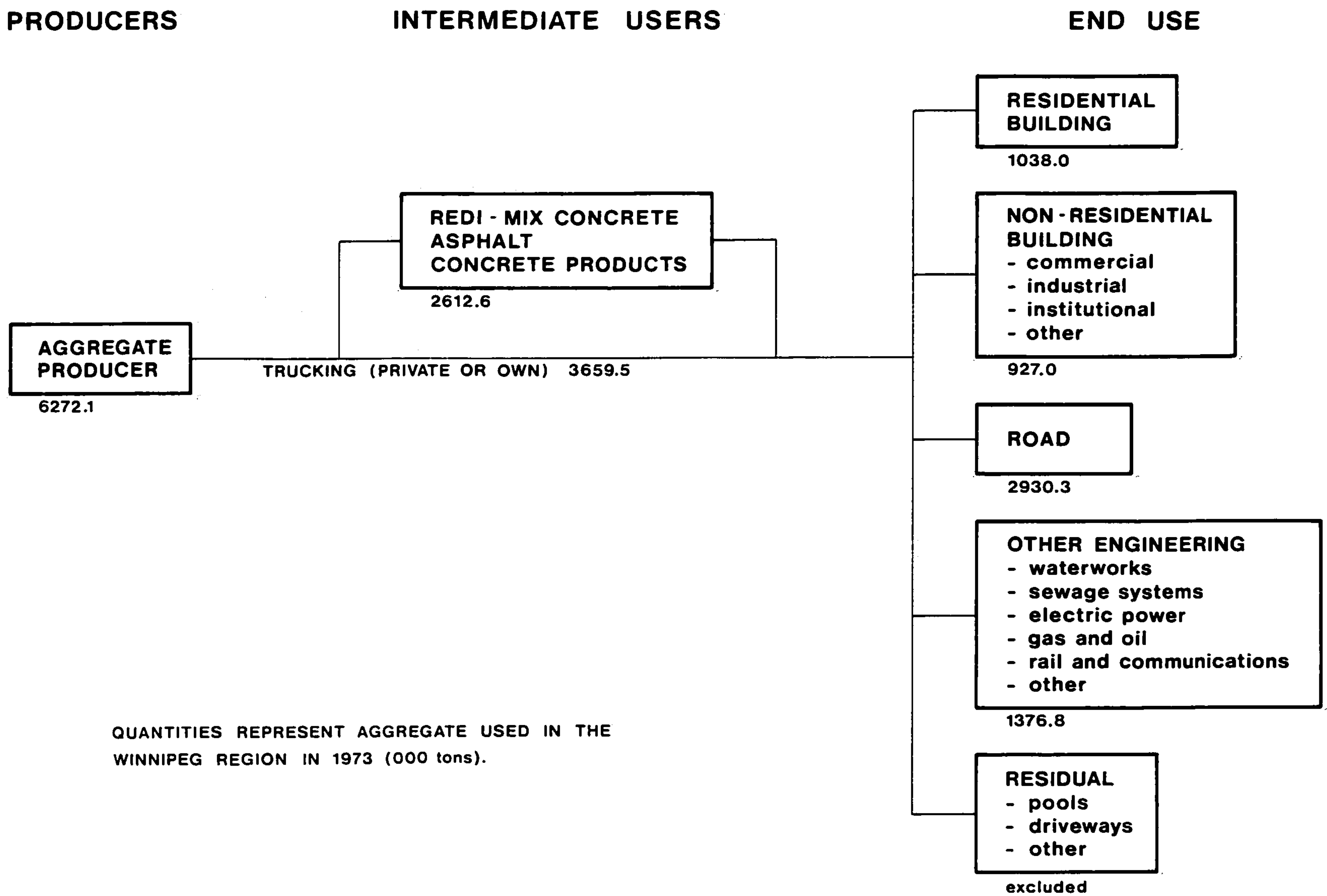
Plate C-2 depicts the nature of the industry flow of aggregate from producer through intermediate and end user. The quantities shown are for the Winnipeg Region for 1973, and correspond to the end use consumption figures in Table C-5.

[1] Details of this method of analysis are contained in Sub-Section 5 which deals with forecasts.
[2] Aggregate uses for municipal local improvements fall into the other engineering category.

TABLE C-5
CONSUMPTION OF AGGREGATE
WINNIPEG REGION 1973
(000 tons)

	Winnipeg Region	Revised Manitoba Total	Winnipeg Region Percent of Province
Residential			
Sand & Gravel	869.9	974.7	89.2
Limestone	168.1	191.3	87.9
Total	1038.0	1166.0	89.0
Non-Residential			
Sand & Gravel	843.1	963.1	87.5
Limestone	83.9	100.9	83.2
Total	927.0	1064.0	87.1
Road Construction			
Sand & Gravel	2331.2	9218.0	25.3
Limestone	599.1	599.1	100.0
Total	2930.3	9817.1	29.9
Other Engineering			
Sand & Gravel	1296.8	2346.7	55.3
Limestone	80.0	138.3	57.8
Total	1376.8	2485.0	55.4
Total Construction			
Sand & Gravel	5341.0	13,502.5	39.6
Limestone	931.1	1,029.6	90.4
Total	6272.1	14,532.1	43.2

* Excludes Residual Category



Aggregate Resources of the Winnipeg Region

Mineral Aggregate Industry Flow Chart Winnipeg Region, 1973

3. AGGREGATE USAGE COEFFICIENTS

3.1 Aggregate Usage Coefficients

3.1.1 Definition and Use

The aggregate usage coefficient as defined in this study, is a technical/economic measure of the amount of construction aggregate consumed per dollar of construction. As with other types of input-output measure, such a coefficient can be utilized in forecasting future requirements for aggregate, simply by multiplying the value of the coefficient by the projected value of construction measured in constant dollars. These coefficients are derived from the profile of the construction industry in a given year; 1973 has been used for the analysis. In doing this, there is an implied assumption that aggregate usage per dollar of construction, measured in constant dollars, is constant over time.

3.1.2 Sources of Data

Calculation of aggregate usage coefficients was a two-stage process, involving review of published Statistics Canada data on the construction (aggregate) industry, plus detailed discussions with producers and users in the Winnipeg Region and beyond. The principal data base for these calculations is the table of final end use allocation for sand, gravel and limestone in Table C-5 and the Manitoba sector construction values for 1973, contained in Table C-6 of Sub-section 4.

3.1.3 Aggregate Usage Coefficients for Sand and Gravel

The construction value from Table C-6, combined with the construction end use allocation for sand and gravel in Table C-5, yields an aggregate usage coefficient for each construction sector. These are tabulated below.

Aggregate Usage Coefficients for Sand and Gravel

	Sand & Gravel End Use Allocation (000 tons)	1973 Value of Construction ($000)	Aggregate Usage Coefficient (tons per dollar of construction)
Residential	974.7	271,649	0.003588
Non-Residential	963.1	167,950	0.005734
Road Construction	9,218.0	86,806	0.106191
Other Engineering	2,346.7	161,437	0.014536

As expected, the coefficient for road construction is substantially higher than for any other sector, i.e., one-tenth of one ton of sand and gravel is required for every dollar spent in this sector. In contrast, the coefficients for both residential and non-residential building are quite low. It is significant that the largest proportion of sand and gravel used in these two sectors is in the form of concrete aggregate, rather than as a separate granular material. This is apparent from the data presented previously in Table C-3.

3.1.4 Aggregate Usage Coefficients for Limestone

Similarly, Tables C-5 and C-6 yield the following usage coefficients for limestone.

AGGREGATE USAGE COEFFICIENTS FOR LIMESTONE

	Limestone End Use Allocation (000 tons)	1973 Value of Construction ($000)	Aggregate Usage Coefficient (tons per dollar of construction)
Residential	191.3	271,649	0.000704
Non-Residential	100.9	167,950	0.000601
Road Construction	599.1	86,806	0.006902
Other Engineering	138.3	161,437	0.000857

As expected, the values of these coefficients are much smaller than those for sand and gravel. The coefficient for road construction is the largest of these and reflects its direct application as granular material in road construction, rather than as concrete surfaced roads.

3.1.5 Applying Province-wide Coefficients at the Sub-provincial Level

These aggregate usage coefficients developed for forecasting purposes, are based on province-wide data and some unavoidable error is inherent in attempting to apply them to the Winnipeg Region. However, the removal of activities such as hydro construction and mining allows for some of the known differences and helps to improve the reliability of the estimates.

While Table C-5 of Sub-Section 2 details consumption of aggregate in the Winnipeg Region for 1973, it is not possible to calculate aggregate usage coefficients directly for the Winnipeg Region, because of the absence of construction values. However, the relative weights given to residential and non-residential building construction in the region suggest that an aggregate usage coefficient for the total construction in the region (if one were to be calculated) would be 48% lower than a similar coefficient for the province as a whole. This is because of the very high coefficient values for road construction and other engineering activities which occur largely outside the Winnipeg Region.

The aggregate usage coefficients derived here are used in forecasts presented in Sub-Section 5.

4. ANALYSIS OF CONSTRUCTION ACTIVITY IN THE WINNIPEG REGION

4.1 Proportionate Distribution of Total Construction Spending in Manitoba

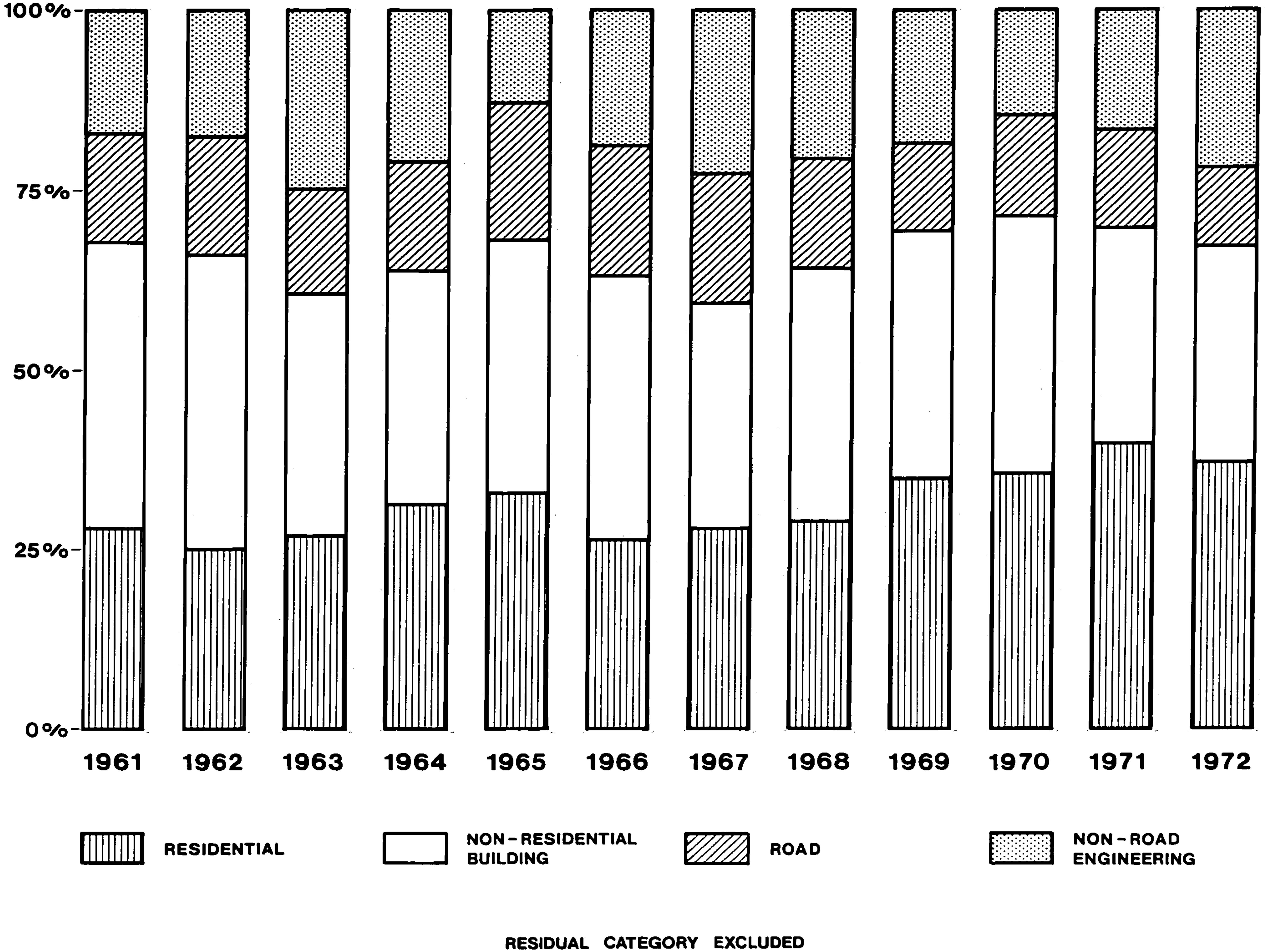
For purposes of this study, construction activities are defined according to five basic sectors or categories — residential, non-residential, road construction, other engineering and residual[1]. The value of construction and percentage share of total construction expenditures in Manitoba, accruing to each of these construction sectors in the period 1963 to 1973 is shown in Table C-6. The value of construction is reported in 1973 dollars (using the GNP implicit price deflator) to facilitate subsequent analysis. Plate C-3 depicts these percentages graphically.

With reference to Table C-6, the percentage data does not reveal any apparent trends in the share of construction activity by sector. In the residential sector, for example, the increase in the percentage share from 26.4% in 1966 to 39.5% in 1973, can probably be described more or less as a short term phenomenon, reflecting very rapid growth in households during the late 1960's (especially non-family households) and corresponding increases in the housing stock. As housing starts in Winnipeg and other Manitoba centres fell off sharply after 1974, there is no basis for assuming that such a trend will continue in the future.

Similar conclusions can be advanced with respect to non-residential building. The fall in percentage share (from 37.1% in 1966 to 24.4% in 1973) is due in part to the rapid increase in the percentage share of residential construction spending during this period, and in part to relative increases in other engineering construction — especially in 1972 and 1973. Again, whether such a trend will continue in the future is open to question.

In cases where trends or relationships in the data are not evident, regression analysis, a popular statistical technique used in analysing the relationship between a number of variables, yields unsatisfactory results. In these cases, an alternative to the projection of trends, involves the calculation of the average or mean value for a set of observations, along

[1] For a definition of these categories, see Sub-Section 1.4.



Aggregate Resources of the Winnipeg Region

Sector Shares of Total Construction Value in Manitoba

TABLE C-6

SECTOR CONSTRUCTION VALUES IN MANITOBA 1963 — 1973
(1973 Constant Dollars)
($000)

Year	Residential	Non-Residential	Road	Other Engineering	Residual	Total
1963	146,829	181,306	76,935	132,083	118,005	655,158
1964	181,102	184,526	84,572	122,967	90,035	663,202
1965	169,985	181,853	95,697	66,678	102,597	616,810
1966	151,888	213,814	98,361	111,930	102,656	678,649
1967	162,938	196,596	91,189	131,802	169,123	751,648
1968	175,872	219,229	87,564	134,278	268,528	885,471
1969	236,565	230,959	85,183	125,851	377,791	956,349
1970	223,630	226,626	81,259	98,000	217,147	846,662
1971	239,308	188,514	79,156	109,188	157,848	774,014
1972	260,621	206,732	83,726	139,110	125,423	815,612
1973	271,649	167,950	86,806	161,437	201,045	889,247

PERCENTAGE DISTRIBUTION OF CONSTRUCTION EXPENDITURES IN MANITOBA*

	Residential	Non-Residential	Road	Engineering	Total
1963	27.3	33.8	14.3	24.6	100.0
1964	31.6	32.2	14.7	21.5	100.0
1965	33.1	35.4	18.6	12.9	100.0
1966	26.4	37.1	17.1	19.4	100.0
1967	28.0	33.7	15.7	22.6	100.0
1968	28.5	35.5	14.2	21.8	100.0
1969	34.9	34.0	12.6	18.5	100.0
1970	35.5	36.0	12.9	15.6	100.0
1971	38.8	30.6	12.8	17.8	100.0
1972	37.8	29.9	12.1	20.2	100.0
1973	39.5	24.4	12.6	23.5	100.0

* Residual category excluded since it represents construction activity unlikely to occur in the Winnipeg Region and therefore is not of interest.

Source: Statistics Canada, Construction in Canada, Cat. 64-201.

with the standard deviation of the data, which is a measure of the average fluctuation of the observed data about this mean. These parameters are then used to determine the average and maximum expected values of any observation or occurrence of the statistic. Statistical theory would suggest, for example, that 68% of all observations will be found within one standard deviation of the mean. This then provides a predictive model for forecasting.

The application of this analytical method to the percentage shares in Table C-6 (eleven observations) yields the following results for each sector.

Proportionate Distribution of Total Construction Spending in Manitoba

Construction Category	Mean (Percent)	Standard Deviation
Residential	32.9	4.81
Non-Residential	33.0	3.60
Road Construction	14.3	2.08
Other Engineering	19.8	3.50
Total	100.0	—

These mean percentage shares, combined with a forecast of total construction value, ultimately provide a forecast of construction expenditures by sector.

4.2 Distribution of Construction Spending Within Subregions of the Winnipeg Region

4.2.1 Subregional Shares of Residential and Non-Residential Construction

The table below outlines the subregional percentage shares of the total provincial residential and non-residential construction for the years 1963 - 1974, based on Statistics Canada data.

Percentage Shares of Residential and Non-Residential Construction

	East	West	Interlake	Greater Winnipeg	Total Winnipeg Region
Residential					
1963	2.3	3.6	0.3	83.5	89.7
1964	3.7	3.8	0.5	80.0	88.0
1965	2.6	3.5	0.7	81.6	88.4
1966	2.1	3.3	0.6	78.9	84.9
1967	2.1	3.5	0.6	75.9	82.1
1968	1.6	3.0	0.4	81.8	86.8
1969	1.4	2.6	0.4	88.6	93.0
1970	3.3	2.8	0.5	83.4	90.0
1971	1.8	3.3	0.9	83.6	89.6
1972	2.7	2.6	0.9	81.4	87.6
1973	4.1	4.7	1.4	76.2	86.4
1974	5.6	5.8	2.3	74.3	88.0

	East	West	Interlake	Greater Winnipeg	Total Winnipeg Region
Non-Residential					
1963	1.0	3.1	0.1	75.4	79.6
1964	1.8	5.1	0.1	80.1	87.1
1965	2.1	3.9	0.4	77.7	84.1
1966	1.3	6.0	2.3	75.0	84.6
1967	2.3	2.5	0.4	75.7	80.9
1968	2.1	4.3	0.7	82.9	90.0
1969	1.8	4.5	1.1	81.6	89.0
1970	4.0	1.8	0.3	59.8	65.9
1971	3.7	2.2	0.1	71.2	77.2
1972	2.3	4.2	0.9	77.4	84.8
1973	3.5	4.0	0.6	76.9	85.0
1974	2.4	4.6	1.9	80.4	89.3

It is difficult to identify any conclusive trends with respect to the share of residential and non-residential construction in the four subregions, compared to the provincial total. The means and standard deviations of each series, can easily be calculated:

Subregional Shares of Residential and Non-Residential Construction

	Mean (Percent)	Standard Deviation
Residential		
East	2.8	1.22
West	3.5	0.97
Interlake	0.8	0.56
Greater Winnipeg	80.8	4.00
Total Winnipeg Region	87.9	—
Non-Residential		
East	2.4	0.93
West	3.9	1.24
Interlake	0.7	0.71
Greater Winnipeg	76.2	6.09
Total Winnipeg Region	83.2	—

While the mean values derived above are not reflective of the total population in each area, there is a strong (albeit approximate) relationship between these values and the distribution of urban population (over 1,000 persons) in these four regions in 1971. This relationship can be illustrated for both the residential and non-residential building sectors by converting the above mean values from a provincial base to a Winnipeg Region base. For example, from the previous analysis, the Greater Winnipeg residential mean value of 80.8 is 91.9 percent of the Winnipeg Region value of 87.9.

Comparison of Residential and Non-Residential Subregional Shares to Winnipeg Region Urban Population

	Residential Mean Value	Non-Residential Mean Value	1971 Winnipeg Region Urban Population
	%	%	%
East	3.2	2.9	2.8
West	4.0	4.7	3.1
Interlake	0.9	0.8	0.3
Greater Winnipeg	91.9	91.6	93.8
Total Winnipeg Region	100.0	100.0	100.0

Based upon population projections developed during this study, the following ratios of urban population levels are forecast for the Winnipeg Region to 1966[1].

Percentage of Urban Population in Subregions

	1971	1976	1981	1986	1991	1996
East	2.8	2.8	2.7	2.7	2.7	2.8
West	3.1	3.0	3.0	2.9	2.9	2.9
Interlake	0.3	0.3	0.3	0.3	0.3	0.3
Greater Winnipeg	93.8	93.9	94.0	94.1	94.1	94.0
Total Winnipeg Region	100.0	100.0	100.0	100.0	100.0	100.0

In other words, while some minor shifts are contemplated in the share of urban population allocated to each subregion, the shifts are not of great enough significance to warrant any modifications to the residential and non-residential mean values calculated above.

[1] See population projections, Appendix 4.

4.2.2 Road Construction and Maintenance

(a) Proportionate Share of Sand, Gravel and Limestone Used in the Winnipeg Region

Road construction by far represents the most important use of aggregate. As expenditures on road construction and maintenance are not available by subregion, survey data on the actual amount of aggregate used, is the basis for the analysis of road construction activity.

Table C-5 presented earlier, reveals that 2930 tons, or 29.9% of the 9817 tons of aggregate used in road construction and maintenance throughout the province in 1973, was used in the Winnipeg Region. This proportionate share factor of 0.299 is ultimately used to calculate the subregional shares of road construction and maintenance activity in the Winnipeg Region.

(b) Proportionate Distribution within Subregions of the Winnipeg Region

(i) Provincial Roads

The amount of aggregate used by the Manitoba Department of Highways in the Winnipeg Region is summarized in Tables C-7 and C-8. The data is shown for alternate years in the period 1965 - 1974 and refers only to road construction and maintenance work carried out by the Department of Highways; federal and municipal road activity is not included.

Table C-7 reveals that considerable fluctuations occur in the subregional shares of road construction and maintenance mileage in the Winnipeg Region. As the amount of aggregate used in road construction may be higher by a factor of five or ten than the amount used in road maintenance, measured on a per mile basis, a forecast of subregional use based on historical mileage shares is not possible. Total aggregate used, in all road construction and maintenance, as set out for each subregion in Table C-8, provides a more reliable data base for forecasting purposes.

With reference to Table C-8, the proportionate distribution

TABLE C-7

SUMMARY OF PROVINCIAL ROAD CONSTRUCTION AND MAINTENANCE ACTIVITY: MILEAGE BY SUB-REGION ALTERNATE YEARS, 1965 to 1974*

	East	West	Interlake	Greater Winnipeg	Total Winnipeg Region
1965					
Construction	47.80	48.35	24.65	29.81	150.61
Maintenance	45.00	173.80	93.40	25.00	337.20
Total	92.80	222.15	118.05	54.81	487.81
1967					
Construction	41.31	56.66	32.25	5.05	135.27
Maintenance	158.30	60.20	19.00	—	237.50
Total	199.61	116.86	51.25	5.05	372.77
1969					
Construction	50.78	44.10	57.82	8.25	160.95
Maintenance	28.70	40.60	29.70	—	99.00
Total	79.48	84.70	87.52	8.25	259.95
1971					
Construction	55.20	50.58	5.60	4.10	115.48
Maintenance	60.00	161.80	51.80	—	273.60
Total	115.20	212.38	57.40	4.10	389.08
1973					
Construction	94.80	27.75	73.00	5.90	201.45
Maintenance	47.30	102.90	16.30	14.00	180.50
Total	142.10	130.65	89.30	19.90	381.95
1974					
Construction	39.80	44.35	2.10	4.50	90.75
Maintenance	16.40	63.25	3.90	7.10	90.65
Total	56.20	107.60	7.00	11.60	181.40

Source: Department of Highways.

* Alternate years' data were considered sufficient for the analysis in view of the effort required to assemble this detailed information.

varies widely by year, according to the incidence of road construction and maintenance contracts in any given locality. Since road work is a "lumpy" investment designed to provide benefits to users over a number of years, it follows that the total aggregate used over a period of years, is the most appropriate basis for calculating subregional shares.

TABLE C-8

AGGREGATE USED IN PROVINCIAL GOVERNMENT ROAD CONSTRUCTION AND MAINTENANCE: WINNIPEG REGION ALTERNATE YEARS, 1965 to 1974* (Tons)

	East	West	Interlake	Greater Winnipeg	Total Winnipeg Region
1965	407,810	982,645	312,303	462,052	2,164,810
Per cent	18.8	45.4	14.4	21.4	100.0
1967	827,013	515,470	79,050	80,950	1,502,483
Per cent	55.0	34.3	5.3	5.4	100.0
1969	289,015	445,160	149,570	153,335	1,037,080
Per cent	27.9	42.9	14.4	14.8	100.0
1971	657,445	523,224	60,340	161,710	1,402,719
Per cent	56.9	37.3	4.3	11.5	100.0
1973	698,453	215,933	94,526	124,650	1,133,562
Per cent	61.6	19.1	8.3	11.0	100.0
1974	440,904	300,170	72,900	81,590	895,564
Per cent	49.2	33.5	8.1	9.1	100.0
Total Selected Years	3,320,640	2,982,602	768,689	1,064,287	8,136,218
Per cent	40.7	36.7	9.5	13.1	100.0

Source: Manitoba Department of Highways

* Alternate years' data were considered sufficient for the analysis in view of the effort required to assemble this detailed information.

The totals shown in Table C-8 represent the total amount of aggregate used for provincial road construction and maintenance within each subregion, in the years covered by the analysis. These totals are summarized below.

Aggregate Used in Provincial Road Construction and Maintenance 1965 - 1974

Subregion	Tons (000)	Proportionate Distribution %
East	3320.6	40.7
West	2982.6	36.7
Interlake	768.7	9.5
Greater Winnipeg	1064.3	13.1
Total Winnipeg Region	8136.2	100.0

Source: Table C-8.

It must be appreciated that the above shares refer only to provincial road activity, and exclude road work performed by the municipalities in the Winnipeg Region.

(ii) Municipal Roads

The amount of aggregate used for municipal road construction and maintenance in 1973 was obtained through a survey of the municipalities in the Winnipeg Region.

Table C-9 incorporates this municipal data with the provincial data for 1973. On the basis of this, the proportionate distribution of aggregate for road construction and maintenance handled by both levels of government in 1973, is as follows:

Proportionate Distribution of Aggregate Used in Road Construction and Maintenance in the Winnipeg Region, 1973

Subregion	Total Aggregate Used, 1973 (000 tons)	1973 Proportionate Share
East	1015.4	50.2
West	414.4	20.5
Interlake	159.2	7.9
Greater Winnipeg	432.7	21.4
Total Winnipeg Region	2021.7	100.0

Source: Table C-9.

Compared with 1973 data in Table C-8, the effect of adding municipal road activity is to shift the distribution in favour of Winnipeg itself and away from the East subregion. The shares attributable to both the West and Interlake in 1973 change only moderately; 8.3% for the Interlake in 1973 in Table C-8, versus 7.9% for the combined 1973 total above.

TABLE C-9

AGGREGATE USED IN ROAD CONSTRUCTION AND MAINTENANCE ACTIVITY IN THE WINNIPEG REGION BY PROVINCIAL AND MUNICIPAL GOVERNMENTS 1973

(tons)

	Road Construction		Road Maintenance		
	Provincial	Municipal	Provincial	Municipal	Total
East	651,140	86,390	47,310	230,605	1,015,445
West	131,550	92,740	84,380	105,730	414,400
Interlake	78,140	39,700	16,380	25,030	159,250
Greater Winnipeg	110,630	173,200	14,020	134,800	432,650
Total Winnipeg Region	971,460	392,030	162,090	496,165	2,021,745*

Source: Survey results.

* Ignoring asphalt and concrete aggregate, the total reported is some 522,000 tons below the totals recorded for road construction in the Winnipeg Region in Tables C-1 and C-2, namely 2.025 million tons of sand and gravel and .519 million tons of limestone. User figures from the survey were typically lower than producer figures.

(iii) Combined Average for Road Construction and Maintenance 1964 - 1974

In the absence of municipal data for other years, it has been assumed that the volumes of aggregate used for municipal roadwork in 1973 also apply in other years. Given this assumption, the combined average proportionate distribution is determined as follows:

Aggregate Used in Provincial/Municipal Road Construction and Maintenance in the Winnipeg Region (000 tons)

	Total in Selected Years 1965 - 1974			
	Provincial*	Municipal**	Total	Proportionate Distribution %
East	3320.6	1902.0	5222.6	38.8
West	2982.6	1190.8	4173.4	31.0
Interlake	768.7	388.4	1157.1	8.6
Greater Winnipeg	1064.3	1848.0	2912.3	21.6
Total Winnipeg Region	8136.2	5329.2	13,465.4	100.0

* *Source:* Table C-8
** Estimate derived from survey of 1973 consumption.

(c) Subregional Shares of Road Construction and Maintenance

The proportionate distribution of aggregate by subregion, combined with the earlier estimate of Winnipeg Region's proportionate share of the total amount of aggregate used in road work throughout the province (29.9%)[1]; yields subregional shares relative to the total province. These are shown below:

Subregional Shares of Road Construction and Maintenance

Subregion	Proportionate Distribution %	Subregional Share %
East	38.8	11.6
West	31.0	9.3
Interlake	8.6	2.6
Greater Winnipeg	21.6	6.4
Total Winnipeg Region	100.0	29.9

The above subregional shares for road construction apply to **sand and gravel** consumption only. **Limestone** is a special case since almost all limestone used for road construction in the

[1] See Sub-Section 4.2.2.a)

province is used in roads within the Winnipeg Region. Thus the subregional shares for purposes of allocating limestone to the road sector, are identical to the figures in the above column labelled "proportionate distribution". In other words, the sum of the subregional shares for limestone must equal 100%. This is brought into full perspective in Sub-Section 5 which deals with forecasts.

4.2.3 Other Engineering Construction

(a) Proportionate Share of Aggregate Used in the Winnipeg Region

Table C-5, presented earlier, provides a summary of the amount of aggregate used in other engineering construction in the Winnipeg Region in 1973. From this, the Winnipeg Region share of the total province can be calculated.

Aggregate Used in Other Engineering Construction in 1973 (000 tons)

	Sand and Gravel	Limestone	Total
Winnipeg Region	1296.8	80.0	1376.8
All Manitoba	2346.7	138.3	2485.0
Winnipeg Region Share (%)	55.3	100.0	55.4

Source: Table C-5

The above table indicates that 55.4% of the aggregate used in other engineering construction throughout the province in 1973, was used in the Winnipeg Region. This proportionate share factor of 0.554 is ultimately used to calculate the subregional shares for other engineering construction.

(b) Proportionate Distribution Within Subregions of the Winnipeg Region

With reference to Table C-10, it is clear that capital spending by municipalities is subject to considerable fluctuation. All regions except Winnipeg for example, sharply reduced their local improvements capital spending in 1970 and 1971, and then increased expenditures again in 1972 and 1973. In lieu of being able to establish a trend, therefore, it would appear reasonable to accept the 1973 spending levels as "representative" of local improvement expenditures in these regions, viz:

East Region	$21.00 per capita
West Region	13.50 per capita
Interlake Region	13.00 per capita
Greater Winnipeg	53.25 per capita

TABLE C-10

MUNICIPAL CAPITAL WORKS SPENDING

Subregion	Total Municipal Works Capital Spending	Population	Per Capita Spending
	($000)	(000)	(Dollars)
East			
1969	1,462.1	57.3	25.21
1970	1,020.7	57.8	17.67
1971	719.9	58.5	12.30
1972	1,217.9	57.3	21.27
1973	1,191.2	56.8	20.99
West			
1969	691.5	39.4	17.57
1970	428.3	39.1	10.95
1971	429.6	40.3	10.67
1972	640.8	40.6	15.79
1973	545.7	41.0	13.32
Interlake			
1969	41.8	12.2	3.44
1970	2.1	11.7	0.18
1971	3.4	11.8	0.29
1972	183.2	12.5	14.70
1973	170.1	12.9	13.17
Greater Winnipeg			
1969	29,766.8	540.3	55.09
1970	20,515.7	544.4	37.68
1971	30,512.3	540.3	56.47
1972	29,020.4	542.9	53.45
1973	29,108.7	547.0	53.22

Sources: 1. Manitoba municipalities statistical summaries
2. Statistics Canada Cat. 91-206

The one major disadvantage of using such levels of per capita expenditures to establish proportionate distribution, is that they do not reflect the extent to which urbanization outside of Winnipeg proper leads to a rapid increase in municipal works spending in the other three subregions. In the **Winnipeg Region Planning Study Demand Analysis**, for example, the Municipal Planning Branch forecasts major population growth on the finges of Greater Winnipeg,particularly in the Winnipeg-Selkirk corridor. Strictly speaking, this growth is occuring outside Greater Winnipeg as defined here.

There has been no attempt to assign to the other three subregions any of the growth "spill over" occurring as residents increasingly occupying dwellings outside of the current boundaries of the City of Winnipeg. For this reason population, per capita spending, and other data can best be regarded as indicative of an area encompassing Winnipeg and any highly urbanized areas adjacent to the City.

Regarding the proportionate distribution within subregions, the per capita spending estimates, coupled with urban population ratios for the various subregions, presented previously in Sub-Section 4.2.1, provide the basis for the allocation as follows:

Proportionate Distribution of Other Engineering Construction

Subregion	Per Capita Spending ($)	Share of Urban Population %	Weighted Per Capita Spending	Proportionate Distribution %
East	21.00	2.7	0.567	1.1
West	13.50	3.0	0.405	0.8
Interlake	13.00	0.3	0.039	0.1
Greater Winnipeg	53.25	94.0	50.055	98.0
Total Winnipeg Region	51.07	100.0	51.066	100.0

(c) Subregional Shares of Other Engineering Construction

The relative percentage distribution of activity by subregion, combined with the Winnipeg Region's proportionate share of the aggregate used in other engineering construction, presented previously in Sub-Section 4.2.3.(a), yields the subregional shares for this sector.

Subregional Shares of Other Engineering Construction

Subregion	Proportionate Distribution %	Subregional Share %
East	1.1	.61
West	0.8	.44
Interlake	0.1	.06
Greater Winnipeg	98.0	54.29
Total Winnipeg Region	100.0	55.4

5. PROJECTED DEMAND FOR MINERAL AGGREGATE IN THE WINNIPEG REGION

5.1 Forecasts of Construction Activity and Spending

5.1.1 Methodology

An outline of the methodology used in forecasting construction aggregate requirements to 1996 in the Winnipeg Region and its respective subregions is briefly summarized below:

(a) Forecast Manitoba households.

(b) Forecast total construction spending in the province in 1973 constant dollars, using number of households as the independent variable. The linear regression equation developed for this purpose is:

$$Y = 162{,}394 + 2{,}968.2\,x$$

where

Y = total construction value (1973 constant dollars), excluding the residual category

X = number of Manitoba households

(c) Allocate total construction spending to residential, non-residential, road and other engineering.

(d) Allocate spending within each construction sector in the Winnipeg Region and its respective subregions.

(e) Apply aggregate usage coefficients to forecasts of construction spending.

The development of the above regression model is discussed in Appendix 5.

5.1.2 Forecast of Manitoba Households

A forecast of households is derived from population forecasts. In recognition of forecasting inaccuracies, some range estimate of future aggregate requirements is more desirable than a single point forecast. To achieve this, two population projections have been selected for purposes of forecasting Manitoba households — a "preferred" projection which is referred to as the base case, and a second or alternate projection.

The base case assumes a 1991 provincial population of 1,260 thousand persons. This corresponds to Projection G of the recent series of Statistics Canada projections. As an alternate to this base forecast, it is reasonable to consider a lower level of population in Manitoba in the year 1991. Projection A of the Statistics Canada series is appropriate for this, in that it assumes relatively high fertility and immigration rates, but also assumes that the out-migration levels of the 1968-71 period will prevail (resulting in a net interprovincial migration loss of some 10,000 persons per year). Projection A generates a Manitoba provincial population of 1,160 thousand in 1991.

Although some adjustments might theoretically be required, it has been assumed that the Winnipeg Region and subregion shares will not change with variations in estimated population.

A forecast of Manitoba households is presented in Appendix 4. The results of these forecasts are presented below for reference purposes.

	Base Projection G		Alternate Projection A	
	Number of Households (000)	Persons Per Household	Number of Households (000)	Persons Per Household
1976	304.7	3.40	297.1	3.41
1981	330.9	3.35	316.4	3.36
1986	366.4	3.24	333.9	3.35
1991	374.1	3.37	349.2	3.35
1996	415.5	3.20	360.4	3.35

Given a recent Statistics Canada estimate of 306,000 households in Manitoba in 1974, it should be appreciated that the above figures are likely conservative estimates of the future number of households in Manitoba. In other words, the propensity to form households is likely even higher than suggested by 1971 Census data, especially for age groups under 25 years and over 55 years.

5.1.3 Forecast of Construction Spending

Tables C-11 and C-12 detail construction spending in Manitoba by sector to 1996 in 5 year intervals[1] for a base case and for an alternate economic projection as derived from the regression model presented earlier[2]. The only substantive difference between these two projections is the number of households assumed in Manitoba in each five year interval.

The factors employed in Tables C-11 and C-12 to allocate total construction spending by sector in the province are shown below. These represent the proportionate distribution of total construction spending calculated and presented earlier in Sub-Section 4.1.

Proportionate Distribution of Total Construction Spending

Sector	Proportion %
Residential	0.329
Non-Residential	0.330
Road	0.143
Other Engineering	0.198
Total	1.000

TABLE C-11

BASE CASE FORECAST OF CONSTRUCTION ACTIVITY BY SECTOR IN MANITOBA 1973 — 1996

Construction Spending, 1973

Constant Dollars ($000)

	1973	1976	1981	1986	1991	1996
Residential	$271,649	$244,076	$269,698	$304,339	$311,922	$352,333
Non-Residential	167,950	244,818	270,518	305,264	312,870	353,404
Road	86,806	106,088	117,224	132,281	135,577	153,142
Other Engineering	161,437	146,891	162,311	183,159	187,722	212,043
Total*	687,842	741,872	819,750	925,043	948,091	1,070,922
Number of Households (000)	292.0	304.7	330.9	366.4	374.1	415.5

* excludes residual category

[1] Corresponds to population forecast intervals.

[2] Since 1973 shares of total construction are apparently somewhat "abnormal" in relation to long term trends, forecasted values for residential construction and for other engineering decline initially from 1973 actual values.

TABLE C-12
ALTERNATE FORECAST OF CONSTRUCTION ACTIVITY BY SECTOR IN MANITOBA 1973 — 1996

Construction Spending, 1973 Constant Dollars ($000)

	1973	1976	1981	1986	1991	1996
Residential	$271,649	$236,673	$255,523	$272,670	$287,559	$298,549
Non-Residential	167,950	237,392	256,300	273,499	288,434	299,457
Road	86,806	102,870	111,063	118,516	124,988	129,765
Other Engineering	161,437	142,435	153,780	164,099	173,060	179,674
Total *	687,842	719,370	376,667	838,785	874,041	907,445
Number of Households (000)	292.0	297.1	316.4	333.9	349.2	360.4

* excludes residual category

With reference to construction activity within the Winnipeg Region itself, Tables C-13 and C-14 present the estimated construction values by sector and by subregion for the years 1976 to 1996. These estimates are derived by multiplying the values reported in Tables C-11 and C-12 by the following subregional shares which were developed in Sub-Section 4 of this report.

Subregional Shares of Construction Activity by Sector

Subregion	Residential	Non-Residential	Road[1] Sand & Gravel	Road[1] Limestone	Other Engineering
East	0.028	0.024	0.116	0.388	0.0061
West	0.035	0.039	0.093	0.310	0.0044
Interlake	0.008	0.007	0.026	0.086	0.0006
Greater Winnipeg	0.808	0.762	0.064	0.216	0.5429
Total Winnipeg Region	0.879	0.832	0.299	1.000	0.5540

[1] True subregional shares of road construction activity are those shown for sand and gravel. Subregional shares for limestone reflect limestone consumption, not road construction activity. See Sub-Section 4.2.2.(c) for explanatory comments.

It will be noted that provision is not made for future changes in the mix of construction activity within the Winnipeg Region, since the shares listed above are fixed throughout the period to 1996.

5.2 Forecasts of Aggregate Demand by Sector and Subregion, 1976 - 1996

The final step in the process of calculating construction aggregate requirements in the Winnipeg Region is to apply the aggregate usage coefficients derived in Sub-Section 3 to the construction values from Tables C-13 and C-14. The results of this multiplication are presented in Tables C-15 and C-16 for sand and gravel and for limestone, with annual totals shown by construction sector within each subregion, in five year intervals to 1996.

Trends in base case aggregate requirements by year from 1976 to 1996 for the Winnipeg Region, are presented in Table C-17 and in the accompanying graph, Plate C-4. Table C-17 gives cumulative requirements by subregion while the graph displays total annual Winnipeg Region requirements for sand and gravel and for limestone, as well as total requirements for all aggregate.

Cumulative requirements for construction aggregate for the period 1976-1996 are summarized below for both the base case and the alternate projection. The cumulative totals for the base case are those in Table C-17; detailed year-by-year cumulative totals have not been presented for the alternate projection.

Cumulative Requirements for Aggregate in the Winnipeg Region 1976 — 1996 (000 tons)

	Base Case	Alternate Projection
Sand and Gravel	166,595	151,500
Limestone	27,441	24,970
Total	194,036	176,470

TABLE C-13

WINNIPEG REGION CONSTRUCTION ACTIVITY
BASE CASE PROJECTION

Construction Spending, 1973
Constant Dollars ($000)

	1976	1981	1986	1991	1996
Residential					
Total	214,543	237,065	267,514	274,179	309,701
East	6,834	7,552	8,521	8,734	9,865
West	8,543	9,439	10,652	10,917	12,332
Interlake	1,953	2,158	2,435	2,495	2,819
Greater Winnipeg	197,213	217,916	245,906	252,033	284,685
Non-Residential					
Total	203,689	225,071	253,980	260,308	294,032
East	5,876	6,492	7,326	7,509	8,482
West	9,548	10,550	11,905	12,202	13,783
Interlake	1,714	1,894	2,137	2,190	2,474
Greater Winnipeg	186,551	206,135	232,611	238,407	269,294
Road — Sand and Gravel[1]					
Total	31,720	34,050	39,552	40,538	45,789
East	12,306	13,598	15,345	15,727	17,764
West	9,866	10,902	12,302	12,609	14,242
Interlake	2,758	3,048	3,439	3,525	3,982
Greater Winnipeg	6,790	7,502	8,466	8,677	9,801
Road — Limestone[2]					
Total	106,088	117,224	132,281	135,577	153,142
East	41,162	45,483	51,325	52,604	59,419
West	32,887	36,339	41,007	42,029	47,474
Interlake	9,124	10,081	11,376	11,660	13,170
Greater Winnipeg	22,915	25,320	28,573	29,285	33,079
Other Engineering					
Total	84,903	93,816	105,866	108,503	122,561
East	940	1,039	1,172	1,201	1,357
West	676	747	843	864	975
Interlake	88	97	110	113	127
Greater Winnipeg	83,199	91,933	103,741	106,326	120,101
Total Construction[3]					
Total	534,855	591,002	666,912	683,528	772,083
East	25,956	28,681	32,364	33,171	37,468
West	28,633	31,638	35,702	36,592	51,332
Interlake	6,513	7,197	8,121	8,325	9,402
Greater Winnipeg	473,573	523,486	590,724	605,443	683,881

[1] True proportion of construction activity but applicable to sand and gravel consumption only.

[2] Effective shares of construction activity for purposes of forecasting limestone consumption for roads, i.e., reflecting that the industry use of limestone for roads in the province is essentially confined to road construction activity in the Winnipeg Region.

[3] Including Road[1] above and excluding residual category.

TABLE C-14

WINNIPEG REGION CONSTRUCTION ACTIVITY
ALTERNATE PROJECTION

Construction Spending, 1973
Constant Dollars ($000)

	1976	1981	1986	1991	1996
Residential					
Total	208,036	224,605	239,677	252,764	262,429
East	6,627	7,155	7,635	8,052	8,359
West	8,284	8,943	9,543	10,065	10,449
Interlake	1,893	2,044	2,181	2,300	2,388
Greater Winnipeg	191,232	206,463	220,317	232,348	241,228
Non-Residential					
Total	197,510	213,242	227,551	239,977	249,148
East	5,697	6,151	6,564	6,922	7,187
West	9,258	9,995	10,666	11,249	11,679
Interlake	1,662	1,794	1,914	2,019	2,096
Greater Winnipeg	180,893	195,301	208,406	219,787	228,186
Road — Sand and Gravel[1]					
Total	30,758	33,208	35,436	37,371	38,800
East	11,933	12,883	13,748	14,499	15,053
West	9,567	10,329	11,022	11,624	12,068
Interlake	2,675	2,888	3,081	3,250	3,374
Greater Winnipeg	6,584	7,108	7,585	7,999	8,305
Road — Limestone[2]					
Total	102,870	111,063	118,516	124,988	129,765
East	39,914	43,092	45,984	48,495	50,349
West	31,890	34,429	36,740	38,746	40,227
Interlake	8,847	9,551	10,192	10,749	11,160
Greater Winnipeg	22,220	23,990	25,599	26,997	28,029
Other Engineering					
Total	82,327	88,885	94,849	100,029	103,852
East	912	984	1,050	1,108	1,150
West	655	707	755	796	827
Interlake	85	92	98	104	108
Greater Winnipeg	80,675	87,101	92,946	98,021	101,767
Total Construction[3]					
Total	518,631	559,940	497,513	630,141	654,225
East	25,169	27,173	29,997	30,581	31,749
West	27,764	29,974	31,986	33,734	35,023
Interlake	6,315	6,818	7,274	7,673	7,966
Greater Winnipeg	459,384	495,973	529,254	558,155	579,486

[1] True proportion of construction activity but applicable to sand and gravel consumption only.

[2] Effective shares of construction activity for purposes of forecasting limestone consumption for roads, i.e., reflecting that the industry use of limestone for roads in the province is essentially confined to road construction activity in the Winnipeg Region.

[3] Including Road[1] above and excluding residual category.

TABLE C-15

BASE CASE FORECAST OF AGGREGATE REQUIREMENTS: WINNIPEG REGION 1973 — 1996

(000 tons)

	1973*	1976	1981	1986	1991	1996
Sand and Gravel						
East	N/A	1,379	1,523	1,719	1,762	1,990
West	N/A	1,143	1,263	1,425	1,461	1,650
Interlake	N/A	311	344	388	398	449
Greater Winnipeg	N/A	3,707	4,097	4,624	4,739	5,353
Total	5,341	6,540	7,227	8,156	8,360	9,442
Limestone						
East	N/A	293	324	366	376	423
West	N/A	241	265	300	308	348
Interlake	N/A	67	72	82	84	95
Greater Winnipeg	N/A	479	529	597	611	691
Total	931	1,080	1,190	1,345	1,379	1,557
All Aggregate						
East	N/A	1,672	1,847	2,085	2,138	2,413
West	N/A	1,384	1,528	1,725	1,769	1,998
Interlake	N/A	378	416	470	482	544
Greater Winnipeg	N/A	4,186	4,626	5,221	5,350	6,044
Total	6,272	7,620	8,417	9,501	9,739	10,999

* estimated actual

TABLE C-16

ALTERNATE FORECAST OF AGGREGATE REQUIREMENTS: WINNIPEG REGION 1973 — 1996

(000 tons)

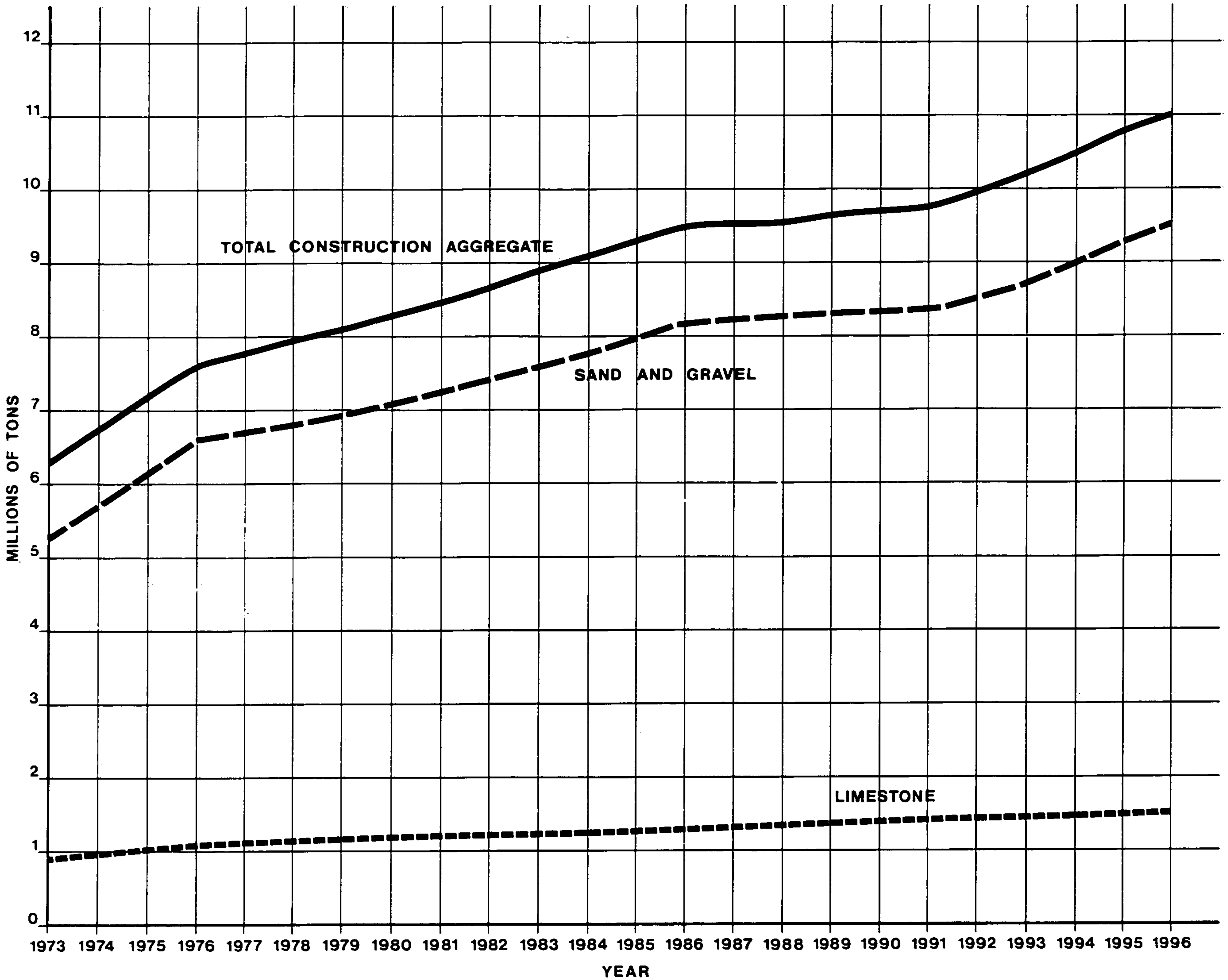
	1973*	1976	1981	1986	1991	1996
Sand and Gravel						
East	N/A	1,337	1,443	1,540	1,624	1,686
West	N/A	1,108	1,196	1,277	1,347	1,398
Interlake	N/A	302	326	347	366	380
Greater Winnipeg	N/A	3,596	3,882	4,142	4,369	4,536
Total	5,341	6,343	6,847	7,306	7,706	8,000
Limestone						
East	N/A	284	307	328	345	359
West	N/A	233	251	268	283	294
Interlake	N/A	64	69	74	78	81
Greater Winnipeg	N/A	464	501	535	564	586
Total	931	1,045	1,128	1,205	1,270	1,320
All Aggregate						
East	N/A	1,621	1,750	1,868	1,969	2,045
West	N/A	1,341	1,447	1,545	1,630	1,692
Interlake	N/A	366	395	421	444	461
Greater Winnipeg	N/A	4,060	4,383	4,677	4,933	5,122
Total	6,272	7,388	7,975	8,511	8,976	9,320

* estimated actual

TABLE C-17

BASE CASE FORECAST OF AGGREGATE REQUIREMENTS
WINNIPEG REGION 1976 — 1996
(000 tons)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Sand & Gravel																					
East	1,379	1,407	1,435	1,463	1,493	1,523	1,561	1,600	1,640	1,681	1,719	1,727	1,736	1,745	1,754	1,762	1,806	1,851	1,897	1,945	1,990
Cumulative	1,379	2,786	4,221	5,684	7,177	8,700	10,261	11,861	13,501	15,182	16,901	18,628	20,364	22,109	23,863	25,625	27,431	29,282	31,179	33,124	35,114
West	1,143	1,166	1,189	1,213	1,237	1,263	1,295	1,327	1,360	1,394	1,425	1,432	1,439	1,446	1,454	1,461	1,498	1,535	1,573	1,613	1,650
Cumulative	1,143	2,309	3,498	4,711	5,948	7,211	8,506	9,833	11,193	12,587	14,012	15,444	16,883	18,329	19,783	21,244	22,742	24,277	25,850	27,463	29,113
Interlake	311	317	324	330	337	344	353	361	370	380	388	390	392	394	396	398	408	418	429	439	449
Cumulative	311	628	952	1,282	1,619	1,963	2,316	2,677	3,047	3,427	3,815	4,205	4,597	4,991	5,387	5,785	6,193	6,611	7,040	7,479	7,928
Greater Winnipeg	3,707	3,781	3,857	3,934	4,013	4,097	4,199	4,304	4,412	4,522	4,624	4,647	4,670	4,694	4,717	4,739	4,857	4,979	5,103	5,231	5,353
Cumulative	3,707	7,488	11,345	15,279	19,292	23,389	27,588	31,892	36,304	40,826	45,450	50,097	54,767	59,461	64,178	68,917	73,774	78,753	83,856	89,087	94,440
Winnipeg Region	6,540	6,671	6,805	6,940	7,080	7,227	7,408	7,592	7,782	7,977	8,156	8,196	8,237	8,279	8,321	8,360	8,569	8,783	9,002	9,228	9,442
Cumulative	6,540	13,211	20,016	26,956	34,036	41,263	48,671	56,263	64,045	72,022	80,178	88,374	96,611	104,890	113,211	121,571	130,140	138,923	147,925	157,153	166,595
Limestone																					
East	293	299	305	311	317	324	332	340	349	357	366	368	370	372	374	376	385	394	403	413	423
Cumulative	293	592	897	1,208	1,525	1,849	2,181	2,521	2,870	3,227	3,593	3,961	4,331	4,703	5,077	5,453	5,838	6,232	6,635	7,048	7,471
West	241	245	250	254	259	265	272	278	285	292	300	301	302	304	306	308	315	323	330	338	348
Cumulative	241	486	736	990	1,249	1,514	1,786	2,064	2,349	2,641	2,941	3,242	3,544	3,848	4,154	4,462	4,777	5,100	5,430	5,768	6,116
Interlake	67	68	69	70	71	72	74	76	78	80	82	82	82	83	83	84	86	88	90	92	95
Cumulative	67	135	204	274	345	417	491	567	645	725	807	889	971	1,054	1,137	1,221	1,307	1,395	1,485	1,577	1,672
Greater Winnipeg	479	488	498	508	518	529	542	556	570	584	597	599	601	604	607	611	626	642	658	674	691
Cumulative	479	967	1,465	1,973	2,491	3,020	3,562	4,118	4,688	5,272	5,869	6,468	7,069	7,673	8,280	8,891	9,517	10,159	10,817	11,491	12,182
Winnipeg Region	1,080	1,100	1,122	1,143	1,165	1,190	1,220	1,250	1,282	1,313	1,345	1,350	1,355	1,363	1,370	1,379	1,412	1,447	1,481	1,517	1,557
Cumulative	1,080	2,180	3,302	4,445	5,610	6,800	8,020	9,270	10,552	11,865	13,210	14,560	15,915	17,278	18,648	20,027	21,439	22,886	24,367	25,884	27,441
All Aggregate																					
Winnipeg Region	7,620	7,771	7,927	8,083	8,245	8,417	8,628	8,842	9,064	9,290	9,501	9,546	9,592	9,642	9,691	9,739	9,981	10,230	10,483	10,745	10,999
Cumulative	7,620	15,391	23,318	31,401	39,646	48,063	56,691	65,533	74,597	83,887	93,388	102,934	112,526	122,168	131,859	141,598	151,579	161,809	172,292	183,037	194,036



Aggregate Resources of the Winnipeg Region

Base Case Forecast of Annual Aggregate Requirements in the Winnipeg Region

5.3 Per Capita Consumption of Aggregate

Taking another perspective, per capita consumption of aggregate in the region under the base case is forecast to grow from 9.54 tons in 1973 to 12.94 tons in 1996, as follows[1]:

Per Capita Consumption of Aggregate in the Winnipeg Region

	Aggregate Consumption (000 tons)	Population (000)	Per Capita Consumption of Aggregate (tons)
1973	6,272	657.7	9.54
1976	7,620	687.2	11.09
1981	8,417	727.1	11.58
1986	9,501	767.6	12.38
1991	9,739	808.9	12.04
1996	10,999	850.0	12.94

5.4 Demand for Aggregate in the Year 2026

Because of the error inherent in any forecasting model, the reliability of the forecast diminishes as the forecast horizon is extended. Beyond 20 years, detailed mathematical forecasts are inappropriate because they employ a level of sophistication which is inconsistent with the reliability with which the results can be accepted. Thus, simple extrapolation is sufficient and appropriate to generate estimates of aggregate requirements in the Winnipeg Region beyond 1996.

Extrapolation of the previous forecast data yields estimates of aggregate requirements in the Winnipeg Region through to the year 2026. Table C-18 shows demand and cumulative demand in five year intervals from 1996 to 2026. The results of this extrapolation suggest that, under the base forecast, the requirements from 1996 to 2026 will be 2.5 times the requirements in the 21-year period from 1976 to 1996. For the alternate forecast, this ratio of consumption is 1.8.

[1] Per capita consumption of total aggregate under the alternate projection has not been calculated here, since no forecasts were prepared of population at the regional level except for the base case.

5.5 Long-Term Requirements for High Quality Gravel

5.5.1 Sector and End Use Allocation

In addition to considering the total quantity of aggregate, it is important to recognize the particular concern for the quality of material that will be required in the future. Since the aggregate used in concrete and asphalt applications must be of the highest quality, the volume of high quality gravel necessary to support future concrete and asphalt needs in the Winnipeg Region is of special interest. A very small proportion of limestone aggregate is used in concrete and asphalt applications and questions of the quality of this material do not hold the same significance.

Table C-1 and C-3 presented in Sub-Section 2 provide the data base for forecasting gravel according to end use requirements. Table C-3 indicates the quantity of gravel used for concrete aggregate in 1973 as distinct from all other uses of sand and gravel. It is to be noted that the road construction and other engineering categories have been combined inTable C-3, and that this quantity does not include asphalt aggregate. Table C-1 contains the asphalt aggregate data.

With reference to Table C-1, the high quality aggregate used in road construction in 1973, is given by the 535,000 tons of asphalt aggregate grossed up to 570,800 tons to account for a share of the unallocated portion of the total, to which 51,200 tons must be added to account for aggregate used in concrete surface road construction in 1973[1]. Thus the estimate of the total high quality aggregate for road work in the province in 1973 is 622,000 tons. Table C-3 indicates that the residential and non-residential sectors took 922.9 and 669.1 thousand tons of high quality aggregate respectively, and that the road and other engineering sectors consumed 733.8 thousand tons of concrete aggregate. This latter figure less the 51.2 thousand tons estimated for concrete surface roads yields 682.6 thousand tons for the other engineering sector.

[1] 5000 tons per mile of road as per Department of Highways sample contract, times the miles of concrete roads completed in the province for the fiscal year ending March 31, 1974 (10.3 miles).

TABLE C-18

TOTAL AGGREGATE REQUIREMENTS
WINNIPEG REGION 1976 — 2026
(000 tons)

BASE CASE FORECAST

	1996	2001	2006	2011	2016	2021	2026
Sand and Gravel							
EAST							
Requirements in year	1,990	2,251	2,545	2,878	3,256	3,683	4,166
Cumulative total from 1976	35,114	45,835	57,957	71,666	87,173	104,711	124,550
WEST							
Requirements in year	1,650	1,867	2,112	2,390	2,704	3,059	3,461
Cumulative total from 1976	29,113	38,003	48,061	59,440	72,315	86,882	103,363
INTERLAKE							
Requirements in year	449	508	575	650	736	832	942
Cumulative total from 1976	7,928	10,347	13,084	16,181	19,684	23,648	28,133
GREATER WINNIPEG							
Requirements in year	5,353	6,056	6,852	7,753	8,772	9,924	11,228
Cumulative total from 1976	94,440	123,281	155,911	192,829	234,599	281,857	335,326
WINNIPEG REGION							
Requirements in year	9,442	10,682	12,084	13,671	15,468	17,498	19,797
Cumulative total from 1976	166,595	217,466	275,013	340,116	413,771	497,098	591,372
Limestone							
EAST							
Requirements in year	423	479	541	613	693	784	887
Cumulative total from 1976	7,471	9,751	12,329	15,247	18,548	22,281	26,507
WEST							
Requirements in year	348	394	445	504	570	645	736
Cumulative total from 1976	6,116	7,992	10,114	12,515	15,231	18,302	21,784
INTERLAKE							
Requirements in year	95	107	122	138	156	176	199
Cumulative total from 1976	1,672	2,183	2,763	3,419	4,161	5,000	5,948
GREATER WINNIPEG							
Requirements in year	691	782	884	1,001	1,132	1,281	1,449
Cumulative total from 1976	12,182	15,905	20,116	24,882	30,274	36,375	43,277
WINNIPEG REGION							
Requirements in year	1,557	1,762	1,992	2,256	2,551	2,886	3,271
Cumulative total from 1976	27,441	35,831	45,322	56,063	68,214	81,958	97,516
All Aggregate							
Winnipeg Region							
Requirements in year	10,999	12,444	14,076	15,927	18,019	20,384	23,068
Cumulative total from 1976	194,036	253,297	320,335	396,179	481,985	579,056	688,888

ALTERNATE FORECAST

	1996	2001	2006	2011	2016	2021	2026
Sand and Gravel							
EAST							
Requirements in year	1,686	1,750	1,816	1,885	1,956	2,030	2,107
Cumulative total from 1976	31,967	41,463	50,959	60,455	69,951	79,447	88,943
WEST							
Requirements in year	1,398	1,451	1,506	1,563	1,622	1,683	1,747
Cumulative total from 1976	26,361	34,192	42,022	49,854	57,684	65,515	73,346
INTERLAKE							
Requirements in year	380	394	409	425	441	458	475
Cumulative total from 1976	7,272	9,432	11,592	13,753	15,913	18,073	20,233
GREATER WINNIPEG							
Requirements in year	4,536	4,708	4,887	5,073	5,265	5,465	5,673
Cumulative total from 1976	85,901	111,418	136,936	162,454	187,972	213,490	239,008
WINNIPEG REGION							
Requirements in year	8,000	8,303	8,618	8,946	9,284	9,636	10,002
Cumulative total from 1976	151,500	196,505	241,510	286,515	331,520	376,525	421,530
Limestone							
EAST							
Requirements in year	359	373	389	404	421	438	456
Cumulative total from 1976	6,792	8,821	10,850	12,879	14,908	16,937	18,967
WEST							
Requirements in year	294	305	317	330	342	356	369
Cumulative total from 1976	5,568	7,232	8,895	10,559	12,222	13,886	15,550
INTERLAKE							
Requirements in year	81	84	87	91	94	98	102
Cumulative total from 1976	1,523	1,978	2,433	2,888	3,343	3,798	4,254
GREATER WINNIPEG							
Requirements in year	586	608	633	657	683	710	737
Cumulative total from 1976	11,087	14,399	17,711	21,023	24,336	27,648	30,960
WINNIPEG REGION							
Requirements in year	1,320	1,370	1,426	1,482	1,540	1,602	1,664
Cumulative total from 1976	24,970	32,430	39,890	47,350	54,810	62,270	69,730
All Aggregate							
Winnipeg Region							
Requirements in year	9,320	9,673	10,044	10,428	10,824	11,238	11,666
Cumulative total from 1976	176,470	228,935	281,400	333,865	386,330	438,795	491,260

5.5.2 Aggregate Usage Coefficients for High Quality Aggregate

The 1973 construction values from Table C-6, presented in Sub-Section 4, combined with the above derived sector and end-use data, yields high quality aggregate usage coefficients for each construction sector. These are tabulated below.

HIGH QUALITY AGGREGATE USAGE COEFFICIENTS

	High Quality Sand & Gravel used in the Province in 1973 (000 tons)	1973 Value of Construction ($000)	High Quality Aggregate Usage Coefficient (tons per dollars of construction)
Residential	922.9	271,649	.003397
Non-Residential	669.1	167,950	.003984
Road Construction	622.0	86,806	.007165
Other Engineering	682.6	161,437	.004228

5.5.3 Forecasts of Demand for High Quality Aggregate by Subregion

The above aggregate usage coefficients applied to the construction values in Table C-13, provide long term forecasts of high quality aggregate for the Winnipeg Region. These are contained in Table C-19. Extrapolation has been used to forecast beyond 1996. The forecasts reflect the base case; an alternate projection has not been included.

TABLE C-19

BASE CASE FORECAST OF HIGH QUALITY AGGREGATE
WINNIPEG REGION 1976 — 2026
(000 tons)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
East	139	142	145	147	150	153	157	161	165	169	173
Cumulative	139	281	425	572	723	876	1,033	1,194	1,359	1,528	1,701
West	146	148	151	154	157	161	165	169	173	177	181
Cumulative	146	294	445	599	756	917	1,082	1,251	1,424	1,601	1,782
Interlake	34	34	35	36	36	37	38	39	40	41	42
Cumulative	34	68	103	139	175	212	250	289	329	370	412
Greater Winnipeg	1,814	1,850	1,887	1,925	1,964	2,005	2,055	2,105	2,159	2,213	2,262
Cumulative	1,814	3,664	5,551	7,476	9,440	11,445	13,500	15,605	17,764	19,977	22,239
Winnipeg Region	2,133	2,174	2,218	2,262	2,307	2,356	2,415	2,474	2,537	2,600	2,658
Cumulative	2,133	4,307	6,525	8,787	11,094	13,450	15,865	18,339	20,876	23,476	26,134

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
East	174	175	176	177	178	182	186	191	196	200
Cumulative	1,875	2,050	2,226	2,403	2,581	2,763	2,949	3,140	3,336	3,536
West	182	183	184	185	186	191	195	200	205	210
Cumulative	1,964	2,147	2,331	2,516	2,702	2,893	3,088	3,288	3,493	3,703
Interlake	42	42	43	43	43	44	45	46	47	48
Cumulative	454	496	539	582	625	669	714	760	807	855
Greater Winnipeg	2,273	2,285	2,297	2,308	2,319	2,376	2,436	2,497	2,560	2,619
Cumulative	24,512	26,797	29,094	31,402	33,721	36,097	38,533	41,030	43,590	46,209
Winnipeg Region	2,671	2,685	2,700	2,713	2,726	2,793	2,862	2,934	3,008	3,077
Cumulative	28,805	21,490	34,190	36,903	39,629	42,422	45,284	48,218	51,226	54,303

HIGH QUALITY AGGREGATE REQUIREMENTS 2001 — 2026

	2001	2006	2011	2016	2021	2026
East	227	256	290	328	371	419
Cumulative from 1976	4,616	5,836	7,217	8,778	10,544	12,542
West	238	270	305	345	391	442
Cumulative from 1976	4,853	6,137	7,590	9,235	11,095	13,199
Interlake	56	63	71	80	91	103
Cumulative from 1976	1,130	1,430	1,769	2,151	2,585	3,075
Greater Winnipeg	2,961	3,350	3,791	4,289	4,853	5,490
Cumulative from 1976	60,284	76,240	94,293	114,718	137,828	163,974
Winnipeg Region	3,482	3,939	4,457	5,042	5,706	6,454
Cumulative from 1976	70,883	89,637	110,869	134,882	162,052	192,790

6. SUMMARY AND CONCLUSIONS

This study involved the research and manipulation of significant amounts of data which were obtained from published sources and through direct contact with over 100 private firms, provincial and federal government departments and municipal users in the Winnipeg Region. The analysis of this data led to the forecasts of future aggregate demand presented in this report.

It is estimated that over the period to 1996, total construction spending in Manitoba (excluding the residual category) will grow from 688 million constant dollars in 1973 to at least 900 million constant dollars in 1996 and perhaps to 1,070 million constant dollars. Barring population and household growth in excess of the rates contemplated, the latter is treated as the "preferred" estimate of total construction spending in Manitoba over the 20 year period to 1996.

Of this total spending, it is projected that approximately 72% will occur within the Winnipeg Region.

The study reveals that over 5 million tons of sand and gravel and over 900 thousand tons of limestone were used in construction activities in the Winnipeg Region in 1973. The forecasts of aggregate demand indicate that approximately 194 million tons of construction aggregate will be required during the forecast period to 1996 to meet the reasonably foreseeable demands of the construction industry within the Winnipeg Region. Under the alternate (lower) projection assumptions, cumulative requirements to 1996 would be about 9% lower at 176 million tons. Extrapolation of forecast results to the year 2026 suggests that consumption from 1996 to 2026 will possibly approach 2.5 times the 1976-1996 figure.

Some 86% of the projected total represents sand and gravel and the balance is limestone. The requirement for high quality aggregate for concrete and asphalt applications is estimated at 33% of the total sand and gravel, i.e., 28% of total aggregate.

The population projections employed in forecasting future requirements anticipate a Winnipeg Region growth from 664,000 in 1971, to 727,000 in 1981 and 850,000 by 1996. The urban population, as a percentage of the total population of the Region, will increase from 88.7% in 1971 to nearly 93.0% in 1996.

It is to be recognized that the forecasts of construction aggregate requirements presented here are based upon a discreet series of assumptions which, when varied, would lead to different results. In particular, under the forecast methodology devised for the study, shifts in assumptions regarding the following variables would yield different estimates of requirements:

- rate of population growth by age and sex
- rate of household formation by age of head
- allocation of total construction value by sector
- allocation of sector construction value to the Winnipeg Region
- aggregate usage coefficient values.

Of the variables listed above, only population growth has been altered to test the sensitivity of aggregate requirements to changes in major assumptions.

SECTION D
AGGREGATE RESOURCE POTENTIAL

SECTION D
AGGREGATE RESOURCE POTENTIAL

1. Introduction

This section discusses the general geology of the region; the subdivision of the region into geologic environments considered to be most hospitable to sand and gravel occurrences; the program for defining the depth to limestone bedrock in the area of the Municipality of Rockwood; the results of an airborne E-Phase geophysical program; and in conclusion the analyses of quality and quantity of aggregates available in the Region.

Plate D-1 defines the boundaries of the Winnipeg Study Region as considered in the estimation of aggregate resource potential. In addition, the areas in which the bedrock seismic survey and the E-Phase survey were carried out are defined on Plate D-1.

The sources of field data are shown on Plates D-3, D-4, and D-5, with these plates being indexed on Plate D-2.

2. General Geology of the Winnipeg Region

2.1 Bedrock

The bedrock of the study area includes rocks of the Precambrian, Paleozoic and Mesozoic ages. Basically there are four distinct types of bedrock which are for the most part buried beneath the blanket of primarily unconsolidated Quaternary sediments.

These are:
— Precambrian granite
— Ordovician sandstone and shale
— Ordovician, Silurian and Devonian limestone and dolomite
— Jurassic shale

2.2 Surficial Geology

The surficial geology of the Region is presented on Plates D-6, D-7 and D-8 with these plates being indexed on Plate D-2.

The physiographic divisions of the Winnipeg Region can be generally defined as:
— the Lake Agassiz Lowlands
— the Interlake Till Plain
— the Lake Terrace Area
— the Belair-Agassiz-Sandilands Uplands
— the Bird's Hill Complex

Plate D-9 shows the locations of these physiographic divisions. Except for the Lake Agassiz Lowlands, each of these divisions was considered to have significant potential for the occurrence of sand and gravel. In addition, it was considered that there is potential in possible eskerine ridges lying buried beneath non-granular surface materials in the area between the Bird's Hill Complex and the uplands to the east.

The appreciation of the potential for occurrence of sand and gravel is dependent upon a basic understanding of the geological history of the Region. The following discussion is intended to provide that understanding.

2.2.1 Quaternary History

Several episodes of continental glaciation and associated interglacial periods are believed to have influenced Manitoba during the Pleistocene Epoch. Most authors accept the beginning of the Pleistocene about a million years ago, even though the trend is towards revision to an earlier date.

Although the number of times that large continental ice sheets invaded the province is not known, probably because much of the older record has been eroded by younger glaciations, we do know by synthesizing stratigraphic data from various parts of the world — on the continents and in the ocean basins — that there were several glacial episodes during the late Cenozoic.

In Manitoba, most of the glacial deposits belong to the latest Wisconsin glacial period although thick deposits related to older glacials are known to exist below the uplands of the Belair-Agassiz-Sandilands region and in the deep bedrock valleys along the front of the Manitoba Escarpment. The chronology of these older glacial sediments is unresolved because of their relatively limited extent and the absence of datable material.

The last major Wisconsinan glaciation covering southern Manitoba occurred about 22,000 years ago. Ice which had accumulated in several dispersal centers in northern Canada, coalesced, and moved across southern Manitoba. The effects of this ice sheet were felt in southern Manitoba before the ice actually invaded the area. One of the most significant influences was on the regional drainage which flowed northward into Hudson Bay. When ice blocked the river mouths in the northern lowlands, water backed up, creating a large reservoir. As the ice dam moved southward, the reservoir did likewise. The amount of sediment being supplied to this pro-glacial lake and the length of its life before being overridden by the glacier dictated the thickness of the clay, silt, and sand that was deposited in the water-filled lowlands. Much of this sediment, along with the sand and gravel deposited directly by meltwater from the glacier was eroded away as the thick ice sheet moved southward.

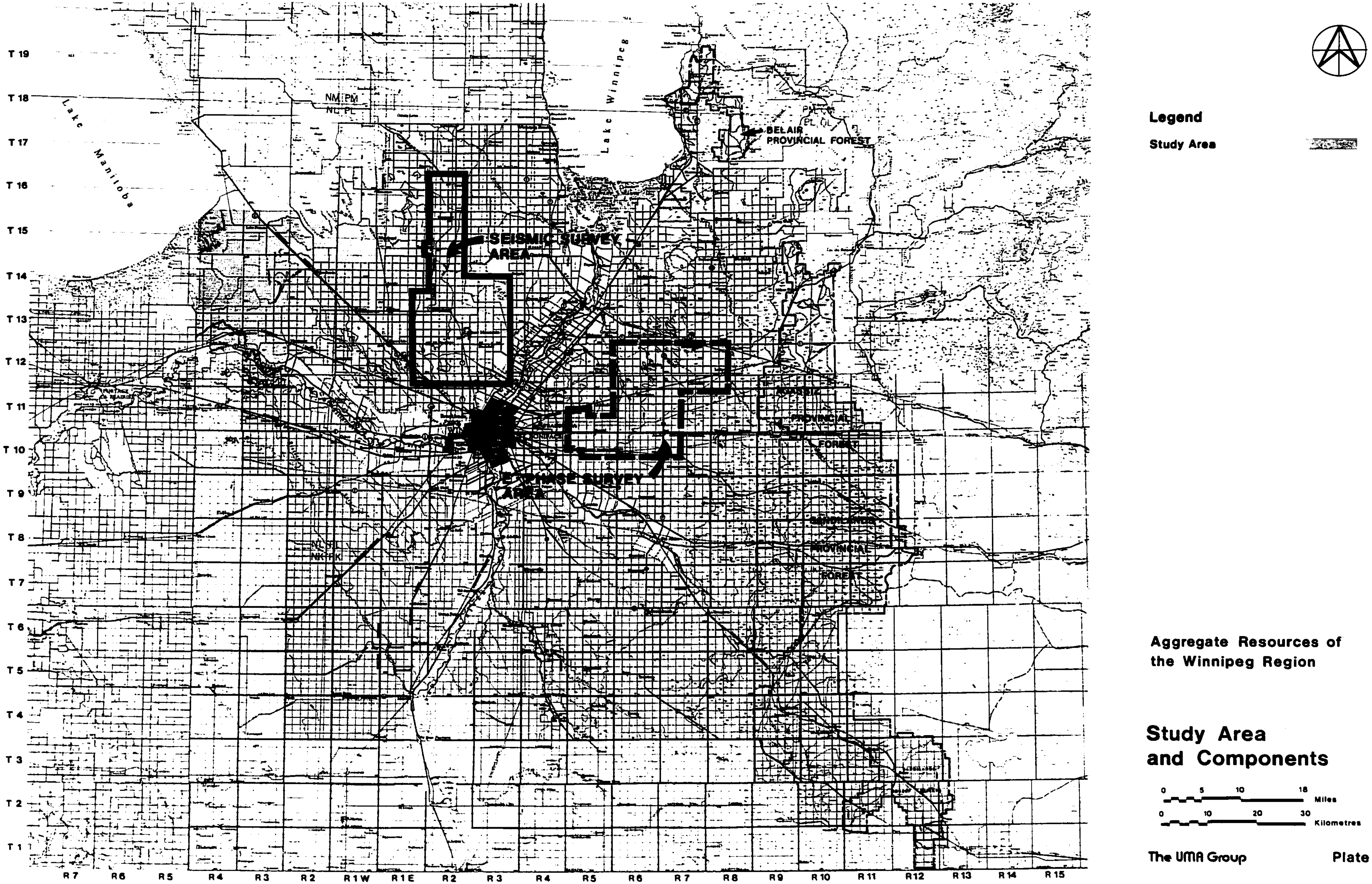
The continental ice sheet deposited till over the region. In places such as the Red River Valley and the Interlake area, the ice scoured away much of the previous glacial and pro-glacial sediment before depositing the till. In other areas, notably in the region to the east of the Red River Valley, tens to hundreds of feet of older clay, silt, sand, gravel and till were not removed by the latest glaciation, and currently form part of the Belair-Agassiz-Sandilands area.

Ice may have covered Manitoba continuously from 22,000 years ago until about 13,000 years ago. Although we do know that the ice margin fluctuated during this period south of the International border, there is no evidence for deglaciation in Manitoba until after 14,000 years ago. During the glacial period, southern Manitoba was affected by ice flowing both from the northeast (the Labrador ice center) and from the northwest (the Keewatin center). Deposits of till from these centers, and their associated sand and gravel outwash, are distinctly different because of the distinctly different bedrock sources eroded by them. The northwest to southeast flowing ice incorporated large quantities of Paleozoic limestone and dolomite as it flowed down the axes of Lakes Winnipeg, Manitoba and Winnipegosis and over the Interlake region. In contrast, ice from the Labrador center scoured the Precambrian (largely granitic) rocks, and throughout southeastern Manitoba deposited sediments that are low in carbonate rock types. From the line where the Labrador ice crossed the Paleozoic bedrock contact, the glacial sediments contain progressively more carbonates toward the southwest. Conversely, where the Keewatin ice overrode the Precambrian Shield, the glacial deposits have a reduced carbonate content and an increased granitic content.

Beginning about 14,000 years ago, the southern margin of the continental ice sheet began to retreat. In places, such as in the Red River Valley, this northward retreat was extremely rapid because the ice front was being influenced by water trapped in the lowland in front of the glacier. This pro-glacial lake, known as Lake Agassiz, first reached Manitoba along the edge of the retreating ice about 13,000 years ago. By this time most of the till that directly overlies the Paleozoic bedrock of the Interlake area and Precambrian Shield, and covers the older sediments of the Lake Terrace and Belair-Agassiz-Sandilands areas had been deposited. While ice stood near the edge of the Red River and Assiniboine River lowlands of southern Manitoba to the north, east, and west, sediment was transported into the depression. Lacustrine clay and silt filled the central part of the Lake Agassiz basin away from the shoreline. Around the margin, coarse sand and gravel accumulated as beaches as resorted sediment derived from pre-existing till in the Lake Terrace area. A new beach was constructed whenever the level of Lake Agassiz changed in response to the position of the glacier's margin, to isostatic crustal adjustments, or to changes in the Lake's overflow outlet. Where the Assiniboine River entered the basin, carrying quantities of sediment derived from western Manitoba and Saskatchewan, a delta was constructed. This delta (the Assiniboine Delta) covers about 2,500 square miles, and was deposited largely during the period between 13,000 and 10,000 years ago. Smaller deltas include the Birds Hill complex which is a composite feature. The southwestern linear portion is a narrow sand and gravel esker deposit which fans out downstream into a deltaic form which grades from gravel to sand and silt toward the east.

As the Labrador ice stood to the east of Lake Agassiz, it continued to supply large quantities of sand sediment to its margin. The result was the construction of the Belair-Agassiz-Sandilands ridge, although this ridge probably is partly a remnant topographic form left from an earlier glaciation. After its construction, Lake Agassiz waters substantially modified its form, eroding in many places (particularly along the windward Lake Terrace side), and depositing a veneer of shoreline and nearshore sand and gravel in other places. After the Labrador ice receeded from this ridge, perhaps as long ago as 12,000 years, Lake Agassiz waters extended northeastward so clay, silt, and sand were deposited over this area. Again, as in the region to the west of the ridge, the coarsest sediment was deposited in the shallowest part of the lake which migrated as the lake levels changed. In general, as the ice continued to retreat northward between 13,000 and 10,000 years ago, the level of Lake Agassiz progressively became lower, dropping from an elevation of over 1,300 feet to almost the 900-foot level. About 10,000 years ago, the Labrador ice readvanced across the lake outlet (which had allowed water to spill into Lake Superior) and caused Lake Agassiz to rise almost 200 feet. This re-ponding lasted only a few hundred years, after which the ice sheet rapidly retreated and the level of the lake fell. Lake Agassiz probably had drained from southern Manitoba by 8,500 years ago.

During the waning shallow stages of Lake Agassiz, wave action on the lake bottom reworked some of the previously deposited sediments. The absence of thick and extensive lacustrine clays and silts in the Interlake region and in numerous local areas east of the Red River can be explained in this way. Although Lake Agassiz itself disappeared from southern Manitoba more than 8,500 years ago, a glacial ice probably has been absent for more than 11,000 years, local deposition has continued adjacent to rivers, in small lakes, and in isolated areas where wind has eroded and redeposited sandy sediment. Thus, coarse aggregate is masked in many locations by up to 200 feet (70 metres) of post-glacial deposits of peat, clay, silt and sand.

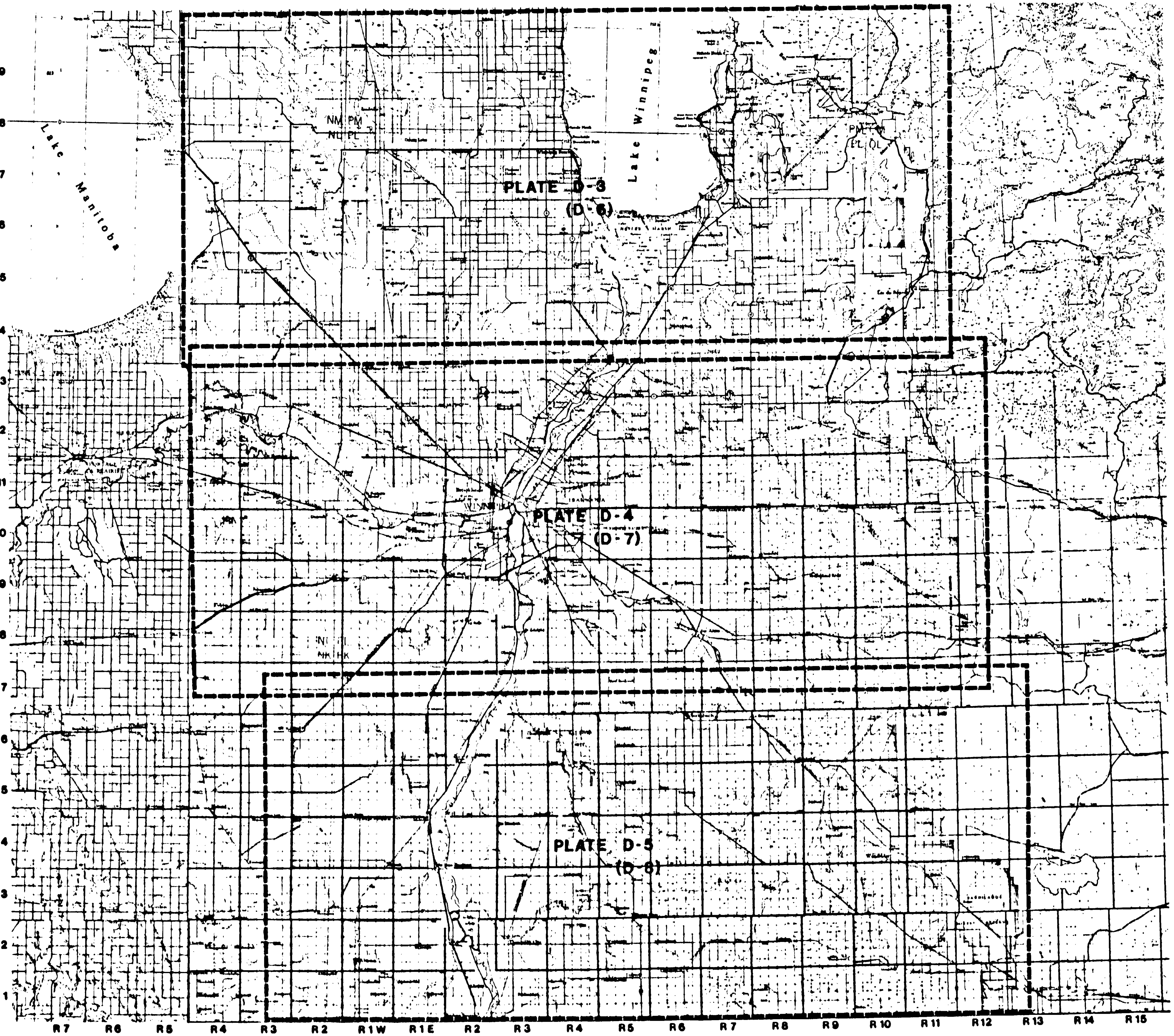


Aggregate Resources of the Winnipeg Region

Study Area and Components

The UMA Group

Plate D-1



Legend

Study Area

Sources of Field Data Plate Nos. D-3

Surficial Geology Plate Nos. (D-6)

Aggregate Resources of the Winnipeg Region

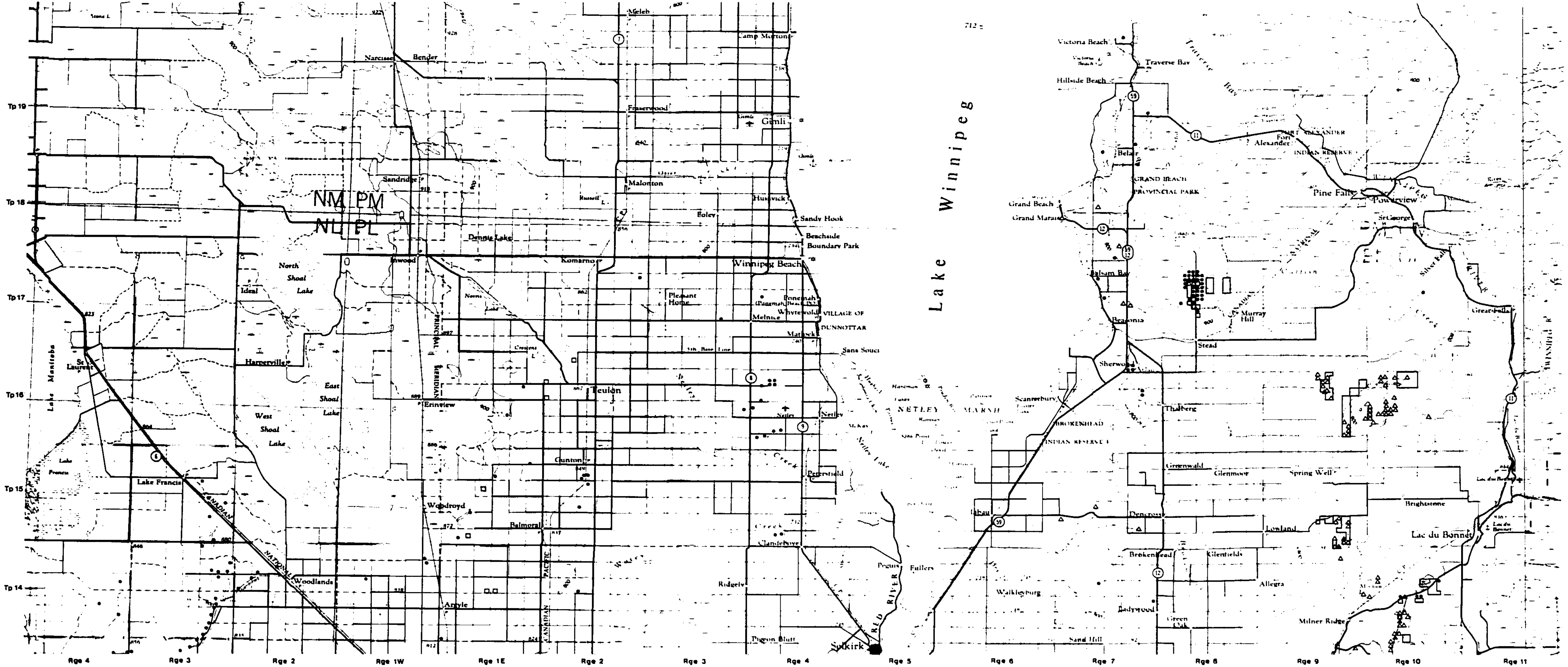
Index to Sources of Field Data and Surficial Geology Sheets

0 5 10 15 Miles

0 10 20 30 Kilometres

The UMA Group

Plate D-2



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Borrow and Test Pits (Manitoba Department of Highways)

Other Pits

Test Locations by UMA

Aggregate Resources of the Winnipeg Region

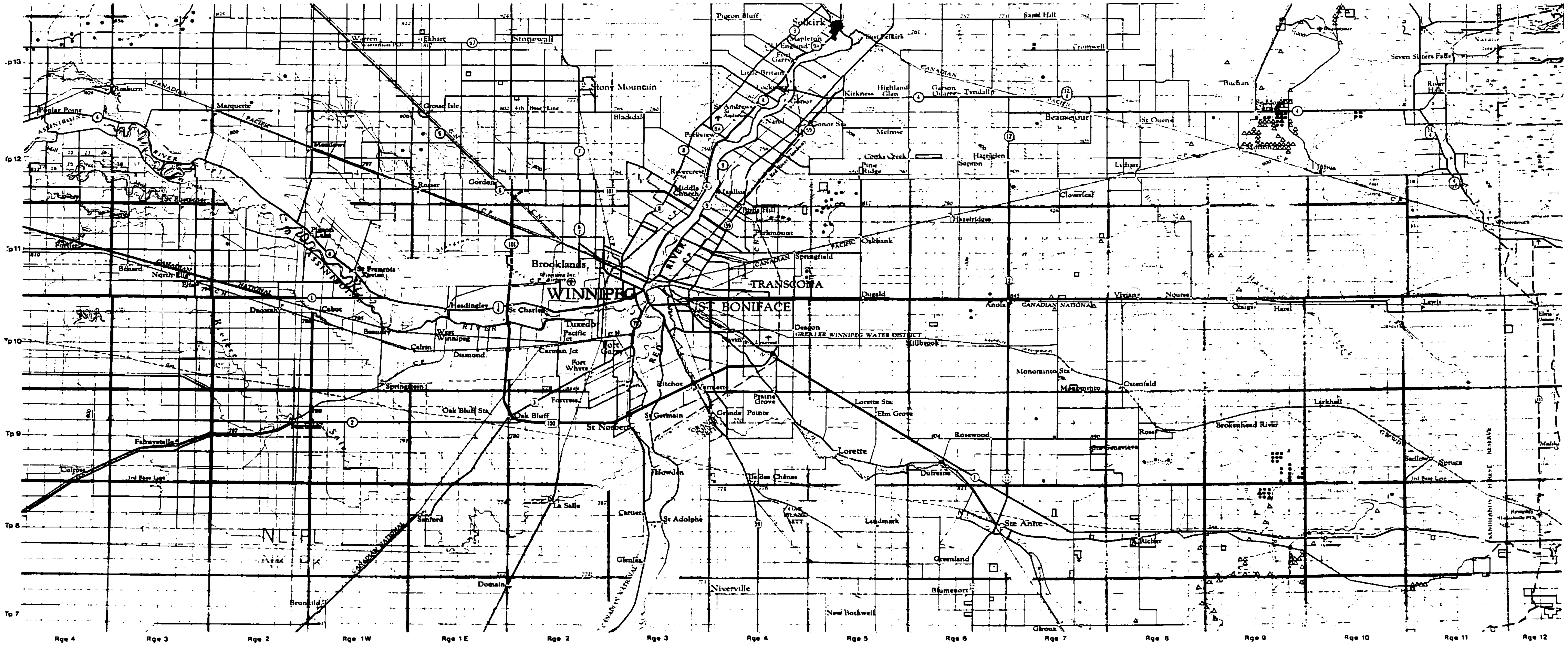
Sources of Field Data

0 1 2 4 6 Miles

0 1 2 3 5 10 Kilometres

The UMA Group

Plate D-3



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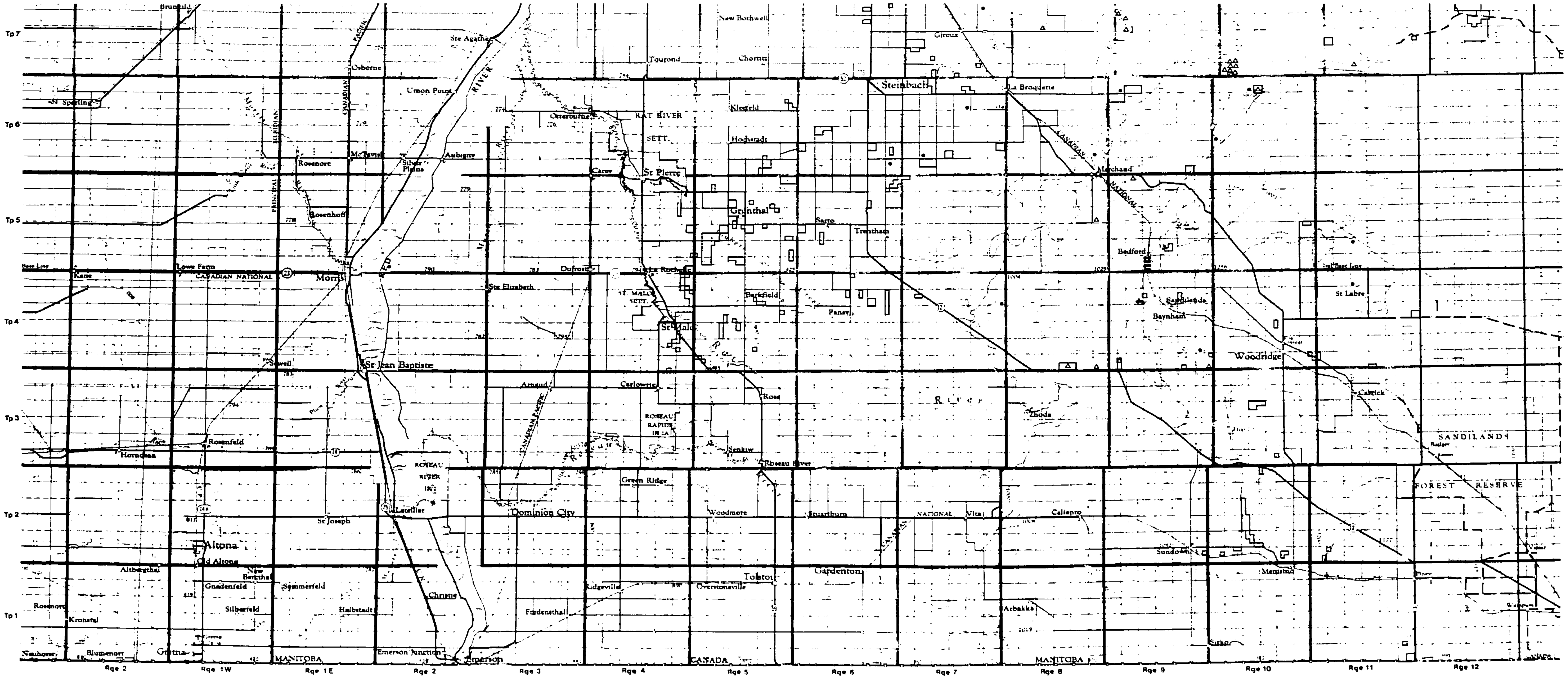
- Borrow and Test Pits (Manitoba Department of Highways) ▭
- Other Pits •
- Test Locations by UMA △

Aggregate Resources of the Winnipeg Region

Sources of Field Data

0 1 2 4 6 Miles
0 1 2 3 5 10 Kilometres

The UMA Group **Plate D-4**



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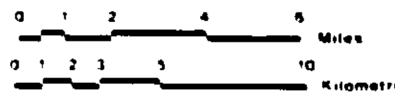
Borrow and Test Pits (Manitoba Department of Highways)	▭
Other Pits	•
Test Locations by UMA	△

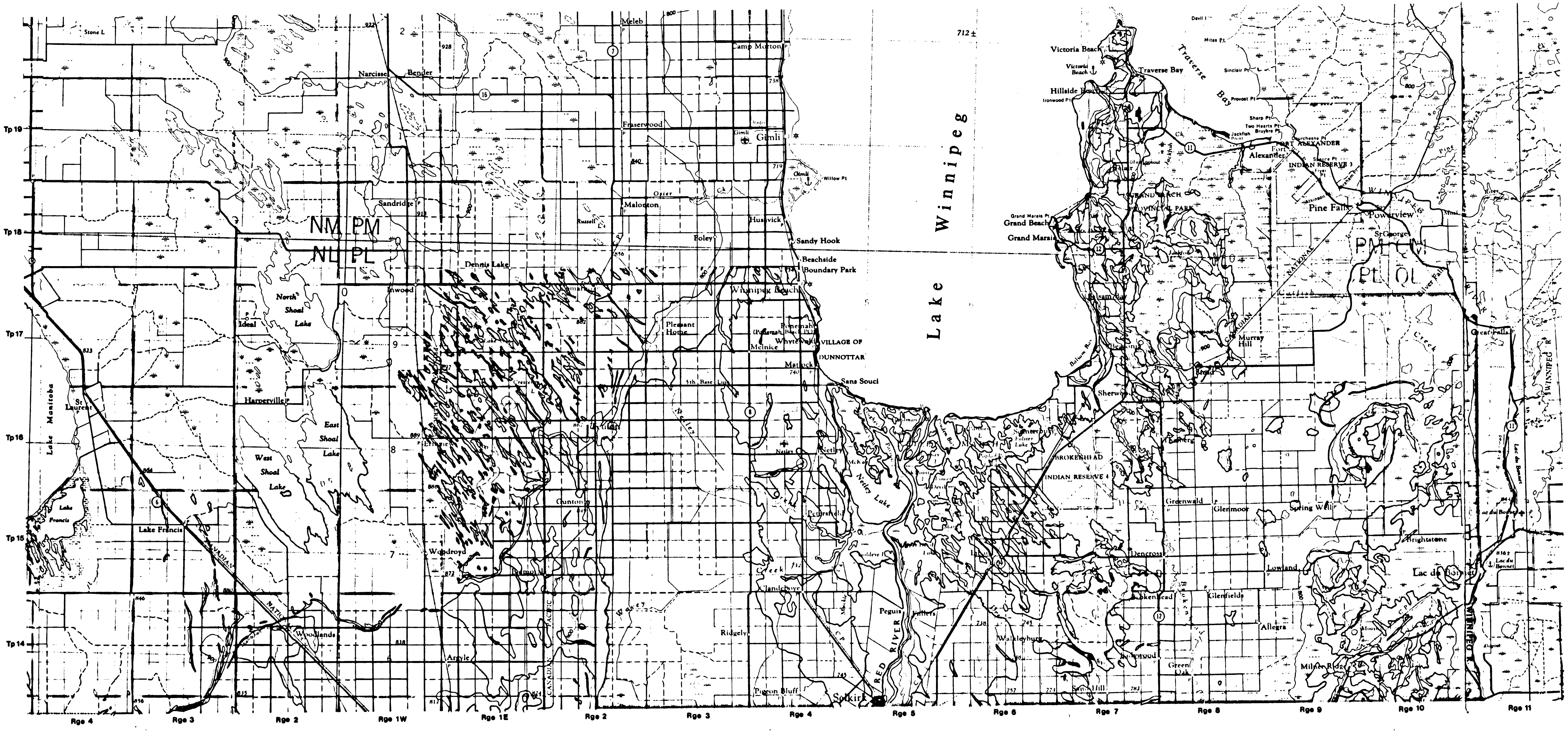
Aggregate Resources of the Winnipeg Region

Sources of Field Data



The UMA Group

Plate D-5



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- Lacustrine Clay (Including Organic Units)
- Glaciofluvial and Littoral Sand
- Glaciofluvial and Littoral Sand and Gravel
- Granular Till
- Clay Till

Aggregate Resources of the Winnipeg Region

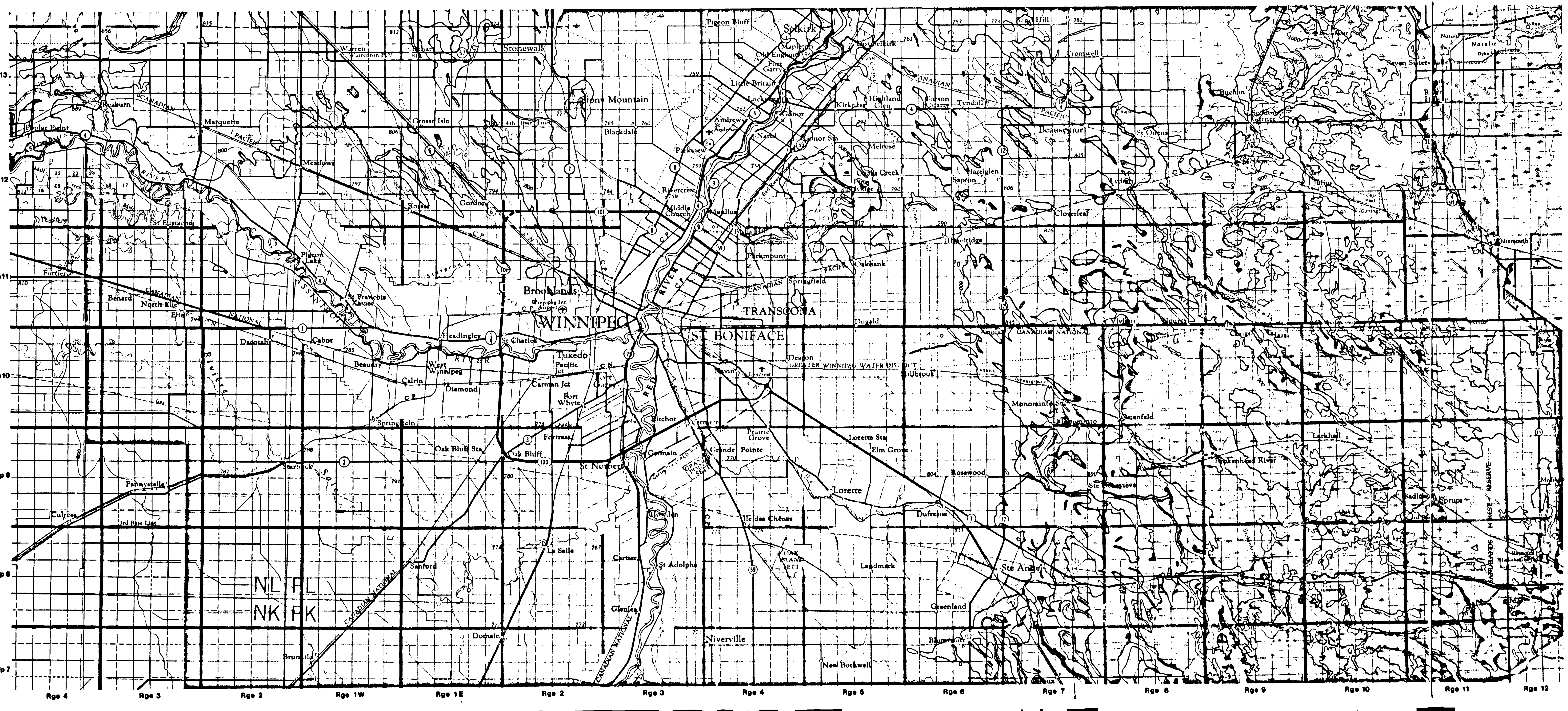
Surficial Geology of the Winnipeg Region

0 1 2 4 6 Miles

0 1 2 3 5 10 Kilometres

The UMA Group

Plate D-6



Legend

Lacustrine Clay (Including Organic Units)

Glaciofluvial and Littoral Sand

Glaciofluvial and Littoral Sand and Gravel

Granular Till

Clay Till

Aggregate Resources of the Winnipeg Region

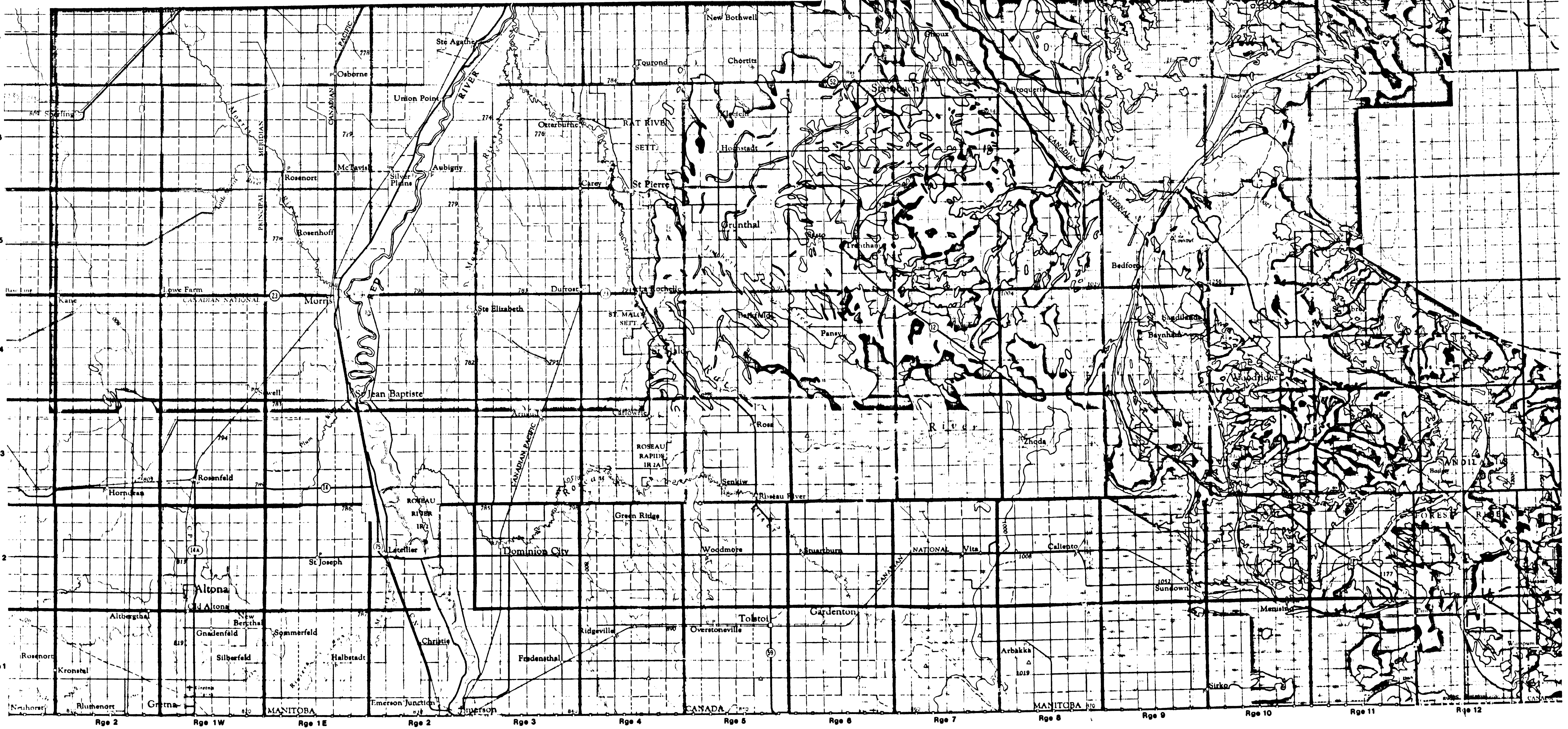
Surficial Geology of the Winnipeg Region

0 1 2 4 6 Miles

0 1 2 3 5 10 Kilometres

The UMA Group

Plate D-7



Legend

- Lacustrine Clay (Including Organic Units)
- Glaciofluvial and Littoral Sand
- Glaciofluvial and Littoral Sand and Gravel
- Granular Till
- Clay Till

Aggregate Resources of the Winnipeg Region

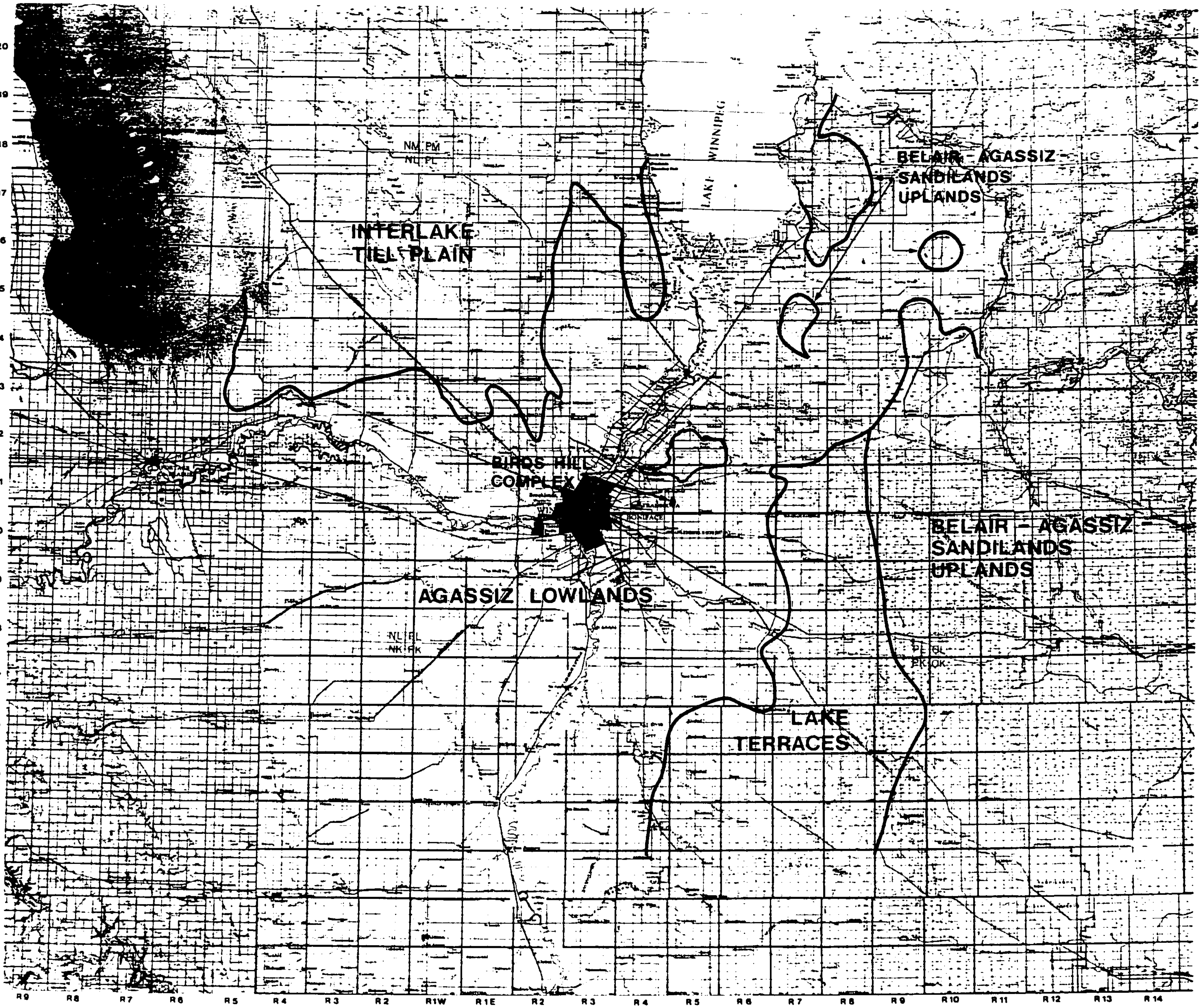
Surficial Geology of the Winnipeg Region

0 1 2 4 6 Miles

0 1 2 3 5 10 Kilometres

The UMA Group

Plate D-8



Aggregate Resources of the Winnipeg Region

Physiographic Divisions of the Winnipeg Region

The UMA Group

Plate D-9

3. QUALITY OF SANDS AND GRAVELS

The study of sand and gravel in the Winnipeg Region has suggested certain consistencies in their quality. It has been concluded that they fall within 6 general grain size distribution ranges as illustrated on Plates D-10 to D-15. These ranges have been grouped as follows, to allow for discussion of quality in other sections of this report.

Ranges 1-3: — High quality or such as required for concrete

Ranges 4-5: — Moderate quality on such as required for road bases

Range 6: — Poor quality or sand.

A comparison of the expected grain size distribution ranges of a particular granular deposit with the specifications for individual uses, should allow an appreciation as to whether the material in that deposit has the potential to meet certain of these specifications.

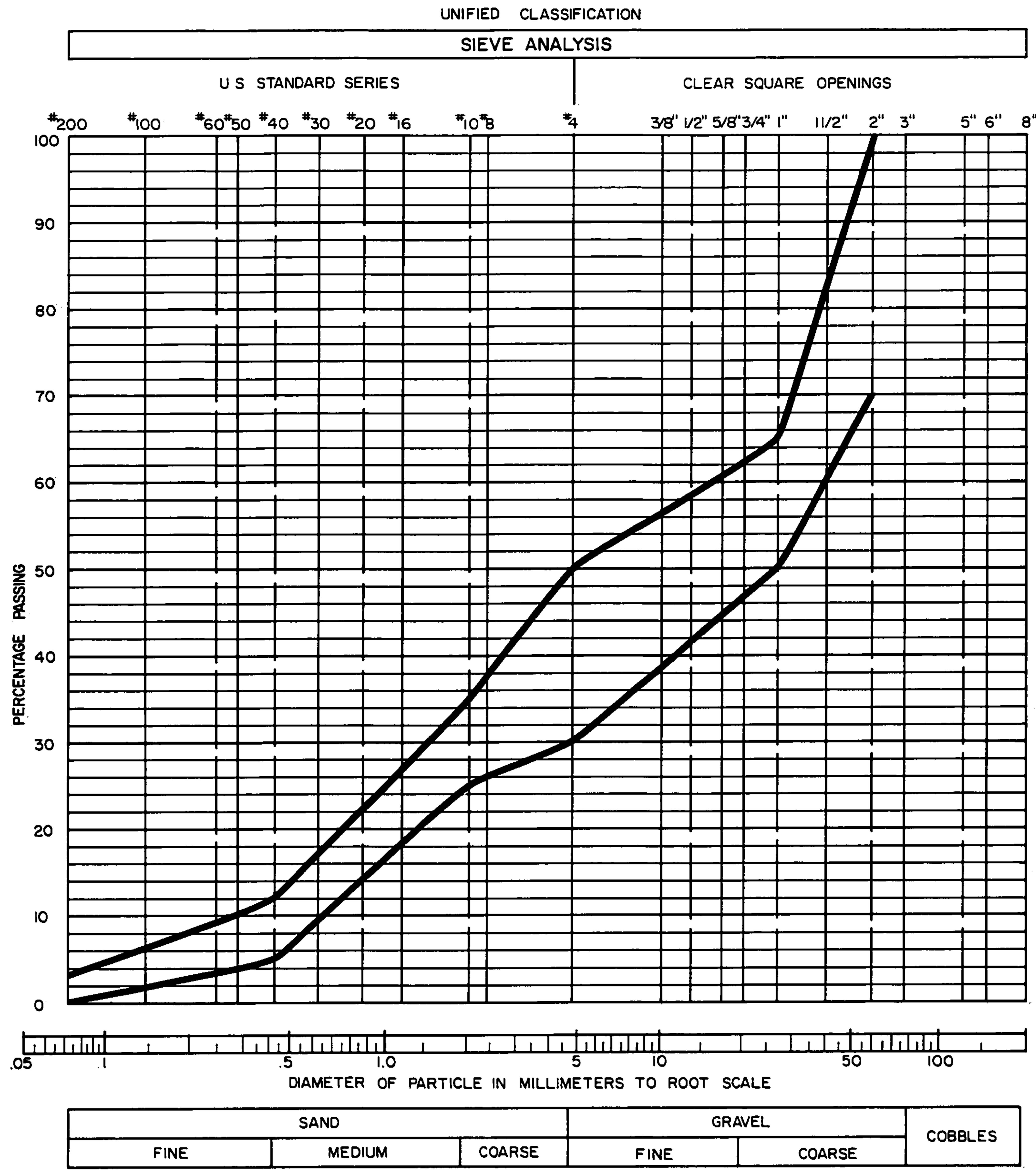
Granulars in the Lake Terrace Area and the Belair-Agassiz-Sandilands Uplands have the following petrographics; with the exception of some anomalies:

Granitics	5 to 15 percent
Diorite-Gabbro	10 to 20 percent
Volcanics	2 to 5 percent
Schists	5 to 10 percent
Gneisses	25 to 35 percent
Carbonates	20 to 40 percent

Granulars in the Interlake Till Plain average 75 to 80 percent carbonates with granitics and minor volcanics making up the remainder.

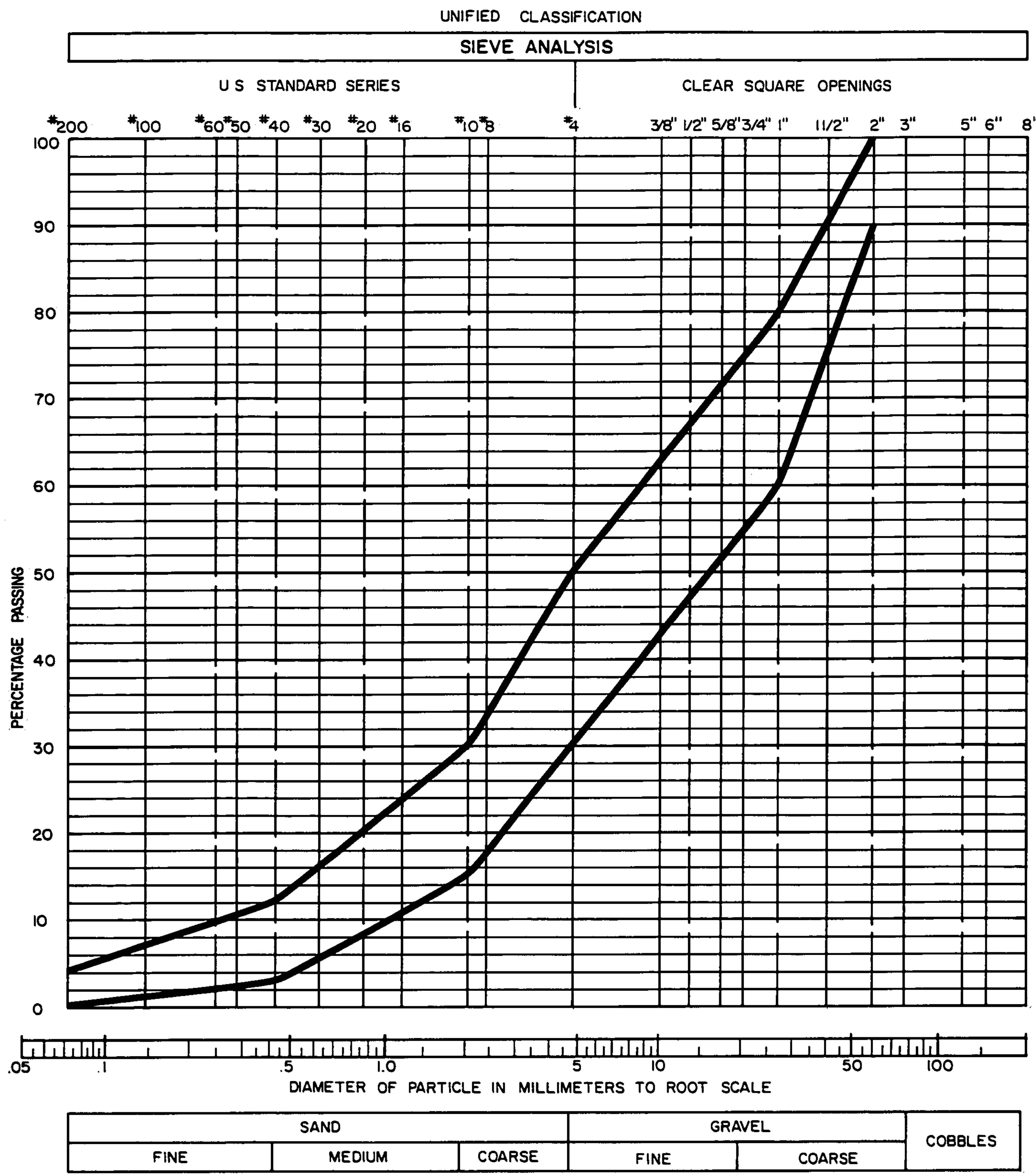
It can be expected that granulars from deposits within the Lake Agassiz Lowlands will be comparable to material from the adjacent physiographic areas with shale content increasing to the west.

As an indication of the competence of granular materials within the Region, Los Angeles Abrasion Loss values in the order of 25% to 35% are common.



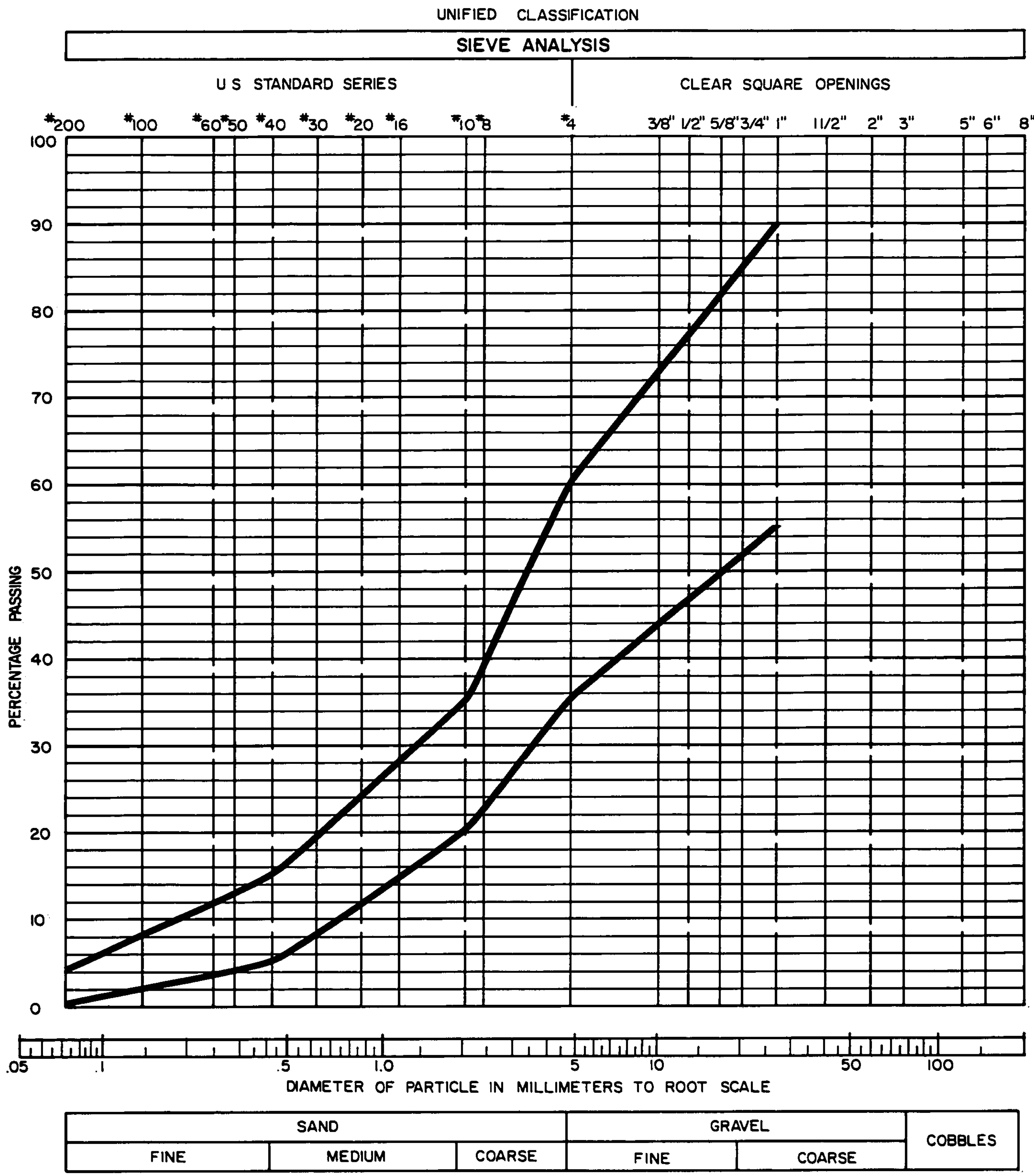
Aggregate Resources of the Winnipeg Region

Grain Size Distribution Ranges Range 1



Aggregate Resources of the Winnipeg Region

Grain Size Distribution Ranges Range 2

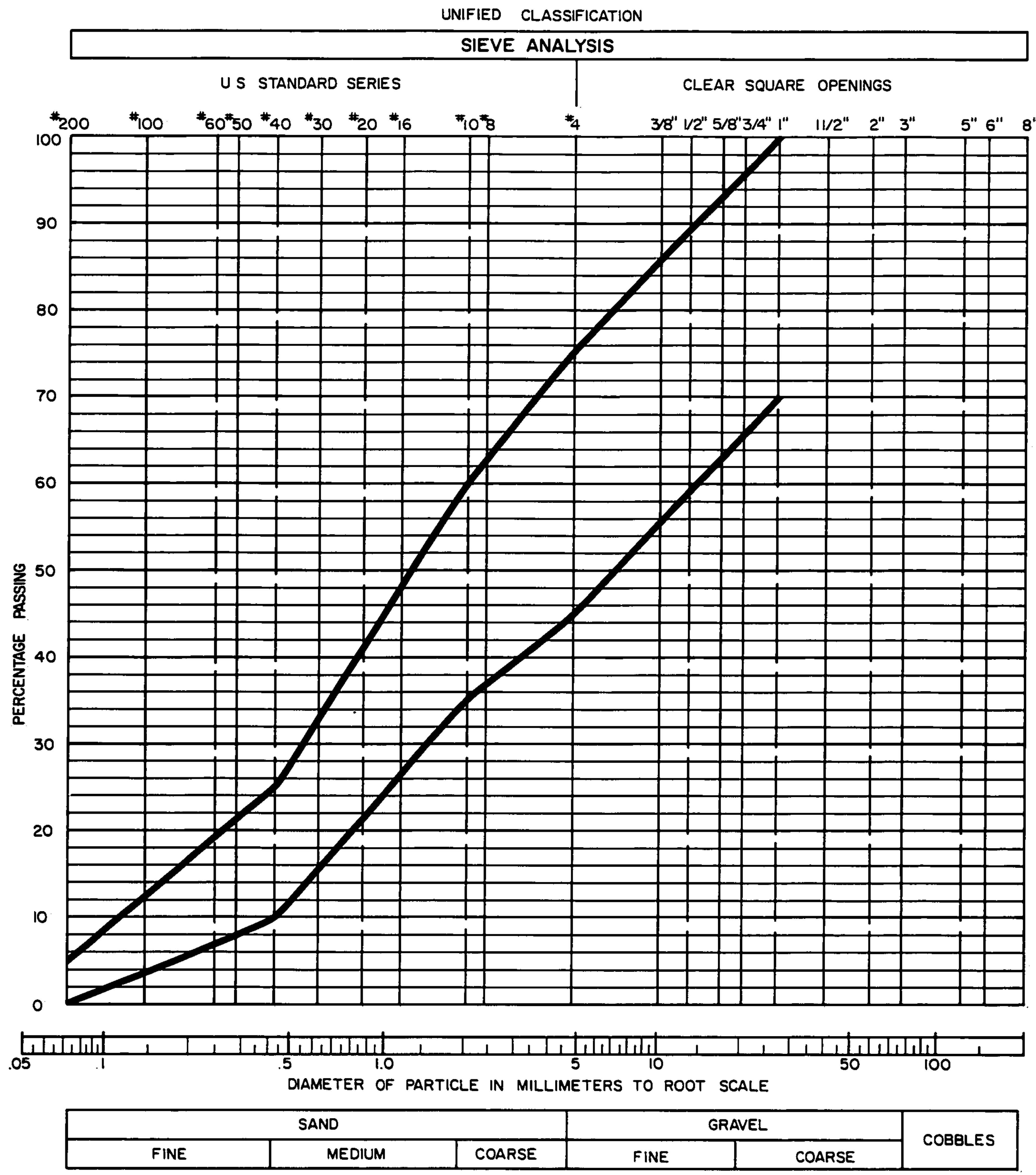


Aggregate Resources of
the Winnipeg Region

Grain Size Distribution Ranges Range 3

The UMA Group

Plate D-12

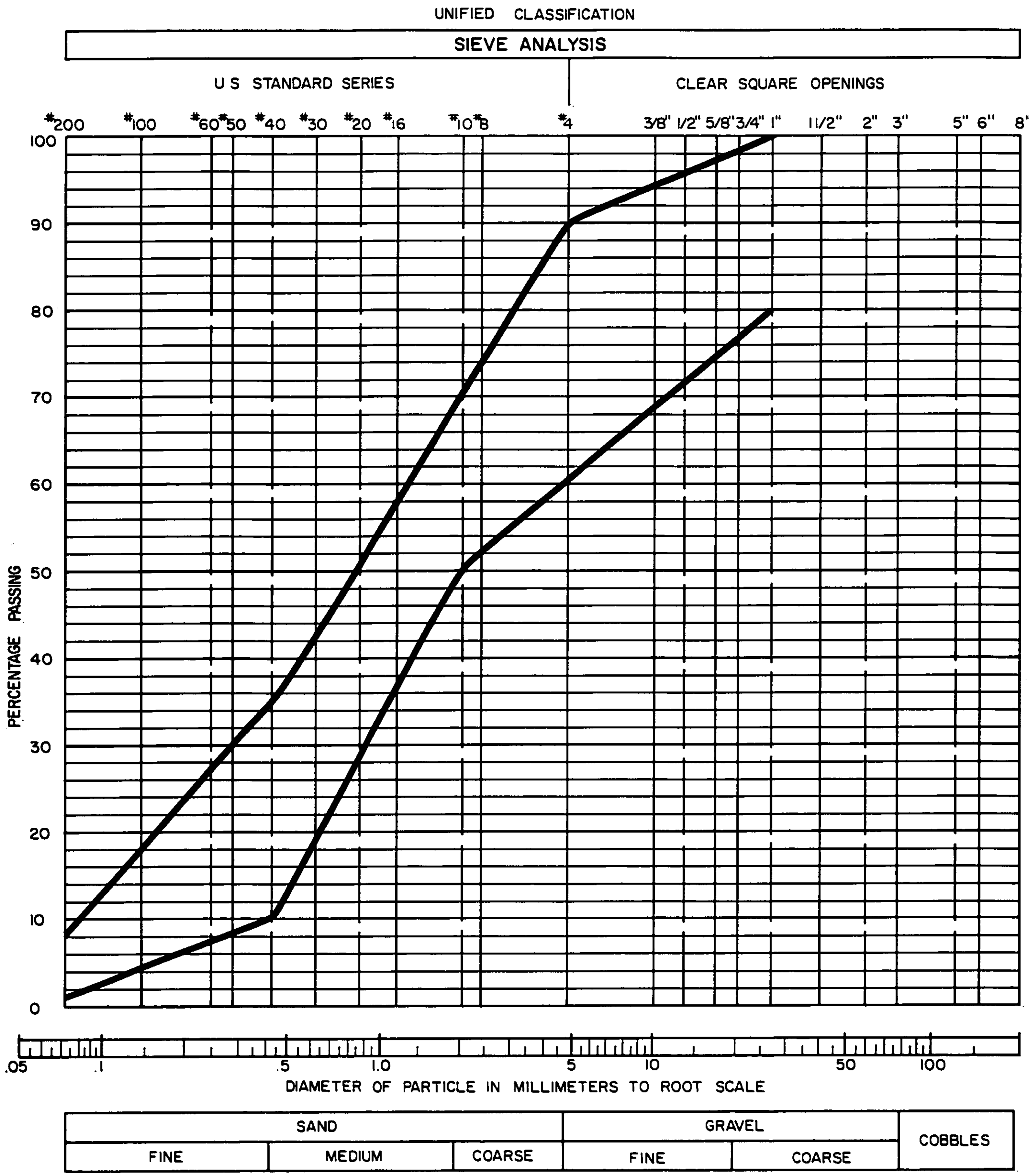


Aggregate Resources of the Winnipeg Region

Grain Size Distribution Ranges Range 4

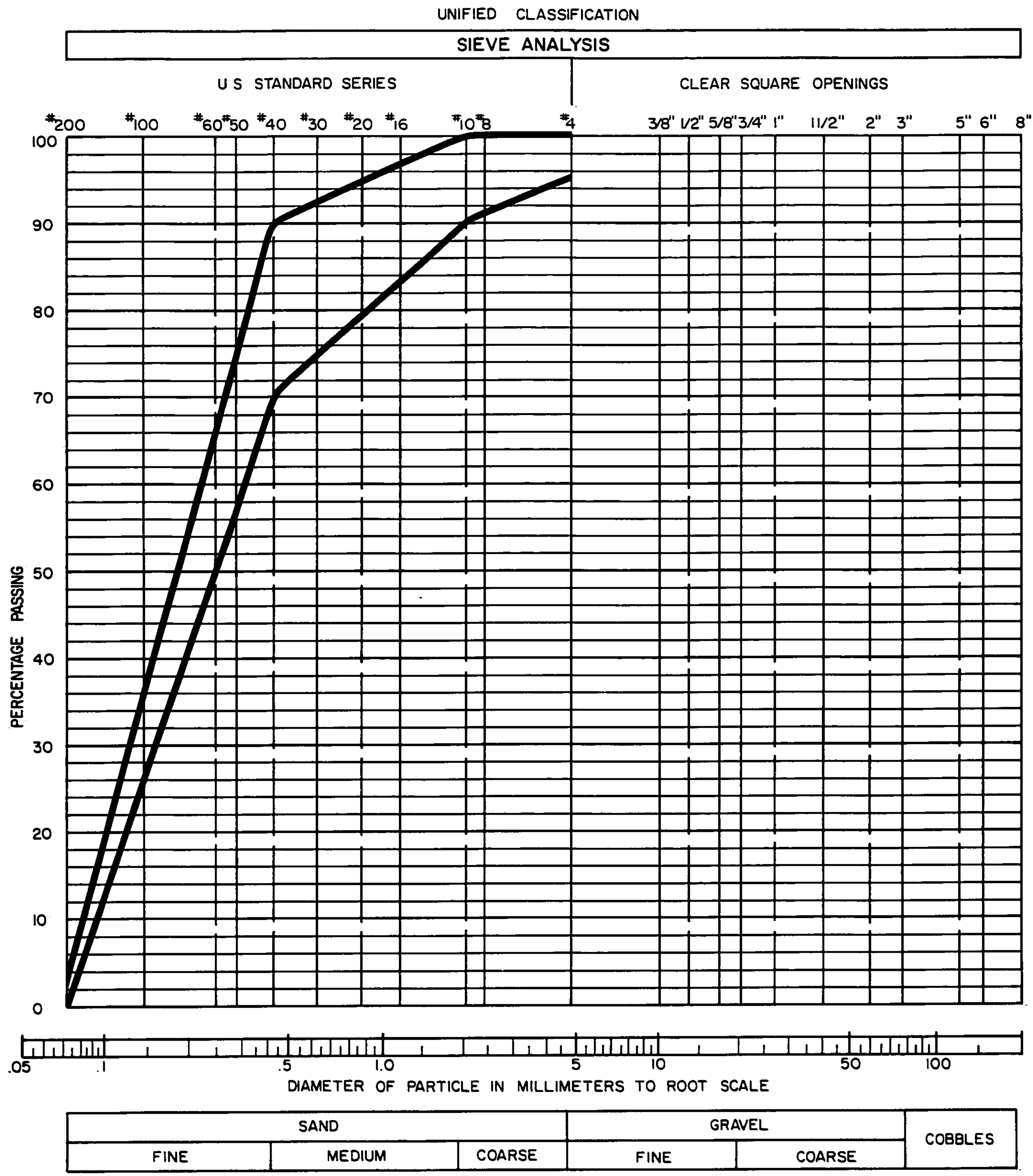
The UMA Group

Plate D-13



Aggregate Resources of the Winnipeg Region

Grain Size Distribution Ranges Range 5



Aggregate Resources of the Winnipeg Region

Grain Size Distribution Ranges Range 6

The UMA Group

Plate D-15

4. LAKE AGASSIZ LOWLANDS

4.1 General Geology

The Lake Agassiz lowlands which can best be described as an offshore clay basin primarily comprise the floodplains of the Red, Assiniboine, Winnipeg, Whitemouth and Brokenhead Rivers. The surficial soils are predominantly clay overlying till. The average clay thicknesses are in the order of 20 to 30 feet (6 to 9 metres).

The glacio-fluvial sand and gravel deposits of the Bird's Hill Complex are the most predominant feature in the lowlands but for the purposes of this report they are dealt with as a separate physiographic feature.

An area of the lowlands between Bird's Hill and Vivian was also suspected to have granular materials buried beneath the non-granular surficial soils and this area is covered in sub-section D-9 of this report which discusses the results of the E-Phase program.

Till outcrops in isolated locations within the lowlands and beach ridges and near-shore lake sediments form granular deposits within the basin.

Topographically the area is level to gently undulating.

The general geology of the Lake Agassiz Lowlands is indicated on Plates D-6, D-7 and D-8 with the location shown on Plate D-9.

4.2 Sand and Gravel Potential

Assessment of sand and gravel potential in the lowlands was based upon:

— Manitoba Department of Agriculture soils surveys
— Field and laboratory test data by the Manitoba Department of Highways
— Air photo interpretation
— Existing N.T.S. topographical maps
— Published geological data
— Field observations by Underwood McLellan and Associates Ltd.

Sand and gravel potential within the lowlands is limited with the material generally falling within grain size distribution ranges 4 and 5 but the majority within range 5.

The potential for sand and gravel is tabulated in Table D-1.

TABLE D-1

SAND AND GRAVEL POTENTIAL — LAKE AGASSIZ LOWLANDS

Location		Expected Grain Size Distribution Range	Total Estimated Quantity Millions of		Estimated Percent Depleted	Estimated Quantity Remaining Millions of	
TWP.	RGE.		Short Tons	Metric Tonnes		Short Tons	Metric Tonnes
5	2E	5	.4	.3	20	.3	.27
11	1W	5	1.0	0.9	30	0.7	0.64
11	2W	5	1.2	1.1	40	0.72	0.66
12	1E	5	2.4	2.2	40	1.4	1.3
12	1W	5	2.2	2.0	50	1.1	1.0
12	2W	5	0.1	0.09	10	0.1	0.09
13	5E	4	2.2	2.0	90	0.2	0.18
13	6E	4	0.6	0.5	10	0.5	0.4
		5	1.6	1.5	5	1.5	1.4
13	7E	5	10.3	9.3	20	8.2	7.4
13	8E	5	0.4	0.36	0	0.4	0.36
13	1W	5	0.09	0.08	5	0.09	0.08
13	2W	5	0.09	0.08	5	0.09	0.08
14	5E	5	0.6	0.5	80	0.1	0.09
14	6E	5	1.2	1.1	80	0.2	0.18
14	7E	5	3.4	3.1	40	2.0	1.8
15	6E	5	1.2	1.1	80	0.2	0.18
15	9E	5	0.6	0.5	0	0.6	0.5
TOTALS			29.6	26.7		18.4	16.6

5. INTERLAKE TILL PLAIN

5.1 General Geology

The Interlake area is characterized by gently undulating ridge and swale topography developed largely on ground moraine. The till is highly calcareous, consisting of boulders and pebbles in a silty clay matrix. Relief diversity is caused by Lake Agassiz beach ridge features which concentrate marginal to the western shore of Lake Winnipeg, and along the northern edge of the Lake Agassiz clay basin. At the latter location they are arcuate in form and oriented in a north-east to south-west direction.

Relief varies from 3 to 24 feet (1 to 8 metres) above the surrounding terrain, averaging at 15 feet (5 metres). In most cases gravel can be obtained from the shoreline features, although generally 30% of the deposit is below static water level. Alternately gravel is derived from a finer lag layer — a pebble concentration — found towards the surface of the till plain.

The general geology is illustrated on Plates D-6 and D-7 with the location of the Interlake Till Plain being indicated on Plate D-9.

5.2 Sand and Gravel Potential

Assessment of sand and gravel potential in the till plain area was based on:

- — Manitoba Department of Agriculture soils survey
- — Field and laboratory test data by the Manitoba Department of Highways
- — Air photo interpretation
- — Existing N.T.S. topographical mapping
- — Published geological data
- — Field observations by Underwood McLellan and Associates Ltd.

The majority of material falls within distribution range 5, and petrographically is limestone based. Coarse granular content is generally low but homogeneous, with fractions ranging from 10-15% and rarely exceeding 20% retained on the No. 4 sieve size. Coarse fractions exceeding this limit are usually found concentrated in "pockets". Detection of coarse concentrations is hindered by a thin mantle of sand which commonly covers the ridges.

Some of the larger beach ridge features, notably around Woodlands, have been 20-30% depleted and several active pit operations still exist. In general, however, less than 10% of the available granular material in the region appears to have been used. Most activity centers around the coarse "pockets" previously mentioned, but in areas where no concentration of coarse is available, coarse material has been collected and concentrated by mechanical means.

On a basis of field work carried out by Underwood McLellan and Associates Ltd., an average depth of 6 feet (2 metres) was selected for quantification of deposits. The granular aggregate potential of the Interlake Till Plain is tabulated by Township and Range in Table D-2.

TABLE D-2

SAND AND GRAVEL POTENTIAL — INTERLAKE TILL PLAIN

Location		Total Estimated Quantity Millions of		Estimated Percent Depleted	Estimated Quantity Remaining Millions of	
TWP.	RGE.	Short Tons	Metric Tonnes		Short Tons	Metric Tonnes
12	2E	0.8	0.7	10	0.7	0.6
13	1E	3.1	2.8	10	2.8	2.5
13	2E	3.8	3.4	10	3.4	3.1
13	3W	13.7	12.4	50	6.8	6.2
13	4W	17.0	15.4	10	15.3	13.9
14	1E	0.4	0.36	10	0.4	0.36
14	2E	3.1	2.8	10	2.8	2.5
14	1W	8.5	7.7	10	7.6	6.9
14	2W	11.3	10.3	10	10.2	9.3
14	3W	15.5	14.1	50	7.8	7.1
15	1E	13.8	12.5	10	12.4	11.3
15	2E	9.4	8.5	10	8.5	7.7
15	4E	5.7	5.2	10	5.1	4.6
15	3W	8.3	7.5	10	7.5	6.8
16	1E	22.2	20.1	10	20.0	18.1
16	2E	11.9	10.8	10	10.7	9.7
16	3E	1.0	0.9	10	0.9	0.8
16	4E	9.7	8.8	10	8.7	7.9
17	1E	4.6	4.2	10	4.1	3.7
17	2E	7.2	6.5	10	6.5	5.9
17	3E	5.9	5.4	10	5.3	4.8
17	4E	0.9	0.8	10	0.8	0.7
TOTALS		177.8	161.16		148.3	134.46

NOTE: Majority of material falls within Grain Size Distribution Range 5.

6. THE LAKE TERRACE AREA

6.1 General Geology

Between the Lake Agassiz Lowlands and the Belair-Agassiz-Sandilands Uplands is the Lake Terrace Area with elevations intermediate between that of the Lowlands and the Uplands. The general area of the Lake Terrace Area is indicated on Plate D-9 with the surficial geology shown on Plates D-7 and D-8.

It is believed that sand and gravel was deposited as water from the melting glacier cut and then filled channels in the ice and in previously deposited sediments. Because many of these streams likely were short-lived and often extended but a few miles beyond the glacier margin, this type of granular deposit is not expected to have formed an extensive sand and gravel unit. As the glacier retreated, Lake Agassiz encroached on the Lake Terrace area and reworked some of the previously deposited materials into elongated, slightly elevated ridges of sand and gravel along the shoreline which conforms roughly to the contour of the land. Where there were broad shallow areas in this lake which yielded granular material when eroded, blankets of sand and gravel were left as a lag deposit.

6.2 Sand and Gravel Potential

Most of the granular material at the surface in this region is expected to be less than 10 feet (3 metres) in thickness with some thicknesses reaching 20 feet (6 metres).

Sand is predominant in most of the deposits with the material falling within Distribution Ranges 4 and 5.

The estimated sand and gravel potential for the Lake Terrace area is presented in Table D-3.

TABLE D-3

SAND AND GRAVEL POTENTIAL — LAKE TERRACE AREA

Location		Expected Grain Size Distribution Range	Total Estimated Quantity		Estimated Percent Depleted	Estimated Quantity Remaining	
			Millions of			Millions of	
TWP.	RGE.		Short Tons	Metric Tonnes		Short Tons	Metric Tonnes
4	4E	5	3.9	3.5	50	2.0	1.8
4	5E	4	1.8	1.6	10	1.6	1.5
		5	8.4	7.6	10	7.6	6.9
4	6E	4	6.7	6.1	5	6.4	5.8
4	7E	4	10.3	9.4	0	10.3	9.4
4	8E	4	0.2	0.1	0	0.2	0.1
5	5E	5	15.1	13.7	15	12.9	11.7
5	6E	4	10.5	9.5	5	9.9	9.0
		5	27.4	24.8	5	26.1	23.7
5	7E	4	11.5	10.4	5	10.9	9.9
5	8E	4	17.2	15.6	10	15.4	14.0
5	9E	4	3.9	3.5	10	3.5	(3.2
6	5E	5	8.8	8.0	30	6.2	5.6
6	6E	5	16.9	15.2	20	12.6	12.3
6	7E	5	26.8	24.4	10	24.1	21.9
		4	4.6	4.2	0	4.6	4.2
6	8E	4	10.9	9.9	25	8.2	7.5
6	9E	4	18.9	17.2	5	18.0	16.4
		5	0.7	0.6	0	0.7	0.6
7	6E	5	4.6	4.2	10	4.1	3.7
7	7E	4	8.4	7.6	25	6.3	5.7
		5	28.9	26.2	25	21.6	19.6
7	8E	4	38.2	34.7	10	34.4	31.2
7	9E	3	57.9	52.7	0	57.9	52.7
		4	6.6	6.0	5	6.3	5.7
		5	0.2	0.1	0	0.2	0.1
8	6E	5	0.6	0.5	50	0.3	0.3
8	7E	4	51.9	47.0	5	49.3	44.7
		5	0.8	0.7	0	0.8	0.7
8	8E	4	36.7	33.3	10	33.1	30.0
8	9E	4	6.3	5.7	50	3.1	2.8
9	7E	4	10.8	9.8	20	8.6	7.8
9	8E	4	33.1	30.0	30	23.2	21.0
10	7E	4	16.2	14.7	25	12.1	11.0
10	8E	4	30.3	27.5	40	18.2	16.5
11	7E	4	25.5	23.1	10	22.9	20.8
11	8E	4	5.8	5.2	5	5.6	5.1
12	8E	4	2.2	2.0	25	1.6	1.5
TOTALS			569.5	516.3		490.8	446.4

7. BELAIR-AGASSIZ-SANDILANDS UPLANDS

7.1 General Geology

The Belair-Agassiz-Sandilands Uplands comprise a series of north-south trending discontinuous uplands flanked generally by peat, silts and clays of the Lake Agassiz Lowlands and the intermediate Lake Terrace Area. These uplands are interpreted as being deposited by glacial meltwater either in a broad channel within the glacier (i.e., as an esker) or along the outer (western) edge of the glacier as an outwash apron or reworked end moraine. Evidence exists for both mechanisms and it is likely that both occurred. Following initial deposition, reworking of these materials by wave action formed beach ridges, spits, bars and beach ridge complexes. This reworking occurred due to the existence of glacial Lake Agassiz which may at times have covered these deposits at shallow depth. At other times these deposits were reworked in the littoral environment. The effect was to concentrate the coarsest size fractions into slightly elevated ridges which conform roughly to the contour of the land. Eolian (wind action) working of these sediments is also evident, particularly within the Sandilands Provincial Forest. The location of the Uplands division is shown on Plate D-9 with the general geology illustrated on Plates D-6, D-7, and D-8.

7.2 Sand and Gravel Potential

The Uplands were considered in two parts.

— those areas within the boundaries of the Provincial Forest Reserves
and
— those areas adjacent to the Provincial Forest Reserves.

The analysis within the boundaries of the Provincial Forest Reserves was much more detailed than in other physiographic areas considered in this report for the following reasons:

— The Uplands were considered to offer the best potential as the long term future sources of sand and gravel for the Winnipeg Region.
— The area represented a large area of Crown lands.
— The variety of environments for the deposition and formation of granular deposits suggested that detailed information gained in this area could be utilized to assess adjacent areas where lesser information was obtained.

The analysis of the quantity and quality of granular aggregates available within the Uplands was based primarily on:

— Manitoba Department of Agriculture soils maps
— Field and laboratory test data by the Manitoba Department of Highways
— Field and laboratory test data by Underwood McLellan and Associates with emphasis placed within the Forest Reserve boundaries
— Air photo interpretation
— Water well records
— Theses by MacPherson and Fenton
— Existing N.T.S. topographic mapping
— Published geological data

Within the Forest Reserve boundaries a review of existing data coupled with air photo interpretation resulted in the definition of areas with the highest potential as sources of granular aggregates. It was in these areas that field mapping and test pitting was concentrated. Where this field work coincided with previous work done by the Manitoba Department of Highways, the intent was to extend the testing beyond that carried out by the Department of Highways. The result of this approach was to tend to evaluate the best of the granular materials available.

Table D-4 presents the sand and gravel potential within the boundaries of the Belair-Agassiz-Sandilands Provincial Forests by Township and Range. Entered into Table D-5 is a column denoted as "Not Classified" which represents the estimate of granular material not considered to fall within the bounds of the 6 grain size distribution ranges. Also entered is a column "Estimated Percent Depleted". This applies to the total deposit, to the depths assumed in calculating the quantities. No attempt has been made to project the percent depleted to the individual grain size distribution ranges. However, by using weighted averages, an average of 10 percent depletion was developed. It can be assumed, based on field observation, that most of the depletion occurred within grain size

TABLE D-4

SAND AND GRAVEL POTENTIAL — BELAIR-AGASSIZ-SANDILANDS FOREST RESERVES

(Within Boundaries of the Forest Reserves)

Location TWP.	Location RGE.	Estimated Percent Depleted	Total Estimated Quantity Millions of Short Tons	Percentage of Total Quantity per Grain Size Distribution Range 1	2	3	4	5	6	Not Classified	Total Estimated Quantity of Material per Grain Size Distribution Range (Millions of Short Tons) 1	2	3	4	5	6	Not Classified
1	11	50	0.3				20		80					.06		.24	
1	12	20	45.0				20	30	50					9.00	13.5	22.6	
1	13	0	0.75				15	40	55					0.11	0.3	0.42	
2	11	5	142.0			5	5	5	70	15			7.1	7.1	7.1	99.6	21.1
2	12	0	32.0				5	5	80	10				1.6	1.6	25.6	
2	13	5	7.0			1	2	3	80	14			0.07	0.15	0.21	5.4	0.94
3	9	10	57.0			5	10	30	40	10			2.8	5.7	17.1	22.9	5.7
3	11	0	26.0			5	10	30	40	10			1.3	2.7	7.9	10.6	1.4
3	12	0	151.0			10	20	20	30	20			15.1	30.1	30.1	45.3	30.1
4	9	5	129.0			5	5	30	30	30			6.5	6.5	38.6	38.6	38.6
4	10	5	69.0				10		40	50				6.9		27.4	34.3
4	11	5	5.0				10	10	40	40				0.45	0.45	1.9	1.9
5	9	15	46.0			5	10	20	40	25			2.3	4.7	9.2	18.3	11.4
5	10	0	45.0				10	20	50	20				4.5	9.0	22.3	9.0
6	9	0	11.0		5			15		80		0.54			1.6		8.6
6	10	5	166.0				5	5	40	50				8.4	8.4	66.6	83.2
6	11	0	10.0		5	5	10	20	60			0.45	0.45	0.90	1.9	5.7	
7	10	0	160.0		5	10	10	20	20	35		7.9	15.9	15.9	31.8	31.8	55.9
7	11	5	39.0		5	5	20	20	20	30		1.9	1.9	7.8	7.8	7.8	11.6
8	9	15	105.0		5	10		30	30	25		5.2	10.5		31.5	31.5	26.2
8	10	5	93.0			5		5		90			4.6			4.6	83.7
8	11	30	38.0			5	5	30	20	40			1.9	1.9	11.4	7.6	15.1
8	12	30	7.0			5	5	20	55	15			0.3	0.3	1.5	3.9	1.1
9	9	30	69.0		2	10	10	20	20	35		3.5	6.9	6.9	13.8	13.8	24.1
9	10	0	11.0		5	5	10	10	40	30		0.6	0.6	1.0	1.0	4.4	3.4
9	11	0	0.9					10	40	50					0.09	0.36	0.45
10	9	0	18.0				20	20	30	30				3.6	3.6	5.2	5.2
10	10	20	32.0		5	5	10	10	40	30		1.6	1.6	3.3	3.3	12.9	9.4
11	9	5	20.7		5	5	15	20	40	15		1.1	1.1	3.1	4.2	8.2	3.1
11	10	5	12.5		5	5		30	30	30		0.6	0.6		3.7	3.7	3.7
12	9	40	90.0		5	10		30	30	25		4.5	9.0		26.8	26.8	22.3
12	10	0	9.1				25	25	25	25				2.2	2.2	2.2	2.2
13	9	10	57.0		10	5	10	25	25	25		5.7	2.8	5.7	14.2	14.2	14.2
13	10	10	44.0		2	3	20	20	30	25		0.9	1.3	8.8	8.8	13.5	11.1
14	9	10	60.0		2	3	20	20	25	30		1.1	1.5	10.5	10.5	13.0	15.6
14	10	25	89.0		2	3	25	25	25	20		1.8	2.7	22.2	22.2	22.2	17.7
15	9	10	17.0		5	15	20	20	20	20		0.9	2.5	3.3	3.3	3.3	3.3
17	8	20	74.4	20		15	20	25		20	18.6		13.9	18.6	23.4		18.6
18	7	0	0.9			5	10	20	40	25			0.04	0.09	0.15	0.3	0.22
18	8	0	62.0			5	20	20	30	25			3.1	12.4	12.4	18.7	15.6
19	7	15	42.0			5	20	20	30	25			2.1	8.4	8.4	12.6	10.5
										TOTALS Millions of Short Tons	18.6	38.4	121.0	225.2	393.4	676.6	621.0
										Millions of Metric Tonnes	16.9	34.9	110.1	204.9	358.0	615.7	565.1

distribution ranges 1 to 4, as the tendency was to remove the best material.

Table D-5 presents the sand and gravel potential within the Uplands area but outside the boundaries of the Forest Reserves.

TABLE D-5

SAND AND GRAVEL POTENTIAL — BELAIR-AGASSIZ-SANDILANDS UPLANDS
(Ourside the Boundaries of the Forest Reserves)

Location TWP.	RGE.	Expected Grain Size Distribution Range	Total Estimated Quantity Millions of Short Tons	Metric Tonnes	Estimated Percent Depleted	Estimated Quantity Remaining Millions Short Tons	Metric Tonnes
2	10E	4	53.2	48.4	5	50.5	46.0
		5	7.5	6.8	5	7.1	6.5
3	9E	4	16.2	14.7	5	15.4	14.6
		5	1.9	1.7	5	1.8	1.6
3	10E	4	20.2	18.4	5	19.2	17.5
		5	1.6	1.5	5	1.5	1.4
4	10E	4	1.8	1.6	5	1.7	1.5
9	9E	4	5.5	5.0	0	5.5	5.0
10	9E	4	1.0	0.9	5	0.9	0.8
11	9E	4	1.9	1.7	10	1.7	1.5
12	9E	4	13.3	12.1	40	8.0	7.3
13	9E	4	1.9	1.7	10	1.7	1.5
14	9E	4	1.4	1.3	0	1.4	1.3
15	7E	5	1.6	1.5	20	1.3	1.2
		6	27.9	25.3	0	27.9	25.3
15	9E	4	3.0	2.7	10	2.7	2.5
16	7E	4	24.9	22.6	30	18.1	16.4
		5	0.8	0.7	30	0.6	0.5
		6	31.9	28.9	0	31.9	28.9
16	9E	5	25.0	22.7	20	20.0	18.2
	10E	5	37.0	33.7	20	30.0	27.3
17	7E	4	4.6	4.2	25	3.5	3.2
		6	4.0	3.6	15	3.4	3.1
18	7E	3	1.0	0.9	15	0.9	0.8
		4	4.8	4.4	15	4.1	3.7
		6	2.2	2.0	0	2.2	2.0
TOTALS			296.1	269.0		263.0	239.6

8. THE BIRD'S HILL COMPLEX

8.1 Introduction

The Bird's Hill Complex which lies some 10 miles (16 kilometres) northeast of the City of Winnipeg and rises in the order of 125 feet (38 metres) above the surrounding clay plain has been a major source of granular aggregates in the Winnipeg Region for many years. Concern has been growing in recent years as to whether the good quality aggregate in this complex is close to depletion.

8.2 General Geology

The Bird's Hill Complex is believed to be of glaciofluvial origin and consists of fine silty sands to cross-bedded coarse gravels. Till occurs discontinuously beneath the glaciofluvial deposits and overlies them around much of the perimeter of the feature. The western arm of the feature is believed to be of eskerine origin which fans out to the east as a finer grained deltaic feature. It is within this arm that the majority of aggregate extraction has taken place.

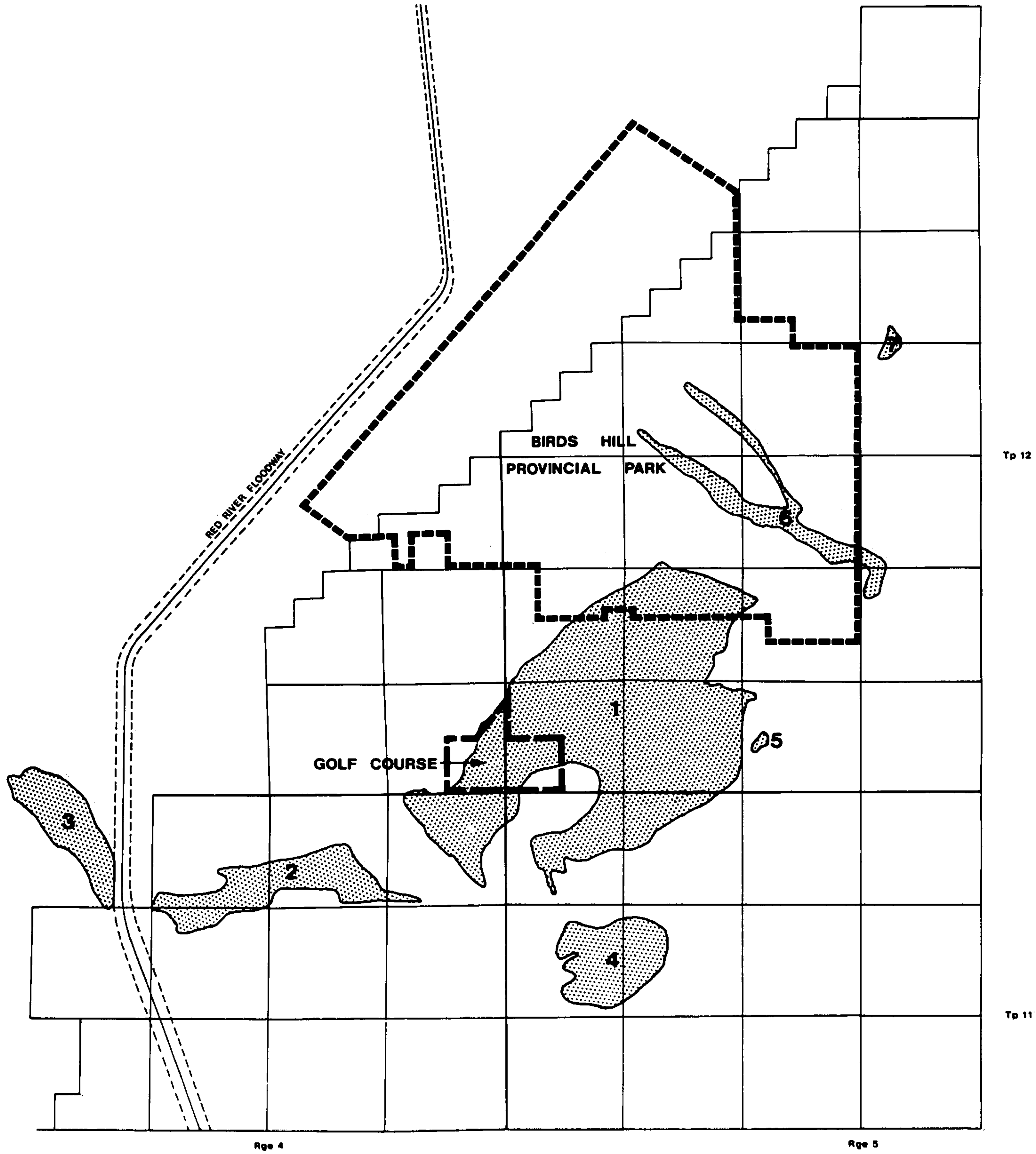
The general surficial geology of the Bird's Hill Complex is shown on Plate D-7 with its location being indicated on Plate D-9.

8.3 Sand and Gravel Potential

Based upon surficial geology, the Bird's Hill Complex was subdivided into 7 areas which were considered to have sand and gravel potential. Plate D-16 shows these areas. Personal communication with existing operators; field assessment of operating and abandoned pits; air photo interpretation; and general field reconnaissance were utilized to estimate the remaining quantity of granular aggregates available above the assumed water table. The results of this analysis are shown in Table D-6.

It is estimated that approximately 238 million short tons of available granular material exist above the water table, of which approximately 29 million short tons are considered to fall within distribution ranges 1 to 3. In other words, the majority or some 90 percent, is considered to be gravelly sands, sands and silts.

As a matter of speculation of the quantity of granular materials which may exist below the water table, calculations were carried out using a thickness of 10 feet (3 metres). This resulted in an estimate of some 98



Aggregate Resources of
the Winnipeg Region

Areas of Aggregate Potential Birds Hill Complex

The UMA Group

Plate D-16

million short tons. Based again on personal communication with operators, it is suggested that 70 to 75 percent of this material is finer than the No. 4 sieve size, which in turn would suggest that there may be a lack of confidence as to the quantities of coarse material existing below water table.

TABLE D-6

SAND AND GRAVEL POTENTIAL — BIRD'S HILL COMPLEX

Area	Total Estimated Granular — Millions of Short Tons	Total Estimated Granular — Millions of Metric Tonnes	Estimated Granular Removed to Date — Millions of Short Tons	Estimated Granular Removed to Date — Millions of Metric Tonnes	Estimated Granular Within Park and Golf Courses — Millions of Short Tons	Estimated Granular Within Park and Golf Courses — Millions of Metric Tonnes	Estimated Available Granular Potential — Millions of Short Tons	Estimated Available Granular Potential — Millions of Metric Tonnes	Estimated Potential Within Distribution Ranges 1 to 3 — Millions of Short Tons	Estimated Potential Within Distribution Ranges 1 to 3 — Millions of Metric Tonnes
1	300	272	70	63	45	41	185	168	18	16.7
2	57	52	39	35			18	16	4.5	4.1
3	27	24	17	15			10	9	2.5	2.3
4	49	44	27	24			22	20	3.3	3.0
5	0.5	0.4					0.5	0.4	0.07	0.06
6	20	18			20	18	0	0.0	0	0.0
7	2.2	2.0					2.2	2.0	0.33	0.30
TOTALS							237.7	215.5	29.2	26.5

9. E-PHASE SURVEY

9.1 Introduction

In the Winnipeg Region, notably in the area between Bird's Hill and Vivian, there was reason to believe that esker-delta complexes may be buried beneath non-granular surface materials. The available surficial geology did not provide sufficient information upon which to base a test drilling program. It was resultantly concluded that airborne E-Phase resistivity, which had been used with some success in Saskatchewan, would be the best tool to provide information as to the nature and potential of any buried granular deposits. The location of the E-Phase Survey Area is shown on Plate D-1.

9.2 Surficial Geology

Plate D-17 presents the surficial geology of the E-Phase survey area. The western portion of the area is covered by clay and the eastern portion by granular till and thin clay over till, with the granular till occurring mainly in the southeast. There are some small eskerine, beach, and outwash features containing sand and gravel scattered over the area.

9.3 The E-Phase Method

The E-Phase survey was carried out by Barringer Research Ltd. who developed the system.

The E-Phase method is based upon the application of wave tilt measurements for inferring the subsurface electrical properties of the ground. The forward tilt of three electric field vectors directed into the earth are measured simultaneously. The degree of forward tilt of the vector is a function of the resistivity of the ground, and the depth of penetration of the electric field vector is a function of both the wave frequency and the ground resistivity. The three frequencies used were:

— very low frequency (VLF) 15-25 kHz

— low frequency (LF) 200-400 kHz

— broadcast band (CBC) 550-1600 kHz

9.4 E-Phase Results

It was determined during the analysis of results that the LF and BCB frequencies provided the best data, so only resistivities derived from these two frequency inputs were contoured. The anomaly selection was done mainly from the LF results, as they reflect the resistivities of a thicker stratigraphic section.

It is important to realize the limitations of resistivity measurements to appreciate the results of the survey. In the case of a three-layer situation, when the middle layer describes the granular material, for a given resistivity contrast with the layers above and below, the middle layer has to have a certain thickness in order to exhibit itself as an electric layer. For smaller thicknesses, the resistivity contrast has to be larger, conversely if the thickness of the layer increases, small resistivity contrasts will be required in order to see it as an electric layer. A large thickness of clay and till, which have low resistivity, covering a granular deposit, can act as a shield and the electric waves will be concentrated in the upper covering layer not penetrating into the granular material. Hence, the granular material may not be indicated by the apparent resistivities.

The depth to bedrock varies considerably throughout the survey area, although it appears to be shallower in the northwestern corner. The bedrock surface has a "knoll and depression" type topography. The bedrock, which is limestone, usually has high resistivity, and it could be expected to produce high apparent resistivity anomalies where it is shallow. Inspection of the northwestern corner of the survey area reveals that anomalies of up to approximately 1,500 ohm-metres are associated with shallow bedrock. This would suggest that the true resistivity of the covering clay-till complex is low, in the order of 50-150 ohm-metres, which would have a reducing effect on the resistivity of the bedrock. Furthermore, it also suggests that the high apparent resistivities observed elsewhere should indicate high resistivity material in the overburden, or even shallower bedrock, assuming that the resistivity of the near surface overburden remains constant.

In evaluating the E-Phase data, all of the available surface and subsurface data in the form of water well records, agricultural soils maps, and air photos were utilized. In addition, field reconnaissance of the area was carried out to generally confirm the surficial geology and to examine existing test pit areas.

Plate D-18 presents a basic plot of the resistivity results with comparison to the surficial geology and the occurrence of granular material in water well logs within approximately 60 feet (20 metres) of ground surface.

The main anomalies shown on Plate D-18 have been designated by a number with any sub-anomalies within the main anomaly being designated alphabetically. Subsequently, they have been rated relative to granular potential as follows:

TABLE D-7

ANOMALY RATINGS

High Potential	Moderately High Potential		Moderate Potential		Low Potential		
8c	2a	30a	5a	19	1	8k	16
8d	2b	30b	6b	22	2c	9a	18
8j	6a	33a	8e	27	3	11d	20
11a	8h	33b	8i	28b	4	11f	21
11c	11b	34a	8l	32	5b	11g	23
28a	11e	34b	8m	37b	7	11h	24
28d	17b	34d	9b	37c	8a	12	25
29a	28c	35	10	38b	8b	13	26
34c	29b	36	17a	40	8f	14	31
38a	29c	37a			8g	15	
39b	29d	38c					
		39a					

The ratings from high to low potential are based upon judgement of the inter-relation of:

— whether both the LF and BCB showed anomaly response
— the value of the LF apparent resistivity
— the surficial geology
— the indication of granular in the subsurface

Table D-8 presents the anomalies in numerical order with the relevant data of resistivity values, subsurface granular indications, surficial geology, and comments on potential. When interpreting the significance of the drill hole data, it must be appreciated that the source is water well logs. The logging done by water well drillers cannot be expected to be accurate in classification, but can be expected to act as an indicator.

9.5 Sand and Gravel Potential

In speculation of the amount of sand and gravel that might be available from the possible buried deposits indicated by the E-Phase survey, calculations were carried out using cut sections varying between 5 and 10 feet (1.5 to 3.0 metres) over the areas of individual anomalies. This approach of using a relatively modest cut section resulted in a quantitative potential of 185 million short tons or 168 million metric tonnes. Although this is a highly unqualified estimate, it does act as an indicator to the potential of the E-Phase survey area, should the majority of the anomaly areas contain good quality sand and gravel above the water table.

TABLE D-8

E-PHASE ANOMALY DATA

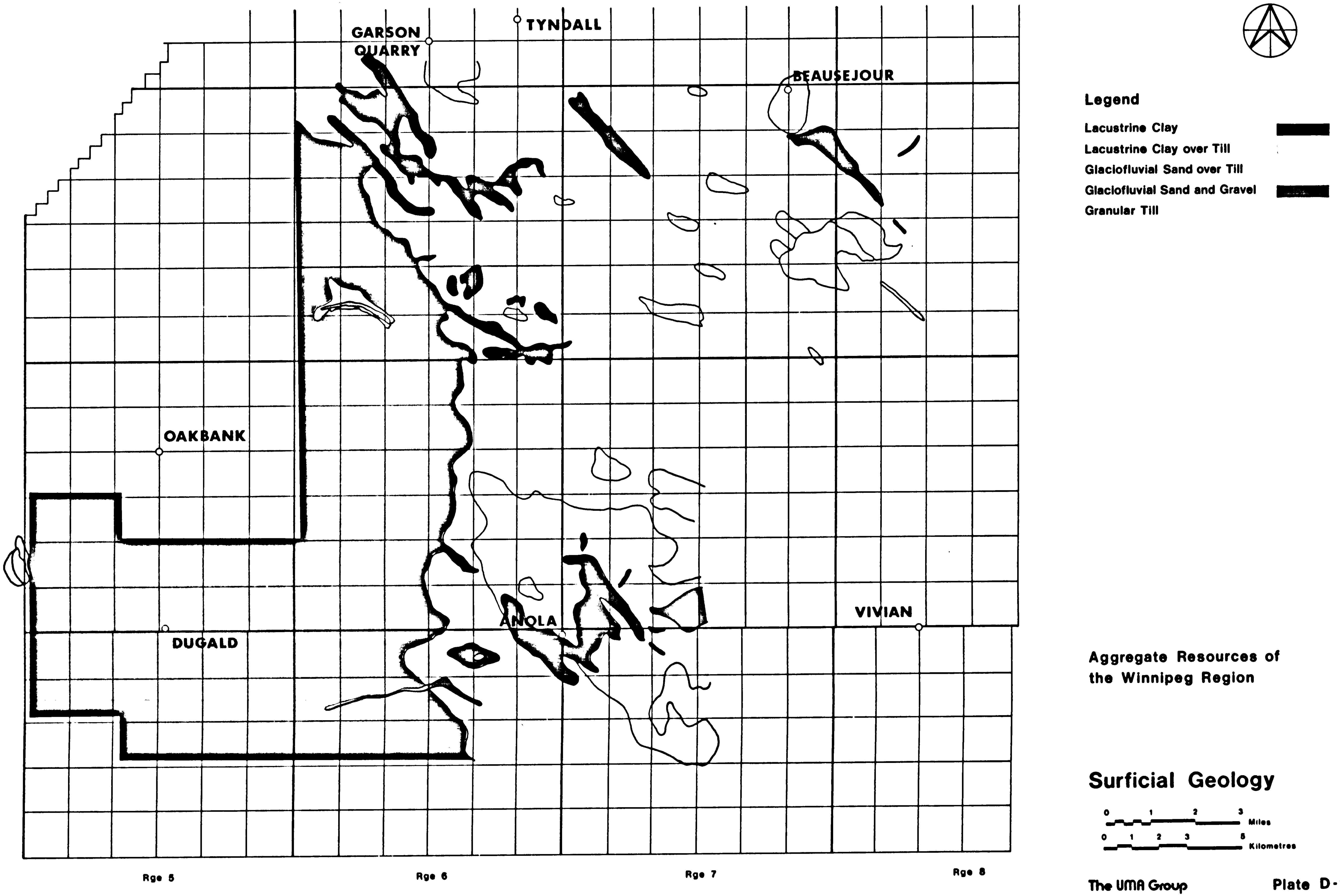
Anomaly	Maximum Low Frequency Resistivity (Ohm-metres)	Associated Drill Hole Data	Association with Surficial Geology	Comments
1 — LF	2000	None	Thin Clay over Till	— Low potential anomaly with no surface or sub-surface correlation
2 a — LF + BCB	1400	Gravel 5 ft.-12 ft.; Gravel 22 ft.-24 ft.	Granular Till	— high potential anomaly — good chance for coarse granular
2 b — LF + BCB	2500	Sand & Gravel 0-20 ft.; Sand, gravel & clay 46-60 ft.	Thin Clay over Till	— same as 2 a
2 c — LF + BCB close	1000	None	Thin Clay over Till	— low potential anomaly
3 — LF	2000	None — 1 drill hole on the flank of the anomaly had no granular material	Granular Till	— low potential anomaly — there may be concentrations of coarse material in the till
4 — LF	1500	1 hole to the south with sand from 20-72 ft.	Granular Till	— same as 3
5 a — LF + BCB	2700	Inter-till Granulars to 119 ft.	Granular Till	— medium potential anomaly — material may be a till with good coarse content
5 b — LF	2300	None	Thin Clay over Till	— low potential anomaly — probably due to till at some depth under clay
6 a — LF + BCB	3000	Several holes with thick sand layers but the gravel is in thin layers. Indication of more coarse material to the north	Thin Clay over Till	— high potential for granular material but it may be predominantly sand
6 b — LF	1600	Thick sand sections in drill holes	Sand and Gravel Beach Deposits	— same as 6 a, but anomaly has lower resistivities and is only of medium potential
7 — LF	1100	None	Thin Sand over Clay	— low potential for any coarse granular
8 a — LF	1500	None	Thin Clay over Till	— low potential anomaly
8 b — LF + BCB	2000	None	Thin Clay over Till	— same as 8 a
8 c — LF + BCB	4500	1 drill hole on south end of anomaly has sand near surface with coarse at 50 ft.	Thin Clay over Till	— good potential for granular but may be sand
8 d — LF + BCB	5500	Sand and gravel from 12 ft. - 16 ft.	Sand over Till	— high resistivities indicate good potential for coarse granular
8 e — LF + BCB	2100	1 hole in the north-west with sand	Granular Till	— medium potential for granular but the material is likely sand or granular till

Anomaly	Maximum Low Frequency Resistivity (Ohm-metres)	Associated Drill Hole Data	Association with Surficial Geology	Comments
8 f — LF	1400	None	Sand over Till and Clay over Till	— low potential for granular material
8 g — LF + BCB	2000	1 hole to the east with sand from 0-10 ft.: sand and gravel from 19-45 ft.	Sand over Clay	— low potential for coarse granular — resistivities are probably reflective of the surficial sand
8 h — LF + BCB	3500	Sand layers in 1 hole to the northwest. Gravel and boulder layers in 1 hole to the southeast	Granular till	— good potential for coarse granular
8 i — LF + BCB	2500	1 hole to the east with coarse granular from 20-60 feet	Thin Clay over Till. Granular Till just south of the anomaly	— good potential for coarse granular
8 j — LF + BCB	4800	1 hole to the north with gravel at 60 ft.	Granular Till and thin Clay over Till	— high potential anomaly — high resistivities indicate coarse material, but it could be bouldery till near surface
8 k — LF + BCB	1800	Shallow sand with deep gravel and boulders to the west	Thin Clay over Till	— low potential for coarse granular close to surface
8 l — LF + BCB	3500	Shallow and deep sand in 1 hole to the south	Thin Clay over Till	— medium potential for granular material but it may be sand
8 m — LF + BCB	2900	1 hole to the north with no granular	Thin Clay over Till (sand over till to the southeast)	— same as 8 l
9 a — LF	1100	None	Thin Clay over Till	— low potential for granular deposit — resistivities may be due to the underlying till or granular material at depth
9 b — LF + BCB	2600	1 hole with sand from 5-11 ft. 1 mile to the north	Thin Clay over Till	— medium potential anomaly — indications of granular in the area but it may be sandy
9 c — LF + BCB	2800	None	Thin Clay over Till	— same as 9 b
10 — LF + BCB	1100	Sand from 0-40 ft. in 1 hole in the immediate area	Granular Till	— medium potential anomaly — good correlation with the geology and drill hole data but low resistivities and drill hole data indicate the granular material is sand
11 a — LF + BCB	2500	Sand and boulders from 0-30 feet	Clay and Thin Clay over Till	— high potential anomaly — good chance for coarse granular material
11 b — LF + BCB	1500	Sand and boulders from 0-30 ft. just east of the anomaly	Clay	— Same as 11 a
11 c — LF + BCB	2700	Sand and gravel from 5-30 feet, ½ mile to the north	Outwash sand and gravel	— same as 11 a
11 d — LF + BCB	1600	1 60 ft. hole just southeast of the anomaly had no granular	Clay, Thin Clay over Till, and outwash sand and gravel to the east	— low potential anomaly — no indication of granular associated with the anomaly
11 e — LF + BCB	3000	1 hole with sand and gravel from 32-39 ft. 1 mile north of the anomaly	Clay	— high potential anomaly — sand and gravel to the north (at depth) — high resistivities indicate the potential for granular at shallow depth
11 f — LF + BCB	1500	None	Clay	— low potential anomaly — no indication of granular in holes close by. Resistivities could be till or sand and gravel at depth
11 g — LF + BCB	1100	None	Clay	— same as 11 f
11 h — LF	1400	None	Clay and Thin Clay over Till	— same as 11 f
12 — BCB	400	1 hole close by with no granular	Clay	— low potential anomaly — little potential for an economic granular deposit
13 — BCB	400	1 hole, ½ mile to the northwest with gravel and boulders from 25 to 30 ft.; closer to the anomaly, drill holes had only clay and till	Clay	— same as 12
14 — BCB	400	1 hole close by had thin sand layers at depth	Clay	— same as 12
15 — BCB	300	Several holes in the area have thin (2-3 ft.) gravel layers but generally 25 ft. or more below surface	Clay	— same as 12
16 — BCB	800	Drill holes show granular layers 5-10 ft. thick at the 40 ft. depth	Clay	— same as 12
17 a — LF + BCB	2000	Pit excavations in the granular till unit	Granular Till	— medium potential anomaly
17 b — LF + BCB	3500	Pit excavations in the granular till unit	Granular Till	— high potential anomaly — there are pits in the granular till with 15%-20% of plus # 4 material, but the deposit is almost depleted down to the water table

Anomaly	Maximum Low Frequency Resistivity (Ohm-metres)	Associated Drill Hole Data	Association with Surficial Geology	Comments
18 — LF	1400	1 hole just to the west had no granular	Clay	— low potential for granular as the anomaly may be due to shallow bedrock in the area
19 — LF	2500	Several holes in the area have gravel sections from 7-28 ft. thick, but they are 40 or more ft. below ground level	Clay	— medium potential anomaly — there are indications of both shallow bedrock and granular sections in the area. The anomaly could be the result of either
20 — BCB	600	Thin (3-4 ft.) granular sections	Clay	— low potential for an economic granular deposit
21 — LF	1000	9-20 ft. of granular material under 40 ft. of cover	Clay	— same as 20
22 — LF + BCB	3000	None	Clay	— medium potential anomaly — could be shallow bedrock or granular material
23 — BCB	500	None	Clay; beach ridge 1 mile to the east	— low potential for an economic granular deposit
24 — LF	1000	None	Clay	— low resistivity and lack of associated granular material make this a low potential anomaly
25 — LF + BCB	700	None	Clay	— same as 24
26 — LF + BCB	500	None	Clay and Thin Clay over Till	— low potential anomaly — no granular indicated in the area and resistivities are low
27 — LF + BCB	1600	1 hole with gravel and clay from 22-46 ft.	Granular Till	— medium potential anomaly — resistivities may represent coarse concentrations in the till that might be usable as aggregate
28 a — LF + BCB	2000	5-10 ft. sections of both sand and gravel size material from surface to 60 ft. down	Thin Clay over Till	— high potential anomaly — granular material in drill holes and the associated outwash feature make this a good prospect
28 b — LF + BCB	1000	Same as 28 a	Thin Clay over Till	— medium potential anomaly — there is granular in associated drill holes but the resistivities are low
28 c — LF + BCB	2200	1 hole with sand and boulders from 43-48 ft.	Granular Till	— high potential anomaly — association with the granular till and the high resistivity means this could be a source of coarse aggregate
28 d — LF	3500	Same as 28 c	Granular Till	— same as 28 c

Anomaly	Maximum Low Frequency Resistivity (Ohm-metres)	Associated Drill Hole Data	Association with Surficial Geology	Comments
29 a — LF + BCB	5500	Near surface sand, gravel and boulders in adjacent holes	Granular Till and outwash sand and gravel	— high potential anomaly — high resistivity and associated granular make this a good prospect for coarse aggregate
29 b — LF + BCB	2400	Sand and gravel in nearby drill holes	Granular Till	— same as 29 a
29 c — LF	3400	Same as 29 b	Granular Till	— same as 29 a
29 d — BCB	1500	Sand and gravel in holes north and west of the anomaly	Granular Till	— same as 29 a
30 a — LF + BCB	3000	— 1 hole with gravel and clay at depth (28 ft.) — 1 pit in the till with an average of 20%-25% plus # 4 material	Granular Till	— high potential anomaly — there could be some sorted coarse granular associated with the beach ridge
30 b — LF	2500	same as 30 a	Granular Till	— same as 30 a
31 — LF + BCB	900	1 hole with gravel and clay at 28 ft. 1 mile east of the anomaly	Thin Clay over Till	— low potential anomaly — low resistivities and a lack of associated granular make this a poor prospect for a granular source
32 — BCB	1100	Both shallow and deep granular sections in adjacent holes	Granular Till	— medium potential anomaly — the resistivities are not high but the associated granular till and sub-surface granular sections give it some potential
33 a — LF + BCB	3100	Sand and gravel in holes nearby at 30-40 ft. depth. Further east, granular in holes is closer to the surface	Granular Till	— high potential anomaly — there are sand and gravel sections in nearby drille holes and the resistivities are quite high
33 b — LF	2400	Same as 33 a	Granular Till	— Same as 33 a
34 a — LF + BCB	2800	Sand and gravel at depth (30-50 ft.) in nearby holes	Granular Till	— high potential anomaly — resistivities are high and there is a lot of associated granular in the area
34 b — LF + BCB	2000	Both shallow and deep sand and gravel sections in nearby holes	Outwash sand and gravel	— same as 34 a
34 c — LF + BCB	4100	Sand and gravel at depth (30-50 ft.) in nearby holes	Granular Till	— same as 34 a
34 d — LF + BCB	3500	Same as 34 c	Granular Till	— same as 34 a

Anomaly	Maximum Low Frequency Resistivity (Ohm-metres)	Associated Drill Hole Data	Association with Surficial Geology	Comments
35 — LF + BCB	3000	Sand and gravel at the 20 ft. depth just west of the anomaly	Granular Till	— high potential anomaly — high resistivities and associated granular make this a good prospect for coarse material
36 — LF + BCB	2500	1 hole with sand from 32-38 ft.	Sand and Gravel surrounded by Clay	— high potential anomaly — good resistivities and association with granular in drill holes and surficial geology. There may be good coarse granular related to the beach ridge
37 a — LF	2700	Several holes with granular sections ranging from surface to 40 ft. down	Thin Clay over Till	— high potential anomaly — good resistivity and association with granular in drill holes, but the depth to the material is unknown
37 b — LF + BCB	1500	Holes to the north and southwest with granular	Thin Clay over Till	— medium potential of granular deposit at an economic depth. — resistivities are not very high and there is no associated granular
37 c — LF + BCB	1700	1 hole close to the anomaly with granular from 65-70 ft.	Thin Clay over Till	— same as 37 b
38 a — LF + BCB	4200	Gravel and boulders from 7-22 ft. 1 mile to the west	Thin Clay over Till	— high potential anomaly — good drill hole correlation and high resistivities make this a good prospect for coarse material
38 b — LF	2100	None	Thin Clay over Till	— medium potential anomaly — resistivities are lower and there is no drill hole data in the immediate area — 38 a and 38 c should be investigated before deciding on 38 b
38 c — LF + BCB	3000	1 hole with gravel and sand from 20-35 ft., just northeast of the anomaly	Thin Clay over Till	— high potential anomaly — high resistivities and sand and gravel in one drill hole make this a good prospect
39 a — LF + BCB	3000	1 hole in the immediate anomaly area with sand and gravel from 18-24 ft.	Thin Clay over Till	— high potential anomaly — there is sand and gravel in the area and the resistivities are high — anomaly should be tested to see at what depth the granular occurs
39 b — LF + BCB	3500	Sand, gravel and boulders in holes east, west and south of the anomaly	Thin Clay over Till	— same as 39 a
40 — LF + BCB	1100	Sand, gravel and boulders at varying depths in holes all around the anomaly	Thin Clay over Till	— medium potential anomaly — there are granular sections in adjacent drill holes, but the lower resistivities indicate that it may be too deep to be economic

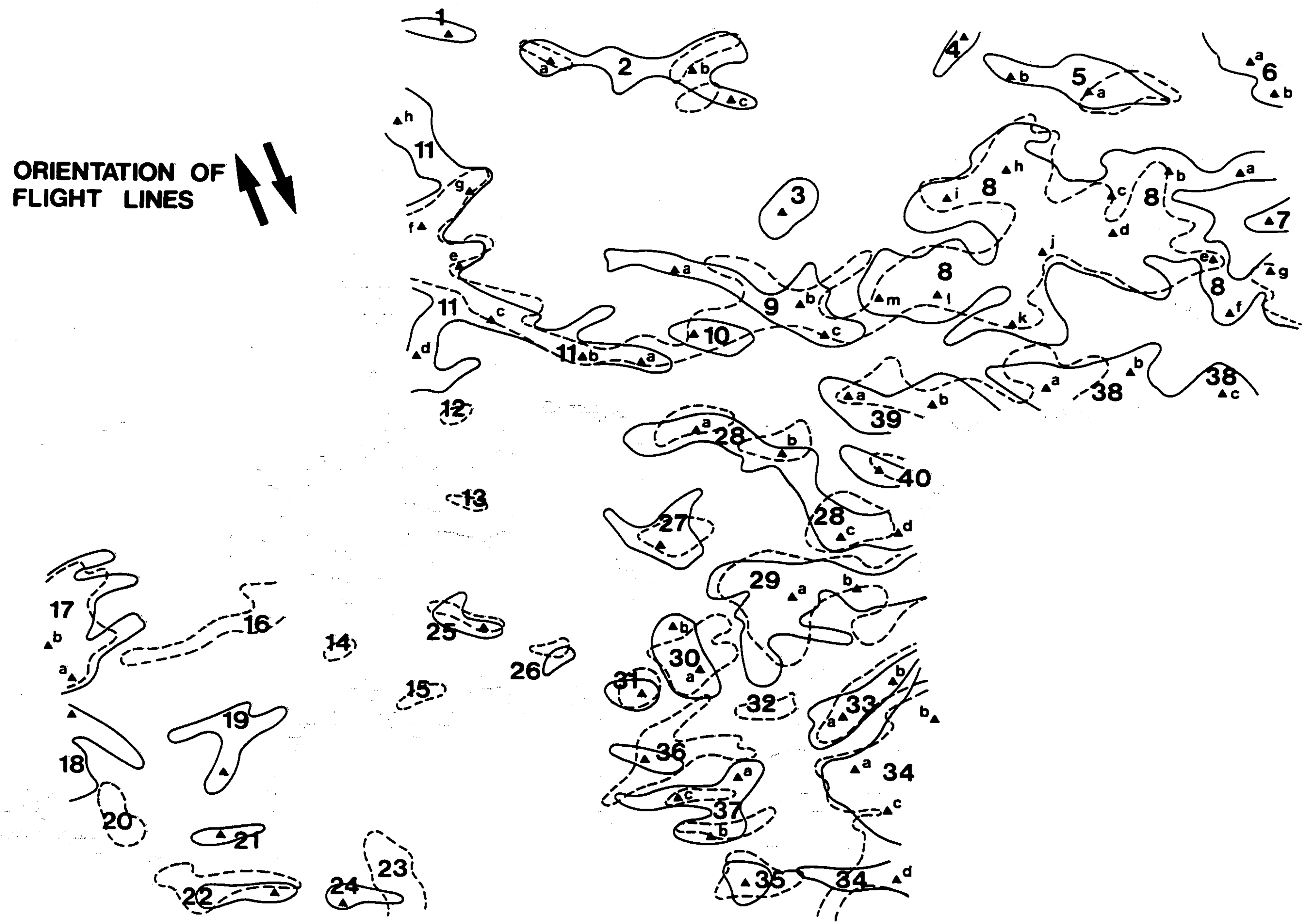


Aggregate Resources of the Winnipeg Region

Surficial Geology

The UMA Group

Plate D-17



Broadcast Band Anomaly ------
Low Frequency Anomaly ——
Anomaly Location 23
Sub - Anomaly Location b
**Location of Maximum Low Frequency Resistivity ▲

** Resistivity Values shown on Table D - 8

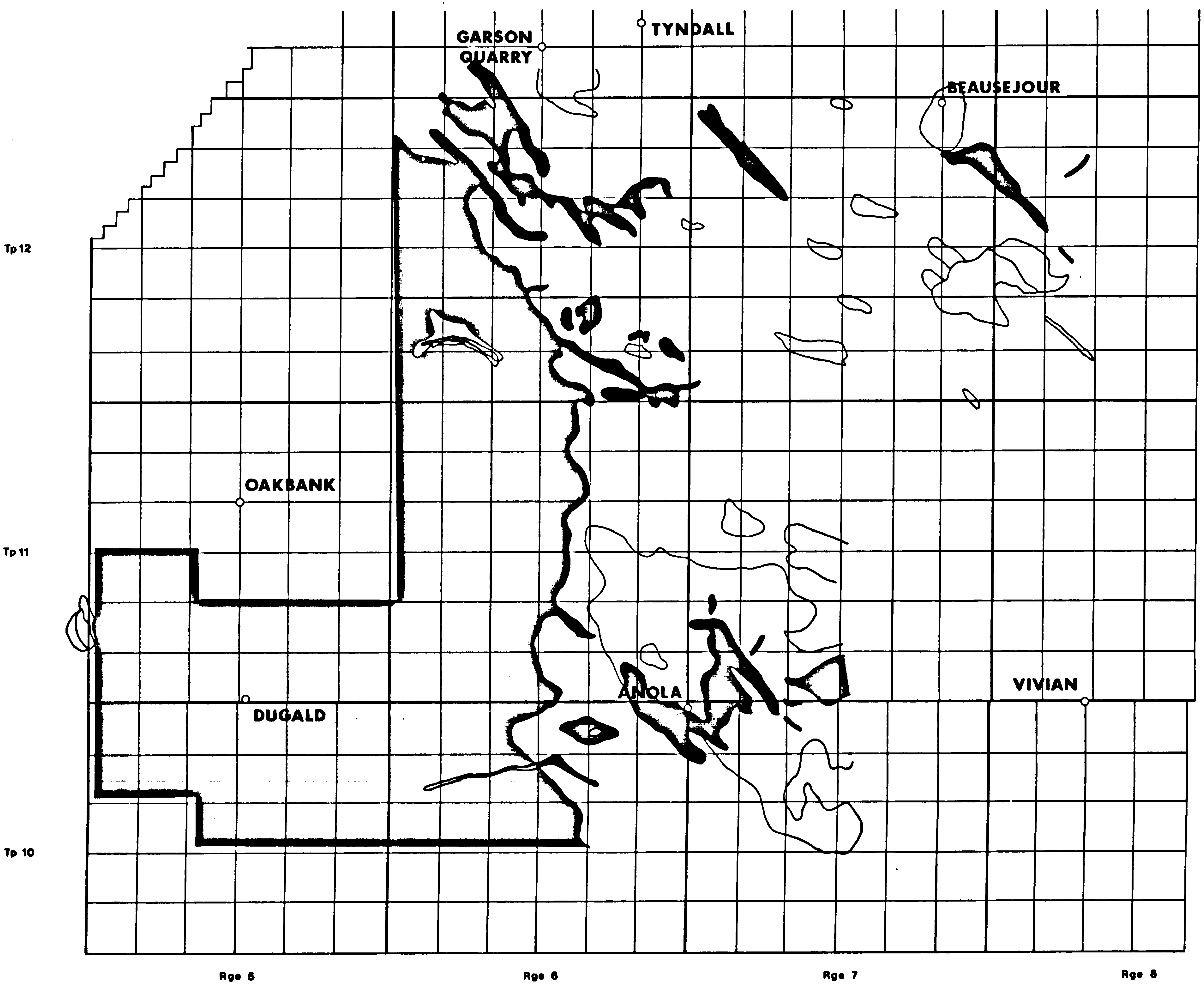
E - Phase Anomalies,

∗1/4 Sections with granular material within 60 feet of ground surface ■

Note

∗ From Water Well Drill Hole Logs.

Drill Hole Data and



Legend

- Lacustrine Clay
- Lacustrine Clay over Till
- Glaciofluvial Sand over Till
- Glaciofluvial Sand and Gravel
- Granular Till

Aggregate Resources of the Winnipeg Region

Surficial Geology

0 1 2 3 Miles

0 1 2 3 5 Kilometres

The UMA Group

Plate D-18

10. ROCKWOOD AREA — HAMMER SEISMIC SURVEY

10.1 Introduction

As part of the investigation of aggregate resources in the Winnipeg Region, a hammer seismic geophysical survey was conducted in the Rockwood municipality and an area south and east of the Municipality boundary. The area is defined on Plate D-1.

The purpose of the survey was to define locations of bedrock with thin overburden and as such be potentially suitable as new quarry sites for crushed limestone or dolomite. These locations would act as targets for test drilling to be carried out by the Mineral Resources Division.

10.2 General Geology

As shown on Plates D-19 and D-20, the study area is underlain by the Stonewall Formation in the west, the Stony Mountain Formation in the central portion and the Red River Formation to the east. The Stonewall Formation consists solely of dolomite. The Stony Mountain Formation, however, is made up of Gunton Member dolomite in the west and Penitentiary Member argillaceous dolomite and Gunn Member calcareous shale to the east. There are known outliers of the Gunton dolomite in the eastern area of the Stony Mountain Formation. The portion of the Red River Formation which underlies the study ares is the Fort Garry Member, composed of interbedded limestone and dolomite strata.

The Stonewall Formation (dolomite), the Gunton Member of the Stony Mountain Formation (dolomite) and the Fort Garry Member of the Red River Formation (limestone and dolomite) are the bedrock formations most suitable for use as construction materials. The Gunn and Penitentiary Members of the Stony Mountain Formation are softer rock types and not as desirable for use as construction material.

10.3 The Hammer Seismic Method

Overburden depths were determined at 1 mile stations with a Huntec FS-3 seismograph. The FS-3 uses the impact of a sledge hammer on a steel plate to send shock waves into the ground. Two geophones at the instrument location sense the return waves and the times of arrival are recorded on a roll of heat sensitive paper on the instrument. Overburden and bedrock velocities are calculated from the slopes of the first arrival returns and from this information the depth of overburden can be calculated.

10.4 The Hammer Seismic Results

Overburden depths were calculated for each station and these depths supplemented by known drill hole information were used to draw contours of drift thickness in the study area, as shown on Plate D-19. Approximate surface elevations were established for each location and, by subtracting overburden thickness, bedrock elevations were determined. The contours developed for the bedrock surface are shown on Plate D-20.

Although several sites with less than 10 feet of drift are indicated on the contour plan (Plate D-20), 12 selected sites have been identified as targets for further evaluation because of their proximity to the prime market area of Winnipeg. The following Table D-9 lists these 12 selected sites.

TABLE D-9

SELECTED BEDROCK TEST SITES

Site	Location	Estimated Drift Thickness (ft.)	Assumed Underlying Bedrock, Member or Formation (after Bannatyne)
1	SE 11-13-1E	10	Stonewall Formation (dolomite)
2	SE 12-13-1E	10	Gunton Member (dolomite)
3	NE 19-13-2E	10	Gunton Member (dolomite)
4	SW 16-13-2E	10	Gunton Member (dolomite)
5	NW 19-13-3E	9	Fort Garry Member (limestone & dolomite)
6	NW 32-13-3E	8	Fort Garry Member (limestone & dolomite)
7	NE 17-13-3E	10	Fort Garry Member (limestone & dolomite)
8	NW 33-12-3E	7	Fort Garry Member (limestone & dolomite)
9	NE 35-12-2E	6	Gunn Member (shale) or Fort Garry Member (limestone & dolomite)
10	SE 32-12-2E	7	Gunton Member (dolomite)
11	SE 27-12-1E	8	Stonewall Formation (dolomite)
12	SW 14-12-1E	10	Stonewall Formation (dolomite) or Gunton Member (dolomite)

10.5 Test Drilling

The Mineral Resources Division of the Department of Mines, Resources and Environmental Management had, as of May 15, 1976, drilled holes at sites 2, 3, 5, 6 and 7 and encountered the following:

SITE #2

	0 - 6'	— clay
	6' - 12.5'	— sand and gravel
Stony Mountain Formation	12' - 46'	— Gunton Member — dolomite
	46' - 68.1'	— Penitentiary Member — argillaceous dolomite
	68.1' - 124.8'	— Gunn Member — interbedded calcareous shale, limestone and argillaceous limestone.
Red River Formation	124.8' - 138.5'	— Fort Garry Member — interbedded limestone & dolomite.

SITE #3

(drilled	0 - 14'	— overburden
0.4 mile south)	14 - 47'	— Gunton Member — dolomite.

SITE #5

	0' - 7'	— clay
	7' - 8'	— gravelly till
Red River Formation	8' - 123'	— Fort Garry Member — interbedded limestone and dolomite with a 2 foot shale layer at 59 feet.
	123' - 144.3'	— Selkirk Member — 10 feet of limestone over 11 feet of dolomitic limestone.

SITE #6

0 - 10'	— overburden
10 - 47'	— Fort Garry Member — dolomite, with red shale marker bed at 45'.

SITE #7

0 - 22'	— overburden
22 - 44'	— Fort Garry Member, dolomite, with red shale marker bed at 35'.

The test drilling, to date, indicates that the seismic surveys can be utilized to locate the depth of bedrock and to assist in the planning of test drilling programs. Future drilling should be carried out on the remaining locations to confirm overburden depths, identify the underlying bedrock formations and evaluate the suitability of the site for a crushed rock quarry. If test drilling confirms shallow and suitable bedrock at a site, more detailed seismic work should be considered to better define the areal extent of the bedrock high and to assist in the layout of a detailed testing program.

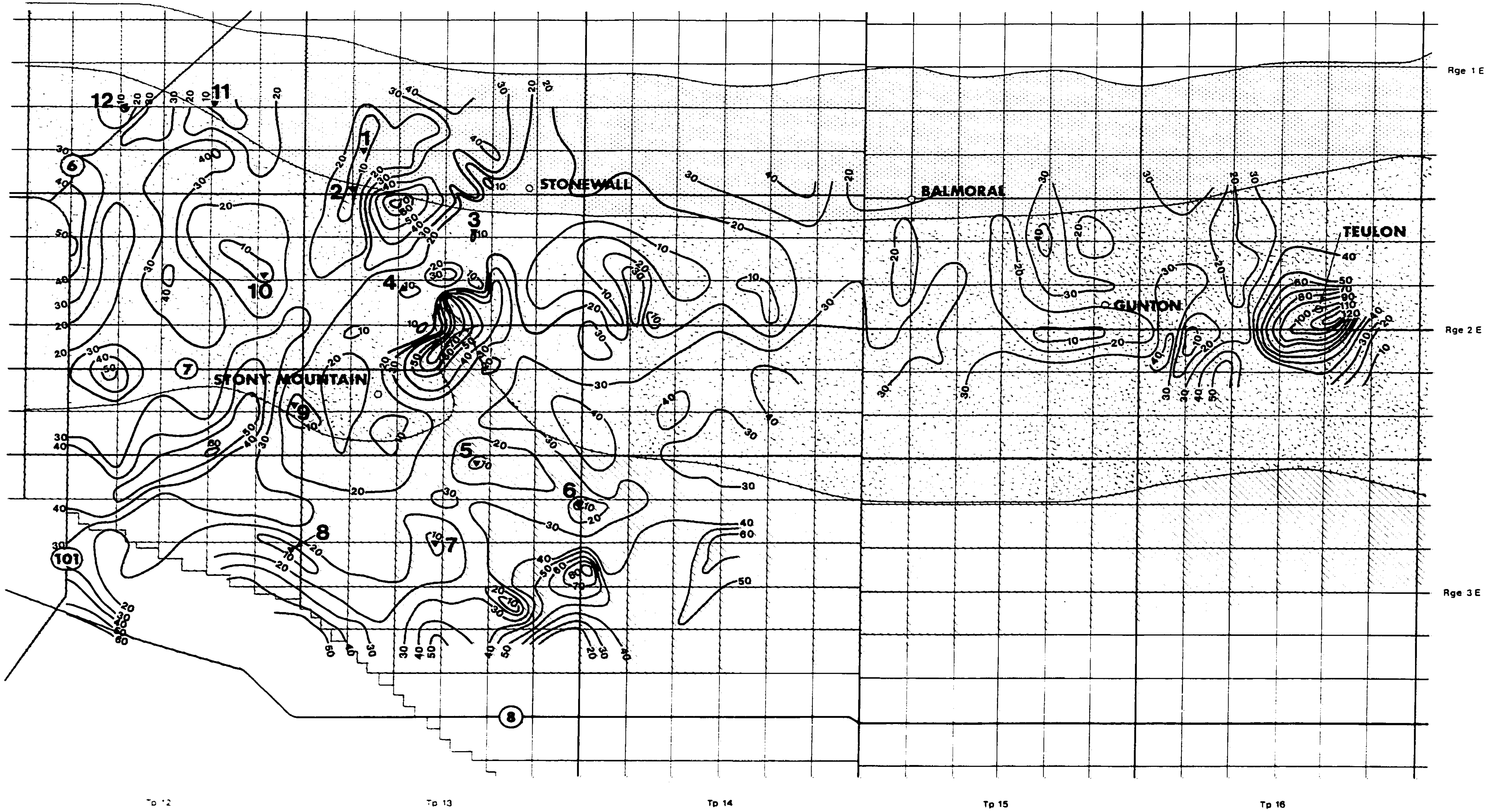
Additional seismic work on ½-mile spacing would undoubtedly indicate additional areas with near-surface bedorck.

10.6 Limestone Potential

In order to assess the order of magnitude of the quantity of suitable limestone available in the Rockwood area, quantities were calculated using both 10 foot (3 metre) and 20 foot (6 metre) sections of limestone, at the 12 selected sites, within the areas assumed to have 10 feet (3 metres) or less of overburden. The resulting quantities were:

a) for a 10 foot (3 metre) section — 60 million short tons or 54 million metric tonnes.

b) for a 20 foot (6 metre) section — 120 million short tons or 108 million metric tonnes.



Legend

Stonewall Formation

Stony Mountain Formation

Red River Formation

Overburden Thickness Contour —30—

Location of Bedrock High ▾7

Note

Overburden Thickness Contour Interval 10'

Aggregate Resources of the Winnipeg Region

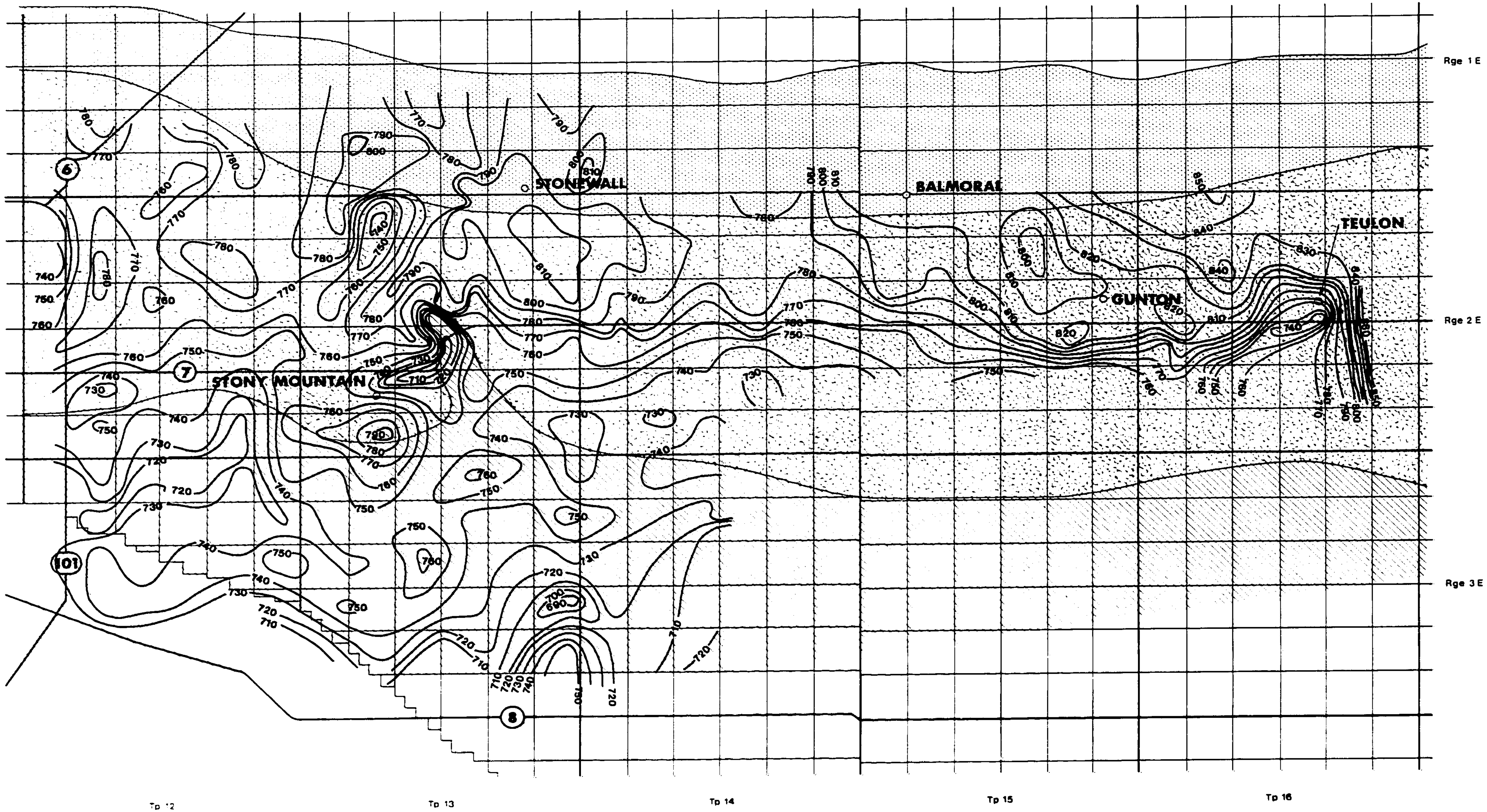
Overburden Thickness Contours Rockwood Area

0 1 2 3 Miles

0 1 2 3 5 Kilometres

The UMA Group

Plate D-19



Legend

Stonewall Formation

Stony Mountain Formation

Red River Formation

Bedrock Contours —800—

Note

Bedrock Contour Interval 10'

Aggregate Resources of the Winnipeg Region

Bedrock Contours Rockwood Area

0 1 2 3 Miles

0 1 2 3 5 Kilometres

The UMA Group

Plate D-20

SECTION E

TRANSPORTATION OF AGGREGATE

SECTION E

TRANSPORTATION OF AGGREGATE

The transportation of aggregate between the source and the user is an important element in the production and supply of aggregate material. At the present time the majority of aggregate produced within the Winnipeg Region is transported by truck, with the City of Winnipeg being the major destination point. Truck haul distances varying from 12 miles between the Birds Hill source and Winnipeg to 60 miles between Gull Lake and Winnipeg are being experienced on a regular basis. The lone exception to truck transport, is the use of the Greater Winnipeg Water District rail line to transport aggregate to Winnipeg from the Richer area, a distance of approximately 45 miles (72 kilometres).

In the past, a greater use was made of rail transport, particularly from the prime source in the Birds Hill area to Winnipeg via CPR. However, due to increasing problems of undependable rail car supply, and the advent of an improved highway system with larger trucks, rail transport was abandoned in favour of trucking.

Although truck haul is a more flexible method of transportation, requiring very little in the way of special facilities, it is not without its problems. Weight restrictions placed on a majority of the highway system during the spring season, severely restrict the amount of material that can be hauled. As a result, aggregate users must have sufficient storage area to stock pile material to carry over this period, which is usually about 2 months, and which coincides with the start up of the construction season in the Winnipeg region. Although flexible, truck haul is restricted by haul distance, in particular in relation to the number of trips per day that can be made between the source and the user. This ultimately is reflected in the cost of aggregate.

Transportation costs are an important aspect of aggregate production costs. It is estimated that for aggregate produced in the Birds Hill area and delivered to Winnipeg, transportation costs by truck are approximately 30 - 40% of the cost of a ton of aggregate. For aggregate produced in areas with a greater haul distance such as Gull Lake, transportation costs by truck are estimated to be approximately 50 - 60% of the cost of a ton of aggregate.

Experience within the Winnipeg Region would suggest that the unit cost of transporting aggregate decreases as haul distance increases. However, the overall cost per ton of material will increase.

Transportation of aggregate in the future within the Winnipeg Region would appear to remain with the truck. Larger trucks coupled with the increase in allowable highway loadings will result in more aggregate being hauled per trip. This should allow for an increase in haul distances. However, the proposed increase in fuel costs will likely offset any economic benefits as a result of the larger loads and overall transportation costs will likely increase. The use of rail haul for the longer haul distances would be more economical, based on transportation costs alone. However, the provision of a rail line to the source and the user, along with loading and unloading facilities, would require a large capital expenditure and unless the source was extremely large with long term potential, such an expenditure would be difficult to justify. Since there are no large sources designated within the Winnipeg Region, rail haul of aggregate would not appear to be likely at this time, although consideration should be given to retaining any existing rail lines, such as the Greater Winnipeg Water District Railway, which may be proven in the future to be located near deposits with sufficient reserves to justify rail haul.

SECTION F

CONCLUSIONS ON SUPPLY AND DEMAND

SECTION F

CONCLUSIONS ON SUPPLY AND DEMAND

1. Demand

Section C of this report has discussed the expected demand for sand and gravel and crushed limestone aggregates to the year 1996 and has extrapolated these requirements to the year 2026. The expected demand for high quality sand and gravel, such as required for concrete production, has been extracted from the total sand and gravel requirement. Plate F-1 graphically illustrates these expected demands. For year by year and sub-regional demands, reference can be made to Tables C-17, C-18 and C-19.

In summary, the expected demands are:

	Cumulative to 1996 Millions of		Cumulative to 2026 Millions of	
	Short Tons	Metric Tonnes	Short Tons	Metric Tonnes
Total Sand and Gravel	167	151	591	536
High Quality Sand & Gravel	54	49	193	175
Crushed Limestone	27	24	98	89

2. Supply

2.1 Sand and Gravel

This study has indicated that the estimated reserves of high quality sand and gravel will just marginally meet requirements of the region for the next 50 years. This statement can only be made with the qualifications that the estimates of available sand and gravel as presented in this report represent a judgement based upon an understanding of the geological history of the Region and limited test data. However, it is considered that they do represent a reasonable assessment that is on the conservative side.

A review of Table F-1 which presents the estimated potential of each of the physiographic divisions and of Plate F-1 which presents supply versus demand for the Region, leads to the following conclusions. It should be noted that these conclusions assume that available high quality sand and gravel is limited to being used for production of high quality products.

a) High quality sand and gravel (grain size distribution ranges 1 to 3) available above water table in the Bird's Hill area is expected to be depleted during the mid 1980's.

b) There appears to be sufficient high quality sand and gravel within the Region (including the Forest Reserves) to meet demands until 2026 but probably not more than 5 to 10 years beyond that time.

c) There appears to be sufficient moderate quality sand and gravel (grain size distribution ranges 4 and 5) to meet the regional demands to well beyond the year 2026.

d) Once the Bird's Hill supplies are depleted, the next significant source area for high quality sand and gravel will be the Lake Terrace Area and the Belair-Agassiz-Sandilands Uplands.

The major factor which will affect development of these areas will be transportation costs. Haul distances of 30 to 50 miles (50 to 80 kilometres) will be required with the City of Winnipeg being considered as the user point. It will simply be a matter of how much economics is a function of need when that need arises.

2.2 Limestone

A review of Plate F-1 indicates that the availability of limestone within the Rockwood areas as defined in this report, should be sufficient to meet the crushed limestone requirements to beyond the year 2026. The 20 foot (6 metres) assumed in quantification is conservative.

2.3 Alternatives to Sand and Gravel

Because haul costs can be expected to increase the costs of aggregates substantially in the near future, as haul distances necessarily increase, more thought will have to be given to alternatives to sand and gravel as an aggregate.

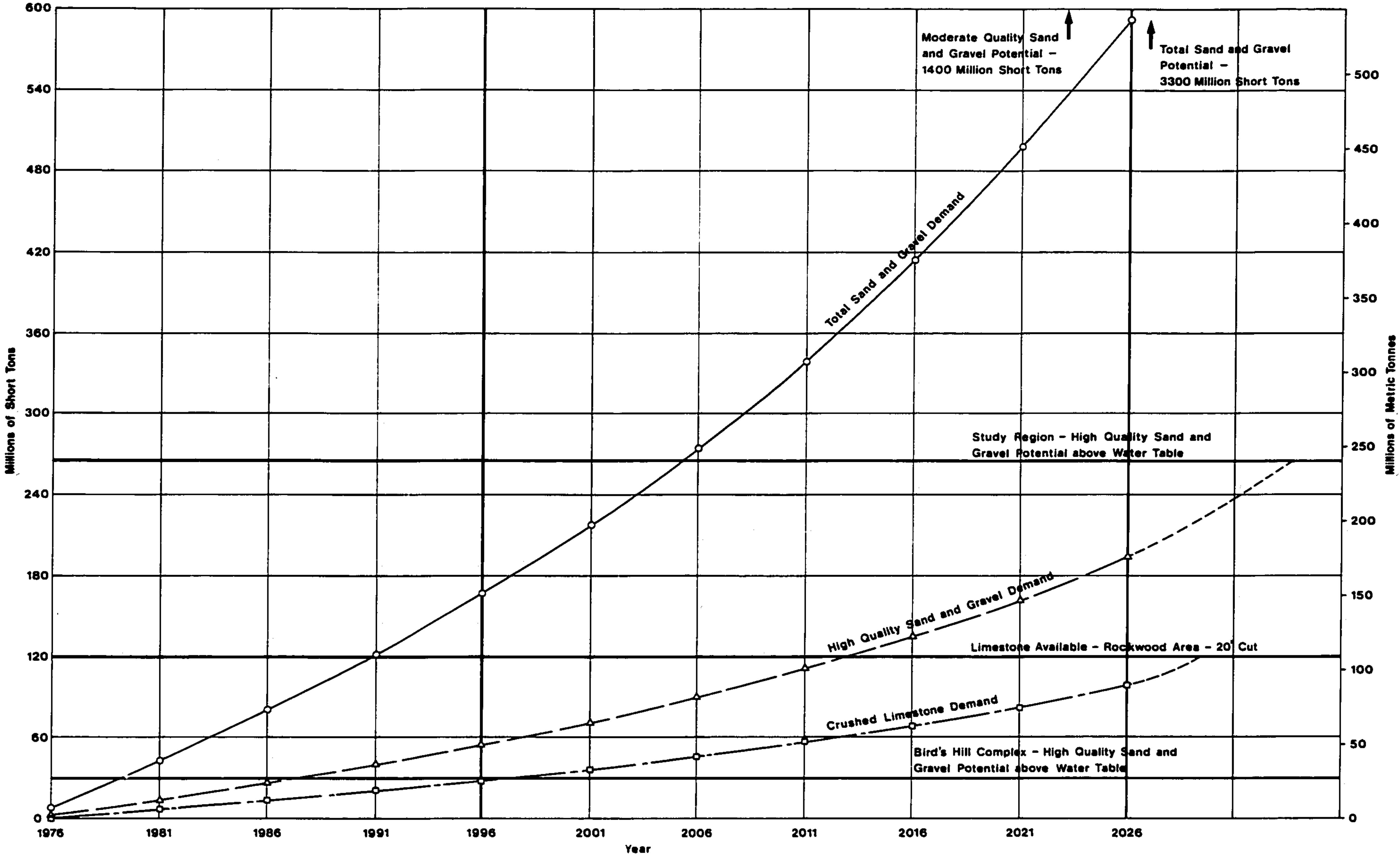
Examples of some alternatives requiring further study are:

a) the use of lightweight (clay-shale) aggregates
b) the use of soil cement as road base
c) the development of blasting techniques which will produce a graded aggregate from bedrock sources and eliminate much of the crushing process.

TABLE F-1

SAND AND GRAVEL POTENTIAL — WINNIPEG REGION

Physiographic Divisions	Grain Size Distribution Ranges 1-3 Millions of Short Tons	Grain Size Distribution Ranges 1-3 Millions of Metric Tonnes	Grain Size Distribution Ranges 4-5 Millions of Short Tons	Grain Size Distribution Ranges 4-5 Millions of Metric Tonnes	Grain Size Distribution Range 6 Millions of Short Tons	Grain Size Distribution Range 6 Millions of Metric Tonnes	Unclassified Millions of Short Tons	Unclassified Millions of Metric Tonnes
Agassiz Lowlands			18.4	16.6				
Interlake Till Plain			148.3	134.5				
Lake Terrace	57.9	52.7	432.9	393.7				
Belair-Agassiz-Sandilands Uplands								
a) In Forest Reserves	178.0	161.9	618.6	562.9	676.6	615.7	621.0	565.1
b) Outside Forest Reserves	.9	.8	196.7	179.5	64.5	59.3		
Bird's Hill	29.2	26.5					237.7	215.5
Totals	266.0	241.9	1414.9	1287.2	742.0	675.0	858.7	780.6
E-Phase Area Potential							185	168



Aggregate Resources of the Winnipeg Region

Supply versus Demand

SECTION G

LAND USE PLANNING AND ENVIRONMENTAL CONSIDERATION

SECTION G
LAND USE PLANNING AND ENVIRONMENTAL CONSIDERATIONS

1. Land Use

Sequential land use planning allows aggregates to be extracted from an area with the alternative to use that land at a later date for such other uses as urban development, recreation, agriculture or forestry. A given deposit area may also be given a non-conflicting use, such as agriculture or forestry, prior to extraction.

The Bird's Hill deposit is projected for depletion of high quality aggregates from above the water table, by about the mid-1980's. This will tend to put increased pressure on remaining deposits in the Agassiz Lowlands, Interlake Till Plain, Lake Terrace Area and the Belair-Agassiz-Sandilands Uplands, with probable emphasis on the latter two areas. The estimated quantity of high quality sand and gravel in all of these areas is projected as being marginally sufficient to support construction demand to only 5 to 10 years beyond the year 2026.

It, therefore, becomes imperative that those areas indicated as having occurrences of significant quantities of moderate to high quality sand and gravel should be reserved primarily for aggregate supply with other land uses being considered secondary.

Plate G-1 illustrates the qualitative potential for sand and gravel by township and range. Detailed investigation of these areas will be necessary to verify the indicated potential and to allow a final judgement on land use planning priorities. The Provincial Forests provide an example of this planning requirement particularly in areas where unique tree species such as red pine are being fostered. The potential for direct or alternate reforestation would have to be given special consideration before extraction of sand and gravel could be allowed.

2. Environmental

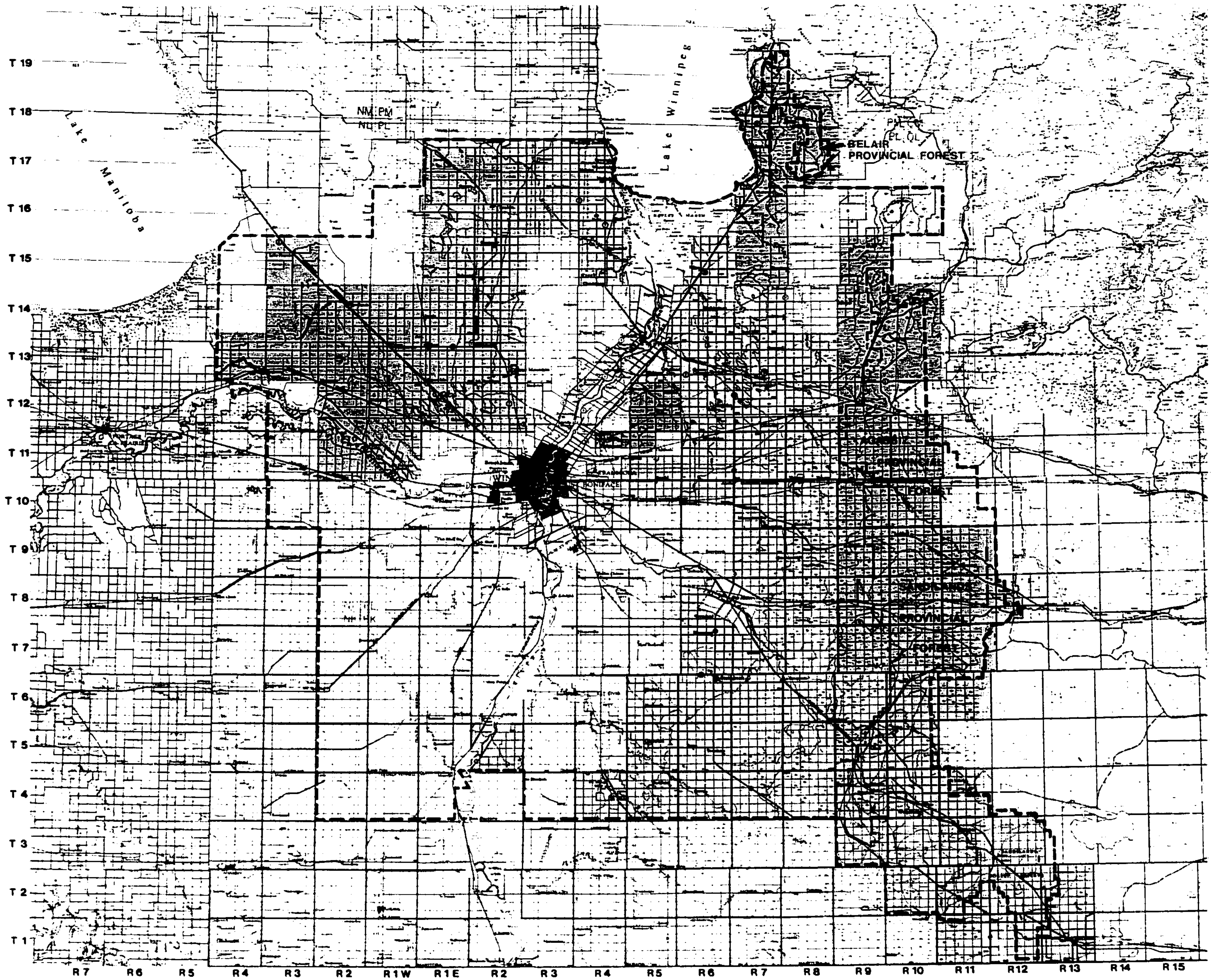
A definite end-use should be established for each pit or quarry area prior to aggregate extraction. Rehabilitation costs should become part of the overall cost of the aggregate production from new pits and quarries.

Where rehabilitation costs have not been considered as part of extraction costs in existing pits and quarries, incentives should be established that will encourage the producers to plan for rehabilitation. One such incentive could be a publication of ideas on how pit and quarry areas can be rehabilitated to such end use as urban or recreational, to provide a continuing income from the land after aggregates have been depleted.

Of immediate concern in the Winnipeg Region is the rehabilitation of pit areas in the Bird's Hill Complex. Planning will have to consider the whole area and not just the individual pits. Planning will also have to recognize the importance of this area as a major source of groundwater recharge to avoid end uses that could result in contamination of the local and regional groundwater regimes. In fact, most granular areas in the Winnipeg Region act as sources of groundwater recharge.

A fallacy which exists is that rehabilitation should return the landscape to as near the original state prior to aggregate extraction as is possible. In many cases, a properly planned and reconstructed topography could enhance either the wildlife or recreational capability of an area.

In areas where forestry is now of prime concern, careful consideration will have to be given to extraction and rehabilitation techniques which will allow reforestation that fits into the long range planning for the Forest Reserve Areas.



Legend

High Quality

Moderate Quality

Moderate to Poor Quality

Study Area

Aggregate Resources of the Winnipeg Region

Sand and Gravel Quality Potential

0 5 10 15 Miles

0 10 20 30 Kilometres

The UMA Group

Plate G-1

APPENDICES

APPENDIX 1
SURVEY RESPONDENTS

WINNIPEG REGION SAND AND GRAVEL PRODUCERS

Fort Garry Building Supply (Selkirk Redi-Mix)
Fraser Gravel and Stone
Birds Hill Gravel and Stone Ltd.
Selk-Ridge Gravel & Stone Co. Ltd.
City of Winnipeg
McCurdy Supply Co. Ltd.
Harrison Brothers Ltd.
C.T. Loewen & Sons Ltd.
Pembina Valley Gravel
Gagne Gravel Co. Ltd.
Nelson River Construction Ltd.
J.S. Dueck
Diamond Redi-Mix Concrete Ltd.
Jake's Gravel Ltd.
Royal Paving Co. Ltd.
Supercrete Ltd.
Mulder Bros. Ltd.
Standard Cartage & Redi-Mix
Building Products & Concrete Supply
Winnipeg Supply and Fuel Co. Ltd.
Forsythe A. Coal Co.
Ramsay & Bird Ltd.
Fraser Sand and Gravel Co. Ltd.

MISCELLANEOUS (Truckers, Transporters and Others)

W. Kachur Sand and Gravel Ltd. — trucking and screening
A.M. Kelly & Sons Ltd. — crushing
Favourite Transport Ltd. — sand pits
Pearce Construction — crushing
Gillis Quarries Ltd. — limestone
Michael's Enterprises Ltd. — City of Winnipeg pits
G.W.W.D.R. — Supplies from outside Winnipeg region
C.N.R. — supplies self from outside Winnipeg Region
C.P.R. — supplies self from outside Winnipeg Region

WINNIPEG REGION INTERMEDIATE USERS

READY MIX

Beausejour Redi-Mix Concrete & Supply
Carman Concrete
Portage Concrete Products
Building Products & Concrete Supply
Provincial Concrete and Builders Supply
Selkirk Redi-Mix Co. Ltd.
Diamond Redi-Mix Concrete Ltd.
C.T. Loewen & Sons Ltd.
Standard Cartage & Redi-Mix
McCurdy Supply Co. Ltd.
Supercrete Ltd.
Winnipeg Supply & Fuel Co. Ltd.
City of Winnipeg

SAND AND GRAVEL SUPPLY

Stefanchuk Lumber Company Ltd.
Thompson Lumber & Fuel Ltd.
Winnipeg Supply & Fuel Co. Ltd.
Selkirk Lumber Co.
Mulder Bros. Ltd.

CONCRETE PRODUCTS

Kildonan Concrete Products Ltd.
Midland Concrete Products
R. & D. Concrete Products
Wash Drain Tile
Barkman Concrete Ltd.
Alsip Brick & Tile

ASPHALT

Atlas Asphalt Paving
Borger Industries Ltd.
Maple Leaf Construction Ltd.
Tallman Paving
Custom Asphalt Paving Ltd.
Royal Paving Co. Ltd.

WINNIPEG REGION END USERS

Dept. of Highways
City of Winnipeg
CFB Winnipeg
C.N. Railways
G.W.W.D. Railway
R.M. De Salaberry
R.M. Hanover
R.M. Ritchot
R.M. Ste. Anne
R.M. Tache
R.M. Dufferin
R.M. Morris
R.M. Roland
R.M. Brokenhead
R.M. St. Andrews
R.M. St. Clements
R.M. Springfield
R.M. Cartier
R.M. Grey
R.M. MacDonald
R.M. Portage la Prairie
R.M. Rockwood
R.M. Rosser
R.M. St. Francois Xavier
R.M. Woodlands
R.M. East St. Paul
R.M. West St. Paul
St. Pierre Village
Steinbach Town
St. Anne Village
Carman Town
Morris
Beausejour Town
Selkirk Town
Garson Village
St. Claude Village
Portage City
Stonewall Town
Teulon Village
Dept. of Municipal Affairs
Dept. of Northern Affairs
Public Works of Canada
Parks Canada
National Harbours Board
Prairie Farm Rehabilitation Administration
Ministry of Transport
Indian Affairs & Northern Development
C.P. Railway
Canada Cement Lafarge Ltd.
Inland Cement Industries Ltd.

APPENDIX 2
QUESTIONNAIRE FORMS

SURVEY OF AGGREGATE PRODUCERS

1. Name of Company

2. (a) Location of Plants (b) Type of Production

3. Volume of Production in Tons (indicate Year) (b) Capacity

   Past Present Future Present Future

4. Value of Production, i.e., Cost/Ton

   Past Present Future

5. 1973 Production Costs — Amount ($)
   - Cost of Products (at pit without the transportation component)
   - Labour Costs
   - Transportation Costs
   - Pricing Practices (e.g. fixed price for one year)

6. End Uses — Estimated Percent
   - Residential
   - Non-Residential
   - Engineering
   - Intermediate Processors (concrete products, etc.)

SURVEY OF AGGREGATE USERS

1. Amount (tons) — Cost/ton

   Total Annual Requirements:
   - Sand —
   - Gravel —
   - Crushed Stone —
   - Limestone —

2. Destination of end products: — Estimated Percent

   Greater Winnipeg —
   Winnipeg Region (within 65 miles) —
   Manitoba (outside Winnipeg & Region) —
   Other Provinces or States —

3. End Uses — Estimated Percent
   - Residential
   - Non-Residential
   - Engineering i.e. roads, water & sewer
   - Intermediate Processors i.e. concrete products

4. Main Customers: — Estimated Percent
   - Municipal
   - Contractors
   - Province
   - Manufacturers

5. Reserves
   - Leased or Owned
   - Estimated Reserves
   - Operations Contracted If so, name contractor

6. Transportation Component — Estimated Percent
   — Private Truckers
   — Gravel Companies
   — Municipalities
   — Own Trucks
7. (a) What are the main factors that influence market trends?
   (b) Is there new technology that could influence future production patterns?

SURVEY OF MUNICIPALITIES

1. Where do you obtain your supply of aggregate for road construction and maintenance?

	Location (Municipality)	Private or Self Owned	% of Total Aggregate Used
1.			
2.			
3.			

2. Requirements for Road Building and Maintenance

	Roadbuilding Amount (tons)	Cost/ Ton	Maintenance Amount (tons)	Cost/ Ton	No. of Miles
Sand					
Gravel and Crushed Stone					
Concrete-Products					
Asphalt Aggregate					
Building Material Aggregate					

3. Do you have local reserves of aggregates?
4. Growth Trends in Municipality?
5. Transportation problems?
6. Requirements for other purposes?

Dear Sirs,

Underwood McLellan & Associates Ltd., are compiling information for a Resource Inventory Study for the Department of Mines, Resources and Environmental Management. It would be greatly appreciated if you would aid us in this study by answering the following questionnaire regarding gravel pits you control in the Birds Hill Region.

Pit Location: Sec.____ Twp.____ Rge.____ L.S.____ __________acres owned.

Estimated quantity extracted from pit ____________________

Estimated quantity remaining ____________________

Approximate depth of water table ____________________

Depth you have taken gravel from ____________________

Quality of gravel remaining ____________________

Enclosed is a self-addressed envelope.

Thanking you very much for your co-operation in this matter.

Yours truly,
UNDERWOOD McLELLAN & ASSOCIATES LTD.

APPENDIX 3

MANITOBA SAND AND GRAVEL AND CRUSHED STONE PRODUCTION

(000 tons)

	SAND AND GRAVEL	CRUSHED STONE*
1963	9,635	3,693
1964	9,872	1,035
1965	10,463	971
1966	9,676	2,023
1967	10,289	2,013
1968	9,564	2,306
1969	8,142	699
1970	14,930	1,273
1971	16,695	1,102
1972	14,763	610
1973	13,700	700

Source: Statistics Canada 26 - 201.

* Excludes limestone for Canadian cement and lime plants.

APPENDIX 4

POPULATION AND HOUSEHOLD PROJECTIONS

From the outset, it was established that this study would not encompass the development of population projections for Winnipeg and surrounding sub-regions (Interlake, Southeast and Southwest), but rather would rely on existing reports and studies wherever possible for forecasts of future population levels.

1. City of Winnipeg

For the City of Winnipeg itself, there are numerous population projections available. However, only more recent projections have been summarized here since the underlying assumptions of some of the earlier studies are open to question:

1. Maki-Framingham (University of Manitoba) — Series A of this study assumes medium fertility levels and continuation of 1966 - 1971 migration patterns. Estimated population levels for Winnipeg for 1975, 1980 and 1990 are 590,150, 633,000 and 701,050 persons respectively.

2. City of Winnipeg — The City of Winnipeg has recently prepared a series of population projections under a variety of assumptions; the "preferred" estimate assumes low fertility and medium migration. Forecasted population levels are as follows:

1976	575,500
1981	624,200
1986	675,950
1991	725,575
1996	773,000

3. CHMC — A 1974 study prepared by John Kirkland, using low fertility and medium migrations assumptions, provides the following population estimates for Winnipeg:

1976	565,700
1981	593,300
1986	618,600

4. Ministry of State for Urban Affairs (MSUA) — A recent (1975) study by MSUA provides a series of population projections, based on varying assumptions for fertility, international and internal migration. Series 2 assumes medium fertility (2.2 children per woman), 200,000 net external migration and 1966 - 1971 net internal migration levels; Series 3, in contrast, assumes net international migration levels of only 100,000 persons per year. Resulting population estimates are as follows for Winnipeg:

	SERIES 2	SERIES 3
1976	578,205	562,755
1981	619,345	586,240
1986	660,590	610,588
1991	701,184	634,150
1996	740,265	656,190

It is clear that variations in assumptions regarding fertility, migration and (to a lesser extent) mortality, can significantly influence projections of future population levels. The projection prepared by the City of Winnipeg, for example, generates a far higher total in later years than any other projection, primarily as the result of using a fertility rate well above that assumed in any other report. As indicated in the text above, forecasts of the Winnipeg population vary anywhere from 635,000 to 725,000 persons by 1990/1991.

Selection of a "preferred" population estimate for Winnipeg must necessarily be dictated by a review of recent trends in population growth in the city, as well as judgements concerning the extent to which overall trends in fertility and migration rates in Canada are likely to influence the level of Winnipeg population. On balance, both Series 2 of MSUA study and the Maki-Framingham Series A appear to be appropriate for this study, for the following reasons:

1. The most recent Statistics Canada estimate of Winnipeg population is 560,000 (1973); on this basis, a population of 580 - 590 thousand would appear to be reasonable for 1976.
2. Recent presentations of forecasts at the national level (e.g. National Energy Board hearings) suggest continuation of low to medium fertility levels throughout Canada for at least the next few years, with only modest variations in levels across provinces.

3. The Joint House of Commons — Senate Committee Report on Immigration (tabled in the House of Commons in November, 1975) would suggest future international migration levels of not less than 100,000 persons per year[1], but probably not more than 200,000 persons per year. Results, therefore, would likely fall between the Series 2 and 3 projections prepared by MSUA.

4. Continuation of prevailing fertility rates in Manitoba, combined with anticipated changes in migration patterns, would imply a population level in Manitoba of at least 1,160 thousand by 1990, and a "preferred" estimate of 1,260 thousand persons. This latter estimate is consistent with both Projection G of the recent Statistics Canada series of provincial and national population estimates (91 - 514), and series A of the Maki-Framingham report.

The Series 2 MSUA projection has been utilized in this report, simply because data is more complete than that contained in the Maki-Framingham report.

2. Population Projections for Other Subregions

Regarding the three subregions outside of Winnipeg, no estimates of population were specifically available. Projections of population by municipality, known to have been prepared by the Department of Health and Social Development, were not approved for release to the study team. In the absence of published forecasts, projections for these subregions were prepared, utilizing as inputs, the appropriate Series A assumptions of the Maki-Framingham report concerning fertility, migration[1] and mortality/survival. Separate projections at 5 year intervals were made for rural municipalities and for urban centres in the following population size classes (as of 1971):

0	—	500
500	—	1,000
1,000	—	2,000
2,000	—	5,000
5,000	—	10,000
10,000+	—	

Detailed calculations for each size class are not presented here, but projected total and urban (over 1,000) population by subregion and 5 year interval are as follows:

	Urban Population (Centres over 1,000 persons)	Total Population	Percent Urban
WEST			
1971 (Census)	16,395	40,725	40.3
1976	17,083	40,325	42.4
1981	18,082	40,281	44.9
1986	19,161	40,415	47.4
1991	20,433	41,135	49.7
1996	21,772	42,105	51.7
EAST			
1971 (Census)	17,810	58,509	30.4
1976	18,525	57,237	32.4
1981	19,497	56,324	34.6
1986	20,465	55,679	36.8
1991	21,531	55,739	38.6
1996	22,743	56,782	40.1
INTERLAKE			
1971 (Census)	1,580	11,845	13.3
1976	1,691	11,425	14.8
1981	1,813	11,105	16.3
1986	1,963	10,903	18.0
1991	2,162	10,814	20.0
1996	2,406	10,815	22.2

[1] Assuming low fertility rates of 1.8 children per woman, this level of net immigration was seen to be necessary to maintain a projected population of 30 - 33 million during most of the 21st century. See Special Committee on Immigration Policy *Report to Parliament*, (Ottawa: 1975), pages 5 - 7

[1] As outlined in Appendix F of the Maki-Framingham report, a migration adjustment procedure was employed to equate internal migration levels to provincial migration levels. Owning to an absence of reported data in the report, this procedure was not employed in the projections for the subregions.

Although total population in these subregions is forecast to remain relatively static throughout the period to 1996, the proportion of urban residents within each subregion is expected to rise sharply. This growth in urban population can be expected to generate increased per capita requirements for residential, road and other forms of construction requiring aggregate.

3. Winnipeg Region Population

In summary, within the entire Winnipeg Region, it is anticipated that population will grow from 664,000 in 1971 to 727,000 in 1981 and possibly to 850,000 by 1996. The urban population, as a percentage of the total, will increase during this period from 88.7 percent in 1971 to nearly 93.0 percent in 1996.

4. A Forecast of Manitoba Households

In order to utilize the regression equation to forecast construction spending at the provincial level, provincial population forecasts were converted into number of households. The technique here is simply one of assuming that within each cohort, the number of household heads in 1971 as a percentage of total population will remain constant over time. The factors utilized here (derived from the 1971 Census) are as follows:

	Percent
15 - 24 years	11.4
25 - 34 years	42.6
35 - 44 years	46.7
45 - 54 years	49.8
55 - 64 years	55.3
65 + years	58.5

Employing the age-sex population distributions for Projections G and A of Statistics Canada population projections for Manitoba[1], the estimated numbers of Manitoba households to 1996 are as follows:

	BASE PROJECTION G		ALTERNATE PROJECTION A	
	Number of Households (000)	Persons Per Household	Number of Households (000)	Persons Per Household
1976	304.7	3.40	297.1	3.41
1981	330.9	3.35	316.4	3.36
1986	366.4	3.24	333.9	3.35
1991	374.1	3.37	349.2	3.35
1996	415.5	3.20	360.4	3.35

[1] See Sub-Section C.5.1.2 for a discussion of the Statistics Canada population projections.

APPENDIX 5

A REGRESSION MODEL FOR FORECASTING TOTAL CONSTRUCTION SPENDING IN MANITOBA

Future construction spending can be forecasted by first forecasting the future values of an independent variable which is known to influence construction spending. Through a derived relationship, the dependent variable, i.e., total construction spending, can then be forecasted from the values of the independent variable.

Regression analysis is a technique whereby this procedure can be extended to a number of variables. A linear regression model establishes a relationship between one dependent variable and several independent variables.

A regression model was fit to total construction value in Manitoba, population, population change, number of households, annual change in households, personal income and value added in manufacturing. In the same way, a similar analysis using only one independent variable was carried out. As the reduction of the equation to a simple relationship did not detract from the reliability of the results, the simple regression model was ultimately selected to forecast total construction spending. Of all the independent variables examined, the number of households was discovered to be the best single variable for predicting the level of construction activity in Manitoba — sufficient that the addition of other variables did little to improve the quality of the regression equation.

The choice of households over other variables is not surprising, since the household is the major consumption unit within the Manitoba economy. Household formation, for example, has a major impact on the residential construction market, and indirectly impacts on all other sectors as well.

The regression model is:

$$Y = -162,394 + 2,968.2x$$

where

Y = total construction spending (excluding residual item) in 1973 constant dollars (thousands)

X = number of Manitoba households (thousands)

Overall F Statistic = 29.570 (a measure of the statistical significance)

Coefficient of Determination = 0.767 (a measure of the fraction of variation in construction spending accounted for by the regression)

This model is used in the analysis. It employs total construction value as the dependent variable. Efforts were made to forecast each sector independently, but these met with limited success; the results for the residential sector were adequate but similar results could not be obtained for any of the other sectors, combined or separately.

APPENDIX 6

POSTSCRIPT ON ROAD CONSTRUCTION AND MAINTENANCE

1. Proportionate Share of Road Activity in the Winnipeg Region

Table A7.1 on the following page compares the volume of aggregate used in provincial government road construction and maintenance in the Winnipeg Region with the total volume of aggregate used in the province for the same purpose, as reported by Statistics Canada. The derived percentages were not used directly in the analysis contained in the report since the Winnipeg Region figures exclude municipal road work[1]. However, the data does provide some indication of any trend towards higher levels of road work activity outside of the Winnipeg Region.

The data in the table illustrate the profound changes in road construction and maintenance activity that have occurred in Manitoba since the mid 1960's, when the province took over responsibility for many of the roads hitherto maintained by municipal governments. Whereas in 1965, at least 30 percent of all aggregate devoted to road work in the province was used within the Winnipeg Region, by the early 1970's that share had been cut in half. This shift in utilization reflects that a higher priority was being given to development of roads elsewhere in the province, e.g., Northern Manitoba, as well as the simple fact that much of the required expansion in the Winnipeg Region had been completed by 1971.

[1] As discussed earlier, the volumes of aggregate reported by end use by Statistics Canada are somewhat suspect. Also, the Manitoba total excludes concrete aggregate used in road construction.

TABLE A6.1

WINNIPEG REGION SHARE OF AGGREGATE USED IN MANITOBA ROAD CONSTRUCTION AND MAINTENANCE (000 tons)

	Provincial Government: Aggregate Used in Winnipeg Region	Total Aggregate Used in Manitoba Road Construction[1]	Percent Winnipeg Region
1965	2,164.8	7,456.0	29.0
1967	1,502.5	7,559.5	19.9
1969	1,037.1	6,007.4	17.3
1971	1,402.7	11,627.7	12.1
1973	1,133.6	9,797.6[2]	11.6
1974	895.6	N/A	—

Source: Department of Highways; Statistics Canada Cat. 26-215 and 26-217

TABLE A6.2

IMPLIED AGGREGATE USAGE COEFFICIENTS FOR ROAD CONSTRUCTION AND MAINTENANCE: WINNIPEG REGION

	Road Construction			Road Maintenance		
	Aggregate Used (000 tons)	Miles of Construction	Aggregate Usage Coefficients (tons/mile)	Aggregate Used (000 tons)	Miles of Mainten-ance	Aggregate Usage Coefficients (tons/mile)
1965	1,810.0	150.6	12,018	354.8	337.2	1,052
1967	1,265.2	135.3	9,353	237.3	237.5	999
1969	938.0	161.0	5,828	99.1	99.0	1,000
1971	1,128.1	115.5	9,769	274.6	273.6	1,004
1973	971.5	201.5	4,822	162.1	180.5	898
1974	803.9	90.8	8,858	91.7	181.4	506
Total Selected Years	6,916.7	763.9	9,054	1,219.6	1,309.2	932

Source: Department of Highways

[1] Sand and Gravel and Crushed Stone used in road construction and asphalt aggregate. Excludes concrete aggregate.
[2] As revised; see Tables C-1 and C-2. (Road construction and asphalt aggregate from Table C-1 plus asphalt aggregate and road metal from Table C-2).

Since the provincial government share of activity within the Winnipeg Region appears to have held firm at approximately 12% in both 1971 and 1973, it is reasonable to assume that the combined provincial and municipal share for 1973, referred to in the report as the proportionate share (.299), is acceptable as a minimum guide for projecting the fraction of the total Manitoba road construction and maintenance activity that will occur in the Winnipeg Region.

2. Aggregate Usage Coefficients — Tons per Mile

The study derives aggregate usage coefficients for road construction and other sectors for 1973, based upon the total dollar value of construction in each sector and amount of aggregate employed (both limestone and sand and gravel). Table A6.2 on the following page presents a set of usage coefficients measured in tons per mile as calculated from data supplied by the Department of Highways for the Winnipeg Region. Since the coefficients are on a tons per mile basis, they cannot be compared directly with the coefficients used in the analysis.

Discussions with Department of Highways officials had previously indicated that aggregate requirements per mile of road construction could vary widely within the region, depending upon (among other factors) topography, nature of surfacing and road base. As expected, Table A6.2 indicates that requirements per mile of construction and maintenance have had a tendency to vary over time.

Perhaps the most appropriate tons per mile coefficients are the weighted average of all selected years, namely 9,054 tons per mile for road construction and 932 tons per mile for road maintenance.

While the above coefficients have not been employed directly in the analysis, they emphasize the probable variability in the particular road sector coefficients that are used in the study. Any such coefficients will vary with specific road site requirements, surfacing types and the extent of construction versus maintenance activities.

APPENDIX 7

ALTERNATE FORECASTING APPROACHES

1. Developing Aggregate Usage Coefficients Directly From Statistical Data

An initial attempt was made to test the possibility of forecasting aggregate usage directly from statistical data which, if it had proven successful, may have eliminated the need for detailed data research, analysis and manipulation.

Multiple linear regression analysis was employed to test the sensitivity of aggregate usage with levels of construction spending by construction sector. Separate regression models were prepared for sand and gravel; and for limestone.

With reference to sand and gravel, statistical tests revealed the results were not statistically significant. In addition, the coefficients for all variables except residential construction were negative, suggesting declining aggregate usage with increasing construction expenditures.

Experience gained during the study part with sand and gravel production data as reported by Statistics Canada. The detailed survey of the actual 1973 production suggests some inconsistency in the treatment of data by Statistics Canada, although their total production figures approximate the revised totals calculated in the study. Similar variations in earlier years, for which source data can no longer be obtained, may have had a marked influence on the multiple regression results.

The nature of the reporting format for crushed stone precluded using Statistics Canada data directly in calculation of a regression equation. Specifically, production figures as reported by Statistics Canada exclude limestone used by Canadian lime and cement plants. The limestone quarry operations of Canada Cement Lafarge and Inland Cement are therefore excluded from these totals and must be added back in order to arrive at a true estimate of crushed stone production in the province. The regression equation derived for limestone resulted in negative coefficients and was therefore not acceptable for forecasting purposes.

In summary, the aggregate usage coefficients cannot be derived by this method of analysis for either limestone or sand and gravel.

2. Economic Scenarios

It would be difficult to develop a variety of economic scenarios on the basis of the variables employed in this study, other than perhaps population and/or households. Projections of such variables as Gross Provincial Product, value added from manufacturing and personal income are subject to considerable uncertainty, not only in terms of future levels of activity but also with respect to their ultimate valuation (as each is measured in money terms). Sophisticated models such as CANDIDE, for example, are directed towards forecasting of future levels of economic activity for periods not exceeding 5 - 10 years.

An additional problem in forecasting at the sub-provincial level is the lack of meaningful and consistent data. With the exception of census value added in manufacturing and possibly farm cash receipts, there is no data available on economic activity at the regional, census division or group district level. Estimates of population, on the other hand, have been published by Statistics Canada for economic regions since as early as 1966.