MANITOBA
DEPARTMENT OF ENERGY AND MINES
OPEN FILE REPORT OF83-2

SURFICIAL GEOLOGY & AGGREGATE RESOURCES INVENTORY OF THE RUSSELL-SHOAL LAKE AREA

Prepared for
Mineral Resources Division
of the
Manitoba Department of Energy
and Mines

Gartner
Lee
Associates
Limited

February 1983

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Consulting
Engineering
Geologists and
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Toronto-Buttonville Airport ▪ Markham, Ontario ▪ L3P 3J9 ▪ 416-477-8400

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February 16, 1983.

Mr. W.A. Bardswich,
Director,
Mines Branch,
Mineral Resources Division,
Manitoba Department of Energy and Mines,
989 Century Street,
Winnipeg, Manitoba,
R3H OW4.

Dear Mr. Bardswich:

Re: Surficial Geology and Aggregate Resource Inventory, Russell-Shoal Lake Area - GLAL 82-19

We respectfully submit our final report describing the surficial geology and aggregate resources of this area.

The work was carried out by our geological staff under the direction of Mr. A.J. Cooper, M.Sc. The report contains a complete description of aggregate resources. Sixty-four separate deposits were analysed, and results are summarized in the report. Surficial Geology maps are found in the pocket at the back of the report.

It has been a pleasure to present you with these results, and we thank you for allowing us to be of service.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED

J.F. Gartner, P.Eng.,
Consulting Engineering Geologist.
President.

AJC:jcm

SURFICIAL GEOLOGY AND AGGREGATE RESOURCE INVENTORY OF THE RUSSELL-SHOAL LAKE AREA

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SUMMARY

The Russell-Shoal Lake area is dominated by a large relatively flat till plain. Two large river valleys -- the Assiniboine and the Qu'Appelle -- cut the till plain in the west and the Birdtail Creek Valley trends southwestward from the northeast corner and bisects the area. Large volumes of fluvial sands and gravel are associated with these three valleys. A kame moraine cuts across the northeast corner of the study area and smaller ice contact deposits occur sporadically, particularly in the north. Shale bedrock is at or near surface in much of the western half of the area. Subsurface materials consist of a sequence of silt tills with occasional buried bodies of sand, silt and/or clay.

Outwash plain deposits associated with the Assiniboine and Qu'Appelle drainage systems contain very large quantities of medium to high quality aggregate. Fluvial terraces, especially along the Birdtail Creek Valley contain substantial quantities of high quality aggregate. Smaller deposits of outwash and kame materials of variable qualities occur in the northern portion of the study area.

Total aggregate reserves in the study area are estimated to be approximately 1,458 million cubic metres. Aggregate usage in the area is estimated to be approximately 50,000-75,000 cubic metres per year. Usage is not likely to change in the immediate future unless major construction projects are implemented.

The Rural Municipalities of Russell and Archie have sufficient aggregates to meet local demand for the foreseeable future although these materials are not evenly distributed. The Rural Municipalities of Rossburn, Ellice and Birtle have abundant aggregate resources. The Rural Municipality of Silver Creek contains limited resources and the importation of certain types of aggregate is necessary. The Rural Municipality of Shoal Lake contains no commercially usable aggregate and all materials must be imported.

1.0 INTRODUCTION:

1.1 PURPOSE AND SCOPE:

The present study is one of a series conducted by the Manitoba Department of Energy and Mines in recent years. The prime objectives were to map and characterize the surficial geologic materials in the study area, and to determine the quality and quantity of the sand and gravel deposits. An assessment of the hydrogeologic properties of the geologic units and an estimate of the existing and projected usage of aggregates in the study area were also included in the study objectives.

The main tasks included:

- mapping and describing all the surficial geologic units in the area;
- describing the geologic history with particular reference to features significant to planning and development within the area;
- delineation and evaluation of all granular landforms;
- assessment of the quality of sand and gravel;
- estimation of available granular material by deposit and by municipality;
- evaluation of hydrogeologic properties and relationship of surficial geological materials;

- an assessment of aggregate production, demand and future requirements.

The study was designed to provide a general framework for planning purposes. Site specific studies, such as aggregate value assessments, are beyond the scope of this study.

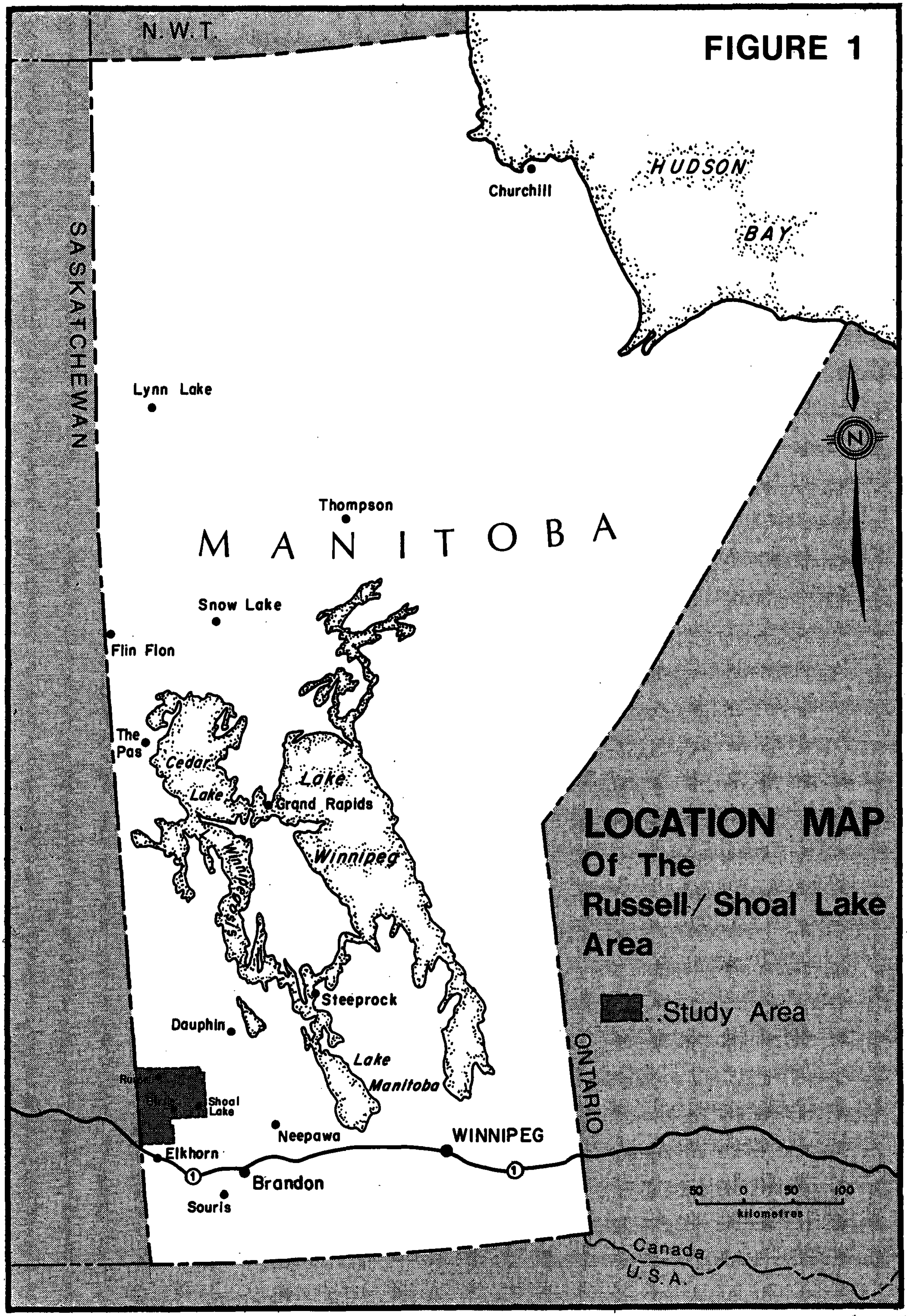
The scope of the work was established in the "Proposal for Consulting Services" submitted by Gartner Lee Associates Limited in June, 1981 in response to the "Terms of Reference" prepared by the Mineral Resources Division of the Manitoba Department of Energy and Mines, May 1981.

A contract between the Province of Manitoba and Gartner Lee Associates Limited was signed on February 25, 1982.

1.2 STUDY AREA:

The study area is located in south-western Manitoba on the Manitoba-Saskatchewan border approximately 90 km northwest of Brandon. Riding Mountain National Park abuts the map area to the north and northeast. Access is provided by Provincial Highways 16, 45, 42, 41 and 83 and by numerous smaller provincial and municipal roads. The area is served by two Canadian Pacific Railway lines and one Canadian National Railway line.

The study area comprises slightly over 5000 km^2 and



Gartner Lee Associates Limited

contains the following rural municipalities:

Russell
Silver Creek
Rossburn
Ellice
Birtle
Shoal Lake
Archie

1.3 STUDY METHODS:

The initial thrust of the present survey was to compile a surficial geology map and establish the stratigraphy and history of the study area. The first phase involved researching previous work which applied to the study area. Topographic maps at a scale of 1:50,000 were used as a mapping base and stereoscopic airphoto interpretation of 1:70,000 black and white airphotographs was carried out prior to field work. Supplementary airphotographs at a scale of 1:10,000 were also employed.

An initial reconnaissance survey of the field area was conducted in order to check regional patterns and then detailed survey work was begun. All the accessible roads in the study area were driven (including Indian Reserve lands) and airphoto interpretations were verified. Road cuts and landscape features were recorded on field maps and significant geological exposures were recorded in detail. Hand auger holes and test pits were used where natural exposures were inadequate. Gravel pits and potential aggregate deposits were noted for the aggregate sampling program which followed.

Airphotographs were re-examined in light of the ground truthing and a surficial geological map was prepared along with an appropriate map legend.

The surficial geological survey was used as a basis for evaluating the aggregate resources of the Russell-Shoal Lake Area.

Sand and gravel pits and aggregate landforms were identified and delineated during the initial interpretation of airphotographs. The aggregate records of the Department of Highways were consulted to obtain additional locations and past quality data from pits used by that department. Additional geologic data were obtained during the surficial mapping phase of the study. All of this information was synthesized and the detailed aggregate sampling program was implemented. Sampling was carried out and detailed exposure description computer forms were completed for each accessible pit. Selected road cuts were also sampled and described where no pits existed. A proposed backhoe test pit program was abandoned in favour of a more detailed mapping program in selected areas.

The pits and exposures were described using computer forms 1 through 4 (Appendix A). Form 1 is an aggregate deposit form which is used to outline the area, depth and depletion of each deposit for calculation of deposit volumes. Form 2 records stratigraphic data for each exposure. Section heights, lithology, deleterious substance content and sampling are recorded on this form. Form 3 records geologic details of units and sub units found in geologic sections. Form 4 is a laboratory form which is filled out during laboratory sieve analysis of granular channel samples obtained in the field.

Most data were recorded directly onto the computer form at the exposure site in the field. Estimates of gravel contents, lithologies and other parameters were made on site and a channel sample was taken at most accessible pits to provide laboratory verification of field estimates of grain size. A photograph was taken of the face wherever practical. All accessible pits in the area were described on the computer forms. Most were also sampled for laboratory analysis. Where there were few pits, additional geological observations were made to gain an understanding of the deposit. A continuous series of geological observations were made along each road to aid in the final airphotograph interpretation.

Upon completion of the field work, all of the data were collated and checked. Final airphotograph interpretation was carried out, deposit numbers were assigned and the maps were compiled. Deposits are numbered from 12201 through 12264 and are in approximate numerical order within each municipality from the top left to bottom right. The municipalities are similarly ordered: Russell, Silver Creek, Rossburn, Ellice, Birtle, Shoal Lake and

Archie. A deposit numbered in one municipality retains the same number if it crosses a municipal boundary. Where several portions of a deposit are geographically distinct but geologically similar they retain the same deposit number but are noted with a letter designation (e.g. Deposit 12251A through 12251F). All sites with computerized data files are noted as "Exposures" on the maps and each has a three digit number preceded by the letter G, (e.g. G099). If that site was sampled an S appears after the exposure number. Access to this computer file may be obtained through the office of the Aggregate Resources Section of the Mineral Resources Division in Winnipeg. Additional field notes and original airphotographs are also retained at the same office.

The four types of computer forms have been processed into the Mineral Resources Division computer system "PLSTCNG". The PLSTCNG system calculates deposit volumes, calculates grain size parameters and gives a quality assessment of each deposit and exposure. A printout is available for each exposure and deposit. An example is presented in Appendix B and a summary of deposit data appears in Appendix C.

1.4 PRESENTATION OF DATA:

The findings of this study are presented in three components:

1) The published report and accompanying map folio.

2) Computer data file.

3) Background data file.

The present report is a synthesis of all of the data gathered during the study. It presents summaries of the data collected and explains the geology and aggregate deposits of the area. The accompanying maps at a scale of 1:50,000 show the major geological features and highlight the aggregate deposits of the area.

The computer data file is a detailed computer-based data storage system maintained by the Mineral Resources Division in Winnipeg. It contains geological descriptions, quality descriptions, ownership information and detailed grain size testing results for all of the exposures noted on the 1:50,000 scale maps in the map folio. The computer program calculated the deposit volumes used in this report, indicated the standard industrial products that each test sample is capable of manufacturing, and notes if the sample requires any form of beneficiation by screening, crushing or blending. An example of this computer output is presented in Appendix B. The computer forms, filled out in the field and laboratory, which comprise the computer data input are presented in Appendix A. The computer files are available to the public through the Aggregate Resources Section of the Mineral Resources Division.

The background data file contains all the working notes, records, maps and airphotographs used during the study. These materials are also retained by the Mineral Resources Division.

1.5 ACKNOWLEDGMENTS:

The successful completion of the Russell-Shoal Lake study was dependent upon the assistance and cooperation of many individuals. Mr. R.V. Young and his staff at the Mineral Resources Division provided valuable assistance throughout the study. Mr. T. Wong provided information from the Manitoba Department of Highways. The clerks of the municipalities in the study areas provided gravel consumption data and the pit owners and construction companies provided access to their properties and information on aggregate consumption.

The Gartner Lee Associates Limited study team consisted of:

J.F. Gartner, P.Eng.
A.J. Cooper
A.G. Hims, P.Eng.
B.M. Hachkowski

2.0 SURFICIAL GEOLOGY:

2.1 PHYSIOGRAPHY:

There are four major physiographic regions in the Russell-Shoal Lake study area: till plain, outwash plain, an area of morainic topography, and two large river valleys (Figure 2).

Till plain is the major physiographic unit in the study area. This unit is referred to by Klassen (1979) as the Assiniboine River Plain. The plain slopes gently toward the Assiniboine River and drops from an elevation of approximately 610 m a.s.l. near Rossburn to approximately 460 m a.s.l. at the edge of the Assiniboine Valley, (Figure 3). It displays local relief up to 10 m and is punctuated by numerous shallow depressions which contain water. These depressions are locally termed "sloughs" and are very typical of the till plain areas, (Photo 1). Minor variations in the surface topography were noted where small eskers or kames are present. The area around Binscarth contains a concentration of drumlinoid ridges and flutings oriented in a northwest-southeast direction. To the west of Binscarth, shale bedrock is known to occur at or near surface with only a thin till veneer. The till plain in the Rural Municipality of Archie displays a striking pattern of small parallel morainic ridges. Prest (1968) has aptly called these features "corrugated ground moraine". These features usually exhibit 5 to 10 m relief and are oriented in a northeast-southwest direction.

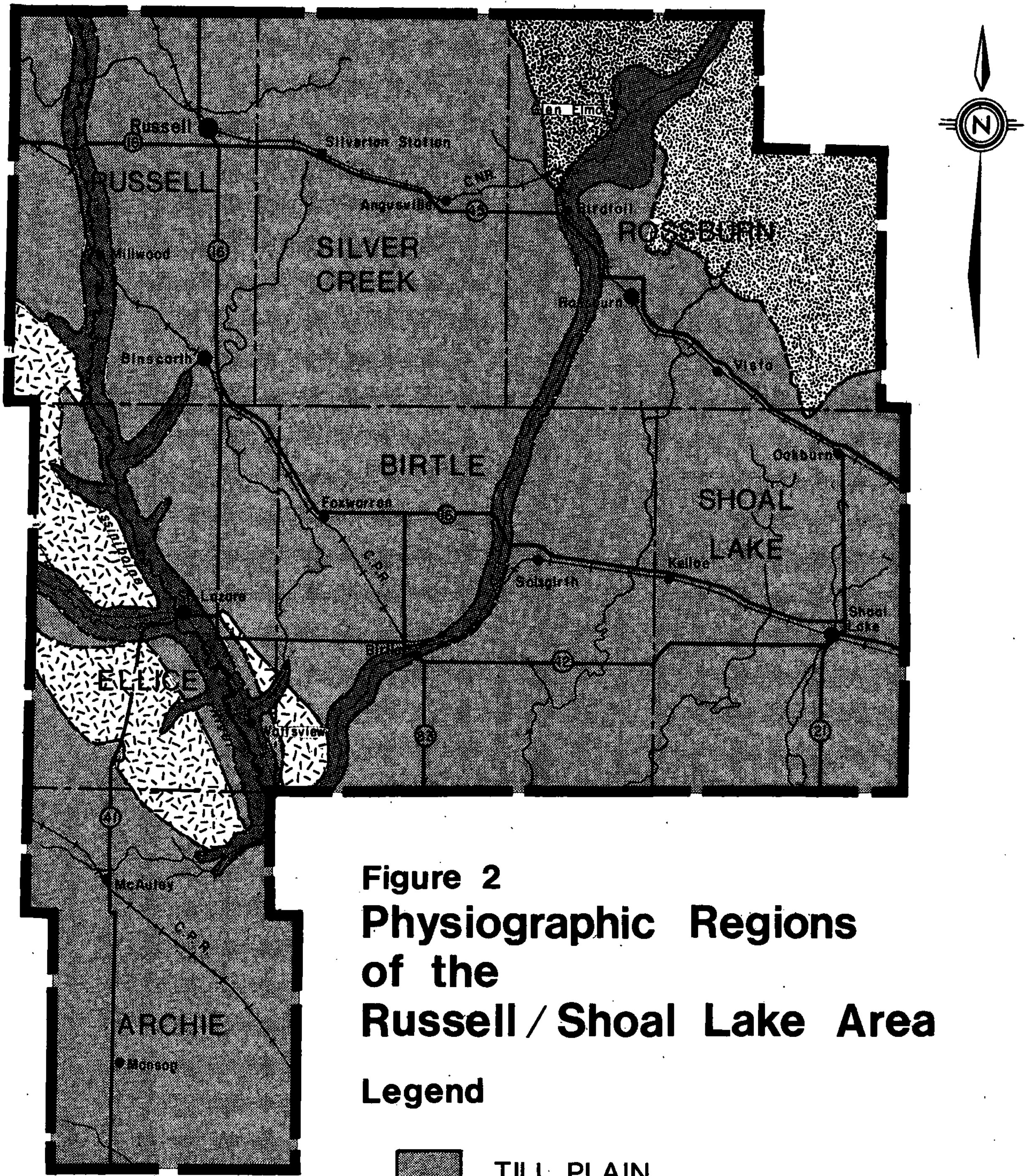


Figure 2

Physiographic Regions of the Russell / Shoal Lake Area

Legend

- **TILL PLAIN** — low relief, occasional kames, eskers, morainic ridges
- **MAJOR RIVER VALLEYS** — steep sides and flat bottoms, occasional terraces
- **OUTWASH PLAIN** — low relief, locally areas of sand dunes
- **MORAINIC TOPOGRAPHY** — moderate to high local topography, hummocky

SCALE 1:500,000

10 0 10 20
kilometres

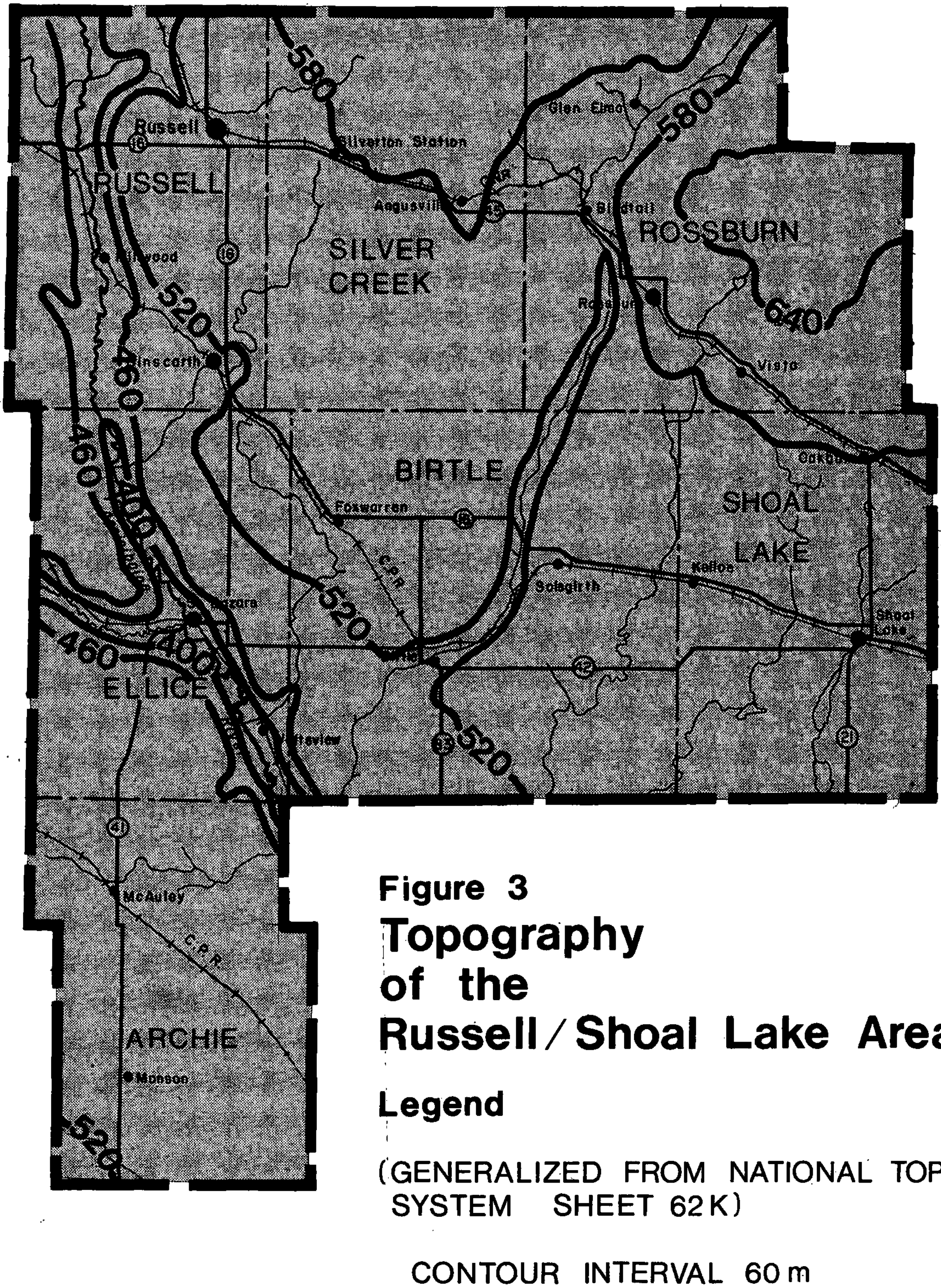


Figure 3
Topography of the Russell / Shoal Lake Area

Legend

(GENERALIZED FROM NATIONAL TOPOGRAPHIC SYSTEM SHEET 62 K)

CONTOUR INTERVAL 60 m

SCALE 1:500,000

10 0 10 20
kilometres

PHOTO 1

Typical "slough" topography on the till plain area, southeast of Russell.

An area of hummocky morainic topography was noted in the northeast corner of the study area. This region is the southern edge of Klassen's Riding Mountain upland. This hummocky topography exhibits 50 m or more relief and is found in the highest portion of the study area, above 600 m a.s.l.

The surficial geology as well as the general orientation of this feature indicates that it is a small portion of a morainic belt trending northwest to southeast.

Several large areas of outwash plain are present near the confluence of the Qu'Appelle and Assiniboine Rivers. These plains occur at approximately 465 m a.s.l. and are notable for their extremely flat nature and large size. Sand dunes have been developed on portions of the plain, particularly adjacent to the Assiniboine River. The land on the outwash plains is notably dry and difficult to farm.

The valleys of the Assiniboine and Qu'Appelle Rivers (Photo 2) and Birdtail Creek are striking topographic features. They exhibit over 100 m relief in places and may be 1 to 5 km in width. They generally exhibit steep sides with a broad flat bottom but there are large terraces present in some areas, particularly along Birdtail Creek.

PHOTO 2

Junction of the Assiniboine and Qu'Appelle River valleys at St. Lazare. Looking south-east. St. Lazare is immediately to the east (left) of the photo.

The present rivers are underfit streams in glacial melt-water valleys. The valley bottoms often display well developed meander features.

2.2 BEDROCK GEOLOGY:

The entire study area is underlain by the upper Cretaceous shales of the Riding Mountain Formation. Wickendin (1945) and Lang (1965) have mapped and described the formation in the area. It is a soft medium to light grey shale with occasional hard siliceous interbeds where it was observed in the field.

Major exposures of the Riding Mountain Formation were observed along the entire length of the Assiniboine River Valley and in the upper reaches of the Birdtail Creek Valley in the northeast corner of the study area. Scattered outcrops were noted adjacent to the Assiniboine Valley in the Russell-Binscarth area and to the east of the Birdtail Valley, adjacent to Riding Mountain National Park. The outcrops are noted on the surficial geology maps and on Figure 4, (in pocket) the drift thickness map.

In many locations along the Assiniboine River Valley the shale has experienced some slope movement. Several inactive, though clearly visible, landslide scars were observed on the airphotographs, but the majority of the slopes consist of sloughed, weathered shale that is mixed with till and the occasional small body of outwash gravel.

2.3 DRIFT THICKNESS:

The drift thickness in the study area is presented on Figure 4 (back pocket). The data used to compile this map include:

- outcrop data from the present survey
- outcrop data from Klassen (1966)
- Manitoba Water Well Drillers' Report

Figure 4 places strong emphasis on bedrock outcrops and extends interpretations to depth by interpreting borehole patterns. The overall interpretation is similar to that developed by Klassen (1966) for the bedrock topography -- additional data have enabled a more accurate placement of several bedrock valleys.

Fortunately, the large number of bedrock outcrops in the study area yields a relatively high degree of accuracy in locating shallow bedrock areas. These areas of less than 15 m of drift are centered on the Assiniboine River and upper Birdtail Creek Valleys. Several small areas of shallow drift, located with water well records, were noted north and northeast of Foxwarren and north of Shoal Lake. Areas containing 15 to 30 m of drift commonly follow the trends of the surface outcrops. They occur around the margins of the thin drift areas and at several isolated areas, interpreted from water well records, in the Kelloe-Shoal Lake-Oak Burn area. Areas containing 30 to 45 m of drift are present in the central and eastern portions of the map area. These areas often represent the edges of bedrock valley areas. Areas containing more than

45 m of drift are probable bedrock valleys. The major valley trends north-south through the study area immediately east of the Towns of Angusville and Birtle. A probable tributary of the main valley passes beneath the Towns of Marco and Oakburn, and joins the main valley at Solsgirth. Bifurcations of the main valley occur at Angusville-Russell and near Birtle. The entire buried channel system appears to be interconnected with the modern Assiniboine-Qu'Appelle system and exhibits similar physical proportions. Connections between the modern and buried valley systems are present near Russell and St. Lazare. The sparcity of wells penetrating to bedrock in the buried valley areas makes the exact positioning of the valleys somewhat interpretive. Future data may be of assistance in locating the exact position of these features.

2.4 QUATERNARY MATERIALS:

2.4.1 STRATIGRAPHY:

Interpretation of the stratigraphy in the study area is important to the understanding of the geological history of the area. The stratigraphy has a significant effect on aggregate resources, engineering geology and hydrogeology.

Klassen (1975, 1979) has studied the stratigraphy of the area and mapped many of the deposits. His investigations included a number of borings to establish and name stratigraphic units. The present study encountered the same geological units proposed by Klassen with the exception of the Shell and Largs Formations which are deeply buried and not exposed at surface. A summary of the geological units in the study area is presented in Table 1.

The stratigraphy and surface deposits are dominated by sandy silt to silt tills of the Lennard and Minnedosa Formations. Of particular significance for applied purposes are a number of buried granular bodies observed between these two tills and within the Lennard Till. Klassen (1979, P.11) also notes the presence of buried sand, silt and clay in association with the Shell and Largs Formations.

2.4.2 TILL AND ASSOCIATED MATERIALS:

The oldest till unit present in the study area is the Largs Formation. This unit is deeply buried and was not encountered in the present survey. Klassen (1979) describes this till as a very dark grey silty to to clayey till. He notes a high shale content for this till and associates it with buried sand in several boreholes west of the study area. "The stratigraphic position of this formation indicates that it is of pre-Wisconsin age and probably is early Pleistocene". (Klassen 1979, P.7).

The Shell Formation is also deeply buried in the study area. Klassen (1975, 1979) has studied the unit in

TABLE 1: SUMMARY OF GEOLOGICAL UNITS IN THE RUSSELL-SHOAL LAKE AREA

AGE	UNIT	LANDFORM	COMPOSITION
Postglacial	Alluvium	Flood plains	silt, sand, organics
	Eolian Material	Sand dunes	sand
	Organics	Sloughs, depressions	organics, peat, muck
	Colluvium	Valley sides	shale, till, gravel
Proglacial	Outwash	Plains, terraces	sand and gravel
Glacial	Ice-Contact Drift	Kames, eskers	sand, gravel, till, silt
	Moraine Plateaux	Moraine Plateaux	silt, clay, till
	Lennard Formation	Till plain	sandy silt till
	Kames and Outwash	Buried	sand and gravel
	Minnedosa Formation	Till plain	sandy silt till
	Shell Formation*	Buried	sandy silt till
	Largs Formation*	Buried	clayey silt till
Cretaceous	Riding Mountain Formation	Bedrock	Shale

* = not exposed in study area

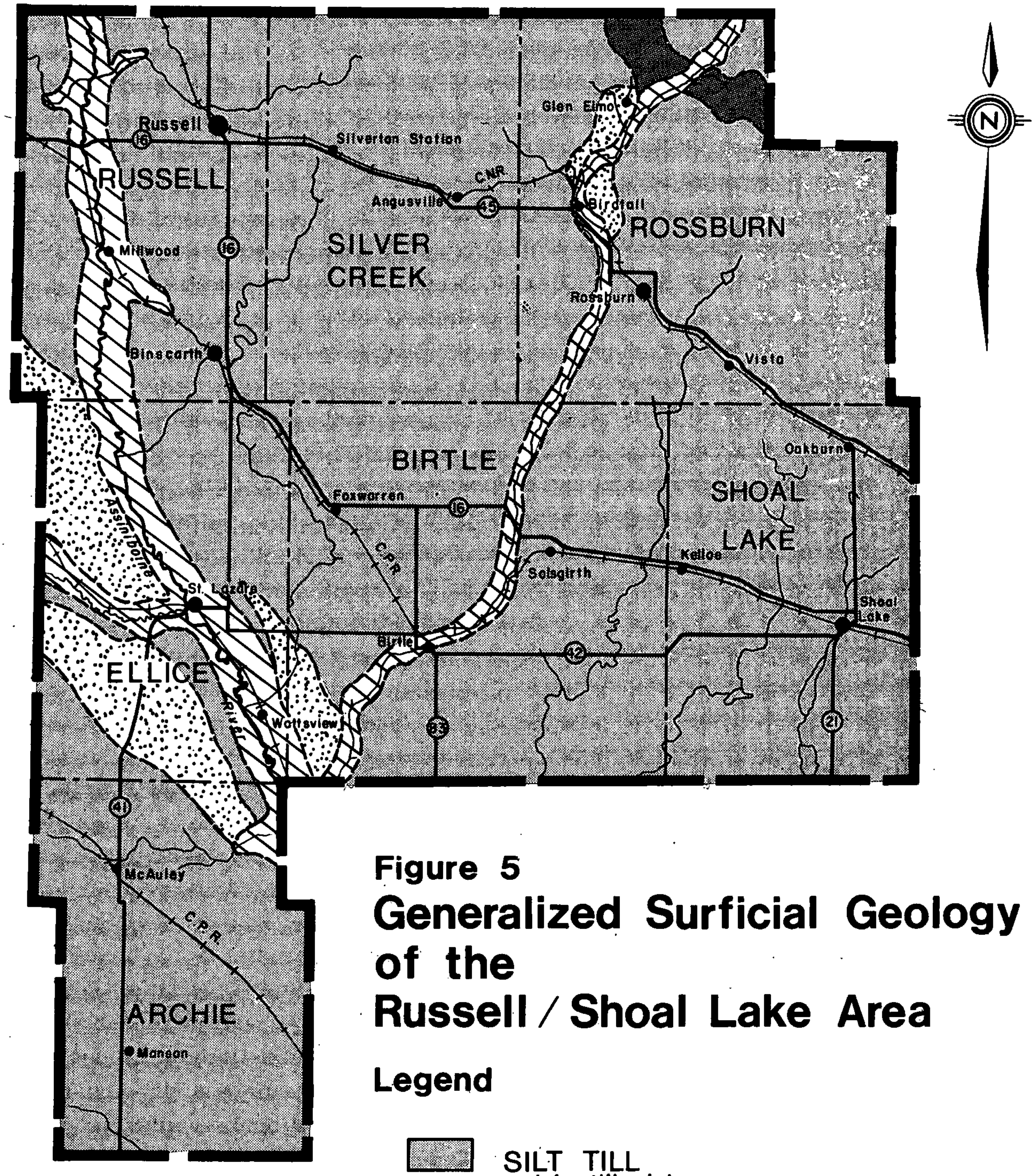


Figure 5
Generalized Surficial Geology of the Russell / Shoal Lake Area

Legend

- SILT TILL — mainly till plain
- VALLEY SLOPE & ALLUVIAL MATERIALS
- OUTWASH — sand and gravel
- KAME MORAINE — sand, minor gravel

SCALE 1:500,000

10 0 10 20

kilometres

exposures outside the study area and within the study area using boreholes. He indicates that the formation is commonly discontinuous and generally consists of one till unit but in places contains several tills plus intertill sediments. A diagnostic weathering zone on the upper surface of the till serves to separate it from the overlying Minnedosa Formation. The Shell Till is a sandy silt unit and is sandier than most other tills in the area. Klassen (1979) concludes that the Shell Formation is of early Wisconsin or pre-Wisconsin age.

The Minnedosa Formation is the oldest glacial unit observed during the present study of the area. This till was encountered in several cuts and excavations in the Russell area but it was commonly buried beneath the overlying Lennard Formation. In many portions of the study area the Minnedosa Till directly overlies shale bedrock. It exhibits a substantial amount of variability as a result of incorporation of the shale bedrock. It is commonly a silt to clayey silt till with a yellowish brown (10YR5/4) colour although it may vary to a dark yellowish brown (10YR4/2) massive silt with few clasts. In some locations it contains more than 70% shale debris. Klassen (1979) states that this till contains somewhat more clay than other tills in the area, however, his grain size data (Figures 9 and 10, P. 8, 9) record similar grain size parameters and considerable overlap in properties between the Minnedosa and the overlying Lennard Till. This similarity in grain size properties was noted in the field throughout the study area. Where the two tills are weathered, as is usually the case, it is difficult to separate the two units without stratigraphic evidence. Such stratigraphic evidence was present in the Russell-

Binscarth area. A pronounced boulder pavement and/or glaciofluvial sand and gravel often separate the two till units.

Intertill glaciofluvial sand and gravel occurring sporadically between the Minnedosa and Lennard Tills are significant geologically, historically, geomorphologically and economically (Photo 3). These materials occur as a variety of different sediment types but occupy a similar stratigraphic position and have therefore been grouped together. As noted, these materials serve to separate the two upper till units. Historically, they indicate an interstadial, or longer, non-glacial interval in which outwash, kames and eskers were deposited. Geomorphic expression of these features has not always been destroyed by ice advances. Therefore, these features may pre or post-date the most recent ice advance, which deposited the Lennard Till. These buried or partially buried glaciofluvial deposits have a significant economic impact.

There are a number of pits which have been developed in these buried materials in the Russell-Binscarth area (e.g. G002, G174, G560). The occurrence of these materials may also have a profound impact on the local hydrogeological or geotechnical conditions in that they are markedly more permeable than the enclosing till units.

Klassen reports that "The Lennard Formation occurs over most of the Assiniboine River plain but is very thin in places west of the Assiniboine River Valley....." .

PHOTO 3

Till overlying glaciofluvial sand,
G555 southeast of Binscarth
(Shovel is approximately 1 m in length)

(Klassen 1979, P.10). The present study tends to confirm this summary, although detailed till differentiation techniques were not employed. The Lennard Till is generally a yellowish brown (10YR5/4) silt till but varies to a sandy silt till, particularly where it is in association with sand and gravel. This till is known to overlie glaciofluvial materials, particularly in the Russell-Binscarth area (Photo 3). A number of sand and gravel inclusions have been noted as discrete lenses within the till body (e.g. G591, G602). All of the till directional indicators (corrugated moraines, drumlins, flutings and eskers) appear to correlate with this till unit. The Lennard Formation is believed to be late Wisconsin in age.

2.4.3 GLACIOFLUVIAL MATERIALS:

Glaciofluvial materials in the form of kames, kame moraines, eskers, outwash and terraces are present within the study area. These landforms range in size from small kames of less than one hectare to extremely large features such as the outwash plain at St. Lazare.

Kames and kame moraine complexes are fairly common in the northern portions of the study area. These range from single well-formed conical kames (e.g. G031), to hummocky features of several square km (e.g. G155, G179), to the massive kame moraine feature in the northeast corner of the map area (G157, G161, G163). These materials often exhibit characteristic ice-contact features such as rapid variation in sediment type and gravel is often present as lenses or zones within a generally sandy deposit. The kame moraine in the northeast corner is an excellent example of this phenomenon. The moraine is generally composed of sand, silt and occasional till. Small discrete gravel zones have been isolated and described as "Aggregate Deposits".

Eskers within the map area are notable for their small size and lack of coarse grained sediment (Photo 4). They are commonly composed of sand and till, and only small amounts of gravel occur. The only eskers containing appreciable gravel are those associated with the outwash adjoining the Assiniboine River Valley (G611, G612) and within the kame moraine (G157, G164). One esker, southeast of Birtle, attains a length of approximately 12 km but most eskers in the area are less than 3 km in length. To date,

PHOTO 4

Small esker southeast of McAuley. The small overgrown pit visible in the photo is one of the few excavations in eskers within the study area. (1.9 km south of G563)

there have been no sizeable pits excavated in any esker other than those noted above which are directly associated with other granular materials.

Huge outwash plain deposits are present near the confluence of the Assiniboine and Qu'Appelle Rivers. The outwash is primarily sandy gravel but some variation was noted to gravelly sand as the distance from the river valley increases. In general, these deposits are 5 to 10 m in thickness (locally thicker) and a thin surface veneer of wind-blown sand is common. Areas where the wind-blown sand is consistently more than 1 m in thickness are noted as a separate map unit (4c).

Fluvial terraces are similar to the outwash plains although deposits are smaller and restricted to the major river valleys. These deposits are common along the Assiniboine and Qu'Appelle Rivers and Birdtail Creek and occur at various levels. The fluvial terraces along the Birdtake Creek are particularly well developed and exhibit some of the coarsest granular materials in the study area, (Photos 5 and 6). Thicknesses of these materials vary from an intermittent metre or two (north of Birtle G190, G191 - map unit 5c) to 15 m (G183 south of Birtle).

A number of very thin, small granular deposits are present in the study area in old glacial meltwater channels. These materials are generally sand, limited in surface area and seldom more than one to two metres in thickness. In view of the limited area of these deposits, an arrow symbol was used to denote the small meltwater channel areas. Bodies of outwash sand which are too small to show at present map scale may be located along these channels. In a few cases, these deposits are large enough to be expressed as a separate map unit (e.g. G186, G187 south of McAuley). Since these deposits are planar and not terraced or restricted to river valleys they are noted as "outwash plain" on the surficial geology maps.

PHOTO 5

Fluvial terrace on Birdtail Creek, G088 southwest of Birtle.

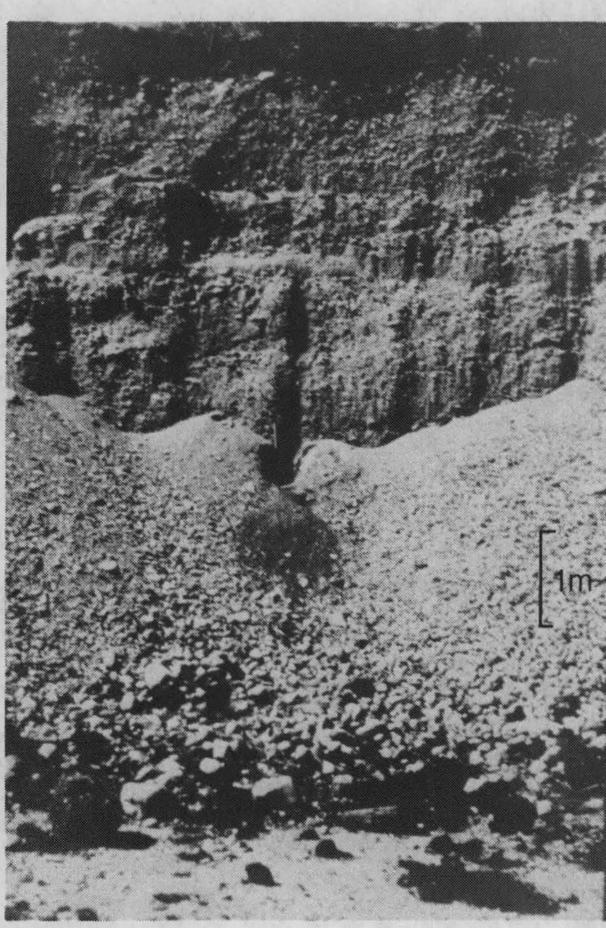


PHOTO 6

Pit face in fluvial terrace materials, G613 northeast of Birtle.

2.4.4 POST GLACIAL MATERIALS:

Three types of post glacial materials were mapped during the present survey: alluvium, colluvium and organics.

Alluvium is present in nearly all the stream valleys of the study area. It is not present where a stream is cutting a sharp "V"-shaped valley and erosion is extremely active. The alluvium observed in the study area is commonly silt to medium sand and often contains organics. The major alluvial deposit in the area is in the flat bottom of the Assiniboine River where there are numerous meander loops and oxbow lakes. These deposits are seldom more than 3 or 4 metres above the river level and are often prone to spring flooding. Locally the alluvium contains a high gravel content (e.g. the Birdtail Creek).

Colluvium is present along the valley walls of the Assiniboine and Qu'Appelle Rivers and Birdtail Creek and along several tributary streams. This material is usually slumped and is composed primarily of weathered shale bedrock, till and minor amounts of sand and gravel. Most of the valley walls show evidence of previous slope instability and there are several locations where clear landslide scars are visible.

Organics are common throughout the study area but they seldom occur in large enough areas to warrant a discrete map unit. Many of the sloughs in the study area contain organics but only one area, along the Manitoba-Saskatchewan border, is large enough to require separate mapping.

Organic areas often contain peat, muck, marl and modern plant detritus.

2.5 QUATERNARY HISTORY:

The Quaternary history of the Russell-Shoal Lake area has been established over many years by numerous authors and was recently summarized by Klassen (1975, 1979). The various geologic units in the study area are summarized on Table 1.

The oldest material encountered in the study area is the Cretaceous shale bedrock of the Riding Mountain Formation. As noted in the discussion of drift thickness, there are large bedrock valleys eroded in the upper surface of the bedrock. Klassen (1979, P.4) indicates that the Assiniboine and Qu'Appelle bedrock valleys were cut in pre-Pleistocene times. This appears reasonable in view of the age of some of the deposits contained in the valley fills.

The Largs Formation is the oldest recorded glacial material in the study area. Klassen (1979) encountered the formation in boreholes and concluded that is is probably of early Pleistocene age because of its stratigraphic position.

The Shell Formation was encountered overlying the Largs Formation in boreholes in the southern portion of the study area. It is believed to be of early Wisconsin or pre-Wisconsin age. Plant detritus overlying the formation was used to determine a minimum age of 38,000 radiocarbon years BP. (Klassen 1979).

The Minnedosa Formation is present overlying the Shell Formation. Klassen indicated a southwesterly flow for this till and an early Wisconsin age.

The last (late Wisconsin) glacial advance in the map area left abundant evidence of a southeasterly advance which deposited the Lennard Formation. All of the drumlins, flutings, eskers and corrugated moraine ridges noted on the accompanying maps in the Russell-St. Lazare-Shoal Lake area appear to be related to this till. During the ice advance which formed the Lennard Till, Lake Souris existed near the ice front and the Pipestone Spillway fed glacial meltwater into it from the northwest. During the withdrawal of the ice from the Lennard maximum the Qu'Appelle Spillway, and later the portion of the Assiniboine Spillway north of St. Lazare was exposed and became active. This spillway system conducted meltwater from the area west of Regina into glacial Lake Agassiz. The size of the meltwater flow is indicated by the size of the eroded valleys of the Qu'Appelle and Assiniboine Rivers, (Photo 2), the large outwash deposits associated with the channel, and boulder pavements (Photo 7).

The Birdtail Creek meltwater channel became active at this time, probably during the late Wisconsin advance of the Valley River Sublobe situated to the northeast of the study area. It is probable that this advance, which was

PHOTO 7

Surface boulder lag adjacent to the Assiniboine River Valley west of Binscarth. (Township 18, Range 29, Section 12 NE)

a brief readvance of the northeastern ice which deposited the Minnedosa Till, formed the kame moraine in the extreme northeast corner of the map area. The sandy nature of the deposits in this moraine, the topography and the moraine plateaux present, suggest a stagnant ice front. The well developed terrace system along the Birdtail Valley suggests that the water flow was somewhat less catastrophic than in the main Assiniboine system. It is also possible that the till noted in the extreme northeast corner of the study area correlates with the southern edge of Klassen's Zelna Formation.

As the ice withdrew north of the study area, the meltwater quantities slowly waned and successively lower terrace levels were formed. The general sparcity of intermediate terrace levels in the Assiniboine and Qu'Appelle Valleys in the study area would suggest a fairly abrupt decline in meltwater volumes.

In post-glacial times relatively little has happened in the study area. Sand dunes developed on the surface of the outwash plains near St. Lazare. Both the Qu'Appelle and Assiniboine Rivers have developed broad flood plains and now exhibit the characteristic meandering of underfit streams. The valley walls of the Qu'Appelle and Assiniboine Rivers and Birdtail Creek have eroded and slumped over much of their length and tributary streams are cutting down to the base level represented by these major river systems.

2.6 ENGINEERING TERRAIN APPLICATIONS:

A geological mapping program can provide a sound framework for many types of applied geological studies. The terms of reference for the present study required that hydrogeological parameters of the surficial materials be established. Selected aspects of the regional geological setting are presented so that the reader may have a basic appreciation for the significance of these numbers. The comments made here are strictly general in nature. Any project which might affect the ground water of the area would require a full and complete hydrogeological site investigation.

In general, the ground water table is a subtle reflection of surface topography, with the ground water flowing from areas of topographic highs to areas of topographic lows. It is, therefore, reasonable to assume a broad regional ground water flow from higher (recharge) areas, such as the Riding Mountain Uplands, (Figure 3), toward the lower areas, particularly the deep valleys of the Assiniboine and Qu'Appelle Rivers, which are probably regional ground water discharge areas. In a similar manner local topographic features will affect local ground water flows.

The most common materials encountered in the field were silty sand to sandy silt tills. These tills are estimated to have permeabilities ranging from 10^{-5} to 10^{-7} cm/sec. The sands and gravels encountered in the study probably have permeabilities ranging from 10^{-2} to 10^{-4} cm/sec. The other major geologic material in the map area, the shale bedrock, has more complex ground water flow characteristics. The shale itself is very slowly permeable but fractures which occur commonly in shale will greatly increase the effective permeability through secondary fracture flow phenomena.

The actual permeabilities of a material are significant only if one has a clear and detailed picture of the distribution of the geologic materials and measurements of hydraulic gradients. The present geologic study has identified several stratigraphic relationships that may have a direct influence on ground water movements. These are summarized in Figure 6.

Briefly, there are three types of hydrostratigraphic problems:

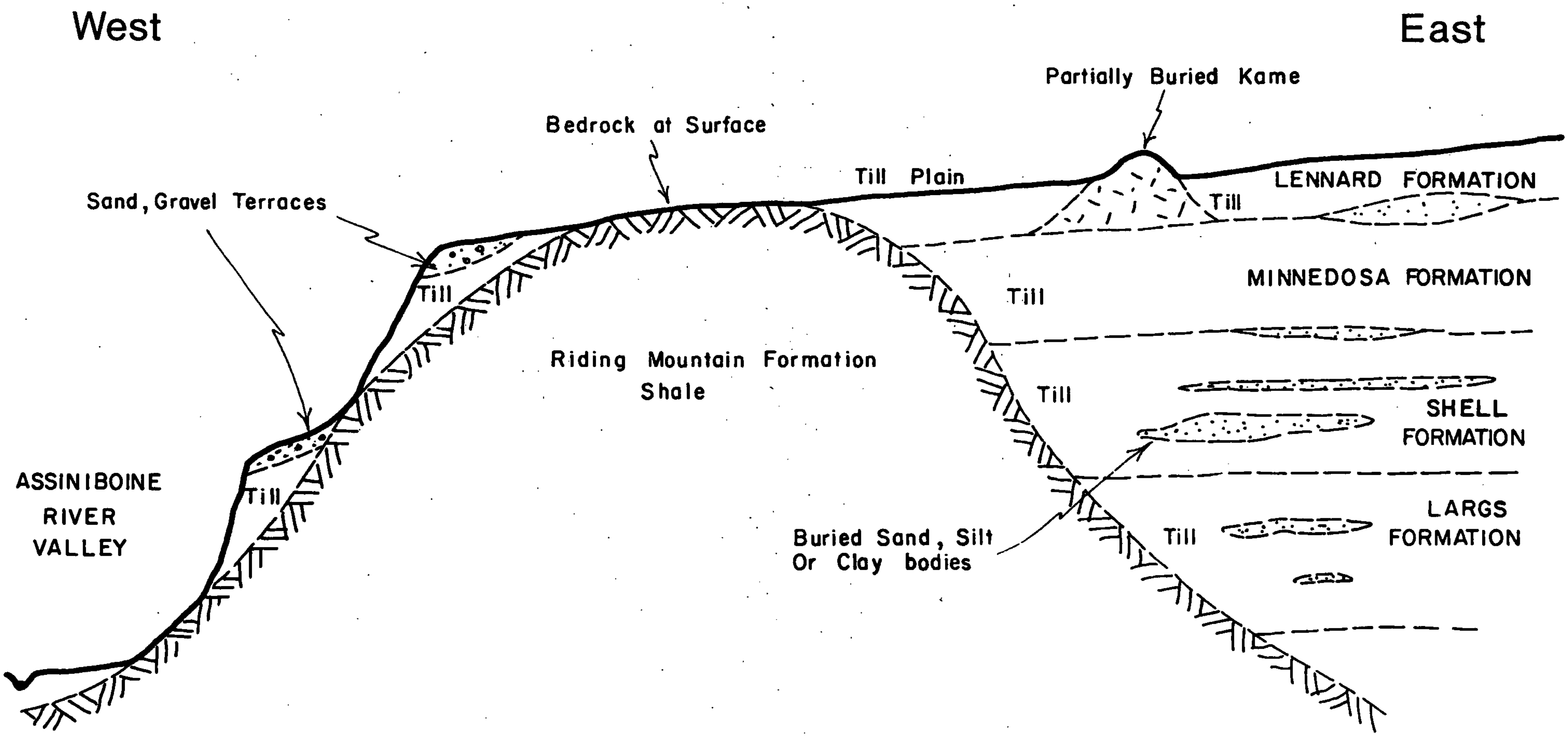


FIGURE 6 **Potential Hydrostratigraphic Influences In The Russell - Shoal Lake Area**

- the presence of surface sand;
- the presence of buried sand;
- the presence of bedrock.

The exact nature of these occurrences has been set out in the preceding geological discussions.

Each of these problems involves the predictability of ground water movements. It is possible to estimate the rate and direction of ground water movement through a uniform body of till under a given set of conditions. If, however, the ground water encounters a more permeable material, such as sand or bedrock, it could move from 10 to 1000 times more quickly, through the same distance and under the same conditions. The occurrence of bedrock or a sand body could also permit movement in a different direction. The accurate identification of these geologic occurrences is a fundamental tool for the prediction of ground water movement.

These hydrogeological theories can be used to draw general conclusions concerning, say, the movement of contaminants through the geological system and the sensitivity of various geological landforms to contaminant movement. In the Russell-Shoal Lake area the outwash and kame moraine landforms are the most susceptible to contaminant movement. The valley slopes and the alluvial materials are also sensitive, while the till plain is less sensitive.

In summary, it is possible to draw some general conclusions about the ground water flow in the area from the surface topography, the physical properties of the material and the geologic stratigraphy. In situ site specific testing would be necessary to demonstrate that this general pattern can be applied to a specific site.

3.0 AGGREGATE RESOURCES:

3.1 DEPOSIT TYPES:

3.1.1 GENERAL:

The aggregate deposits of the Russell-Shoal Lake area can be grouped into three major types: a) outwash; b) kames, eskers and buried materials; and c) kame moraine. The largest of these categories is outwash. It has been further subdivided into outwash plains, fluvial terraces and small channel deposits. The geology of these deposits have been discussed in a previous chapter. The present discussion will focus on the factors which affect the usage of the deposits as aggregate.

The industrial usage assessment (computer print-out - Appendix B) assesses each sample with respect to the requirements for a variety of products. These standards are primarily set by the American Society for Testing and Materials or the Province of Manitoba. "Gravel" is defined by the Mineral Resources Division as material greater than 2 mm.

3.1.2 OUTWASH:

Outwash Plains: Outwash plains are relatively large, flat-surfaced deposits of sand and gravel which are not confined by a well defined river valley. In the study area, these deposits appear to represent the initial proglacial flood of meltwater. They are transitional to the fluvial terraces which are more confined to the river valleys. They are found adjacent to the Qu'Appelle and Assiniboine River Valleys near St. Lazare.

These deposits generally exhibit three main traits: they occupy very large areas, they are relatively thin (commonly less than 10 m), and they are found close to the major river valleys. The eskers associated with these outwash deposits south of St. Lazare exhibit similar granular materials. Many of these deposits are covered with a veneer of wind-blown sand in the study area. The deposits examined in the study area display moderate to high gravel contents and grain size variations are fairly gradual.

Industrial usage analysis indicates that these deposits are suited for usage as traffic gravel, base course, asphaltic aggregate and several specialty uses. Screening and the removal of fines is commonly required, but crushing is not generally necessary.

<u>Fluvial Terraces</u>: There are a large number of fluvial terraces along the creeks and rivers in the study area. The Birdtail Creek has a particularly large number of terraces. The terraces were formed by meltwater, as were the outwash plains, but the water was generally confined to a distinct channel. Deposits are flat but much more restricted in area than outwash plains. They are commonly long narrow deposits on a valley side or present as flat valley bottoms. Thicknesses can vary from a few metres to more than 10 m. As

with other outwash varieties, these deposits are prone to gradual textural changes and usually exhibit moderate to high gravel contents. The esker found on the outwash terrace north of St. Lazare exhibits materials similar to the outwash.

Industrial usage is similar to that of the outwash plain deposits: traffic gravel, base course and asphaltic gravel, and some specialty uses. Screening is generally required, and crushing may be necessary in some of the coarser deposits.

Small Meltwater Channel Deposits: Small channel deposits are scattered throughout the till plain of the study area. These deposits are significantly different from other outwash deposits in that they are very small in area, often only one or two hectares, very thin, often only one or two metres, and are composed mainly of sand. In many cases, these channel deposits indicate a minor surface washing of the till plain by meltwater. The meltwater eroded small channels in the till surface, occasionally depositing a small shallow body of sand. These tiny deposits seldom show on airphotos and are consequently difficult to detect where no pits exist. Several of these deposits achieve a mappable size and are noted near the Town of McAuley. The remainder can be inferred by the presence of the arrow symbol which notes the eroded channels.

These deposits generally contain less than 40% gravel and are marginally suitable for base course and traffic gravel. In most cases these deposits are so small as to warrant usage as fill materials only. However, in aggregate-poor areas they can assume some importance for local supply.

3.1.3 KAMES, ESKERS AND BURIED MATERIALS:

A variety of kame, esker and related materials were noted in the study area, particularly in the three northern municipalities. Included in this grouping are both surface and buried features and occasional granular lenses found within the till. These deposits range from several square km in size down to tiny exposures. As discussed in the previous chapter, a number of these occurrences are known to be capped by till.

These deposits are unpredictable in occurrence and grain size, and often exhibit high fines contents and very variable materials. Buried materials may be difficult to detect and require overburden removal. In general, the eskers in the area, except those directly associated with kame moraines or outwash, are seldom used as aggregate. They contain mainly sand with large amounts of fine material. Selective extraction has been used to take the better material from several kames in the area. Buried or partially buried materials were generally observed to be sandy.

The materials in these deposits tend to be usable as base course or traffic gravel. These deposits are often found in till plain areas and are therefore of some strategic importance, particularly for the gravelling of municipal roads.

3.1.4 KAME MORAINE:

A sizeable kame moraine is present in the northeast corner of the map area. Portions of this feature are considered to be aggregate deposits. In general, the moraine is composed of sand with occasional lenses of gravel, silt and till. The surface topography is hummocky and several bedrock outcrops are present in the moraine area. Several definable kames and eskers, containing coarser materials, are present. These portions of the moraine are considered to be aggregate deposits. It is possible that additional buried gravel bodies may exist elsewhere in the moraine.

The deposit areas within the kame moraine are expected to exhibit characteristics similar to those of the kames described in the previous passage. The materials tend to be variable in grain size and changes may be abrupt. The sites sampled generally contained a high gravel content.

The materials tested indicate that many traffic gravel, base course and some asphaltic specifications can be met. Screening, crushing and/or the addition of finer material may be required, depending on the desired product.

3.2 RESERVES:

Rural Municipality of Russell: The Rural Municipality of Russell contains approximately 122 million cubic metres of granular materials (Table 2).

TABLE 2: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF RUSSELL

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12201	Small Meltwater Channel	90,000
12202	Small Meltwater Channel	102,200
12203	Fluvial Terrace	36,000
12204	Fluvial Terrace	2,739,000
12205	Small Meltwater Channel	21,000
12206	Small Meltwater Channel	14,000
12207	Esker	195,000
12208	Buried	67,500
12209	Kame	325,000
12210	Fluvial Terrace	11,787,000
12211	Fluvial Plain	98,892,000
12212	Buried	168,000
12213	Fluvial Terrace	6,532,500
12214	Fluvial Terrace	502,500
12215	Buried	9,000
12216	Fluvial Terrace	870,000
	TOTAL:	122,350,700

The majority of these materials are contained in deposit 12211. This deposit is large in area but very thin and has a moderate gravel content. Other sizeable reserves are contained in deposits 12210 and 12213. All three deposits are located in the southern portion of the municipality and all are fluvial in origin. One fluvial deposit (12204) is located at the north end of the Municipality but much of this material has been removed. The remaining deposits contain limited reserves. Deposits 12208, 12212 and 12215 are buried beneath a till cover and reserves, though undetermined, are probably limited.

Rural Municipality of Silver Creek: The Rural Municipality of Silver Creek contains approximately 2 million cubic metres of granular materials (Table 3).

Most of this material is present in two kame features (deposits 12217 and 12218) located north of Silverton Station. The remaining deposits are small and all are located in the southwest quadrant of the Municipality. Deposit 12219 is a small esker, deposit 12220 is probably buried by a till cap, and deposits 12221 and 12222 are both small channel deposits. Of these deposits, 12220 and 12221 are capable of supplying traffic and base course products (with processing) but 12219 and 12222 are capable of meeting only a few selected specifications. The two deposits near Silverton Station are capable of producing base course, traffic gravel and some asphaltic products.

TABLE 3: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF SILVER CREEK

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12217	Kame	1,792,000
12218	Kame	204,000
12219	Esker	17,000
12220	Buried	50,000
12221	Small Meltwater Channel	72,000
12222	Small Meltwater Channel	30,000
	TOTAL	2,165,000

Rural Municipality of Rossburn: The Rural Municipality of Rossburn contains a total of approximately 135 million cubic metres of aggregate materials (Table 4). These resources include a variety of geological types and the deposits are relatively evenly spread throughout the Municipality.

The largest grouping of deposits is the sequence of fluvial terraces along the Birdtail Creek. Several large terraces are located in the northern portion of the Municipality (deposit 12228A, B, C) and a series of smaller terraces occur along the river to the south (deposits 12229A, B, 12235A, B, 12237, 12240). These deposits display medium to high gravel contents and are generally suitable for base course, traffic gravel and some asphaltic gravel uses. The coarser deposits are capable of manufacturing a greater number of products.

A similar grouping of fluvial terrace deposits is located along Heron Creek on the eastern edge of the Municipality. These deposits (12231A through F) are somewhat smaller than most of the Birdtail Creek terraces, but maintain a high gravel content and are capable of producing most traffic base course and asphaltic gravel products.

A large kame moraine is located in the northeast corner of the Municipality. Although the moraine is largely composed of sand, small portions exhibit materials of commercial potential. These features are noted as deposits while the remainder of the moraine is not. Samples from these deposits (12224A, B, 12225, 12226) indicate that many base course, traffic and asphaltic gravel specifications can be met but that slightly more processing would be required than for many fluvial terrace materials in the same area.

Deposits 12223, 12233 and 12234 are kames or kame complexes and exhibit a generally sandy composition with considerable variability. Testing indicates that these materials can meet some of the specifications for base course, traffic and asphaltic gravels. These deposits may be useful in reducing haulage costs to certain parts of the Municipality.

Small fluvial deposits comprise deposit numbers 12230 and 12238.

TABLE 4: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF ROSSBURN

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12223	Kame	300,000
12224A	Kame Moraine	127,500
B	Kame Moraine	387,000
12225	Kame Moraine	112,500
12226	Esker	930,000
12227	Small Fluvial Terrace	34,000
12228A	Fluvial Terrace	28,924,000
B	Fluvial Terrace	9,180,000
C	Fluvial Terrace	28,760,000
12229A	Fluvial Terrace	5,107,500
12230	Small Fluvial Terrace	50,000
12231A	Fluvial Terrace	5,506,000
B	Fluvial Terrace	2,716,000
C	Fluvial Terrace	640,000
D	Fluvial Terrace	360,000
E	Fluvial Terrace	620,000
F	Fluvial Terrace	16,252,500
12232	Buried	3,000
12233	Kame	1,272,000
12234	Kame	4,257,500
12235A	Fluvial Terrace	7,144,000
B	Fluvial Terrace	4,480,000
12236	Kame	20,000
12237	Fluvial Terrace	15,112,000
12238	Small Meltwater Channel	30,000
12239	Kame	20,000
12240	Fluvial Terrace	472,500
	TOTAL:	135,360,500

A small Kame is present at 12239 and a lens of gravel within the till was tested at 12232. These four sites all contain very limited volumes of aggregate.

Rural Municipality of Ellice: The present study indicates that approximately 885 million cubic metres of aggregate are present in the Rural Municipality of Ellice (Table 5).

Approximately 95% of the resources are contained in the large outwash plain centered at the confluence of the Qu'Appelle and Assiniboine Rivers (deposits 12244, 12245, 12248 and 12249). Although these deposits are relatively thin, commonly 5 to 10 m, they cover a very large area and consequently contain very large volumes of material. Testing indicates a range of gravel contents from low to high in the various portions of the outwash plain. The various gravel contents are noted on the accompanying maps. It should benoted that a large proportion of deposits 12245 and 12248 are covered by a variable thickness of eolian (wind blown) fine to medium sand. This material reaches more than 10 m in thickness in some portions of the deposit. Areas with greater than 1 m of sand cover are noted as unit 4c on the accompanying surficial geology maps. Testing of samples from various portions of the outwash plain yield somewhat variable results which reflect grainsize variations in the deposit. Most samples would meet specifications for traffic and base course aggregate but some will not meet asphaltic aggregate requirements.

Deposits 12216, 12243 and 12247 are fluvial terrace deposits. These deposits exhibit a similar range in grain

TABLE 5: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF ELLICE

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12211	Outwash Plain	9,160,000
12216	Fluvial Terrace	907,000
12241	Buried	28,500
12242	Kame	17,000
12243A	Fluvial Terrace	3,095,000
B	Fluvial Terrace	475,000
12244A	Outwash Plain	10,845,000
B	Outwash Plain	15,237,500
C	Outwash Plain	4,425,000
12245A	Outwash Plain	329,855,000
B	Outwash Plain	23,360,000
12246	Small Meltwater Channel	18,000
12247A	Fluvial Terrace	6,552,000
B	Fluvial Terrace	2,722,500
12248A	Outwash Plain	242,866,250
B	Outwash Plain	12,205,000
C	Outwash Plain	205,150,000
12249A	Outwash Plain	13,455,000
B	Outwash Plain	4,792,500
	TOTAL:	885,166,750

size and in industrial usage potential. Gravel contents range from low to high. Deposit 12247 has the highest gravel content and greatest usage potential.

Pits were noted in three other small deposits in the area. Deposit 12241 is a till covered deposit with very limited reserves located at the north end of the Municipality near Binscarth. Deposit 12242 is a small shallow, sandy kame deposit in the same area. Deposit 12246 is a small channel deposit located east of St. Lazare. The material in the pit contains a moderate amount of gravel and is capable of producing certain base course, traffic and asphaltic aggregates.

Rural Municipality of Birtle: There are approximately 180 million cubic metres of aggregate resources in the Rural Municipality of Birtle. All of these deposits have outwash plain, fluvial terrace or small meltwater channel origins (Table 6).

The largest single deposit is a portion of deposit 12249B which is located in the southwest corner of the Municipality. Samples indicate a low to moderate gravel content with a somewhat restricted industrial usage potential. The material is capable of producing some base course, traffic and asphaltic gravels with processing.

Most of the remaining resources are located in or adjacent to the Birdtail Creek Valley, which trends from northeast to southwest through the Municipality. Deposit

TABLE 6: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF BIRTLE

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12249B	Outwash Plain	124,590,000
12250	Small Meltwater Channel	16,000
12251A	Outwash Plain	656,250
B	Outwash Plain	457,500
C	Outwash Plain	810,000
D	Outwash Plain	525,000
E	Outwash Plain	573,750
F	Outwash Plain	1,788,000
12252A	Fluvial Terrace	2,075,000
B	Fluvial Terrace	9,580,000
C	Fluvial Terrace	620,000
12253	Fluvial Terrace	1,225,000
12254	Small Meltwater Channel	33,000
12255	Small Meltwater Channel	30,000
12256A	Fluvial Terrace	1,785,000
B	Fluvial Terrace	1,450,000
C	Fluvial Terrace	4,125,000
D	Fluvial Terrace	1,015,000
E	Fluvial Terrace	3,000,000
F	Fluvial Terrace	12,150,000
G	Fluvial Terrace	850,000
H	Fluvial Terrace	2,801,500
12257A	Fluvial Terrace	9,330,000
B	Fluvial Terrace	600,000
12258	Fluvial Terrace	175,000
12259	Small Meltwater Channel	10,000
	TOTAL:	180,271,000

12251 (A through F) includes several thin outwash plain features located on the till plain near the river valley northeast of Birtle. Testing indicates a moderate gravel content. Some portions of the deposit exhibit broad industrial usage potential while others are more restricted.

Fluvial terrace deposits 12252 (A through C), and 12256 (A through H) are spread along the Birdtail Creek Valley in the Municipality. Several of these deposits stretch for several kilometres along the valley. Thicknesses of 7 m or more have been observed indicating that significant resource quantities are present. The terrace materials of deposit 12257A and B are notably thinner (approximately 3 m) than other terrace materials in the valley. Samples from all the terrace deposits indicate a high degree of usage for base course, traffic and asphaltic gravels and other selected uses.

Smaller deposits in Birtle include a thin (2.5 m) fluvial terrace along Snake Creek (12253) and four small meltwater channel deposits (12250, 12254, 12255, 12259). Deposit 12253 has a gravel content and industrial usage similar to the fluvial terraces along the Birdtail Creek. The four small channel deposits are commonly thin (2 to 3 m) and small in area. They commonly contain a much larger proportion of sand and are therefore more restricted in their industrial usage.

<u>Rurual Municipality of Shoal Lake</u>: The Rural Municipality of Shoal Lake is essentially a featureless till plain containing no aggregate deposits. Several small meltwater

channel systems were identified on the till plain surface and several bodies of sand were identified. These sand bodies were extremely small and very thin (approximately 1 m) and do not warrant notation as a commercially viable deposit. They have, however, provided small quantities of fill and sand for local uses.

Rural Municipality of Archie: The Rural Municipality of Archie contains approximately 113 million cubic metres of aggregate resources (Table 7). The majority of this material is contained in outwash plain deposits 12248C, D and E in the northeast corner of the Municipality. Five fluvial terrace deposits (12260A, B, 12261, 12262, 12263 and 12264) are present along creek valleys eroded into the till plain in the vicinity of McAuley.

Deposits 12248C, D and E represent the southern tip of the large outwash plain complex present in the St. Lazare area. There is no road access and no pits were observed in this portion of the deposit. Data from airphoto analysis and other portions of the deposit indicate that the deposit is veneered with a layer of windblown sand and that the deposit may be thinning toward this southern extremity. Sample data from other portions of the deposit indicate some variability in properties but the production of many base course, traffic and asphaltic products are possible with suitable screening and crushing.

The meltwater channels eroded into the till plain which occupies most of the Municipality are somewhat larger and more deeply incised than elsewhere in the study area.

TABLE 7: SUMMARY OF RESERVES

RURAL MUNICIPALITY OF ARCHIE

DEPOSIT NUMBER	LANDFORM TYPE	ESTIMATED RESERVES (m^3)
12248C	Outwash Plain	102,500,000
D	Outwash Plain	5,575,000
E	Outwash Plain	2,575,000
12260A	Fluvial Terrace	144,000
B	Fluvial Terrace	316,000
12261	Fluvial Terrace	394,000
12262	Fluvial Terrace	180,000
12263	Fluvial Terrace	268,500
12264	Fluvial Terrace	1,186,500
	TOTAL:	113,139,000

Several of these channels contain fluvial terraces. They are of sufficient size and thickness (2 to 3 m) to be useful local aggregate sources. Deposits 12260, 12261, 12262 and 12264 contain sufficient gravel to be capable of producing many of the base course, traffic and some asphaltic gravels (with processing). Deposit 12263 is markedly finer grained and meets only a few of these specifications. Samples from the esker in the southern portion of the Municipality indicate extreme variability in quality.

3.3 AGGREGATE DEMAND:

A summary of the annual demand for sand and gravel forms part of the present work. These data are required in order to assess the balance between aggregate supply and demand in each rural municipality. A detailed survey was beyond the scope of this study. Demand estimates are based on:

- recent municipal usage records;
- recent Department of Highways usage records;
- interviews with major gravel producers and consumers.

The quality of this information varies. However, cross-checking between major consumers and producers confirms that the amounts quoted are fair estimates. The general observations on aggregate demand are presented below and an analysis of supply and demand relationships in each individual municipality follows.

Most of the municipalities have an accurate record of the aggregate used on municipal roads in the last five years. An average usage figure for this period was calculated for each municipality. These averages bore a close relationship to the areas of the municipalities and were very consistent from municipality to municipality. The total length of roads present in any one range block (6 mile or 9.7 km square) will vary, but, on average, the municipalities in the study area use slightly less than 1200 m^3 of aggregate per year per range block on road maintenance. The average total annual municipal usage for the entire study area is approximately 56,000 m^3.

The Department of Highways maintains exact consumption figures for all of the municipalities in the study area. The Department used aggregate from Russell, Rossburn, Ellice and Birtle Municipalities between 1978 and 1981. These volumes fluctuate from year to year. An average annual figure was used for each of those four municipalities for the present estimate.

There is very limited data available to document the amount of aggregate consumed for private and commercial purposes in the study area. Two previous aggregate demand studies in this portion of Manitoba, (Underwood McLellan and Associates Limited 1977; Gartner Lee Associates Limited 1978) in nearby agricultural areas, indicate that the combined municipal and Department of Highways consumption accounts for approximately 80 to 85% of the total aggregate consumed. These two studies incorporated a detailed data gathering process and analysis. A total of aggregate consumed in the present map area was determined from the major local construction companies. The data suggest a slightly higher proportion of private and commercial usage. For the purposes of this estimate, the figure of 80% was used.

The three usage factors mentioned above normally account for the entire aggregate consumption in a rural area such as the Russell-Shoal Lake area. This type of consumption figure cannot, however, account for major construction projects. Such projects could have a pronounced effect on aggregate consumption and could use up many years' normal production quotas. The recently proposed potash development by I.M.C. Canada Limited in the St. Lazare area could be such a project.

As of the time of writing, the exact nature, or even the exact placement, of such a facility is not known. No decision has been made as to the size and type of facilities that such a development would entail. This type of decision would have a direct effect on the aggregate demand. Aggregate would be required for the mine construction and the construction of attendant storage, processing and shipping facilities. Aggregate would not be required in the actual mining operation. A large demand for aggregate could be met easily in the St. Lazare area where the large outwash plain is located. Some portions of the Birdtail Creek Valley could also provide large quantities of aggregate. However, in most other parts of the study area it is possible that local reserves would not be sufficient to meet the requirements.

The following paragraphs summarize the supply of aggregate available in each municipality and indicate a normal average consumption rate. A few additional comments are made respecting each municipality's supply and demand relationship.

Rural Municipality of Russell: It is estimated that the Rural Municipality of Russell consumes approximately 10,600 m^3 of aggregate per year. Approximately 7,600 m^3 of this amount is used on municipal roads, 900 m^3 on

Department of Highways projects and the remainder is estimated private and commercial usage.

The resources present in the Rural Municipality of Russell (122 million m^3) can meet this demand for many years. These resources are concentrated in the southern and western portions of the Municipality and a local shortage of aggregate may exist in future in the area around the Town of Russell.

Rural Municipality of Silver Creek: It is estimated that the Rural Municipality of Silver Creek consumes approximately 9,600 m^3 of aggregate per year. Of this amount 7,600 m^3 or 80% is used for municipal roads and the remainder is used for commercial and private purposes.

Resources in the Rural Municipality of Silver Creek are limited (2 million m^3). Deposits are small and commonly of poor quality. It is probable that even these deposits may be depleted of good quality aggregate within the foreseeable future and some aggregates will have to be imported. Sizeable deposits of good quality materials are available in the adjoining Rural Municipality of Rossburn.

Rural Municipality of Rossburn: It is estimated that the Rural Municpality of Rossburn consumes approximately 11,900 m^3 of aggregate a year. Approximately 8,400 m^3 is used by the Municipality and 1,100 m^3 by the Department of Highways. The remainder is used by private and commercial concerns.

The Rural Municipality of Rossburn has a relatively large supply of aggregate (135 million m^3) which is spread through a large portion of the Municipality. Only the southeast corner of the Municipality is devoid of deposits. These reserves will last for many years at present usage rates and it may be possible to export some materials to aggregate-poor areas.

Rural Municipality of Ellice: The Rural Municipality of Ellice consumes approximately 9,600 m^3 of aggregate per year. Approximately 6,100 m^3 is used on municipal roads, 1,600 m^3 is used by Department of Highways and the remainder is used privately.

The Rural Municipality of Ellice contains very large aggregate reserves (885 million m^3) which are fairly well spread throughout the Municipality. The reserves are capable of supporting a major exportation program in addition to supplying local needs for many years.

Rural Municipality of Birtle: The Rural Municipality of Birtle consumes approximately 15,200 m^3 of aggregate per year. The Municipality is estimated to consume 11,000 m^3 and the Department of Highways 1,400 m^3, with the remainder supplying private and commercial requirements.

There are substantial resources in the Rural Municipality of Birtle (180 million m^3). These resources are well spread throughout the Municipality and they are of generally good quality.

Rural Municipality of Shoal Lake: The Rural Municipality of Shoal Lake consumes an estimated 8,600 m^3 of aggregate per year. Approximately 6,900 m^3 of this amount is used on municipal roads and the remainder is used for private or commercial purposes.

The Rural Municipality of Shoal Lake contains no aggregate resources. All sand and gravel must be imported.

Rural Municipality of Archie: The Rural Municipality of Archie consumes an average of 11,000 m^3 per year. Approximately 8,000 m^3 is used by the Municipality and the remainder is the estimated private and commercial consumption.

Reserves in the Rural Municipality of Archie are substantial (113 million m^3) but are of limited quality. These resources are all located in the northern portion of the Municipality; the southern portion is aggregate poor. Substantial additional reserves are located immediately to the north in the Rural Municipality of Ellice.

3.4 SUPPLY-DEMAND SUMMARY:

A summary of total estimated resources and estimated annual demand is presented in Table 8. It is important to note that these figures present a broad regional summary of aggregate supply and demand and should be used with caution. The reserve quantities include all reserves regardless of quality -- the commercially usable reserves may be only a portion of this amount. These numbers also do not account for transportation of materials across municipal boundaries and do not indicate the substantial differences in the supply-demand relationship within an individual municipality.

TABLE 8:

SUMMARY OF SUPPLY AND DEMAND QUANTITIES

MUNICIPALITY	ESTIMATED RESOURCES (m^3)	ESTIMATED ANNUAL DEMAND (m^3)
Russell	122,350,700	10,600
Silver Creek	2,165,000	9,600
Rossburn	135,360,500	11,900
Ellice	885,166,750	9,600
Birtle	180,271,000	15,200
Shoal Lake	----	8,600
Archie	113,139,000	11,000
	1,428,452,950	76,500

The following broad observations can be made using these and other data present in this report.

- The Rural Municipalities of Rossburn, Ellice and Birtle have abundant aggregate resources.
- The Rural Municipalities of Russell and Archie have sufficient resources to meet local demand for the foreseeable future but these resources are not evenly distributed throughout the municipality.
- The Rural Municipality of Silver Creek contains limited quantities of aggregate and much of this material is of low quality.
- The Rural Municipality of Shoal Lake contains no aggregate resources -- all aggregate must be imported.

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APPENDIX A

COMPUTER FORMS

FORM 1

SAND & GRAVEL INVENTORY

DEPOSIT STATUS

DEPOSIT NO: ________ _ SUB

LANDFORM _ (if K specify landform under depcom field)

DEPOSIT COMMENTS ______________________________

OWNERSHIP & RESERVES

LOCATION							OWNERSHIP				
TWP	RNG	SCT	¼ SCT	APPROXIMATE AREA (HA.)	AVERAGE DEPTH (m.)	% DEPLETED NOT AVAILABLE					

MG-9465

Sand and Gravel Inventory

Form 2

Exposure — Stratigraphic Section Data

DEPOSIT NO. SUB

TOWNSHIP RANGE SECTION 1/4 SECTION

EXPOSURE NO.

EXPOSURE TYPE

EXP. LAND USE

SUR. LAND USE

THICKNESS OF ECONOMIC UNIT (m.)

ESTIMATED GRAVEL CONTENT

Y M D
DATE EXAMINED

MATERIAL DESCRIPTION

COMMENTS

STRATIGRAPHIC SECTION

GEOLOGIST

HEIGHT OF SECTION

HEIGHT EXAMINED

DEPTH TO WATER TABLE (m.)

MATERIAL AT BASE OF SECTION

% LITHOLOGY (PRIMARY) % LITHOLOGY (SECONDARY) — GROSS LITHOLOGY

PRIMARY SECONDARY — DELETERIOUS SUBSTANCES

CHANNEL SAMPLE (Y, N)

CHECK
MATERIAL LARGER THAN 15CM AVAILABLE BUT NOT SAMPLED

STRATIGRAPHIC SECTION

GEOLOGIST

HEIGHT OF SECTION

HEIGHT EXAMINED

DEPTH TO WATER TABLE (m.)

MATERIAL AT BASE OF SECTION

% LITHOLOGY (PRIMARY) % LITHOLOGY (SECONDARY) — GROSS LITHOLOGY

PRIMARY SECONDARY — DELETERIOUS SUBSTANCES

CHANNEL SAMPLE (Y, N)

CHECK
MATERIAL LARGER THAN 15CM AVAILABLE BUT NOT SAMPLED

SAND AND GRAVEL INVENTORY

FORM 3

QUATERNARY GEOLOGY (SUB-UNIT DATA)

DEPOSIT	SUB	TOWNSHIP	RANGE	SECTION	1/4 SECTION	EXPOSURE	STRAT. SECTION

	TOP (m.)	BOTTOM (m.)	DELETERIOUS SUBSTANCES	LITHO-MORPHOLOGY				COHESION	ACID REACTION (N,W,S)	SEDIMENT TYPE	SEDIMENTARY STRUCTURE	NATURE OF DEPOSITIONAL INTERFACE	POST-DEPOSITIONAL STRUCTURE/WEATHERING	PALEOFLOW DIRECTION	DIP		NO. OF STRAT. SAMPLES
				%	LITHOLOGY	ROUNDNESS	CLAST SHAPE								DEGREES	DIRECTION	
1.																	
2.																	
3.																	
4.																	
5.																	
6.																	
7.																	
8.																	
9.																	
10.																	

MG-3024

APPENDIX B

EXAMPLE OF COMPUTER PRINT OUT

SAMPLE IDENTIFICATION 012204 02129W34SE08520A 1

AVAILABILITY OF CRUSHABLE MATERIAL ON SITE - NONE

WEIGHT OF SAND 3081.70 GMS. WASHED SAMPLE - WEIGHT BEFORE 1061.00 AFTER 1051.10 % LOSS 0.93

SIEVE SIZE	FINE FRACTION (GMS.)	SIEVE WEIGHTS (GMS.)	PERCENT	PERCENT PASSING	PERCENT RETAINED
4 IN		0.0	0.0	100.00	0.0
3 1/2 IN		0.0	0.0	100.00	0.0
3 IN		0.0	0.0	100.00	0.0
2 1/2 IN		0.0	0.0	100.00	0.0
2 IN		0.0	0.0	100.00	0.0
1 1/2 IN		114.20	3.36	96.64	3.36
1 IN		112.90	3.32	93.32	6.68
3/4 IN		89.40	2.63	90.69	9.31
5/8 IN	0.0	0.0	0.0	90.69	9.31
1/2 IN	8.40	24.40	0.72	89.97	10.03
3/8 IN	53.20	154.52	4.55	85.42	14.58
1/4 IN	91.90	266.93	7.85	77.57	22.43
# 4	90.40	262.57	7.73	69.84	30.16
# 8	199.80	580.32	17.08	52.76	47.24
# 10	41.30	119.96	3.53	49.23	50.77
# 16	154.80	449.62	13.23	36.00	64.00
# 30	324.30	941.94	27.72	8.28	91.72
# 40	43.40	126.06	3.71	4.57	95.43
# 50	22.50	65.35	1.92	2.65	97.35
# 80	15.40	44.73	1.32	1.33	98.67
# 100	1.50	4.36	0.13	1.21	98.79
# 200	0.0	0.0	0.0	1.21	98.79
<200 + W	14.10	40.95	1.21	0.0	100.00
TOTALS	1061.00	3398.20			

SPLITTING FACTOR 2.90

FINENESS MODULUS 4.57

% COBBLES 0.0 % PEBBLES 30.16 % GRANULES 20.61 % SAND 48.03 % SILT/CLAY 1.21

* NOTE - SUITABILITY OF SAMPLE IS BASED ONLY ON GRADING SPECIFICATIONS *

INDUSTRIAL USE	TOTAL RESIDUAL	RATING	SCREENING REQUIRED	REMOVAL OF <#200 MATERIAL	CRUSHING REQUIRED MATERIAL ON SITE	CRUSHING REQUIRED MATERIAL NOT ON SITE	ADDITION OF FINES (MATERIAL <#4)
ASPHALT A (P. OF M.)	21.84	MARGINAL	YES	YES	YES		
ASPHALT B (P. OF M.)	7.64	MARGINAL	YES	YES	YES		
ASPHALT C (P. OF M.)	67.16	NOT SUIT					
BASE COURSE A (P. OF M.)	23.64	MARGINAL	YES	YES	YES		
BASE COURSE B (P. OF M.)	13.02	MARGINAL	YES	YES			
BASE COURSE C (P. OF M.)	2.79	MARGINAL		YES			
SUB-BASE/BASE COURSE A (ASTM D1241)	48.71	NOT SUIT					
SUB-BASE/BASE COURSE B (ASTM D1241)	38.71	NOT SUIT					
SUB-BASE/BASE/SURFACE COURSE C (ASTM D1241)	32.95	NOT SUIT					
SUB-BASE/BASE/SURFACE COURSE D (ASTM D1241)	24.81	MARGINAL	YES	YES			
SUB-BASE/BASE/SURFACE COURSE E (ASTM D1241)	19.81	MARGINAL	YES	YES			
SUB-BASE/BASE/SURFACE COURSE F (ASTM D1241)	34.05	NOT SUIT					
TRAFFIC GRAVEL A (P. OF M.)	47.14	NOT SUIT					
TRAFFIC GRAVEL B (P. OF M.)	27.85	MARGINAL	YES	YES	YES		
TRAFFIC GRAVEL C (P. OF M.)	16.35	MARGINAL	YES		YES		
TRAFFIC GRAVEL D (P. OF M.)	6.35	MARGINAL	YES		YES		
SEAL COAT A (P. OF M.)	79.39	NOT SUIT					
SEAL COAT B (P. OF M.)	7.63	MARGINAL	YES		YES		
SEAL COAT C (P. OF M.)	0.0	SUITABLE	YES				
COARSE AGGREGATE 1 (ASTM C33,D448)	207.53	NOT SUIT					
COARSE AGGREGATE 2 (ASTM C33,D448)	197.53	NOT SUIT					
COARSE AGGREGATE 24 (ASTM C33,D448)	202.50	NOT SUIT					
COARSE AGGREGATE 3 (ASTM C33,D448)	190.13	NOT SUIT					
COARSE AGGREGATE 357 (ASTM C33,D448)	148.33	NOT SUIT					
COARSE AGGREGATE 4 (ASTM C33,D448)	194.63	NOT SUIT					
COARSE AGGREGATE 467 (ASTM C33,D448)	141.15	NOT SUIT					
COARSE AGGREGATE 5 (ASTM C33,D448)	205.58	NOT SUIT					
COARSE AGGREGATE 56 (ASTM C33,D448)	217.84	NOT SUIT					
COARSE AGGREGATE 57 (ASTM C33,D448)	145.21	NOT SUIT					
COARSE AGGREGATE 6 (ASTM C33,D448)	188.08	NOT SUIT					
COARSE AGGREGATE 67 (ASTM C33,D448)	153.21	NOT SUIT					
COARSE AGGREGATE 68 (ASTM C33,D448)	156.79	NOT SUIT					
COARSE AGGREGATE 7 (ASTM C33,D448)	134.72	NOT SUIT					
COARSE AGGREGATE 78 (ASTM C33,D448)	154.41	NOT SUIT					
COARSE AGGREGATE 8 (ASTM C33,D448)	131.63	NOT SUIT					
COARSE AGGREGATE 89 (ASTM C33,D448)	81.63	NOT SUIT					
COARSE AGGREGATE 9 (ASTM C33,D448)	57.50	NOT SUIT					
COARSE AGGREGATE 10 (ASTM C33,D448)	12.24	MARGINAL	YES				YES
FINE CONCRETE AGGREGATE (P. OF M.)	22.99	MARGINAL	YES				
FINE CONCRETE AGGREGATE I (ASTM C33, C404)	62.12	NOT SUIT					
FINE CONCRETE AGGREGATE II (ASTM C33, C404)	62.53	NOT SUIT					
MORTAR (ASTM C144)	19.45	MARGINAL	YES				
PORTLAND CEMENT (P.C.A.)	37.12	NOT SUIT					
BUILT-UP ROOFS (ASTM D1863)	140.22	NOT SUIT					
AIRFIELD RUNWAYS (P. OF M.)	10.60	MARGINAL	YES		YES		
PIT RUN (P. OF M.)	0.0	SUITABLE	YES				
SEPTIC FIELDS (U.H.A.)	23.64	MARGINAL	YES		YES		
SHOULDERS (P. OF M.)	0.0	SUITABLE					

```
*************    DEPOSIT  NUMBER  012204      LANDFORM  -  OUTWASH TERRACE      OUTWASH TERRACE

021 29W 26 NW    RESERVES      20,000 CU.M.    AMOUNT DEPLETED/NOT AVAILABLE          0 CU.M.
            OWNERSHIP  PRIVATE

021 29W 35 SW    RESERVES     140,000 CU.M.    AMOUNT DEPLETED/NOT AVAILABLE          0 CU.M.
            OWNERSHIP  PRIVATE

021 29W 27 NE    RESERVES     147,000 CU.M.    AMOUNT DEPLETED/NOT AVAILABLE     63,000 CU.M.
            OWNERSHIP  PRIVATE

021 29W 34 NE    RESERVES   1,440,000 CU.M.    AMOUNT DEPLETED/NOT AVAILABLE          0 CU.M.
            OWNERSHIP  PRIVATE

         EXPOSURE  G 011   ROAD CUT/DITCH SECTION    ECON.THICKNESS 1.5 M.   GRAVEL CONTENT LOW           FIRST VISIT 82/08
                  MATERIAL  PEBBLY DIRTY MEDIUM SAND                                                   LAST VISIT  82/08
                  EXP.LAND USE  HIGHWAY, ROADWAY, RAILWAY        SUR.LAND USE  AGRICULTURE

            SECTION  A   GEOLOGIST AC    HT. EXAMINED 1.5  M.   HT. OF FACE 1.5  M.   DEPTH TO WATER TABLE       M.
                  BASE  SAND                  NO CHANNEL SAMPLE TAKEN

 DESCRIPTION OF  G 011  SECTION A

 0.00   1.50  M.  SEDIMENT TYPE  COARSE SAND                                  SAMPLES      COHESION  FRIABLE
               SEDIMENTARY STRUCTURE  MASSIVE

021 29W 34 SE    RESERVES     672,000 CU.M.    AMOUNT DEPLETED/NOT AVAILABLE    288,000 CU.M.
            OWNERSHIP  PRIVATE

         EXPOSURE  G 520   SAND AND GRAVEL PIT      ECON.THICKNESS 3.0 M.   GRAVEL CONTENT MEDIUM        FIRST VISIT 82/08
                  MATERIAL  GRAVELLY FINE TO COARSE SAND                                               LAST VISIT  82/08
                  EXP.LAND USE  ACTIVE PIT                          SUR.LAND USE  AGRICULTURE

            SECTION  A   GEOLOGIST BH    HT. EXAMINED 1.6  M.   HT. OF FACE 3.0  M.   DEPTH TO WATER TABLE       M.
                  LITHOLOGY  75%  PRECAMBRIAN CRYSTALLINES    25%  GENERAL CARBONATES
                  DELETERIOUS SUBSTANCES SHALE                   IRON OXIDE INCRUSTATIONS
                  BASE  SAND                 CHANNEL SAMPLE TAKEN

                     SAMPLE  RATING 4     COBBLES 0.0   %  PEBBLES 30.16 %  GRANULES 20.61 %  SAND 48.03 %  SILT/CLAY 1.21  %

 DESCRIPTION OF  G 520  SECTION A

 0.00   0.20  M.  SEDIMENT TYPE  SOIL                                         SAMPLES
               DELETERIOUS SUBSTANCES  ORGANIC CONTENT

 0.20   1.60  M.  SEDIMENT TYPE  FINE PEBBLES      VERY COARSE SAND   SAMPLES  1   COHESION  FRIABLE
               LITH-MORPHOLOGY (PRIMARY)     75%  PRECAMBRIAN CRYSTALLINES  SUB-ROUNDED TO ANGULAR      COMPACT ELONGATED
```

(SECONDARY) 25% GENERAL CARBONATES SUB-ROUNDED TO SUB-ANGULAR COMPACT ELONGATED
DELETERIOUS SUBSTANCES IRON OXIDE INCRUSTATIONS SHALE
SEDIMENTARY STRUCTURE MASSIVE
DEPOSITIONAL INTERFACE GRADATIONAL POST DEPOSITIONAL CHANGES WEAK OXIDATION

SECTION B GEOLOGIST BB HT. EXAMINED 1.0 M. HT. OF FACE 1.0 M. DEPTH TO WATER TABLE M.
BASE SAND

021 29W 35 NW RESERVES 320.000 CU.M. AMOUNT DEPLETED/NOT AVAILABLE 0 CU.M.
OWNERSHIP PRIVATE

EXPOSURE G 010 ROAD CUT/DITCH SECTION ECON.THICKNESS 2.0 M. GRAVEL CONTENT LOW FIRST VISIT 82/08
MATERIAL PEBBLY COARSE SAND LAST VISIT 82/08
EXP.LAND USE HIGHWAY, ROADWAY, RAILWAY SUR.LAND USE AGRICULTURE

SECTION A GEOLOGIST AC HT. EXAMINED 2.0 M. HT. OF FACE 2.0 M. DEPTH TO WATER TABLE M.
BASE SAND NO CHANNEL SAMPLE TAKEN

DESCRIPTION OF G 010 SECTION A

0.00 2.00 M. SEDIMENT TYPE COARSE SAND SAMPLES COHESION FRIABLE
SEDIMENTARY STRUCTURE MASSIVE

************** TOTAL DEPOSIT RESERVES 2.739.000 (CU.M.)

APPENDIX C

SUMMARY OF DEPOSIT DATA

SUMMARY OF COMPUTER PRINT OUT DATA

GRAVEL - >2 MM
SAND - 2 MM-0.0074 MM
SILT/CLAY - <0.0074 MM

LITHOLOGY - C - CARBONATES
- S - OTHER SEDIMENTS
- X - CRYSTALLINE

GRAVEL CONTENT:

H - >80% GRAVEL
MH - 60-80% GRAVEL
M - 40-60% GRAVEL
ML - 20-40% GRAVEL
L - <20% GRAVEL

DEPOSIT NUMBER	EXPOSURE NUMBER	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT/CLAY	GRAVEL CONTENT	LITHOLOGY	RESERVES (cubic metres)
12201	G526	46.48	51.65	1.86	M	60X 40C	90,000
12202	G152	63.86	33.78	2.37	M.H.	80X 20C	102,200
	G153	68.14	29.15	2.71	M.H.	70X 30C	
12203	G154	71.57	27.11	1.32	M	75X 25C	36,000
12204	G520	50.77	48.03	1.21	M	75X 25C	2,739,000
12205	G151	56.17	39.70	4.12	M	60C 40X	21,000
12206	G533	81.95	14.53	3.52	H	80X 20C	14,000
12207	G150	66.24	24.62	9.15	M.H.	60C 15P	195,000
12208	G002	28.58	5.90	65.57	M.L.	50C 30S	67,500
12209	G031	-	-	-	M.L.	60C 30X	325,000
12210	G165	66.92	27.36	5.72	M.H.	70X 20C	11,787,000
	G167	40.92	57.15	1.94	M	70X 30C	
	G166	79.16	19.08	1.76	M.H.	70X 30C	
12211	G099	-	-	-	H	70P 25C	108,052,000
12212	G174	70.60	28.60	0.79	M.H.	70X 15C	168,000
12213	G171	77.46	17.83	4.70	M.H.	60X 40C	6,532,500
	G172	31.33	60.24	8.84	M.L.	70X 30C	
12214	G173	73.43	23.00	3.57	M.H.	60X 20C	502,500
12215	G560	65.57	32.86	1.57	M.H.	60X 35S	9,000
12216	G168	37.30	58.03	4.66	M.L.	75X 25C	1,777,500

DEPOSIT NUMBER	EXPOSURE NUMBER	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT/CLAY	GRAVEL CONTENT	LITHOLOGY	RESERVES (cubic metres)
12217	G155	52.04	42.64	5.32	M	60C 40X	1,792,000
12218	G156	40.56	52.01	7.43	M	50X 50C	204,000
12219	G061	10.02	72.29	17.69	L	50X 50C	17,000
12220	G063	52.84	44.46	2.70	M	70C 30X	50,000
12221	G176	53.87	43.06	3.07	M	70X 30S	72,000
12222	G175	10.13	77.44	12.43	L	65S 35X	30,000
12223	G096	60.28	34.82	4.91	M.H.	60C 20X	300,000
12224A	G157	81.93	10.06	8.01	H	50X 25C	127,500
12224B	G161	69.34	28.28	2.38	M.H.	55C 20X	387,000
12225	G163	86.23	12.41	1.36	H	55X 40C	112,500
12226	G164	57.54	40.24	2.22	M	45X 25C	930,000
12227	G162	71.72	23.05	5.23	M.H.	60C 25S	34,000
12228A	G159	71.10	20.42	8.48	M.H.	70X 30C	28,924,000
	G160	59.61	38.81	1.59	M	45X 30C	
	G621	70.56	25.04	4.40	M.H.	80X	
12228B							9,180,000
12228C							28,760,000
12229A	G620	54.89	42.68	2.43	M	90X	5,107,500
	G619	71.78	25.67	2.55	M.H.	90X	
12229B							2,542,500
12230	G618	25.43	70.08	4.49	M.L.	100X	50,000
12231A	G204	68.61	29.41	1.98	M.H.	80X 20S	5,506,000
12231B	G203	53.85	23.24	2.91	M	75X 20S	2,716,000

DEPOSIT NUMBER	EXPOSURE NUMBER	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT/CLAY	GRAVEL CONTENT	LITHOLOGY	RESERVES (cubic metres)
12231C	-	-	-	-	-	-	640,000
12231D	-	-	-	-	-	-	360,000
12231E	-	-	-	-	-	-	620,000
12231F	G595	76.28	18.78	4.94	M.H.	80X 20S	16,252,500
	G592	68.30	29.60	2.10	M.H.	75X 20C	
	G202	76.44	18.45	5.11	M.H.	60X 20S 20S	
12232	G591	61.19	36.45	2.36	M.H.	70X 20S	3,000
12233	G205	52.98	42.51	4.51	M	80X 20S	1,272,000
	G206	25.70	59.45	14.86	M.L.		
12234	G579	40.44	55.94	3.63	M	60X 40S	4,257,500
12235A	G617	71.42	24.88	3.70	M.H.	90X	7,144,000
12235B	-	-	-	-	-	-	4,480,000
12236	G572	38.14	58.16	3.70	M.L.	70X 20C	20,000
12237	G615	52.13	43.86	4.01	M	60X 20C	15,112,000
	G616	36.05	53.32	10.63	M.L.	60X 20C	
12238	G622	43.39	52.71	3.90	M	60X 20C	30,000
12239	G623				L	60X 20C	20,000
12240	G614	46.87	48.08	5.05	M	80X 10S	472,500
12241	G181	32.26	64.57	3.16	M.L.	60X 40S	28,500
12242	G180	24.63	65.62	9.76	M.L.	60X 20C	17,000
12243A	G169	59.14	39.12	1.74	M	60X 40C	3,095,000
12243B	-	-	-	-	-	-	475,000
12244A	G170	75.70	22.55	1.75	M.H.	70X 25C	10,845,000

DEPOSIT NUMBER	EXPOSURE NUMBER	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT/CLAY	GRAVEL CONTENT	LITHOLOGY	RESERVES (cubic metres)
12244B	-	-	-	-	-	-	15,237,500
12244C	-	-	-	-	-	-	4,425,000
12245A	G195	4.77	94.15	1.09	L	-	329,855,000
	G196	74.77	23.11	2.11	M.H.	75X 25C	
	G197				L		
12245B	-	-	-	-	-	-	23,360,000
12246	G194	44.04	50.32	5.64	M	75X 20C	18,000
12247A	G198	90.65	7.11	2.24	H	80X 10C	6,552,000
	G199	53.12	45.67	1.22	M	75X 15C	
12247B	-	-	-	-	-	-	2,722,500
12248A	G608	77.88	20.90	1.23	M.H.	60X 20S	242,866,250
	G200	-	99.32	0.68	L		
12248B	G609	12.49	87.04	0.46	L	60X 40S	12,205,000
12248C	-	-	-	-	-	-	307,650,000
12248D	-	-	-	-	-	-	5,575,000
12248E	-	-	-	-	-	-	2,575,000
12249A	-	-	-	-	-	-	13,455,000
12249B	G201	56.52	41.80	1.69	M	60X 40C	129,382,500
	G611	13.49	85.40	1.11	L		
	G612	35.80	60.81	3.39	M.L.	50X 50C	
12250	G177	30.70	58.87	10.43	M.L.	70S 30C	16,000
12251A	-	-	-	-	-	-	656,250
12251B	-	-	-	-	-	-	457,500
12251C	-	-	-	-	-	-	810,000
12251D	-	-	-	-	-	-	525,000
12251E	G578	10.20	83.47	6.33	L	-	573,750
12251F	G577	47.80	46.31	5.88	M	70X 20C	1,788,000

DEPOSIT NUMBER	EXPOSURE NUMBER	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT/CLAY	GRAVEL CONTENT	LITHOLOGY	RESERVES (cubic metres)
12252A	G575	72.51	20.55	6.93	M.H.	80X	2,075,000
12252B	G574	60.50	34.46	5.05	M.H.	90X	9,580,000
12252C	-	-	-	-	-	-	620,000
12253	G178	69.92	26.21	3.87	M.H.	50X 25S	1,225,000
12254	G189	46.06	52.30	1.64	M	60X 20S	33,000
12255	G192	69.11	28.80	2.09	M.H.	80X 20S	30,000 (Typo on computer)
12256A	G613	65.32	32.56	2.12	M.H.	60X 30S	1,735,000
12256B	-	-	-	-	-	-	1,450,000
12256C	-	-	-	-	-	-	4,125,000
12256D	-	-	-	-	-	-	1,015,000
12256E	-	-	-	-	-	-	3,000,000
12256F	G183	89.43	9.01	1.55	H	70X 25S	12,150,000
12256G	-	-	-	-	-	-	850,000
12256H	G088	81.06	14.73	4.27	H	70X 20S	2,801,500
12257A	G182	69.85	25.52	4.63	M.H.	60X 20S	9,330,000
12257B	-	-	-	-	-	-	600,000
12258	G193	77.21	19.97	2.82	M.H.	80X 20S	175,000
12259	G605	28.52	66.03	5.46	M.L.	70X 20C	10,000
12260A	-	-	-	-	-	-	144,000
12260B	G566	46.83	51.03	2.14	M	60X 40S	316,000
12261	G187	50.32	47.37	2.31	M	60X 15G	394,000
12262	G186	82.17	15.33	2.50	H	50X 20S	180,000
12263	G562	0.79	83.46	15.75	L		268,500
12264	G565	47.21	46.26	6.53	M	70X 30C	1,186,500