Aggregate Report AR86-3

Aggregate Resources and Surficial Geology of the Rural Municipality of Roblin

By M.A. Mihychuk and P. Berk

Manitoba
Energy and Mines
Mines Branch

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ABSTRACT

A sand and gravel inventory of the R.M. of Roblin was carried out to delineate deposits, determine their quality and quantity and to provide information for resource management and land use planning.

Late Quaternary surficial geological units include till plain, lineated in the north half of the area and hummocky in the south. The till plain is dissected by meltwater channels which contain thin, isolated sand and gravel deposits. Eskers, an important source of aggregate, are generally found within the meltwater channels. Postglacial fluvial deposits in the form of terraces are located along Badger Creek.

Aggregate quality is poor, due to high shale content and the lack of coarse stone. Most deposits are relatively shallow ranging from 1 to 2 metres. There are 6 active pits in the area; the most productive is located in section 32, Township 3, Range 13 west.

Total reserves in the municipality are estimated to be 5 755 000 cubic metres; 45 per cent of these are low quality. Annual total demand is estimated at 28 800 cubic metres of aggregate, of which approximately 4600 cubic metres is imported to meet the needs for high specification end uses such as seal coat, bituminous pavement and asphalt. The municipality uses over 18 000 cubic metres annually for road maintenance. The amount of aggregate used is expected to increase with the depletion of the better quality reserves as the higher quality resources generally have less shale content and a consequent higher resistance to erosion. Sufficient low quality reserves are available to supply local road maintenance for the foreseeable future.

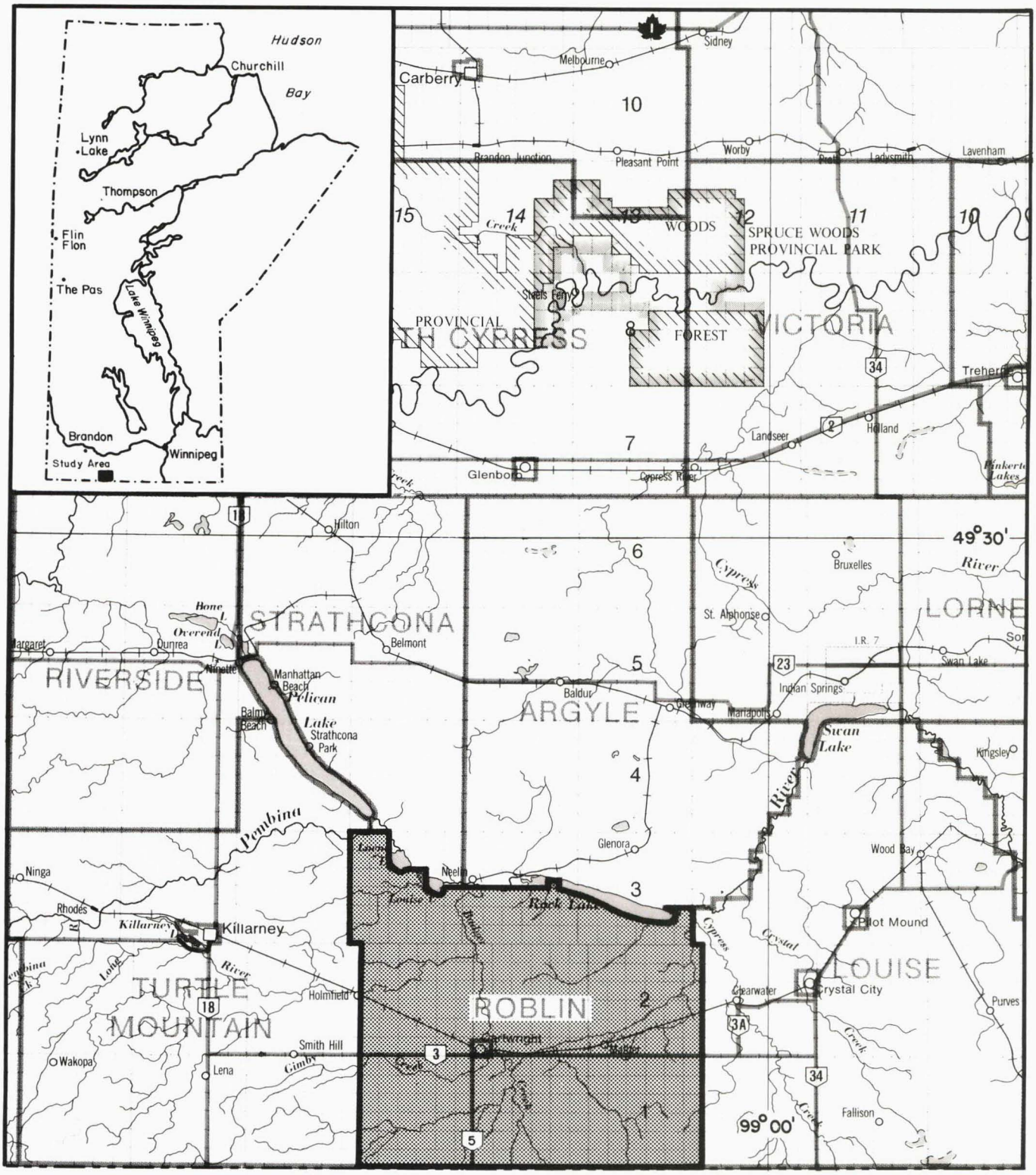

Figure 1: Location of the R.M. of Roblin.

INTRODUCTION

LOCATION AND PHYSIOGRAPHY

The R.M. of Roblin comprises 697 km^2 in southwestern Manitoba and encompasses Ranges 13 to 15 WPM, Townships 1, 2 and part of 3 (Fig. 1). The two townsites in the area are Cartwright and Mather. Provincial Trunk Highways 5 and 3 intersect at Cartwright. A network of gravelled section roads and paved roads provides good access throughout the municipality.

The municipality lies on the second prairie level of the Canadian Plains west of the Manitoba Escarpment, within the Boissevain Plain, and is bounded to the north by the Pembina Trench and to the south by the Canada/U.S.A. border. There is a gentle northeast slope away from the highest elevation at 492 m a.s.l in the southwest toward the Turtle Mountain upland. Elevation decreases northeastward toward the Pembina Trench to 455 m a.s.l.

The topography varies from flat outwash plains to undulating till plain and distinctly rolling corrugated moraine. The till ridges of the corrugated moraine range from 6 to 20 m in height. Eskers are scattered throughout the area, some reaching heights of 20 m. Drainage between ridges is poor and sloughs have formed. Major drainage channels are Badger Creek, flowing north toward Pembina River, and Long River and Gimby Creek, flowing eastward into Badger Creek. The valley of Long River continues from Badger Creek northeastward to the east end of Rock Lake. The Long River channel was once a glacial spillway.

APPROACH AND SCOPE

In the summers of 1985 and 1987 an aggregate inventory was undertaken to evaluate the sand and gravel resources of the R.M. of Roblin. The objectives of the study were to delineate sand and gravel deposits, estimate the quantity and quality of reserves, and provide aggregate information to be included in the background study of the Roblin-Cartwright Planning District.

Initially, existing surficial geology maps by Conley (1986) at a scale of 1:100 000 and Elson (1955) at a scale of 1:253 440, as well as aerial photographs at a scale of 1:50 000, were used to delineate existing gravel pits and potential gravel sources. Ditch sections, existing pits, backhoe test pits and hand-dug holes were examined and samples of granular material collected. Locations of sample sites are shown on Map AR86-3 (in pocket).

Thickness of deposits and material removed were noted during field examination. The area of each deposit was determined using aerial photographs. Reserve estimates were calculated using three variables: extent, depth and amount of depletion.

A sieve analysis of each sample was performed to determine particle size gradation (Appendix C) between 0.074 mm (#200 mesh screen) and 101.6 mm (4" screen). All material greater than 4.76 mm and less than 64 mm constitutes gravel. All material less than 4.76 mm and greater than 0.06 mm constitutes sand. Particles greater than 15 cm were recorded as crushable material. Quality is defined primarily on gravel content and weight per cent shale. Pebble counts of approximately 300 pebbles were carried out for the 5/8"-#4 (15.9 - 4.76 mm) sieve fraction.

All data are stored on computer disc and are available through the Aggregate Resources Section.

PREVIOUS STUDIES

Maps of the surficial geology of southwestern Manitoba are included in Elson (1955) and Conley (1986). A detailed study of the surficial geology and Pleistocene history of the Tiger Hills area, including the R.M. of Roblin, is described by Elson (1955). The underlying bedrock is described by Bannatyne (1970).

ACKNOWLEDGEMENTS

We would like to thank our summer assistants, especially Kim Proctor, for their assistance with the field work. The staff in the Aggregate Resources Section and Barry Bannatyne who critically read the manuscript. Additionally, we would like to thank Manny Carvalho for drafting the maps and figures, and Shirley Weselak for the word processing.

GEOLOGY

BEDROCK GEOLOGY

The R.M. of Roblin is underlain by Upper Cretaceous shales of the Riding Mountain Formation (Bannatyne, 1970). The hard siliceous shale of the Odanah Member is the uppermost unit and outcrops along Pembina River valley (Pembina Trench) and several of its minor tributaries as shown on Map AR86-3. The shale is (1) massive and blocky with purple or iron stained joints or (2) thin and fissile and easily broken into fragments.

QUATERNARY GEOLOGY

Drift thickness

Drift thickness was compiled (Fig. 2) from Water Well Drillers reports (Water Resources, 1975-84). The drift is thickest in a zone extending from Pembina River valley, in Tp. 3, Rge. 13W, southwest through the centre of the study area. This zone is considered to be a buried preglacial valley. Elson (1955) records a drift thickness anomaly which he observed at Pembina Valley and which he interprets as an indication of a pregla-

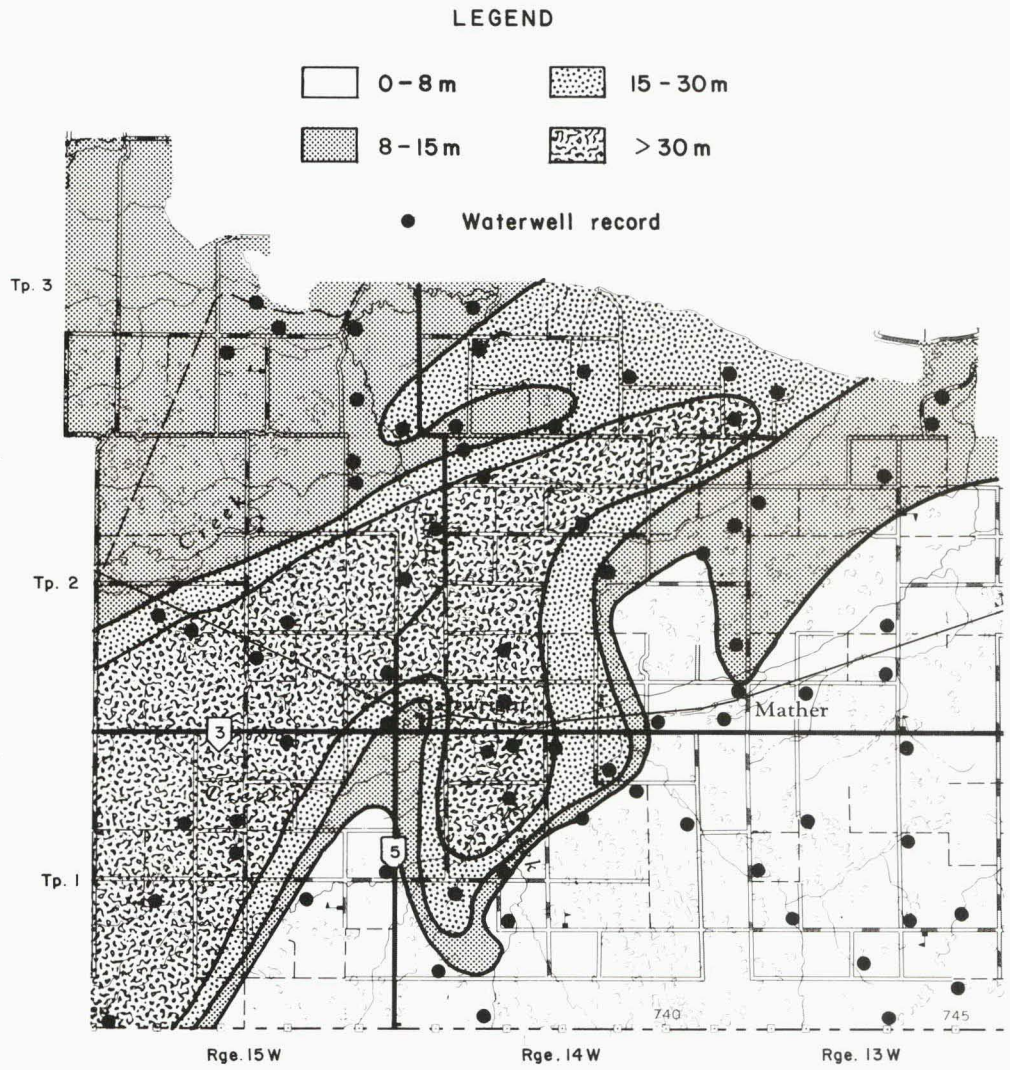

Figure 2: Drift thickness map of the R.M. of Roblin.

cial valley. Klassen (1969) has identified a buried valley oriented north-south through the centre of the study area. In this report, Klassen's valley is considered to be a tributary to a major northeast-trending valley that intersects Pembina Valley at the location cited by Elson (Fig. 2). Drift thicknesses of more than 56 m were recorded in the west part of the main buried preglacial valley. West of the buried valley drift thickness is less than 15 m; to the east, drift averages less than 5 m.

Surficial deposits

The surficial geology of the R.M. of Roblin is delineated on Map AR86-3 (in pocket) and generalized in Figure 3.

Till: (unit 1)

A till plain covers most of the southern half of the municipality, except where it is overlain by outwash.

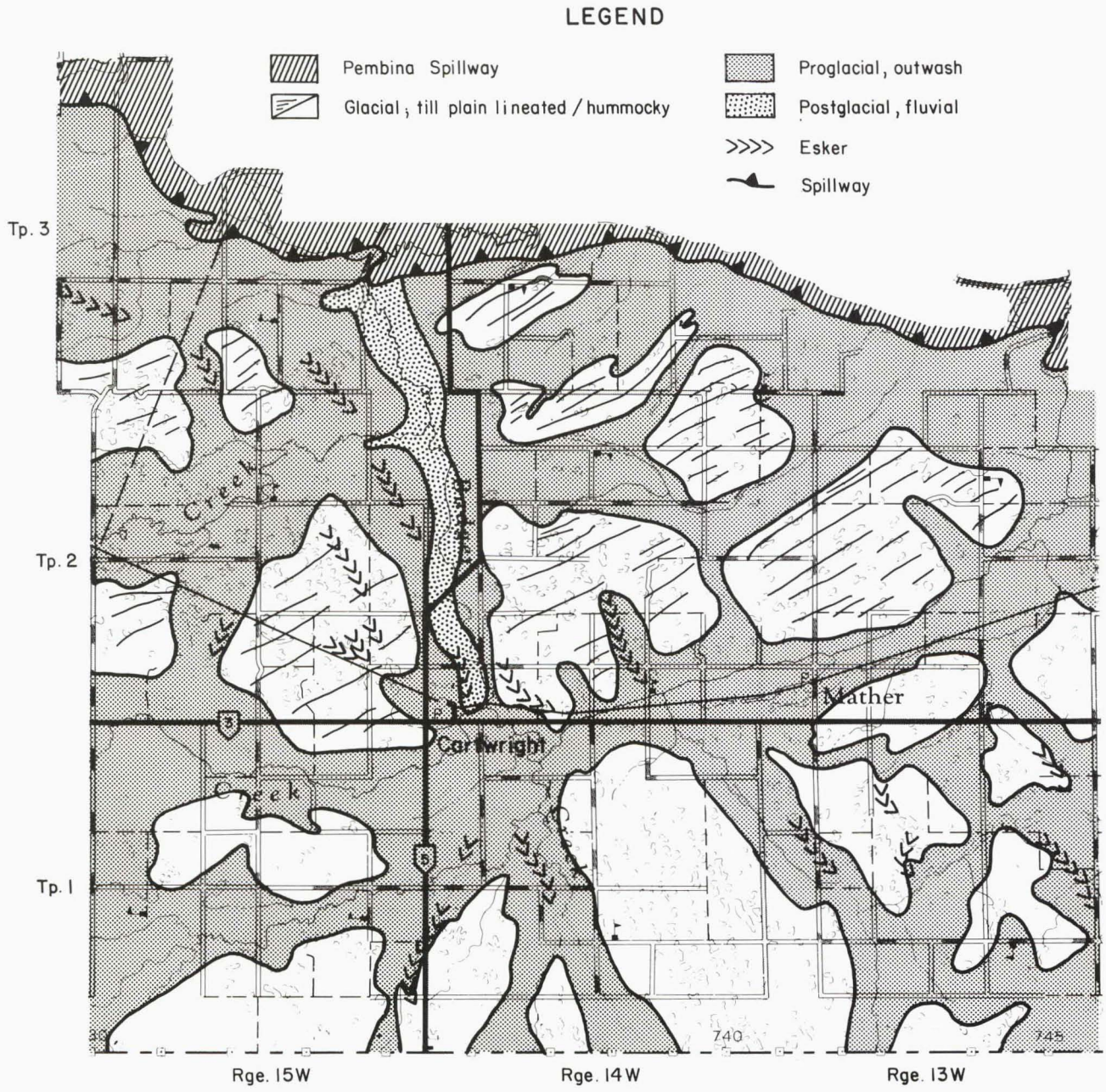

Figure 3: Generalized surficial geology of the R.M. of Roblin.

The till plain has an undulating surface with randomly distributed ridges and knolls. This is the oldest surficial unit in the area and was deposited by southeast-flowing ice of Late Wisconsinan age. Thickness of this unit ranges from 3-23 m.

An expanse of corrugated moraine extends over most of the northern half of the municipality. Subarcuate northeasterly oriented till ridges up to 15 m high are aligned transverse to ice flow direction. The orientation of corrugation ridges indicates that this unit was deposited by southeast-flowing ice of Late Wisconsinan age. The subarcuate system of ridges could mark the positions of former ice lobe margins as ice retreated.

Glaciofluvial deposits: (unit 2)

Southeasterly trending glaciofluvial eskers are scattered throughout the municipality. These are ridges ranging from 1-10 m high and from 5-25 km long. They differ from till ridges in orientation and composition. Composition ranges from fine sand to stratified sand and gravel. The eskers were deposited parallel to ice flow direction near the ice margin.

Outwash: (unit 3a, 3b)

Outwash was deposited by a system of proglacial streams. The outwash deposits, composed of silt, sand and gravel and generally less than 3 m deep, have been subdivided into two units. Unit 3a consists of those areas in which the deposit is generally less than 1 m deep and unit 3b are those areas where the deposit consists of more than 1 m of sand and gravel.

These depositional features occur on the convex side of the meanders of Badger Creek. They are flat, low-lying deposits that dip gently toward the channel. Thickness ranges from 1-3 m and includes deposits of sand, silt and clay.

Fluvial deposits: (unit 4)

These depositional features occur on the convex side of the meanders of Badger Creek. They are flat, low-lying deposits that dep gently toward the channel. Thickness ranges from 1-3 m and includes deposits of sand, silt aand clay.

Alluvium: (unit 5)

There is some deposition of modern stream sediment on the flood plains of Badger Creek and Pembina River. Fine shale gravel was deposited on the floor of Pembina River valley in the northwest corner of the municipality. Alluvial deposits include sand, silt, clay and minor gravel.

Colluvium: (unit 6)

Slope deposits along the major drainage systems have been mapped as colluvium. These deposits consist of silt, sand, gravel, till and bedrock.

Late Quaternary history

Southern Manitoba was deglaciated during the final retreat of Wisconsinan ice toward the northwest. As the ice thinned, uplands such as Turtle Mountain split the ice into lobes that occupied low-lying areas. Ice generally flowed southeastward and deposited a till plain in the south and corrugated moraine in the north of the study area. The northeasterly oriented corrugation are aligned transverse to ice flow direction and show that the ice front withdrew to the northwest.

Northwestern ice and northern ice merged north of Morden. When the ice margin extended from Turtle Mountain to Cardinal, extensive outwash was deposited during a pause in retreat. Meltwater collected in "Whitemud Spillway", now called Long River, that formed the main drainage system. Whitemud Spillway was joined by a southeastward flowing tributary, now called Badger Creek.

As ice continued to withdraw, drainage was concentrated south of Brandon, in the re-entrant between the northwestern and northern ice, determining the position of Pembina Trench. The deepening of Pembina Trench downstream from Rock Lake caused it to erode headward and capture Badger Creek, reversing the drainage of Badger Creek. Because Pembina Trench was receiving meltwater from both northwestern and northern ice its valley deepened rapidly, eroded headward and captured the headwaters of Whitemud Creek. The Pembina River is now the main drainage system of the area.

AGGREGATE RESOURCES

INTRODUCTION:

Aggregate resources and favorable geological environments are shown on Map 86-3. Locations of aggregate deposits are shown in Figure 4 and sand and gravel pits in Figure 5.

Appendix A summarizes collected information for each deposit. Grain size data are given in Appendix B. Descriptive granular terms used in the text are given in Appendix C. Manitoba Highways and Transportation specifications are listed in Appendix D. Sand and gravel pit information is summarized in Appendix E, and a glossary of terms is included as Appendix F.

Aggregate resources are classified on Map 86-3, based on two major components: aggregate quality and production potential (Table 1). Quality of aggregate

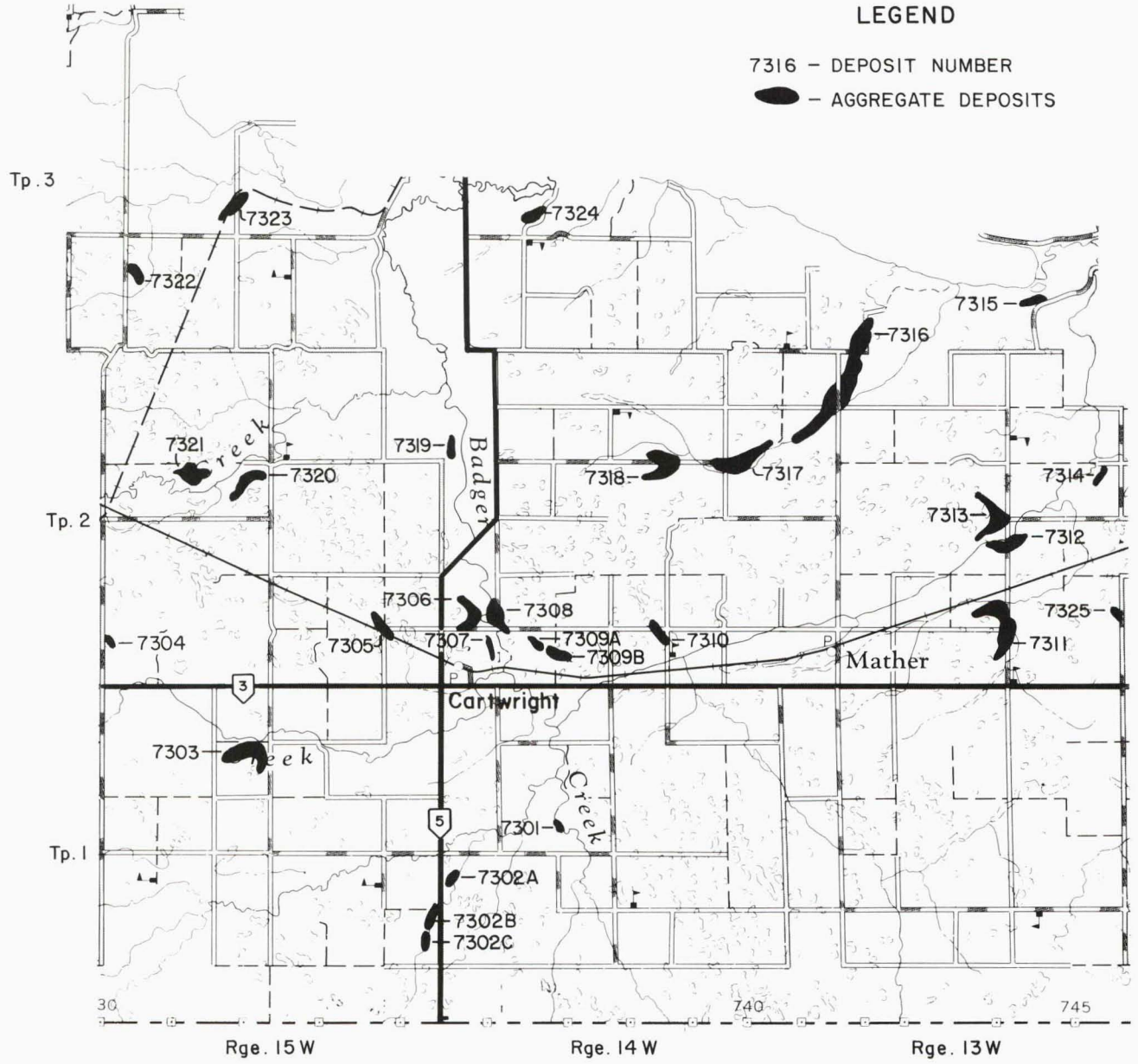

Figure 4: Aggregate deposits in the R.M. of Roblin.

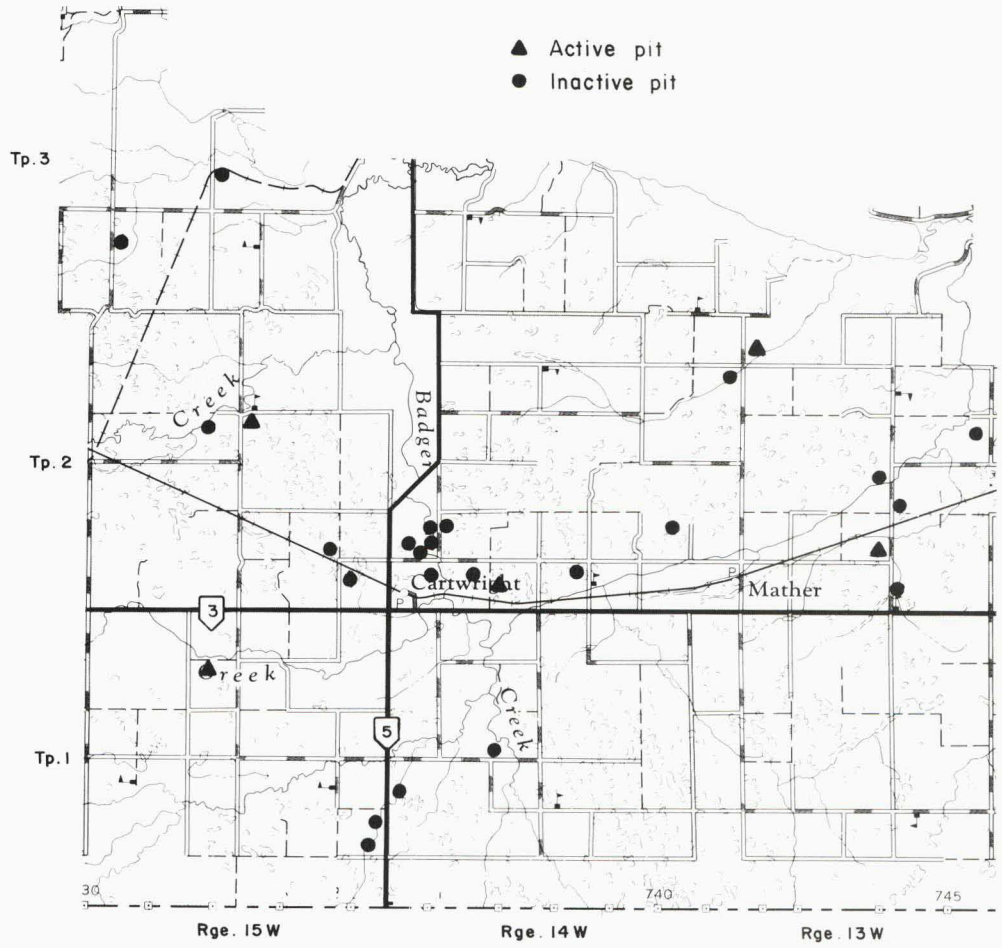

Figure 5: Sand and gravel pits in the R.M. of Roblin.

in a deposit is based on its primary physical characteristics, which are:

(1) amount of shale, by weight per cent;

(2) grain size distribution (per cent stone, sand and mud); and

(3) thickness and uniformity of the deposit.

The presence of shale, even in relatively small amounts, can result in a reduction in the quality of the aggregate, especially for high quality uses such as concrete and asphalt. Aggregate grading specifications (Manitoba Highways and Transportation, 1988) are:

End Use	Maximum Allowable Weight Per cent Shale
Concrete	0
Seal coat	3-4
Bituminous plant mix	3-7
Base course	12
Traffic gravel	12-15

Shale content (Fig. 6) was measured on a weight per cent basis of the stone fraction (6-38 mm). It should be recognized that shale content can vary greatly throughout a deposit or gravel pit, and for this reason shale content of an individual sample may vary dramatically from the average.

Aggregate classification is based on stone content (per cent greater than No. 4 sieve size); sand content (per cent greater than No. 200 sieve size but less than No. 4 sieve size; and the mud content (per cent less than No. 200 sieve size). Gradational specifications for aggregate can be found in the Canadian Standard Association (1977) manual. Manitoba Highways and Transportation grade specifications are shown in Appendix D. Usage of sand and gravel deposit depends upon required gradations. A low quality deposit is usually lacking in coarse materials with less than 30 per cent retained on the No. 4 sieve. Theoretically any material can be modified to meet required specifications through screening, crushing and sieving processes. However, in many situations the processing re-

TABLE 1
AGGREGATE QUALITY AND PRODUCTION POTENTIAL CRITERIA

	Criteria	GOOD	MODERATE	POOR
AGGREGATE QUALITY	Stone %	30	15-30	0-15
	Sand %	0-35	35-70	70
	Mud %	0-7	7-17	17
	Shale %	0-5	5-12	12
	Thickness	>5 m	2-5 m	<2 m
	Uniformity	high	medium	low
DEPOSIT PRODUCTION POTENTIAL	Aggregate Quality	high	medium	low
	Crushable	abundant	moderate	minor
	Overburden	<2 m	2-4 m	>4 m
	Binder	yes	minor	none
	Water Table (depth)	>5 m	2-5 m	<2m
	Geological Potential	good	moderate	low
	Verification	proven	limited	untested
	Local Access	0-1 km	1-5 km	+ 5 km
	Quarrying Status	active	intermittent	inactive
	Planning Constraints	none	conditional	sterilized
	Speciality Material	yes		no
	Aggregate Substitute	none	marginal	proximal

quired to produce a high quality end product from a low quality deposit is uneconomic.

Production potential refers to the likelihood of a particular deposit being exploited in the foreseeable future (25 years). Production potential is based on:

(1) aggregate quality and physical characteristics of the deposit (overburden, binder availability, water table, crushable);

(2) location and geological setting (geological potential, local access, planning constraints, transportation);

(3) economic factors (pit status, speciality material, supply, deposit substitution).

Good production potential status indicates a valuable deposit which is presently being mined or which has high potential of exploitation. Moderate status denotes a deposit which is presently inactive, or a deposit which is expected to be used in the foreseeable future. Those deposits with poor potential are unlikely to be exploited; included are deposits which are near depletion in which the pits are overgrown, and deposits sterilized by cultural features. Resources considered to have poor development potential are not considered reserves.

SELECTED AGGREGATE RESOURCES

Township 01, Ranges 13, 14 and 15 West

Three deposits are located south of Highway 3 in townships 01, Ranges 14 and 15W; none are identified in township 01, Ranges 13W. The highest quality deposit is the esker deposit 7302 which has 3 segments labelled A, B, and C. The esker is orientated north-northeast and is over 6 m high at its crest. Material is highly variable, grain size ranges from coarse pebble gravel to fine sand, and sorting ranges from well sorted sediments to diamictons. Shale amounts are relatively low ranging from 0.5 to 5.3 weight per cent. Three sand and gravel pits occur in deposit 7302, one in each segment. All pits were presently inactive. The central esker segment (7302B) contains the largest pit and the most reserves, approximately 580 000 m^3. The deposit has a high likelihood of future use.

Deposit 7303 located in section 28-01-15W contains 354 000 m^3 of low quality aggregate which is

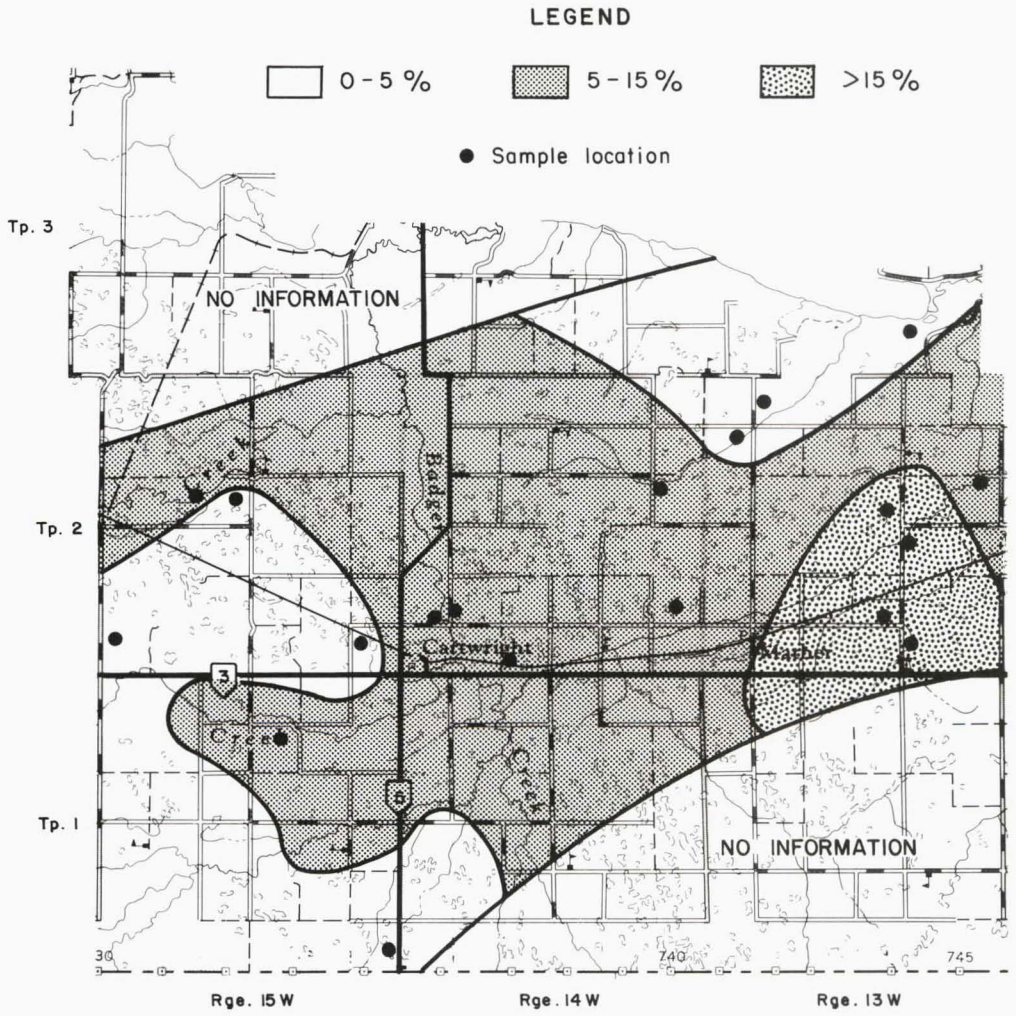

Figure 6: Weight per cent shale from selected aggregate samples in the R.M. of Roblin.

being extracted on an on-demand basis. The outwash deposit consists of a low-lying plain, composed of approximately 1 m of sandy fine pebble gravel, with 9 per cent by weight shale. The deposit is considered to have high potential for continued use.

In section 21-01-14W a small esker deposit (7301) containing 80 000 m^3 of remaining low quality reserves. Exposures in the vicinity of the revegetated pit (PK290) indicate the deposit is composed of 2 to 2.5 m of sand with scattered fine pebbles. The deposit is considered to have moderate potential for future production.

Townships 02 and 03, Range 13 West

The largest sand and gravel pit in the municipality (PB260) occurs in SW32-02-13W, in outwash deposit 7316. The pit is owned and operated by Manitoba Highways and Transportation. Two inactive pits also occur in deposit 7316. The deposit consists of pebble gravel ranging in stone content from 20 to 54 per cent. Weight per cent shale from the Highways pit (PB260) was determined to be approximately 6 per cent. Deposit thickness to water table ranges from 1 m to greater than 2.5 m in the pit. Estimated remaining reserves are 1.3 million m^3 of medium low quality aggregate. The deposit has high potential for continued extraction.

Three shallow outwash deposits, with less than 2 m of aggregate, are located 4.8 km east of Mather. Shale values in the deposits are high, ranging from 13 to 61 per cent by weight. There are 4 gravel pits in deposits 7311, 7312 and 7313; one, which is active, is located at SE10-02-13W.

Township 02, Range 14W

There are several deposits in the Cartwright area, primarily north and east of the community. The deposits contain 10 sand and gravel pits of which 3 are active.

Deposit 7306 in section 07, has the largest pit (PB293) in the township. The pit is presently used as

TABLE 2
DEPOSIT RESOURCES IN THE R.M. OF ROBLIN

Deposit Number	Resources '000 m^3	Quality	Production Potential
7301	80	low	poor
7302A	57	medium-low	poor
7320B	580	medium-low	good
7302C	38	medium-low	good
7303	354	low	good
7304	28	medium	poor
7305	6	medium-low	poor
7306	591	low	good
7307	244	low	good
7308	180	medium-low	good
7309A	691	medium-low	moderate
7309B	46	medium-low	good
7310	141	low	poor
7311	255	low	moderate
7312	130	low	moderate
7313	472	low	moderate
7314	69	low	moderate
7315	56	medium-low	poor
7316	1 329	medium-low	good
7317	340	medium-low	good
7318	108	medium-low	moderate
7319	145	low	moderate
7320	220	medium-low	good
7321	192	low	moderate
7322	138	medium-low	moderate
7323	55	low	moderate
7324	60	low	moderate
7325	40	medium-low	moderate
TOTAL	6 123		

the municipal dump; however, there is still some material being actively removed. Exposures in the pit show over 5 m of faulted and folded variable sediments, indicating an ice contact-esker environment. The esker is extensively excavated. An outwash plain flanks the esker westwards. Two metres of well sorted, sandy fine pebble gravel above the water table is being extracted from PB292.

Material is also being extracted from deposit 7309B, 3 km east of Cartwright. Shaly, sandy fine pebble gravel is being mined from the deposit. The deposit is near depletion with only 46 000 m^3 of material remaining.

Township 02, Range 15W

There are four deposits in the township with the outwash deposits (7321 and 7320) containing the major reserves. The pit in deposit 7320 is active. Shaly, sandy fine pebble gravel is being extracted to the water table at 1.5 m. There is approximately 220 000 m^3 of reserves remaining in deposit 7320, and 192 000 m^3 in deposit 7321.

SUPPLY AND DEMAND

Supply

The Rural Municipality of Roblin contains an estimated 6.1 million m^3 of granular material. A total of 25 deposits were identified containing aggregate resources (Table 2). Most of the recoverable reserves above the water table are located in the outwash plain located in Townships 2 and 3, Range 13W (Deposit 7316). The southeastern portion of the municipality has no identified aggregate resources.

TABLE 3
AGGREGATE QUALITY AND PRODUCTION POTENTIAL RESOURCES FOR THE R.M. OF ROBLIN
('000 m^3)

Aggregate Quality	Production Potential A Good	B Moderate	C Poor	Resource By Quality
Medium	0	0	28	28
Medium Low	2 833	355	119	3 307
Low	1 189	1 378	221	2 788
TOTAL	4 022	1 733	368	Total Resources: 6 123
				* Total Reserves: 5 755

* Total Reserves = Col. A + Col. B

The resources in the municipality are generally of low quality due to high shale content averaging 14 per cent by weight, with values as high as 61 per cent (Fig. 6).

By comparing quality with production potential, reserves can be further separated, as shown in Table 3. Of the total 6.1 million m^3 of aggregate resources only 28 000 m^3 is of medium quality, which is the highest quality of aggregate found in the municipality. Deposit 7304 has medium quality material (little or trace shale observed) and poor development potential because of 2 m of overburden covering the aggregate and the relatively small size of the deposit. Deposits with medium-low quality aggregate amount to 3.2 million m^3 of reserves, of which 28 000 m^3 has good potential for production. Low quality deposits usually have high amounts of shale and are generally less than 1.5 m in depth above the water table. Extraction below the water table has not occurred in the municipality.

Demand

The demand for sand and gravel in the Rural Municipality of Roblin is closely tied to activity in the construction sector and end use requirements. Estimated demand for aggregate resources is based on:

(1) Manitoba Highways and Transportation upgrading and improvements;
(2) requirements for the municipality; and
(3) requirements for redi-mix concrete producers and other private users.

The estimated demand is presented in Table 4.

Demand for sand and gravel in the R.M. of Roblin has been estimated to be 720 000 m^3 of resource for a 25-year planning period. Annual demand is 28 800 m^3 with the municipality the major user, requiring an estimated 18 200 m^3 for road maintenance. The relatively high municipal requirements compared to other municipalities, could be related to the high shale content in the local aggregate supplies. Shale breaks down rapidly resulting in the need for more material. Manitoba Highways and Transportation uses 8600 m^3 annually of aggregate in the municipality, of which 1000 m^3 is used for maintenance traffic gravel, 600 m^3 for seal coat, 3000 m^3 for base coarse, and 4000 m^3 for bituminous aggregate. Approximately half of the aggregate resource used by the Manitoba Highways and Transportation is imported from neighbouring municipalities, primarily the R.M. of Turtle Mountain to meet the specifications of high quality end-use requirements of seal coat and bituminous pavement.

TABLE 4
ESTIMATED DEMAND FOR SAND AND GRAVEL IN THE R.M. OF ROBLIN
m^3

Major consumers		1 Year	25 Years
Manitoba Highways and Transportation		8 600	215 000
R.M. of Roblin		18 200	455 000
Private users		2 000	50 000
	TOTAL:	28 800	720 000

CONCLUSION

Sand and gravel resources in the municipality are limited. Most esker deposits are near depletion and remaining outwash plain resources are generally shallow and of low quality. Total reserves are approximately 5.7 million m^3, of which 45 percent is low quality.

Demand can be separated into: a) that which can be supplied within the municipality and b) that which requires imported material. Local demand is approximately 23 000 m^3 annually which can be met with the supply available. Imported aggregate for municipal use is estimated at 5600 m^3 annually and is used for high specification end uses.

It is expected that there will be the continued need for importation of high quality aggregate and that it is likely to increase with depletion of better quality deposits in the municipality.

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APPENDIX A: AGGREGATE DEPOSITS IN THE R.M. OF ROBLIN

Deposit Number	Legal Description	Station Number	Per Cent Stone (+#4/+4.76 mm)	Per Cent Shale	Deposit Thickness(m)	Aggregate Quality	Production Potential	Pit Quarry* Status	Reserves '000 m^3	Ownership Surface/ Sand & Gravel	Comments
7301	SW21-04-14W	PB290			2.0	L	P	R	80	P/P	Fine pebbly sand, deposit
	SW21-04-14W	PB325			2.5						near depletion.
7302A	SW18-01-14W	PB282	5.4		2.5	ML	P	R	57	P/P	Reserves to NE, deposit
	SW18-01-14W	PB283	26.1	0.5	2.5						near depletion.
	SW18-01-14W	PB378			0.4						
7302B	NE12-01-15W	PB284	59.0	5.3	5.0	ML	G	I	580	P/P	Inactive pit, reserves to
	NE12-01-15W	PB376			0.4						the NE.
	NE12-01-15W	PB377	38.4		0.5						
	SE13-01-15W				2.0					P/P	
	SE12-01-15W				4.0					P/P	
7302C	SE12-01-15W	PB285	57.3		4.0	ML	G	I	138	P/P	Inactive pit used as local garbage dump.
7303	NE28-01-15W	PB286	52.9	9.4	1.0	L	G	A	354	P/P	Shallow deposit.
	NE28-01-15W	PB287	28.2		1.0						
	NW28-01-15W				1.0					P/P	
7304	NW06-02-15W	PB384	35.5		1.5	M	P		28	P/P	2 m of overburden.
7305	NW01-02-15W	PB299	19.9	2.5	2.0	ML	P	R	6	P/P	Deposit depleted.
	NE02-02-15W				1.5					P/P	
	SE11-02-15W				1.5			R		P/P	
7306	SE07-02-14W	PB293A	39.2		1.5	L	G	A	591	C/C	R.M. of Roblin pit.
	SE07-02-14W	PB293B	24.5		1.5			I			Municipal dump.
	SE07-02-14W	PB292	17.9		2.0			A		P/P	
	SE07-02-14W	PB323		12.4	7.0			A		P/P	
	SW07-02-14W	PB266	15.2	15.4	5.0			I		P/P	
	NW07-02-14W				5.0					P/P	
	NE07-02-14W				5.0					P/P	
7307	NE06-02-14W	PB301	5.2		6.0	L	G	I	244	P/P	Shaly, pebbly sand.
7308	SE07-02-14W	PB294	77.4		1.5	ML	G	I	180	C/C	Small inactive pits.
	SW08-02-14W	PB324		5.9	3.0			I		P/P	

APPENDIX A (CONT'D.)

Deposit Number	Legal Description	Station Number	Per Cent Stone (+#4/+4.76 mm)	Per Cent Shale	Deposit Thickness(m)	Aggregate Quality	Production Potential	Pit Quarry* Status	Reserves '000 m^3	Ownership Surface/ Sand & Gravel	Comments
7309A	NE05-02-14W	PB296	41.3		2.5	ML	M	I	69	P/P	Deposit near depletion.
7309B	SW04-01-14W					ML	G			P/P	
	NW04-01-14W	PB295A	26.7	9.4	1.5			A	46	P/P	Pit active on demand,
	NW04-01-14W	PB295B	29.1		2.0			A			deposit near depletion.
7310	NE03-02-14W	PB298	19.7		2.5	L	P	H	141	C/C	Highways pit,
	SE10-02-14W				2.5					P/P	rehabilitated.
7311	NW02-02-13W	PB306	30.4	61.5	2.0	L	M	I	255	P/P	Shallow outwash deposit,
	NE03-02-13W	PB305			0.5					P/P	high shale content.
	SW10-02-13W									P/P	
	SE10-02-13W	PB307	21.7	25.6	1.0			A		P/P	
	SW11-02-13W				0.5					P/P	
7312	SW14-02-13W	PB308	19.9	56.1	1.0	L	M	R	130	P/P	Outwash deposit,
	NW14-02-13W	PB347	22.8		1.8					P/P	revegetated pit, high shale
	NE15-02-13W				1.2					P/P	content.
	SE15-02-13W				1.2					P/P	
7313	NE15-02-13W				2.5	L	M		472	P/P	
	SE22-02-13W	PB270	38.3	12.8	2.0			R		P/P	Very sandy fine pebble
	SE22-02-13W	PB354	12.3		3.2					P/P	gravel.
7314	NE24-02-13W	PB268	8.0		2.0	L	M	I	69	P/P	Deposit near depletion.
7315	NW01-03-13W	PB267		2.6	4.0	ML	P		56	P/P	Sterilized by farm
	NE02-03-13W				4.0					P/P	buildings.
7316	NE30-02-13W				1.0	ML	G		1 329	P/P	
	SE31-02-13W	PB345	53.7		1.2					P/P	
	SW32-02-13W	PB260	32.0	5.7	2.5			A		P/P	Active commercial pit.
	NW03-02-13W				2.0					P/P	
	SW04-03-13W	PB261	34.3		1.5			I		P/P	
	NW04-03-13W	PB262	19.8		1.5					P/P	
	SE05-03-13W	PB347			1.7					P/P	
	SE05-03-13W	PB348	20.1		2.5						

APPENDIX A (CONT'D.)

Deposit Number	Legal Description	Station Number	Per Cent Stone (+#4/+4.76 mm)	Per Cent Shale	Deposit Thickness(m)	Aggregate Quality	Production Potential	Pit Quarry* Status	Reserves '000 m^3	Ownership Surface/ Sand & Gravel	Comments
7317	NE23-02-14W				1.0	ML	G		340	P/P	
	NW24-02-14W	PB263	31.0	10.6	2.0			A		P/P	Deposit thins to north and
	SE25-02-14W				0.5					P/P	east.
	SW25-02-14W				1.5					P/P	
	SE26-02-14W				0.5					P/P	
7318	NE22-02-14W				1.0	ML	M		108	P/P	
	SW26-02-14W	PB264	23.5		2.0			R		P/P	Small revegetated pit in
	SE27-02-14W				1.0					P/P	pasture.
7319	SW30-02-14W				2.5	L	M		145	P/P	
	NW30-02-14W	PB316	44.1		3.5			I		P/P	Two small inactive pits.
7320	SW21-02-15W				1.0	ML	G		220	P/P	
	NW21-02-15W	PB250	38.5	4.9	1.5			A		P/P	Shallow outwash deposit
	NE21-02-15W				1.0					P/P	reserves to the south.
7321	NE20-02-15W				0.8	L	M		192	P/P	
	NW20-02-15W	PB251	18.0	10.6	1.5			I		P/P	Active on demand.
7322	SW08-03-15W	PB272	28.7	8.1	4.5	ML	M	I	138	P/P	Esker deposit.
7323	NW15-03-15W				0.5	L	M		55	P/P	
	NE16-03-15W	PB276		9.8	0.6			I		P/P	
7324	SW16-03-14W	PB250	30.0		2.0	L	M	I	60	P/P	
7325	SE12-02-13W	PB358	21.6		2.5	ML	M		40	C/C	Depleted Highways pit.
							TOTAL RESERVES		**6 123**		

*Pit Status
I - Inactive pit
A - Active pit
R - Revegetated pit
H - Rehabilitated

Production Potential
G - Good
M - Moderate
P - Poor

Aggregate Quality
M - Medium
ML - Medium Low
L - Low

Ownership
P - Private
C - Crown

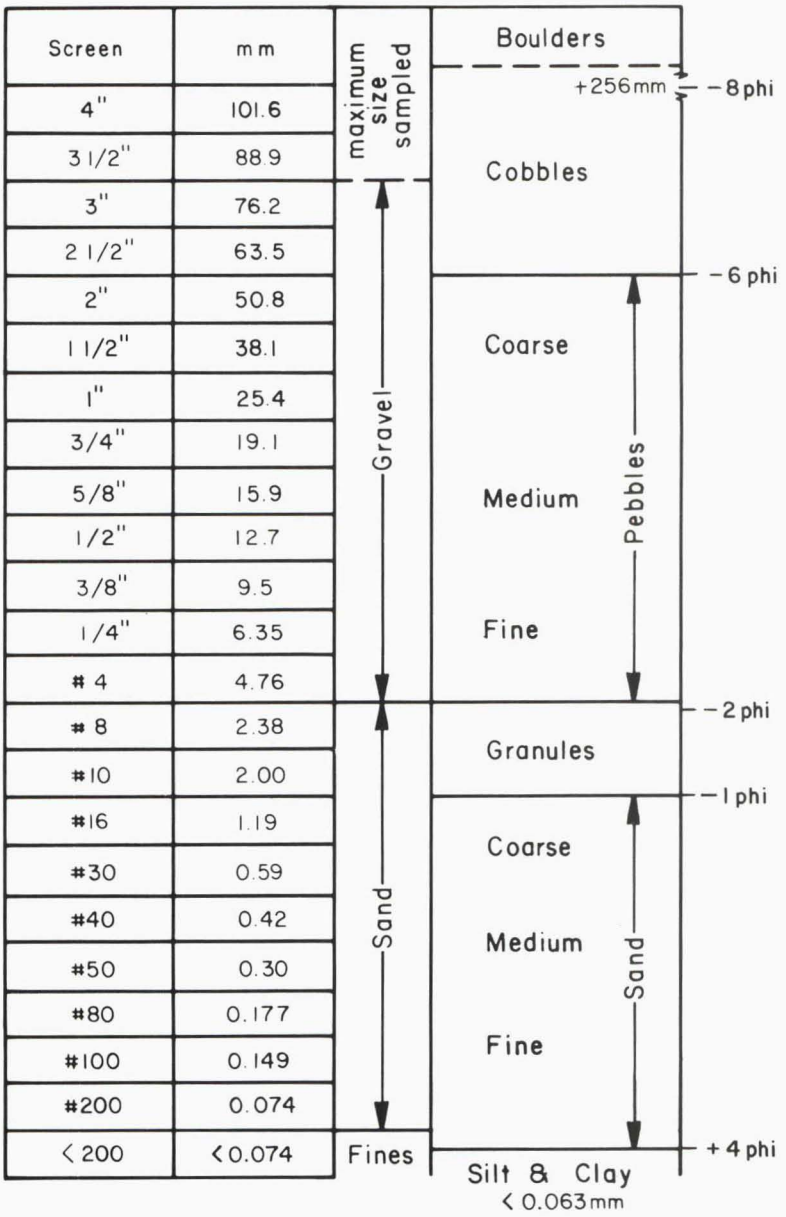
APPENDIX B: GRAIN SIZE DISTRIBUTION OF AGGREGATE SAMPLES FROM THE R.M. OF ROBLIN

Deposit Number	Legal Description	Sample Number	% Pebbles 4 - 64 mm	% Granules 2 - 4 mm	% Sand 0.06 - 2 mm	% Silt & Clay	Crushable On Site > 15 cm X Yes
7302A	SW18-01-14W	PB282	5.35	17.92	73.03	3.70	
		PB283	26.06	23.58	46.99	3.37	
7302B	NE12-01-15W	PB284	58.98	15.42	19.97	3.33	X
		PB377	38.37	28.56	31.10	1.97	
7302C	SE12-01-15W	PB285	57.34	20.56	20.22	1.87	
7303	NE28-01-15W	PB286	52.90	11.55	31.85	3.61	
		PB287	28.17	20.51	47.87	3.46	
7304	NW06-02-15W	PB384	35.48	21.55	40.45	2.53	
7305	NW01-02-15W	PB299	19.94	23.12	53.58	3.36	
7306	SE07-02-14W	PB293A	39.18	21.80	34.66	4.36	
		PB293B	24.51	24.77	47.60	3.11	
		PB292	17.92	18.25	58.46	2.56	X
	SW07-02-14W	PB266	15.17	35.67	45.85	3.31	
7307	NE06-02-14W	PB301	5.22	16.20	75.32	3.25	
7308	SE07-02-14W	PB294	77.41	8.46	12.62	1.51	
7309A	NE05-02-14W	PB296	41.27	21.66	33.22	3.85	
7309B	NW04-01-14W	PB295A	26.72	17.92	53.81	1.55	
		PB295B	29.13	23.68	45.38	1.82	
7310	NE03-02-14W	PB298	19.66	27.18	50.23	2.92	
7311	NW02-02-13W	PB306	30.41	21.69	39.91	7.98	
		PB307	21.71	26.77	46.14	5.37	
7312	SW14-02-13W	PB308	19.93	17.62	54.85	7.60	
		PB357	22.78	18.62	53.97	4.63	
7313	SE22-02-13W	PB270	38.26	15.01	44.14	2.59	
	SE15-02-13W	PB354	12.30	18.80	66.47	2.43	
7314	NE24-02-13W	PB268	8.03	17.40	72.42	2.15	
7315	NW01-03-13W	PB267	13.80	12.80	68.54	4.85	
7316	SE31-02-13W	PB345	53.65	12.60	32.29	1.46	
	SW32-02-13W	PB260	32.02	21.39	44.39	2.20	
	SW04-03-13W	PB261	34.27	20.77	42.31	2.66	
	NW04-03-13W	PB262	19.80	15.98	56.10	8.12	
	SW04-03-13W	PB348	20.06	20.39	56.50	3.06	

APPENDIX B (CONT'D)

Deposit Number	Legal Description	Sample Number	% Pebbles 4 - 64 mm	% Granules 2 - 4 mm	% Sand 0.06 - 2 mm	% Silt & Clay	Crushable On Site > 15 cm X Yes
7317	NW24-02-14W	PB263	30.96	25.27	41.02	1.29	X
7318	SW26-02-14W	PB264	23.48	30.43	43.43	2.66	
7319	NW30-02-14W	PB316	44.11	20.48	29.08	5.21	X
7320	NW21-02-15W	PB250	38.45	20.81	38.78	1.95	
7321	NW20-02-15W	PB251	17.96	30.86	49.39	1.80	
7322	SW08-03-15W	PB272	28.67	16.50	50.68	4.15	
7324	SW16-03-14W	PB259	29.99	23.67	43.78	2.56	
7325	SE12-02-13W	PB358	21.64	27.43	44.28	6.65	
Other occurrences sampled:							
	NE20-02-15W	PB252	12.78	17.63	64.74	4.85	
	NW21-02-15W	PB253	11.26	23.90	63.23	1.62	
	SE28-02-15W	PB254	14.33	21.30	58.48	5.89	
	SE28-02-15W	PB256	27.35	17.69	52.71	2.25	
	SE28-02-15W	PB257	33.88	17.76	45.38	2.99	
	SE25-02-15W	PB258	9.73	15.86	68.36	6.05	
	NE18-02-14W	PB265	26.47	27.12	38.65	7.76	
	NE14-02-13W	PB269	4.97	8.85	83.10	3.08	
	SW23-02-13W	PB271	11.16	20.57	65.64	2.64	
	NE32-03-15W	PB274	16.47	16.29	59.66	7.58	
	SW07-02-15W	PB277	22.87	14.31	59.22	3.60	
	SW31-01-15W	PB278	30.99	18.73	46.86	3.42	
	SW21-01-15W	PB279	11.40	12.16	73.28	3.17	
	SE04-01-15W	PB281	21.16	14.12	55.96	8.77	
	SE20-01-15W	PB288	18.45	22.39	54.87	4.29	
	NE17-01-15W	PB289	16.59	18.06	62.44	2.92	
	SW33-01-15W	PB291	29.33	21.22	48.02	1.43	
	NW04-02-15W	PB297	14.36	10.46	73.09	2.09	
	SW05-02-14W	PB300	32.69	21.57	43.35	2.39	
	SE07-02-14W	PB302	35.67	22.57	37.99	3.77	
	SE15-02-14W	PB303	30.96	17.02	45.65	6.36	
	NW02-02-14W	PB304	49.94	24.22	22.58	3.26	
	SE14-02-13W	PB309	26.78	23.94	44.10	5.18	
	SE01-02-15W	PB311	46.59	20.19	23.55	7.19	X
	SE01-02-15W	PB312	50.10	14.39	30.48	5.03	
	NW20-01-13W	PB313	28.29	16.34	37.81	17.57	
	SW15-01-13W	PB314	14.30	24.23	52.80	8.66	
	NW07-01-13W	PB315	55.89	5.72	19.27	19.12	
	NW06-01-13W	PB351	30.80	35.51	25.45	8.24	
	NW25-01-15W	PB317	25.91	18.44	45.79	9.86	
	SW23-02-13W	PB353	16.26	18.61	63.51	1.62	
	SW15-01-13W	PB366	25.93	26.72	39.73	7.62	

APPENDIX C: GRAIN SIZE CLASSIFICATION



PROVINCE OF MANITOBA
1988 AGGREGATE GRADING SPECIFICATIONS

*NOTE: N.S. = Not Specified
F.M. = Fineness Modulus

PASSING SIEVE SIZE		BITUMINOUS PLANT MIX			BASE COURSE					GRANULAR FILL	CULVERT GRAVEL	TRAFFIC TYPE						CONCRETE			SEAL COAT COVER				PASSING SIEVE SIZE	
					"A"	"A"	"B"	"C"	"C"									Fines	"A" COURSE							
Metric	Imp.	"A"	"B"	"C"	Gravel	Lime-stone	All	Gravel	Lime-stone			"A"	"A" Lime-stone	"B"	"C"	"D" Lime-stone	"D" Quarried rock		65%+ Lime-stone	Gravel	"A"	"B"	Cover "C"	Blotter "D"	Metric	Imp.
50 mm	2"								100	3" 100															50 mm	2"
37.5mm	1½"							100	N.S. 100		100														3.75mm	1½"
25 mm	1"			100										100	100	100				100					25 mm	1"
19 mm	3/4"				100	100	100					100	100			85-100	100		100	90-100					19 mm	3/4"
16 mm	5/8"		100		80-100																	100			16 mm	5/8"
12.5mm	1/2"	100										75-90		70-90	60-95			100			100	80-100	100	100	12.5mm	1/2"
95 mm	3/8"	70-95	70-90															96-100	20-55	20-55					9.5 mm	3/8"
4.75mm	#4	55-70	55-70	60-90	40-70	35-70	30-75	25-80	25-80		N.S. 25-80	45-70	35-60	40-70	30-70	35-60	30-60	90-100	0-10	0-10	0-60	0-65			4.75mm	#4
2.00mm	#10	35-55	35-55	35-80	25-55		25-65																		2.00mm	#10
1.18mm	#16																	50-80							1.18mm	#16
600um	#30																	25-60							600um	#30
425um	#40	17-29	17-29	20-50	15-30	10-30	15-35	15-40				10-35		10-35	5-35						0-15	0-15	0-25	0-50	425um	#40
300um	#50																	10-30							300um	#50
180um	#80	N.S. < 10	N.S. < 10																						180um	#80
75 um	#200	3-8	3-8	5-12	8-15	6-17	4-18	8-20 4-20	5-20	0-15	N.S. 4-20	8-15	6-17	0-15	0-15	0-17	0-10	0-3	0-2	0-2	0-4	0-5	0-5	0-10	75um	#200
MINIMUM CRUSH		50%	50%		35%		25%					35%	100%	35%	25%	100%	100%				30%	20%			MINIMUM CRUSH	
MAXIMUM SHALE		T 3% B 7%	T 3% B 7%		12%		12%	12%			N.S. 15%	12%		12%	15%						3%	4%			MAXIMUM SHALE	
MAXIMUM L.A.		35%	35 %		35%	35%	35%	35%	35%			45%	45%	45%	45%	45%			28%	28%	35%	35%			MAXIMUM L.A.	
MAXIMUM DELETERIOUS																		2%	1.5%	1.5%					MAXIMUM DELETERIOUS	
MAXIMUM IRONSTONE																		F.M. 2.3-3.5			5%	5%			MAXIMUM IRONSTONE	
MAXIMUM ABSORPTION																			2.25%	2.25%					MAXIMUM ABSORPTION	
SPEC NUMBER		920	920	920	900	900	900	900	900	520		910	910	910	910	910	910	930	930	930	940	940	940	940	SPEC NUMBER	

APPENDIX E: SAND AND GRAVEL PITS IN THE R.M. OF ROBLIN

Deposit Number	Station Number	Legal Description LS.	Sec.	Tp.	Rge.	Owner/Operator (as of 1986)	Face Height (m)	Stone %	Shale Wt %	Water Table (m)	Pit Status
TOWNSHIP 01-13W											
						- NONE -					
TOWNSHIP 01-14W											
7302A	PB283 PB378	5	18	01	14W	W.S. Shaw	2.5	26	1		Revegated
7301	PB290 PB325	5	21	01	14W	H.E. Enns	2.2	NA	NA	2.5	Inactive
TOWNSHIP 01-15W											
7302C	PB285	1	12	01	15W	A. & L. Penner	4.0	57	NA		Inactive, garbage dump
7302B	PB284	9	12	01	15W	J.C. McKibbon	5.5	59	5		Inactive
7303	PB286	15	28	01	15W	M. & M. Doerksen	1.0	53	9	1.0	Active on demand
TOWNSHIP 02-13W											
7311	PB306	13	02	02	13W	A. Peters	2.0	30	61	2.0	Revegetated
7311	PB307	8	10	02	13W	G. & A. Gardiner	1.0	22	22	1.0	Active
7312	PB308	5 & 12	14	02	13W	G. Dyck	1.0	20	20	1.0	Revegetated
7313	PB270	16	15	02	13W	E. & A. Gundrum	2.0	38	38	2.0	Revegetated
7313		1	22	02	13W	L. Guy	1.5				Inactive
7314	PB268	15	24	02	13W	L.E. Gundrum	2.0	8	8		Inactive
7316	PB345	16	30	02	13W	D.E. Penner	1.2	54	54	1.2	Inactive
7316	PB260	12	32	02	13W	W.S. Drysdale	2.5	32	32	2.5	Active
		5	32	02	13W	Highways					Active
7325	PB358		12	02	13W	Highways	2.5	22			Depleted
TOWNSHIP 02-14W											
7310	PB298	16	03	02	14W	Highways	2.5	20	20		Rehabilitated
7309B	PB295	6, 11 & 12	04	02	14W	B.W. Bourns	2.0	28	28	2.0	Recently used
7309A	PB296	9, 15 & 16	05	02	14W	W.G. Kelly	2.5	41	41	2.5	Inactive
7309A		5	05	02	14W		3.0				Revegetated
7307	PB301	16	06	02	14W	J.W. Wallace	6.0	5	5	6.0	Revegetated
7306		3	07	02	14W	R.M. of Roblin	4.0	NA	NA		Inactive
7306	PB266	3 & 6	07	02	14W	J.D. Kinley	5.0	15	15		Inactive
7306	PB292	2	07	02	14W	D.J. Wray	2.0	18	18	2.0	Active
7306	PB293	7 & 10	07	02	14W	Highways	6.0	32	NA		Active
7308	PB294	1	07	02	14W	R.M. of Roblin	2.5	77	77	1.5	Active
7308		8	07	02	14W	D.J. Wray	2.0	NA	NA	2.0	Inactive

APPENDIX E: (CONT'D.)

Deposit Number	Station Number	Legal Description LS.	Sec.	Tp.	Rge.	Owner/Operator (as of 1986)	Face Height (m)	Stone %	Shale Wt %	Water Table (m)	Pit Status
TOWNSHIP 02-14W (Cont'd.)											
7308	PB324	5	08	02	14W	D.R. Naight	3.0	NA	6	3.0	Inactive
7317	PB263	13 & 14	24	02	14W	J.A. Fowler	2.0	15	11	2.0	Active
7318	PB265	4	26	02	14W	R.M. Drewry	2.0	24	24		Revegetated
7319	PB316	5	30	02	14W	W.T. Laidlaw	3.5	44	44	4.0	Inactive
TOWNSHIP 02-15W											
7305		13	01	02	15W	E. Robertson & E.M. Reid	2.0	NA	NA		Depleted
7305	PB299	1	11	02	15W	R. Dousselaere	2.0	20	3		Inactive. near depletion
7321	PB251	11	20	02	15W	J.A. Wiebe	1.5	18	11	1.5	Active on demand
7320	PB250	11 & 14	21	02	15W	B.W. Gibson	1.5	38	39	1.5	Active
TOWNSHIP 03-13W						- NONE -					
TOWNSHIP 03-14W											
7324	PB259	6	16	03	14W	J.M. Cummings	2.0	30	30	2.5	Abandoned
TOWNSHIP 03-15W											
7322	PB272	5	08	03	15W	G.T. Schetter	4.5	29	29		Overgrown
7323	PB276	12	15	03	15W	A.N. Guille	0.6	NA	10	0.6	Inactive

NA - Not available

Where more than one sample was analyzed for the pit, the average is presented.

APPENDIX F: GLOSSARY

AGGREGATE

Any inert, construction material (sand, gravel, slag, crushed stone or other mineral material).

AGGREGATE RESERVES

Aggregate in a deposit which is proven and is economically signficiant.

ALLUVIUM

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream.

BEACH DEPOSITS

These are relatively narrow, linear features formed at the shores of glacial lakes that existed during deglaciation. Well developed beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates.

BEDROCK

In-place pre-Quaternary material exposed at the surface or underlying the surficial material.

BINDER

Material that produces or promotes consolidation in loosely aggregated sediments. Usually mud or clay, sometimes till is used for binder.

CARBONATE ROCKS

A broad term referring to those sedimentary rocks consisting chiefly of carbonate minerals, mainly limestone and dolostone.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a large rock mass. Synonyms include particle and fragment.

CROWN LAND

Land reserved and administered by the Crown. Sand and gravel usually administered by the Crown.

CROWN SAND AND GRAVEL

Sand and gravel reserved and administered by the Crown.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly.

DEPOSIT

An accumulation of sediments left in a new location by a natural transportative agent such as water, wind, ice, or gravity.

An aggregate deposit is a deposit of sand and gravel considered to be of economic significance.

DIRT

See fines.

DOLOMITE (DOLOSTONE)

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolomite is also known as dolostone).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DURABLE ROCK

A rock fragment which is hard and inert and can be used as aggregate without breaking, crumbling or reacting with the cementing material.

EOLIAN

Pertaining to wind action.

EPOCH

A geological-time unit longer than an age and a subdivision of a period.

ESKERS

Eskers are narrow, sinuous ridges of sand and gravel. They vary greatly in size. Many eskers consist of a central core of poorly sorted and stratified gravel. The core material is often draped by better sorted and stratified sand and gravel.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

FLUVIAL

Pertaining to rivers or streams.

GLACIOFLUVIAL DEPOSITS

Material deposited by streams flowing from, on, or within melting glacier ice, generally composed of sorted, stratified sand and gravel; includes outwash, kame, esker, etc.

GLACIOLACUSTRINE DELTAS

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. Such deposits tend to consist mainly of sand and abundant silt. However, in near-ice or ice-contact positions, coarse material may be present.

GLACIOLACUSTRINE DEPOSITS

Material deposited in lakes affected by glacier ice or by meltwater flowing directly from glaciers; composed of well-sorted clay, silt, or sand.

GRANULAR BASE COURSE

Components of a road placed on subgrade and designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

GROUND MORAINE

A deposit of till with a flat or undulating surface.

HOLOCENE

An epoch of the Quaternary period covering the time period from the retreat of the continental glaciers to the present, about 10 000 years.

HUMMOCKY

An irregular or knob and kettle surface.

HUMMOCKY MORAINE

A landscape composed primarily of till with a hummocky surface.

ICE-CONTACT DEPOSIT

Material deposited in contact with glacier ice by meltwater; includes kames, eskers, kame terraces, etc.

ICE-CONTACT TERRACES

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure may be similar to outwash deposits.

KAMES

Kames are mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. Deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms.

LACUSTRINE DEPOSIT

Material deposited in a lake.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way produced by water flowing away from a melting glacier margin.

MORAINE

A distinct accumulation of glacial drift. Could represent an ice marginal position.

OUTWASH

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure.

PIT RUN

Unprocessed aggregate removed from pit. Generally consists of fine pebble gravel with minor amounts of material coarser than 38 mm (1 1/2"). It is used for road maintenance, upgrading and resurfacing.

PLEISTOCENE

An epoch of the recent geological past including the time from approximately 1.8 million years ago to 10 000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

QUATERNARY

The second period of the Cenozoic era, thought to cover the last 2-3 million years. It consists of two epochs: The Pleistocene and the Holocene.

RESOURCE

An aggregate deposit or environment which may or may not be proven and is presently not economically significant.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SPILLWAY

Large drainage valley formed by meltwater flowing from a glacial lake. Spillways often have gravel terraces.

STONE

That component of aggregate coarser than 4.76 mm or the #4 sieve, includes pebbles, cobbles and boulders.

SURFICIAL GEOLOGY

A form of geological mapping dealing with all materials occurring at surface in an area: unlithified or lithified (sediments or bedrock).

TERRACE

A relatively flat, stair-stepped, depositional or erosional surface bounded by an ascending slope on one side and a descending slope on the other.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100 000 years ago and ended approximately 10 000 years ago. The glacial deposits and landforms of southern Manitoba are predominantly the result of glacial activity during the Winsconsinan Stage.