Aggregate Report AR90-1

Sand and Gravel Resources in the Rural Municipalities of Winchester and Morton

By H.D. Groom

Manitoba
Energy and Mines
Mines Branch

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MAP

Map AR90-1: Surficial geology and aggregate deposits of the Rural Municipalities of Winchester and Morton . . . . . in pocket

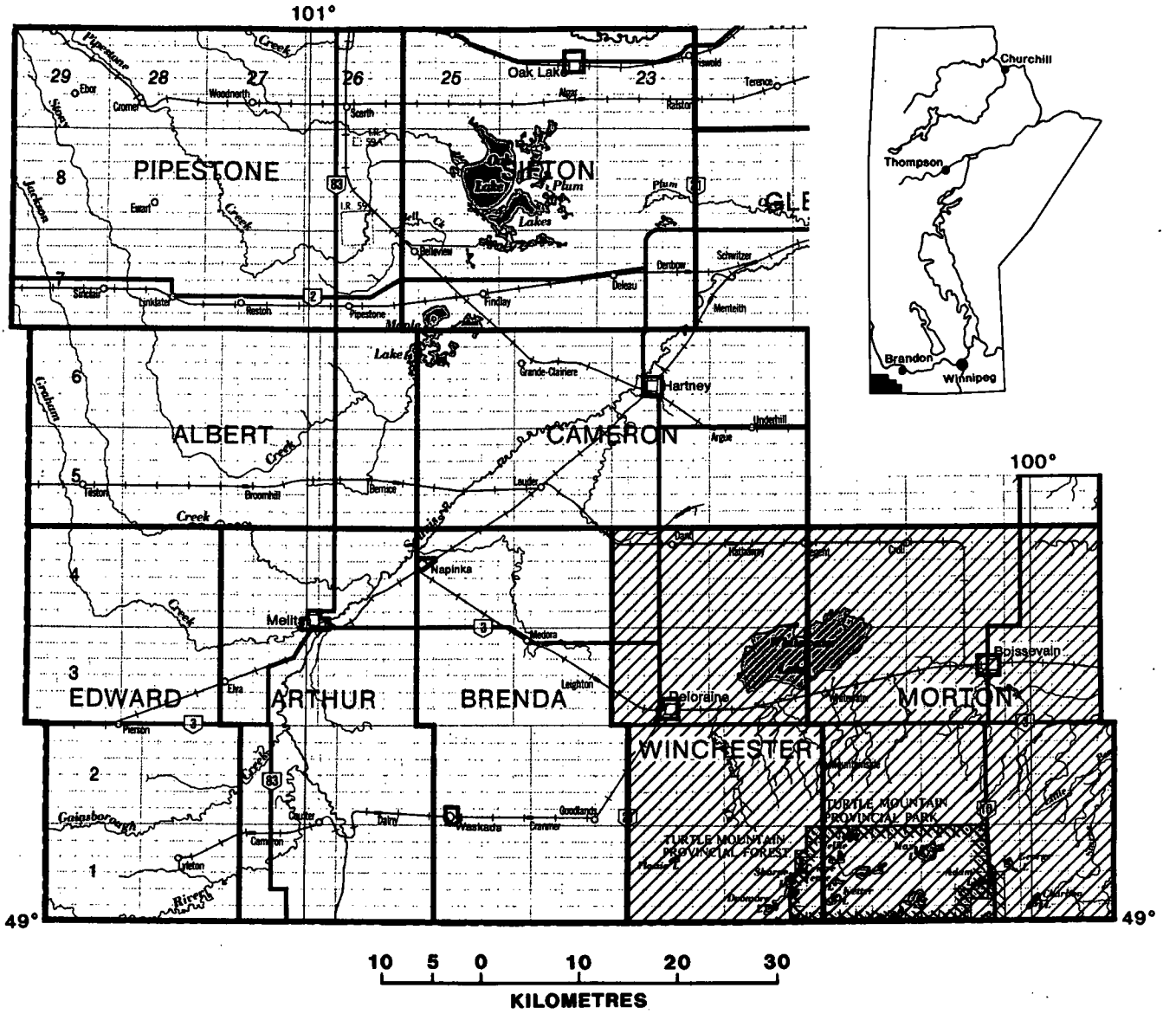

Figure 1: Location map of the R.M.'s of Winchester and Morton.

INTRODUCTION

Objectives

An aggregate resource inventory was carried out during the summer of 1987 in order to:

1) delineate the sand and gravel resources at a scale of 1:50 000; and
2) provide an estimate of the aggregate reserves in the area.

The information is used to provide aggregate users with resource information for construction needs and to facilitate land-use planning designed to protect high quality aggregate deposits from sterilization.

Location and Access

The Winchester-Morton area boundaries encompass 1 865 km^2 that lay between Townships 1-4 and Ranges 19-23W in southwestern Manitoba (Fig. 1). It includes six 1:50 000 map sheets in NTS areas 62F/1, 2, 7 and 8, and 62G/4 and 5.

The area is primarily a farming district, but tourism, supported by Turtle Mountain Provincial Park and the International Peace Garden, is important to the local economy. The towns of Deloraine and Boissevain are the major service centres. Highways 10 and 3, and a network of gravelled Provincial Roads and section roads, provide good access to most parts of the district.

Physiography

Turtle Mountain, rising to elevations of 710 m above sea level (a.s.l.), forms the height of land in the southern part of the area. The mountain plateau is, in general, 190 m above the surrounding prairie. It is formed of bedrock overlain by hummocky stagnation moraine that results in a surface topography of knolls separated by sloughs and lakes. The mountain is steep sided, particularly along the western edge where it rises over 100 m in less than 2 km. The mountain edge is cut by numerous streams, the largest of which is Turtlehead Creek.

Elevations in the rest of the area fall gently from 568 m a.s.l. at the base of Turtle Mountain to 492 m a.s.l. at the northern boundary. Whitewater Lake, in the center of the area, is surrounded by a narrow zone of flat lake sediments. The northern part of the area is underlain by a rolling till plain; till ridges are usually 2-3 m high.

Methodology

Surficial deposits were delineated on 1:50 000 scale airphotos. Airphoto interpretation was based on surficial units outlined by Elson (1961) and incorporated information from Department of Highways and Transportation Service gravel pit inventory files.

Gravel pits, road cuts and natural exposures were examined during the first part of the field investigation. This was followed by a backhoe program to test the extent, depth and quality of identified aggregate deposits.

Aggregate samples were processed in two stages. In the field, samples that weighed between 75 and 100 kilograms were passed through 3" (7.5 cm), 1 1/2" (3.8 cm) and 3/4" (1.9 cm) screens. The weights of the 1 1/2", 3/4" and 3/4" fractions were recorded. Sieve analysis was done on a representative sample of the < 3/4" fraction. Sieve intervals are shown in Appendix A

Pebble counts of the 3/4"-1 1/2" fraction were done to determine the content of shale, carbonate, sandstone and Precambrian intrusive volcanic and metamorphic lithologies. The degree of deleterious, such as weathering and cementation, was noted.

Gravel deposits were delineated on 1:15 850 scale airphotos and transferred to 1:50 000 scale photos for use in production of the 1:50 000 scale map accompanying this report (Map AR90-1, in pocket).

Deposit reserves were obtained by multiplying area by proven aggregate depths; sterilization and depletion factors were taken into account.

Previous Works

The surficial geology of the area has been mapped at a scale of 1:126 700, and the glacial history outlined, by Elson (1956, 1961) as part of a regional study of southwestern Manitoba - southeastern Saskatchewan. The soils were mapped by Eilers *et al.* (1978) at scales of 1:20 000 and 1:40 000, and bedrock geology has been mapped by Bannatyne (1970) and Bamburak (1978). A map of the bedrock topography at a scale of one inch to eight miles has been produced by Klassen *et al.* (1970).

Acknowledgements

Linda Elias provided able field assistance. Dave McShane drafted the map and figures and Shirley Weselak typed the manuscript.

BEDROCK GEOLOGY

The bedrock geology of the area is illustrated in Figure 2. The northern part of the area is underlain by upper Cretaceous marine shale of the Riding Mountain Formation. The Odanah member is a hard grey siliceous shale that outcrops in roadcuts in the northwestern corner of the R.M. of Winchester. The overlying Coulter member, a silty shale, was not seen in outcrop.

The southern part is underlain by sedimentary rocks of the Boissevain and Turtle Mountain formations (Bamburak, 1978). The upper Cretaceous Boissevain Formation is primarily fine grained sandstone; the crossbedded facies is well exposed in ravine cuts along Highway 3 southeast of Boissevain. The overlying Tertiary Turtle Mountain Formation is generally unconsolidated interbeds of sand, silt

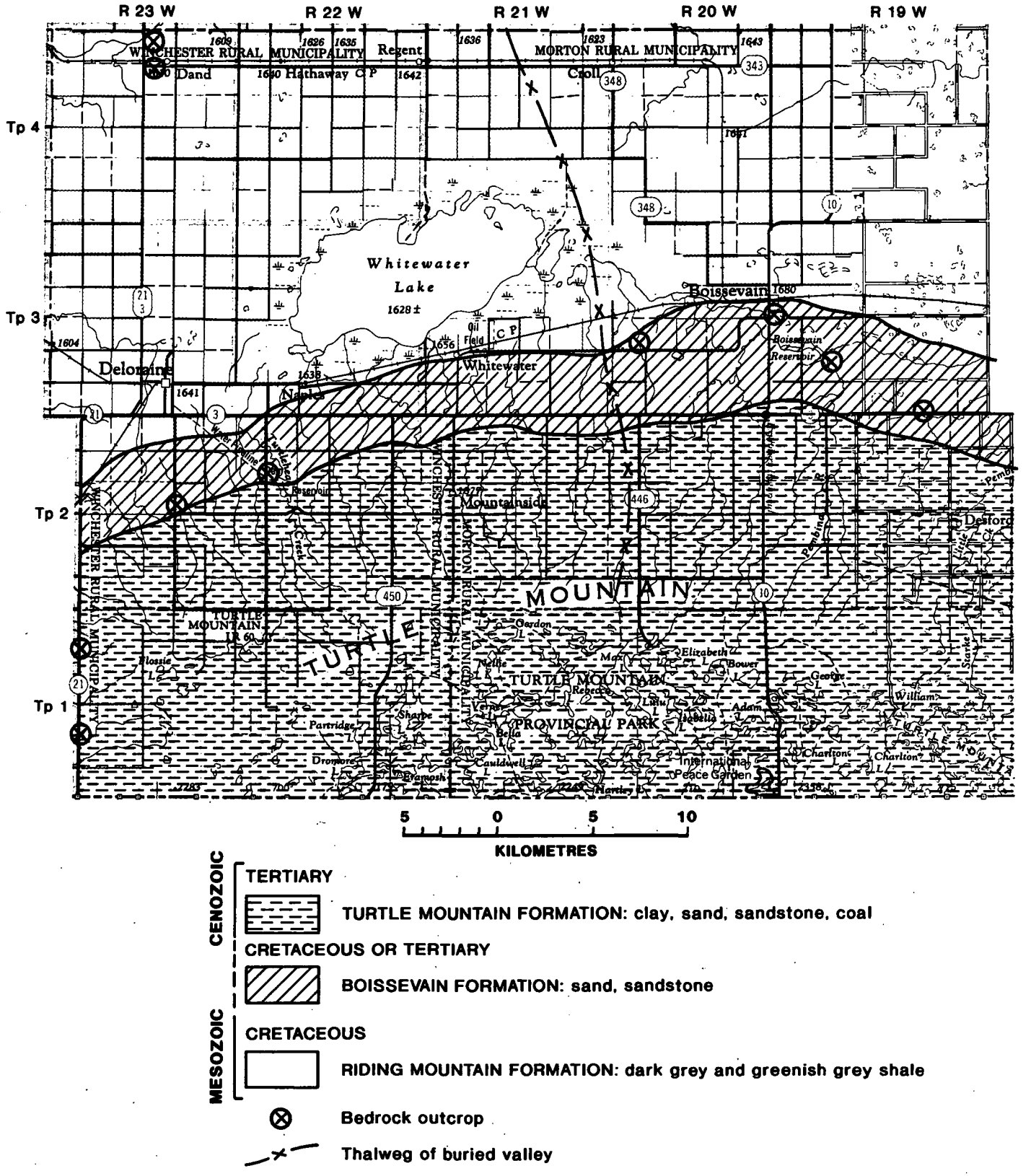

Figure 2: Generalized bedrock geology.

and clay. The Goodlands and overlying Peace Garden members of the Turtle Mountain Formation outcrop along the west side of Turtle Mountain.

LATE GLACIAL HISTORY

A generalized map of the surficial sediments in the region is given in Figure 3. The surface till was deposited by southeastward-flowing ice during the Late Wisconsinan. During deglaciation, the ice overlying Turtle Mountain stagnated resulting in the present day knob and kettle topography. As the active ice on the surrounding plain retreated to the northwest, meltwater ponded between the ice front and Turtle Mountain, and formed a small glacial lake in the Whitewater Lake basin. This lake first drained eastward through channels south of Boissevain. Ice retreat opened lower outlets west of the study area and the lake drained westward into Glacial Lake Souris (Elson, 1956, 1961). The major gravel deposits in the Winchester-Morton area were formed by streams flowing off Turtle Mountain carrying meltwater from the stagnating ice sheet. Most streams deposited alluvial fans at the base of the mountain, but Turtlehead Creek flowed into Whitewater Lake and formed a small delta at its mouth.

AGGREGATE RESOURCES

Introduction

Sand and gravel resources of the Winchester-Morton area occur in ice-contact and meltwater stream deposits scattered primarily across the southern part of the area.

Deposit and sample locations are shown on Map AR90-1 (in pocket). Information about the deposits is presented in summary tables in the text and in detail in the appendices.

Table 1 summarizes status, composition, reserves and site specific information for each deposit. Table 2 summarizes grain size data for all samples. Detailed sieve results are given in Appendix B. Pebble lithology of the 3/4"-1 1/2" (1.9-3.8 cm) fraction and per cent deleterious in each sample is presented in Appendix C. Appendix D presents gravel pit descriptions and logs of the backhoe test pits. Appendix E summarizes aggregate information contained in Manitoba Department of Highways Block Files. Appendix A shows the size limits of granular descriptive terms (e.g. sandy fine pebble gravel) used in the text and tables. Table 3 shows the reserve figures by deposit and material type.

Aggregate Deposits

Ice-contact deposits: map unit 4

Ice contact deposits (Nos. 11705-11714, 11716 and 11734) comprise < 15% of the aggregate reserves in the area and occur as isolated hummocks within the stagnation moraine (map unit 2b). Turtle Mountain Provincial Park occupies most of this area, but several small pits have been opened west and north of the Park.

The deposits are variable in extent, depth and quality of gravel. Depth and quality range from more than 8 m of well sorted sandy pebble gravel at HB 745 to < 4 m poorly sorted gravel under 2 m of till at HB 717. The high shale content and limited volume of gravel as well as the discontinuity of the gravel beds make them uneconomic except as secondary aggregate sources, used primarily to meet local needs.

Meltwater stream deposits: map unit 5

Meltwater stream deposits (11701-11704, 11715 and 11717-11733) are the most important source of aggregate. They contain more than 85% of the area's gravel reserves and in general the material in the deposits is more laterally continuous, more uniform in grain size and coarser than that in the ice contact deposits. For these reasons, there are large pits in most deposits; several have been mined to depletion. Deposits 11703, 11704, 11719 and 11725 are the primary current aggregate producers.

Aggregate Supply

There are 7083.2 x 10^3 cubic metres of aggregate reserves in the Winchester-Morton area. Of these, 3500.8 x 10^3 m^3 are in the R.M. of Winchester and 3582.4 x 10^3 in the R.M. of Morton.

Conclusions

Aggregate deposits in the R.M.'s of Winchester and Morton are widely scattered over the southern part of the area. Most deposits tend to be of limited extent and are composed of shaley, fine grained gravel. Therefore, the large, coarse grained deposits in 1-19W and 1-23W are more important to the local gravel industry than the quality of the aggregate and their isolated locations would indicate. In addition, the shale content makes many of the deposits unsuitable sources of aggregate for certain uses such as concrete production (Fig. 4). The result of these two factors is that some aggregate is imported into the area annually. However, the major portion of the area's aggregate needs will continue to be met by deposits within these municipalities.

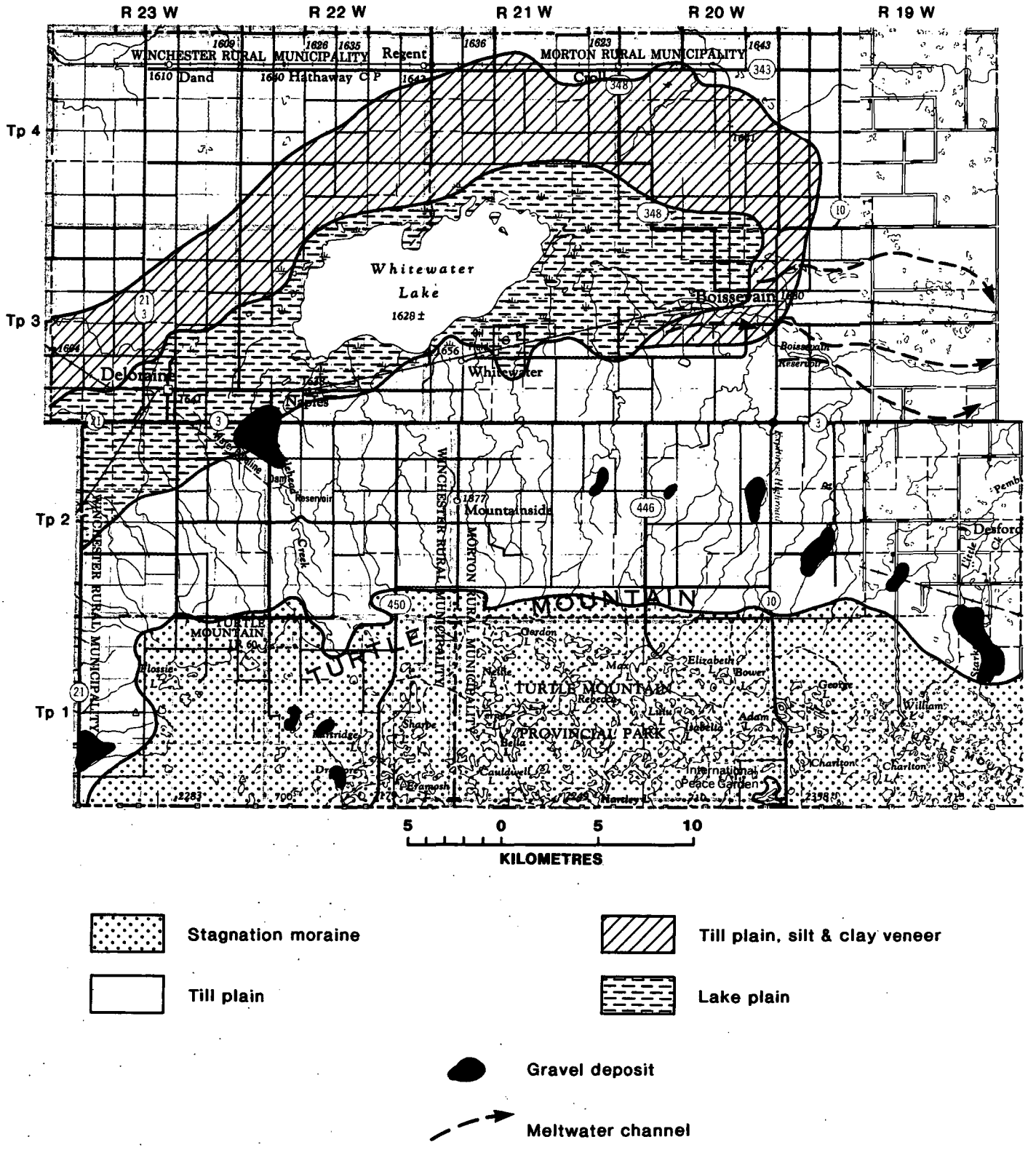

Figure 3: Surficial geology of the R.M.'s of Winchester and Morton; modified from Elson (1961).

TABLE 1
Aggregate Deposits in the Winchester-Morton Area

Deposit Number	Site Number s=sample[1]	Gravel Pit Status	Percent Stone ≥ #4	% Lithology Precambrian	Carbonate	Sandstone	Shale	Concretions	Estimated Reserves (000's m^3)	Comments
11701	HG920	Abandoned							51.3	Pit revegetated, near depletion; deposit is coarse sand, some pebble beds; high shale.
11702	HG921	Abandoned							38.0	Pit revegetated, near depletion; 2 m very sandy pebble gravel.
11703	HG925s	Active	31	32	58	2	2	6	1475.9	Active pit (HG925) is 4.5 m sandy pebble gravel with additional 3 m
	HB762									
	HB763			26	50	0	16	8		sand under pit floor to water table.
	HB764s		38	29	58	0	6	7		Deposit is very coarse in west and
	HB765									south portions (high percentage of.
	HB766			44	44	0	12	0		cobbles and gravel depths vary
	HB767			39	43	6	4	15		from 2.8 m over till to >4 m.
	HB768			44	44	4	4	4		
	HB769			19	56	1	12	12		
	HB770s		50	31	60	1	2	6		
	HB771			45	35	7	7	6		
	HB772									
11704	HG930s	Active	30	33	51	2	9	5	1130.7	Active pit (HG930) is 4 m deep,
	HG931									predominantly sandy fine pebble
	HG932s	Inactive	36	21	56	9	5	9		gravel with some small cobbles.
	HB747									The deposit is 2 - 3 m pebble gravel
	HB748									over bedrock in southeast; depleted
	HB749									and/or sand in SSE36; 1 - 4 m
	HB750									pebble gravel over silt or till in
	HB751s		26	30	50	2	15	3		W 1/2 36.
	HB752s		18	39	51	0	9	1		
	HB753									
	HB754									
	HB756									
	HB757									
	HB758									
	HB759s		29	35	47	3	8	7		

1 HB prefix indicates backhoe test pit in deposit outside of pit area.

11705	HG922	Abandoned							1.3	Pit depleted; cobble pile on site.
11706	HG923s	Active	16	37	52	1	2	8	25.0	Pit used on intermittant basis; 3.5 m sandy pebble gravel.
11707	HG924	Abandoned							6.0	Pit depleted; remaining reserves are very sandy fine pebble gravel. " Waste piles on site contain 2" up to small cobble sized material.
11708	HG948								15.8	Bulldozer test site showing 2 m very sandy pebble gravel; low shale.
11709	HB726s HB727 HB728 HB729 HB730		45	29	62	1	6	2	67.5	Unopened deposit. Gravel depths vary from 1.5 m over till to >3.5 m. Material is usually coarse pebble gravel with cobbles and moderate shale content.
	HB731s HB732 HB733 HB734		49	35	55	0	5	5		
11710	HG947	Active		39	56	0	3	2	78.4	Extensive shallow pits depleted in south and recently active at north end. Bulldozer test pits show 2-3 m sandy pebble gravel, limited by water table.
11711	HB743 HB744								37.5	Unopened deposit; >3 m very sandy fine pebble gravel; high shale and low stone content.
11712	HG951s	Active	30	15	58	0	27	0	66.5	Pit used on intermittant basis; material ranges from fine pebble gravel to silt and clay beds. Sampled wall is 5 m of very shaley sandy pebble gravel.
11713	HG926s		27	30	53	5	9	3	438.1	Deposit is 1.5 - 3 m of very sandy fine pebble gravel overlying sand; high shale content; largely sterilized by road and buildings. Pit HB745 is >8 m of sandy pebble gravel.
	HG950s HB735 HB736 HB737 HB738	Inactive	20	16	55	2	25	2		
	HB739s HB740		26	28	43	0	26	3		

	HB741s		27	15	42	0	41	2		
	HB742									
	HB745s	Inactive	28	22	67	0	9	2		
	HB746			30	26	0	41	3		
11714	HG957	Abandoned							11.3	Pit near depletion; remaining material is very sandy.
11715	HG945s	Inactive	14	34	35	5	22	4	50.0	Old pit in recent use; 1.5 m very sandy pebble gravel over sand and till.
11716	HG927s	Active	18	30	62	1	4	3	163.5	Gravel under 2 - 3 m of till.Pit in recent use; depth of pit varies up to 10 m; material is predominantly interbedded pebble gravel, sand and silt.
	HT008A			17	63	3	13	4		
11717	HB718								151.3	Deposit is gravel ridge flanked by <3 m sand over silt or till.Gravel in ridge is 3 m thick at south end and thins to <5 m at north end.
	HB719									
	HB720									
	HB721									
	HB722									
	HB723									
	HB724s		26	38	58	1	1	2		
	HB725									
11718	HB929	Abandoned							46.5	Extensive pit, revegetated; <1 m of sandy material remaining.
11719A	HB667s		23	33	58	0	6	3	689.5	Large revegetated pit in south part of deposit; north half is unopened. Material is 1 - >2.5 m sandyrlying pebble gravel overlying till or clay. Most holes stopped at water table at approximately 2.5 m.
	HB668									
	HB669									
	HB670s		40	39	55	2	5	1		
	HB671									
	HB672									
	HB673									
	HB674									
	HB675									
	HB676									
	HB677									
	HB678									
11719B	HG938s	Active	21	30	60	3	2	5	202.5	Large shallow pit (HG938) recently active at north end; face 1.5 m with additional metre of coarse pebble gravel below base of pit, limited by water table. North of pit, deposit is
	HB666									
	HB679									
	HB680									
	HB681s		23	38	49	6	7	0		

										2 - 3 m very sandy pebble gravel to water table.
11720	HB664								23.0	<1.5 m sandy coarse pebble gravel.
11721A	HB716	Abandoned							154.7	Revegetated pit; below base is 2-3 m very sandy fine pebble gravel with high shale; water table at 2 m. Pit on north side of road is depleted.
11721B	HG943s	Inactive	31	38	55	1	4	2	132.9	Shallow, extensive pit; material is poorly sorted and ranges from coarse sand to cobbles. Stockpiles on site.
11722	HB684s		24	43	52	1	3	1	124.2	Deposit is unopened in north. Material is 2 - 3 m sandy pebble gravel thinning to <1 m to the east. Pit south of roadline is revegetated and depleted. Test hole (HB698) north of pit is 2.5 m very sandy fine pebble gravel.
	HB685									
	HB688									
	HB693									
	HB694			40	56	0	4	0		
	HB695s		24	37	50	2	7	4		
	HB696									
	HB697	Abandoned		49	48	0	2	1		
	HB698			41	52	0	7	0		
	HB692			41	48	0	9	2		
11723	HG944	Active							76.8	Predominantly sand; some beds of pebbly sand.
11724	HG958	Abandoned							26.2	Pit near depletion; remaining material is very sandy fine gravel.
11725	HG939	Abandoned							1312.3	Deposit is very coarse at south end. Much of the material has been removed and there are large crushed stockpiles on site; remover on site. Deposit is finer and sandier tonorth. Seam of clea pebble gravel runs through farmstead at north end of deposit.
	HG940s	Active	31	27	55	2	4	12		
	HG941s	Active	24	20	71	2	6	1		
	HG942	Inactive								
	HB699									
	HB700									
	HB701									
	HB702s		40	22	72	2	2	2		
	HB703s		24	17	70	2	8	3		
	HB704			37	56	1	3	3		
	HB705s		30	23	67	1	3	6		
	HB706									
	HB707									
	HB709									
	HB712									
	HB714									

	HB715									
11726	HG936	Abandoned							2.0	Revegetated pit; remaining material is coarse sand, some pebble beds.
11727	HG937s	Inactive	31	39	57	1	2	1	50.0	Old pit, intermittant usage; material ranges from fine pebble gravel to sand and till.
11728	HG933	Abandoned							1.8	Revegetated pit; backhoe test at base shows 1.8 m coarse sand.
11729	HG934s	Active	30	17	56	2	25	0	41.6	Pit 2 m deep, recently active at y west end; sandy fine pebble gravel; water table at pit floor.
11730	HG954								33.7	Dugout - 2 m sandy very fine pebble gravel; gravel continues below water table.
11731	HG953								312.9	Deposit mainly sand. Hand dug hole is >1 m very sandy fine pebble gravel over sand.
11732	HG952	Abandoned							10.0	Very old, depleted pit; material is pebbly sand with very high shale content.
11733	HG935	Inactive							7.5	Large shallow pit; <2 m pebble gravel; near depletion.
11734	HB717s	Active	31						27.0	Recently active pit; material ranges from clay to coarse pebble gravel with cobbles; high shale. Pit depth is 3 m; backhoe test pit at base shows 1.6 m pebbly sand limited by water table.
					TOTAL ESTIMATED RESERVES				7083.3	

TABLE 2: Summary of Grain Size Distribution of Gravel Samples

Deposit Number	Sample Number	% Gravel (># 4) (>4.76 mm)	% Sand (4.76 mm - 0.07 mm)	% Silt and Clay (<0.07 mm)	Crushable on Site + Yes/- No
11703	HG925	30.9	64.8	4.4	+
	HB764	37.7	56.8	5.5	+
	HB770	50.3	45.4	4.3	+
11704	HG930	29.8	67.4	2.8	+
	HG932	36.3	59.9	3.8	-
	HB751	26.0	69.2	4.8	+
	HB752	18.4	76.6	5.0	-
	HB759	29.4	65.5	5.1	+
11705	HG923	16.4	77.9	5.7	+
11709	HB726	44.6	49.0	6.4	+
	HB731	48.6	46.3	5.1	+
11712	HG951	29.7	67.1	3.2	+
11713	HG926	27.0	66.6	6.4	-
	HG950	20.1	75.8	4.1	-
	HB739	26.2	70.0	3.8	-
	HB741	27.2	69.3	3.5	-
	HB745	28.3	67.4	4.3	-
11715	HG945	13.7	81.9	4.4	-
11716	HG927	18.0	74.6	7.4	+
11717	HB724	26.0	68.6	5.4	-
11719A	HB667	22.5	72.2	5.3	-
	HB670	39.6	55.6	4.8	+
11719B	HG938	21.1	66.2	12.7	-
	HB681	23.3	70.1	6.6	-
11721B	HG943	31.2	61.6	7.2	+
11722	HB684	23.8	69.2	7.0	+
	HB695	24.0	67.7	8.3	-
11725	HG940	30.5	64.6	4.9	+
	HG941	24.1	72.4	3.5	+
	HB702	39.8	54.7	5.5	-
	HB703	23.9	48.6	27.5	-
	HB705	29.8	65.0	5.2	-
11727	HG937	30.8	64.3	4.9	-
11729	HG934	30.0	64.3	5.7	-
11734	HB717	31.3	63.9	4.8	-
	HB661	44.4	50.7	4.9	-

TABLE 3

Aggregate Reserves in the R.M.'s of Winchester and Morton

Deposit Type	Sand and Gravel ('000 m^3)	Sand or Minor Reserves around abandoned pits ('000 m^3)	Total ('000 m^3)
Ice Contact			
Winchester	691.3	56.1	747.4
Morton	190.5	76.8	267.3
			1014.7
Meltwater Stream			
Winchester	2656.6	96.8	2753.4
Morton	2761.0	554.1	3315.1
			6068.5
	6299.4	783.8	7083.2

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"										"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	Fines	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. 2.3-3.1			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	

Figure 4: Manitoba Highways and Transportation aggregate grade specifications.

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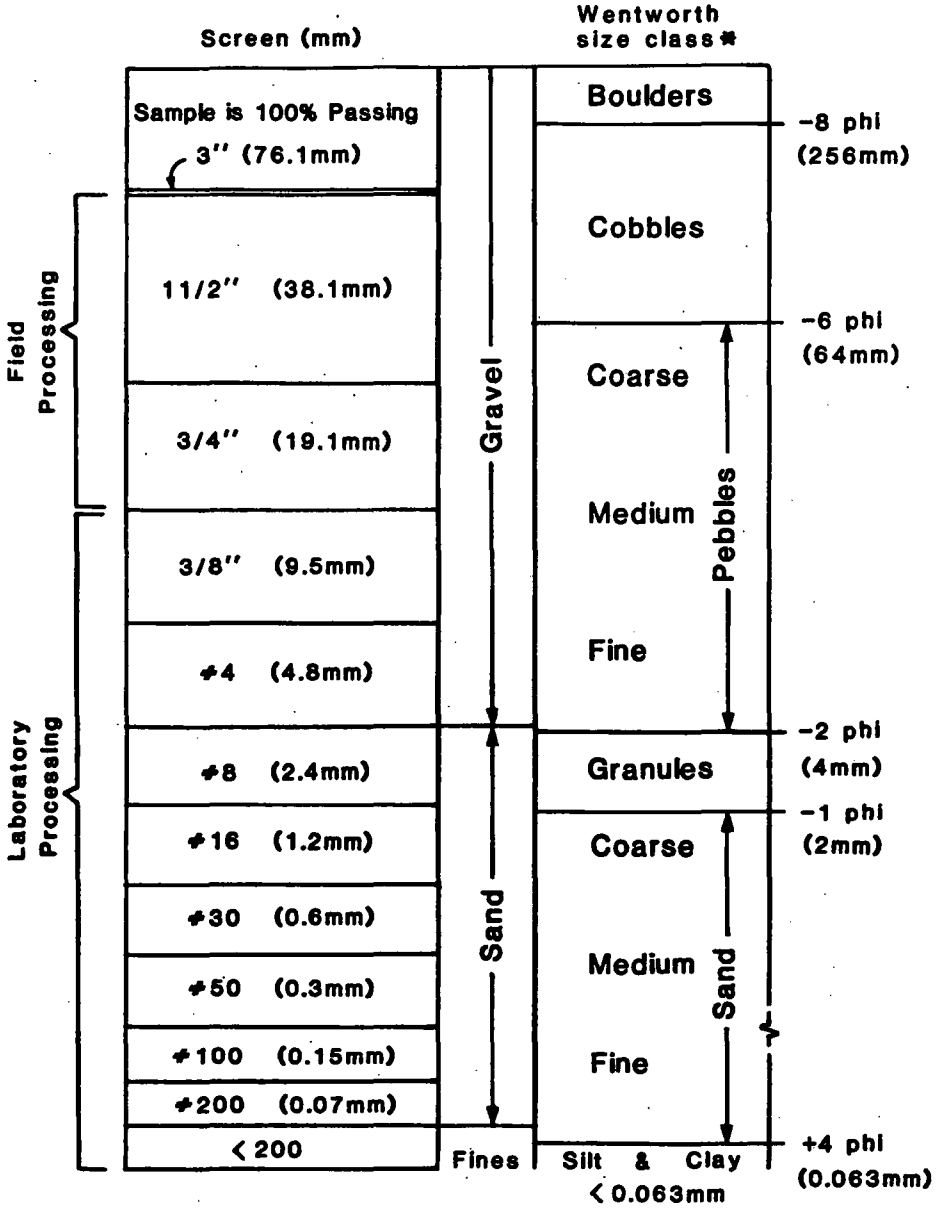
APPENDIX A



* modified from Folk, 1974

APPENDIX B

Detailed Sample Sieve Data

Deposit Number		11703	11703	11703	11704	11704
Sample Number		HG925	HB764	HB770	HG930	HG932
Crushable (>10 cm)		X	X	X	X	-
%	1 1/2"	95	91	90	96	94
	3/4"	89	80	74	90	83
P	3/8"	79	73	61	80	74
A	#4	69	62	50	70	64
S	#8	59	52	41	60	53
S	#16	47	41	31	49	41
I	#30	30	29	23	37	28
N	#50	14	16	13	19	14
G	#100	7	8	6	6	6
	#200	4	5	4	3	4

Deposit Number		11704	11704	11704	11705	11709
Sample Number		HB751	HB752	HB759	HG923	HB726
Crushable (>10 cm)		X	-	X	X	X
%	1 1/2"	97	99	96	97	94
	3/4"	91	95	89	95	79
P	3/8"	82	91	79	92	66
A	#4	74	82	71	84	55
S	#8	65	69	62	73	43
S	#16	54	54	51	60	31
I	#30	40	38	38	46	20
N	#50	20	21	22	27	11
G	#100	8	9	9	11	8
	#200	5	5	5	6	6

Deposit Number		11709	11712	11713	11713	11713
Sample Number		HB731	HG951	HG926	HG950	HB739
Crushable (>10 cm)		X	X	-	-	-
%	1 1/2"	89	100	97	100	99
	3/4"	76	99	93	99	97
P	3/8"	60	88	84	91	87
A	#4	51	70	73	80	74
S	#8	42	55	60	67	59
S	#16	30	39	48	52	44
I	#30	20	24	34	38	29
N	#50	11	11	17	19	12
G	#100	6	5	8	6	5
	#200	5	3	6	4	4

x - present

- = not present

	Deposit Number	11713	11713	11715	11716	11717
	Sample Number	HB741	HB745	HG945	HG927	HB724
	Crushable (>10 cm)	-	-	-	X	-
%	1 1/2"	100	100	100	97	96
	3/4"	97	93	98	93	91
P	3/8"	85	84	93	88	84
A	#4	73	72	86	82	74
S	#8	60	58	75	76	63
S	#16	44	44	56	69	51
I	#30	31	30	36	61	39
N	#50	14	13	16	40	22
G	#100	5	6	6	15	8
	#200	4	4	4	7	5

	Deposit Number	11719A	11719A	11719B	11719B	11721B
	Sample Number	HB667	HB670	HG938	HB681	HG943
	Crushable (>10 cm)	-	X	-	-	X
%	1 1/2"	96	96	99	99	94
	3/4"	92	85	95	95	87
P	3/8"	85	74	87	88	81
A	#4	78	60	79	77	69
S	#8	67	47	70	65	57
S	#16	56	35	60	53	47
I	#30	43	25	48	39	35
N	#50	21	14	28	21	19
G	#100	8	7	16	9	10
	#200	5	5	13	7	7

	Deposit Number	11722	11722	11725	11725	11725
	Sample Number	HB684	HB695	HG940	HG941	HB702
	Crushable (>10 cm)	X	-	X	X	-
%	1 1/2"	98	99	98	98	96
	3/4"	92	94	89	92	86
P	3/8"	87	85	82	84	73
A	#4	76	76	70	76	60
S	#8	65	65	56	63	49
S	#16	52	52	43	49	38
I	#30	40	40	31	36	28
N	#50	24	24	16	16	15
G	#100	11	12	8	6	7
	#200	7	8	5	3	5

x - present

- = not present

Deposit Number		11725	11725	11727	11729	11734
Sample Number		HB703	HB705	HG937	HG934	HB717
Crushable (>10 cm)		-	-	-	-	-
%	1 1/2"	97	97	98	100	95
	3/4"	90	89	91	93	89
P	3/8"	84	80	81	83	81
A	#4	76	70	69	70	69
S	#8	69	61	57	57	57
S	#16	61	51	44	45	42
I	#30	54	39	30	30	27
N	#50	42	23	16	14	12
G	#100	31	9	7	8	6
	#200	27	5	5	6	5

Deposit Number		
Sample Number		HB661
Crushable (>10 cm)		-
%	1 1/2"	96
	3/4"	81
P	3/8"	69
A	#4	56
S	#8	42
S	#16	30
I	#30	21
N	#50	12
G	#100	6
	#200	5

x - present

- = not present

APPENDIX C

Pebble Lithology and Deleterious Content of Samples

Deposit Number	Sample Number	% Lithology of 3/4" - 1 1/2" fraction						%
		Precambrian						Encrusted/
		Crystalline	Volcanic	Carbonate	Sandstone	Shale	Concretions	Cemented
11703	HG925	26	6	58	2	2	6	8
	HB763	20	6	50	0	16	8	5
	HB764	28	1	58	0	6	7	4
	HB766	39	5	44	0	12	0	10
	HB767	31	1	43	6	4	15	6
	HB768	40	4	44	4	4	4	15
	HB769	18	1	56	1	12	12	20
	HB770	31	0	60	1	2	6	16
	HB771	42	3	35	7	7	6	5
11704	HG930	26	7	51	2	9	5	2
	HG932	12	9	56	9	5	9	45
	HB751	28	2	50	2	15	3	4
	HB752	37	2	51	0	9	1	5
	HB759	34	1	47	3	8	7	30
11706	HG923	20	17	52	1	2	8	7
11709	HB726	29	0	62	1	6	2	9
	HB731	33	2	55	0	5	5	14
11712	HG951	15	0	58	0	27	0	5
11713	HG926	24	6	53	5	9	3	36
	HG950	15	1	55	2	25	2	26
	HB739	27	1	43	0	26	3	30
	HB741	15	0	42	0	41	2	32
	HB745	21	1	67	0	9	2	20
11715	HG945	30	4	35	5	22	4	45
11716	HG927	25	5	62	1	4	3	0
11717	HB734	37	1	58	1	1	2	10
11719A	HB667	30	3	58	0	6	3	3
	HB670	33	6	55	2	5	1	0
11719B	HG938	20	10	60	3	2	5	15
	HB681	36	2	49	6	7	0	9
11721B	HG943	32	6	55	1	4	2	18
11722	HB684	38	5	52	1	3	1	1
	HB695	33	4	50	2	7	4	0
11725	HG940	21	6	55	2	4	12	49
	HG941	16	4	71	2	6	1	14
	HB702	20	2	72	2	2	2	6
	HB703	16	1	70	2	8	3	43
	HB705	21	2	67	1	3	6	30

11727	HG937	36	3	57	1	2	1	1
11729	HG934	11	6	56	2	25	0	57
11734	HB717	29	0	58	0	11	2	17
No deposit	HB661	44	1	45	1	7	2	27
No deposit	HT008	13	4	63	3	13	4	1

APPENDIX D

Backhoe Test Pit Logs and Gravel Pit Descriptions

Deposit Number	Site Number s=sample	Site Description
11701	HG920	Pit revegetated; 2 m deep, coarse sand, some pebble beds remain.
11702	HG921	Pit revegetated; 2 m deep, near depletion; sandy fine pebble gravel.
11703	HG925s	Active pit; 4.5 m deep; sandy fine pebble gravel;waste piles of 2" and up. Backhoe test pit at base: 4.5 - 5.0 m sandy fine pebble gravel. 5.0 - 7.5 m coarse sand fining to silty sand at base >7.0 m water table
	HB762	0.0 - 2.8 m sandy coarse pebble gravel with cobbles >2.8 m till.
	HB763	0.0 ->4.0 m sandy pebble gravel, high shale content.
	HB764s	0.0 ->3.6 m sandy coarse pebble gravel-cobbles and small boulders; high shale content.
	HB765	0.0 ->2.4 m sandy coarse pebble gravel.
	HB766	0.0 ->2.8 m sandy pebble gravel,small boulders.
	HB767	0.0 - 3.0 m sandy coarse pebble gravel,bouldery at surface. >3.0 m water table.
	HB768	0.0 ->2.8 m sandy coarse gravel becoming pebble gravel to base.
	HB769	0.0 - 2.0 m sandy coarse pebble gravel. 2.0 ->2.2 m silty sand.
	HB770s	0.0 ->3.3 m sandy coarse pebble gravel, cobbles and small boulders.
	HB771	0.0 ->2.7 m sandy pebble gravel;cobbly at base.
	HB772	till
11704	HG930	Active pit, revegetated at south end;2.5 to 4 m deep; sandy fine pebble gravel interbedded with coarse sand; waste piles of >3".
	HG931	0.0 - 2.0 m fine sand. >2.0 m till.
	HG932s	Inactive pit; 3.5 m deep; sandy fine pebble gravel backhoe test pit at base: 3.5 - 4.3 m sandy coarse pebble gravel; 4.3 - 4.6 m till; >4.6 m bedrock.
	HB747	0.0 - 1.0 m sand. 1.0 - 2.5 m very sandy coarse pebble gravel. 2.5 ->2.7 m silt.

	HB748	0.0 - 3.0 m sandy fine pebble gravel >3.0 m till.
	HB749	0.0 ->2.8 m test hole fines downward from fine sand to silty clay at base.
	HB750	0.0 ->3.0 m very sandy fine pebble gravel;coarse sand matrix.
	HB751s	0.0 - 0.8 m fine sand. 0.8 ->3.8 m very sandy fine pebble gravel, some cobbles and interbeds of coarse sand.
	HB752s	0.0 - 3.0 m very sandy fine pebble gravel. 3.0 ->3.2 m till and water table.
	HB753	0.0 - 1.4 m sandy fine pebble gravel. >1.4 m till.
	HB754	0.0 - 0.3 m sandy fine pebble gravel. >0.3 m till.
	HB756	0.0 ->2.5 m sandy pebble gravel.
	HB757	0.0 - 1.8 m sandy pebble gravel. 1.8 ->2.0 m bedrock.
	HB758	0.0 - 1.8 m sandy coarse pebble gravel. >1.8 m bedrock.
	HB759s	0.0 - 2.3 m sandy coarse pebble gravel with cobbles. 2.3 ->2.6 m bedrock.
	HB760	0.0 - 1.8 m sandy coarse pebble gravel. >1.8 m bedrock.
11705	HG922	Abandoned pit, depleted; waste piles of >2" to small cobbles.
11706	HG923s	Small pit, north end recently used; 3.5m sandy pebble gravel.
11707	HG924	Abandoned pit, depleted; waste piles of >2" to small cobbles.
11708	HG948	Bulldozer test pit; >2m sandy pebble gravel, very high sand content.
11709	HB726s	0.0 - 1.6 m sandy coarse pebble gravel with cobbles. 1.6 ->2.5 m till.
	HB727	0.0 - 0.5 m sandy pebble gravel. 0.5 ->2.5 m till.
	HB728	0.0 - 2.5 m sandy coarse pebble gravel with cobbles. 2.5 ->2.7 m till.
	HB729	0.0 - 1.5 m very sandy coarse pebble gravel with cobbles. >1.5 m till.
	HB730	0.0 - 1.5 m sandy cobbly coarse pebble gravel. >1.5 m till.
	HB731s	0.0 ->3.2 m sandy coarse pebble gravel.

	HB732	0.0 - 0.3 m sandy fine pebble gravel. >0.3 m till.
	HB733	0.0 - 2.5 m sandy coarse pebble gravel with cobbles. >2.5 m till.
	HB734	0.0 - 1.6 m sandy coarse pebble gravel. >1.6 m till.
11710	HG947	Large pits, depleted in south and north end recently active; 2 - 3 m sandy pebble gravel; till floor or water table limits pit depth in most areas.
11711	HG743	0.0 ->2.8 m very sandy fine pebble gravel, high shale content.
	HB744	0.0 - 1.8 m very sandy fine pebble gravel. >1.8 m till.
11712	HG951s	Active pit; material varies from silt to pebble gravel and depths of 2 - 5 m; very high shale content.
11713	HG926s	0.0 - 3.0 m very sandy fine pebble gravel. >3.0 m silty sand, water table.
	HG950s	Inactive pit; 2m deep, sandy fine pebble gravel at top, becomes sandier to base.
	HB735	0.0 - 1.5 m sandy fine pebble gravel. 1.5 -1>.8 m fine sand.
	HB736	0.0 - 1.8 m sandy fine pebble gravel. 1.8 - 2.0 m fine sand grading into silt. 2.0 ->3.0 m interbedded silt and clay.
	HB737	0.0 - 1.8 m very sandy fine pebble gravel. 1.8 - 3.0 m fine sand. >3.0 m silt.
	HB738	0.0 - 3.0 m very sandy fine pebble gravel becoming finer to base. >3.0 m fine sand.
	HB739s	0.0 - 2.3 m sandy fine pebble gravel. 2.3 ->2.9 m fine sand.
	HB740	0.0 - 2.1 m very sandy fine pebble gravel. 2.1 ->2.9 m fine sand.
	HB741s	0.0 - 2.8 m very sandy fine pebble gravel. >2.8 m pebbly sand.
	HB742	0.0 - 2.8 m very sandy fine pebble gravel. >2.8 m fine sand.
	HB745s	Active pit in side of hill; ~5m deep, sandy pebble gravel with high shale content. backhoe test pit at base: >3 m sandy pebble gravel becoming coarser to base.

APPENDIX E

Manitoba Department of Highways Block File Data

Deposit Number	Block File Number	Location	Inventory Type P=pit B=backhoe	Number of Holes	Number of Samples	% Stone > #4	Comments/ End Use
11701	2	LS14-32-4-23W	P	1	1	24	C base.
11702	2	LS5-19-4-23W	P	1	1	20	Dep't pit; pit run
11703	2	NW7-1-23W	P	1	1	40	Dep't pit in LS11 is depleted
11704	2	NW36-2-23W	B	22	22	15-30	Dep't pit(LS1&8) is near depletion traffic, A base, seal coat, bituminous
		NE36-2-23W	P,B	39	39	14-30	
		SW31-2-22W	P	1	1	32	
11705	2	SE27-1-23W	P	1	1	45	Traffic gravel
11706	2	LS2-26-1-23W	P	2	2	-	
11707	2	LS2-25-1-23W	P	3	2	10,25	
11710	2	LS1-17-1-22W	P	5	5	35-42	Pit run, traffic
11715	2	NW26-2-22W	P	2	1	14	Pit run
11716	3	LS14-6-2-21W	P	3	3	13,14 42	C base,pit run, traffic
11718	3	NE19-2-20W	P	4	4	18-23	Traffic, pit run
		SE2-2-20W	B	4	4	14-25	
11719	3	SE22-2-20W	P	7	7	18-29	Traffic, pit run
11721	3	W12-2-20W	P	7	7	24-46	A base, seal coat, traffic
		NE12-2-20W	B	2	2	29,30	
		SE13-2-20W	P	4	4	29-48	
11723	3	NE34-1-19W	P	1	1	39	
11724	3	SE27-1-19W	B	10	4	36-39	
		SW26-1-19W	P	3	3	17-36	
11725	3	NNE23-1-19W	B	25	23	27-60 av=40	Crown gravel
		NW25-1-19W	B,P	8	7	15-43 av=30	
		SNE26-1-19W	B	16	11	31-57 av=39	
		NE26-1-19W	B	15	14	20-52 av=35	

		SE26-1-19W	P	5	5	35-41 av=37	Bituminous, pit run, traffic
		Sec35-1-19W	P,B	28	5	23-38 av=32	Traffic
		SE36-1-19W	B	21	17	23-36 av=27	
11726	3	NE12-3-19W	P	5	5	16-50 av=30	
11727	3	NW14-3-19W	P	3	3	18,26, 32	Traffic, pit run
11728	3	NW28-3-19W	P	2	2	3,10	
11733	3	NW24-3-19W	P	3	3	16,27 45	

APPENDIX F

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.