Aggregate Report AR92-4

Aggregate Resources in the Rural Municipality of Minitonas

by H.D. Groom

Manitoba
Energy and Mines
Mines Branch

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Winnipeg, 1993

Energy and Mines

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MAP

Map AR92-4: Surficial geology and aggregate deposits in the R.M. of Minitonas, 1:50 000 . . . . . in pocket

INTRODUCTION

OBJECTIVES

An aggregate resource inventory was carried out during the summer of 1991 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 R.M. of Minitonas encompasses 1181 km^2 that lie within Townships 35-38 and Ranges 24-27W in western Manitoba (Fig. 1). It is included on six 1:50 000 map sheets in NTS areas 63C/2,3,6 and 7, and 62N/14 and 15.

The area is primarily a farming district and the town of Minitonas is the major service centre. Highway 10, PR 366 and a network of gravelled Provincial Roads and section roads provide good access to most parts of the area; however, there are few roads and limited access in the north east, where the terrain is very swampy, and in the south east within the area of the Duck Mountain Provincial Forest.

PHYSIOGRAPHY

The area has two major physiographic divisions: the Duck Mountain uplands in the south; and the Swan Valley Plain in the north.

The Duck Mountain upland rises to elevations of 610 m above sea level (a.s.l.) within the municipality and is formed of bedrock overlain by more than 100 m of Quaternary sediments (Little and Sie, 1976). The surface is hummocky stagnation moraine; till knolls, 5-10 m high, are separated by low areas most commonly containing sloughs or lakes. Drainage is generally disorganized although the Duck and the East and West Favel rivers all rise in this area.

The Duck Mountain upland is separated from the Swan Valley Plain by a steep escarpment that, on average, rises 100 m in less than 2 km. In this area, river valleys can be 10 to 15 m deep and are commonly cut into bedrock.

The Swan Valley Plain has a gentle north east slope, falling from 335 m a.s.l. at the western municipal boundary to below 280 m a.s.l. in the north. The plain comprises fine sand and silt in the south west; these sediments give way to

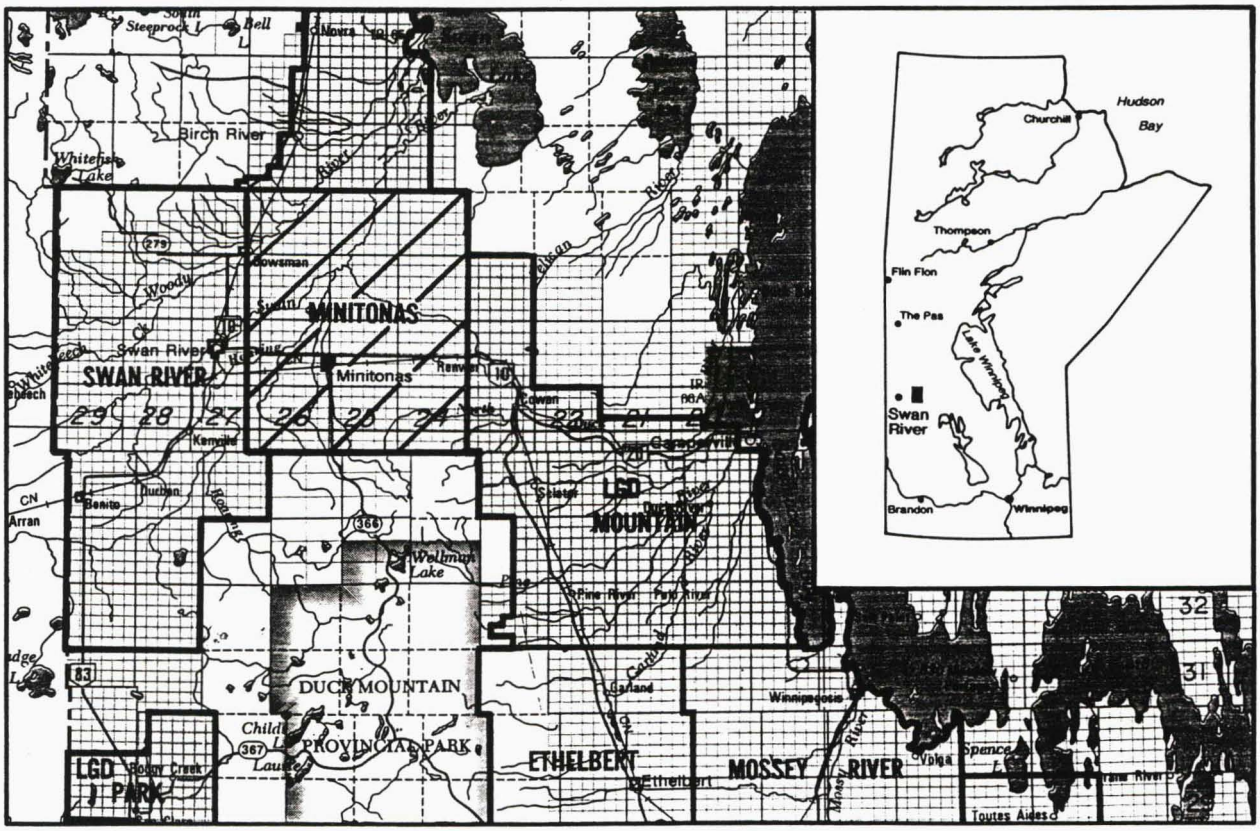

Figure 1: Location map of the R.M. of Minitonas.

a rolling till plain in the north east. Sediment depth across the plain averages 26 m (Klassen, 1979) and rarely exceeds 50 m (Little, 1973). Surface relief is generally 1 to 2 m; the exception being Minitonas Hill, an ice-thrust feature rising 85 m above the surrounding plain.

The central portion of the Swan Valley Plain is well drained by several rivers and creeks; the Sinclair, Roaring, and East and West Favel rivers, as well as the Minitonas Creek, all flow into the Swan River in the central part of the municipality. Woody River flows through the north west corner. The north east portion of the municipality is poorly drained and there are large areas of swamp between the till ridges.

METHODOLOGY

Surficial deposits were delineated on 1:50 000 scale airphotos. Airphoto interpretation was based on surficial units outlined by Nielsen (1988) and 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 program to test the extent, depth and quality of identified aggregate deposits in backhoe pits.

Aggregate samples were processed in two stages. In the field, samples that weighed between 75 and 100 kilograms were passed through 6" (15cm), 3" (7.5 cm), 1½" (3.8 cm) and ¾" (1.9 cm) screens. The weights of the 3", 1 ½", ¾" and <¾" fractions were recorded and the relative abundance of the 3-6" and >6" fractions noted. A representative sample of the <¾" portion was returned to Winnipeg for analysis. Sieve intervals used are shown in Appendix A.

Pebble counts of the ¾"-1½" fraction were done to determine the content of carbonate, sandstone and Precambrian intrusive volcanic and metamorphic lithologies, as well as the extent of deleterious factors such as shale, chert, concretions, weathering and cementation.

Gravel deposits were delineated on 1:15 840 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 AR92-4,in pocket).

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

PREVIOUS WORK

Nielsen (1988) mapped the surficial geology at a scale of 1:100 000, described the Wisconsinan sediments and outlined the late glacial history of the municipality as part of a study of the Swan River area. Klassen (1975; 1979), in regional studies of southwestern Manitoba - southeastern Saskatchewan, described the Quaternary sediments and glacial events that affected the R.M. of Minitonas.

The bedrock geology has been mapped by Wickenden (1945), and Bannatyne (1970) and the units were further described by McNeil and Caldwell (1981). Drift thickness and bedrock topography maps are included in ground water studies prepared by Little and Sie (1976) and Little (1973).

ACKNOWLEDGEMENTS

Lauren Haugh provided able field assistance. Chester Wojciechowski drafted the map and figures, Shirley Weselak did the desktop publishing and D.A.Baldwin edited the manuscript.

BEDROCK GEOLOGY

The area is underlain primarily by Cretaceous sandstone and shale; Devonian carbonate underlies the northeast corner of the municipality (Fig.2).

The Devonian Souris River Formation is formed primarily of fine grained, high calcium limestone in the northern part of its outcrop belt (McCabe and Barchyn, 1982); a detailed description of the lithology and paleontology of the unit is found in Norris et al (1982).

The Cretaceous stratigraphy presented in Figure 3 follows the nomenclature proposed by McNeil and Caldwell (1981). Section descriptions, as well as the lithology and paleontology of the formations, are presented in the above volume. Nielsen (1988) gives a brief description of each of the formations that occur in the Swan River area.

The Swan River Formation outcrops in the R.M. of Minitonas at several locations along the Roaring and Swan Rivers. Here it consists mainly of nonlithified, clean, medium to fine-grained quartzose sand with a minor component of interbedded silt and clay.

There are few outcrops of the Belle Fourche Member of the Ashville Formation in the study area. Where it does outcrop, it is a dark grey, carbonaceous marine shale with thin bentonite interbeds.

The overlying Favel Formation is well exposed along most creeks and rivers that flow north off Duck Mountain. The Keld Member is a dark, calcareous shale interbedded with bentonite and shaley limestone; the unit is richly fossiliferous and *Mytiloides labiatus* fragments are abundant. The upper unit, the Assiniboine Member, is a dark calcareous shale with thin beds of bentonite and calcarenite.

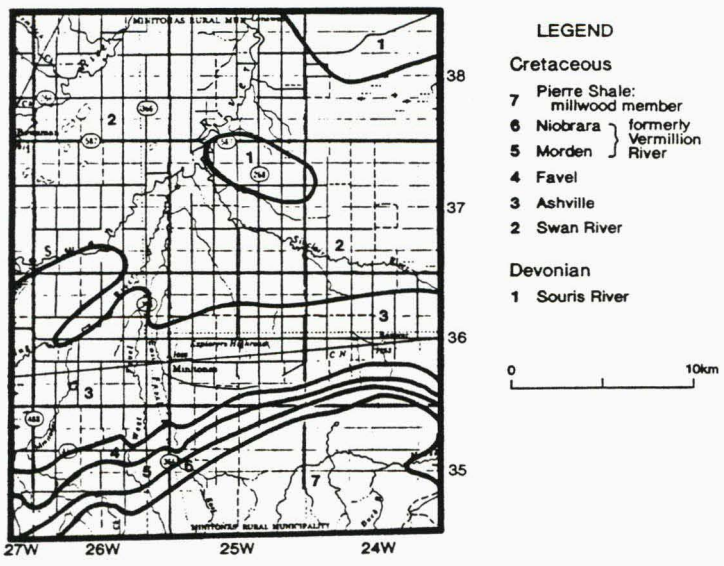

Figure 2: Generalized bedrock geology.

The Morden Shale overlies the Favel Formation and consists of non-calcareous black shale. It outcrops along the East Favel River where it is notable for the associated sulphur odour.

The Niobrara Formation, also outcropping along the East Favel River, consists of two units: a lower calcareous shale and an upper chalky shale or marlstone.

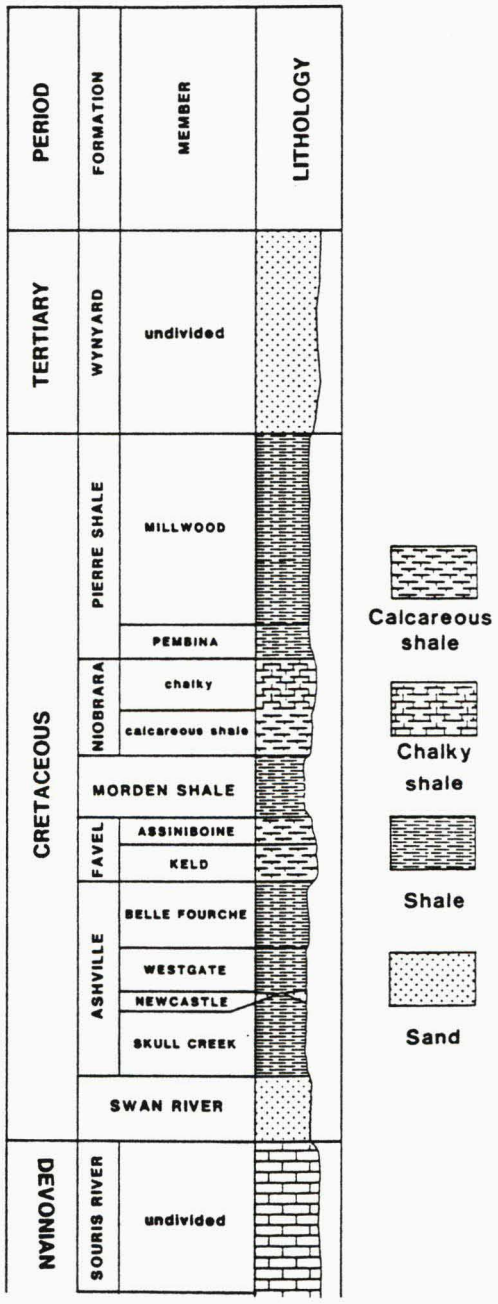

Figure 3: Bedrock stratigraphy (from Nielsen, 1988).

The Millwood Member of the Pierre Shale is a soft, noncalcareous grey-green shale overlying the Niobrara Formation. It is the youngest of the bedrock units that outcrop in the municipality. Klassen (1971, 1979) reports a unit of sorted silt, sand and gravel that overlies the Millwood Member. It has a patchy distibution pattern and may have been deposited by Tertiary rivers; it is assigned to the Wynyard Formation.

LATE GLACIAL HISTORY

The R.M. of Minitonas occurs within the Swan River area mapped by Nielsen (1988). The distribution of the surficial sediments (Fig. 4) and the following outline of late glacial events are summarized from that report.

During the Late Wisconsinan, ice flowed from the north and deposited the shale-rich Zelena Till. This till forms the hummocky moraine that caps Duck Mountain.

Retreat of this ice was followed by the Arran ice advance from the north east; the Swan River Lobe flowed up the valley and deposited the calcareous Arran Till. Minitonas Hill is an ice-thrust feature formed by this advance.

Glacial Lake Swan formed in the Swan River Valley as the Arran ice retreated eastward. For a short time this lake overtopped Duck Mountain and flowed through the North Duck Spillway into Lake Agassiz. Falling levels in Lake Swan allowed water to flow north off of Duck Mountain resulting in the deposition of the delta south of Minitonas.

Eventually, the Arran ice retreated from the valley and Lake Swan merged with Lake Agassiz. Beach ridges and scarps, particularly well developed on the deltaic sediments south of Minitonas, mark the highest levels of Lake Agassiz in the area - probable Herman strandlines. The Upper Campbell shoreline, in the municipality, is primarily a pronounced scarp whereas the successively lower lake levels are marked mainly by beach ridges. Most of the valley portion of the R.M. is underlain by lacustrine sand and silt; all parts show the effects of the recession of Lake Agassiz from the area.

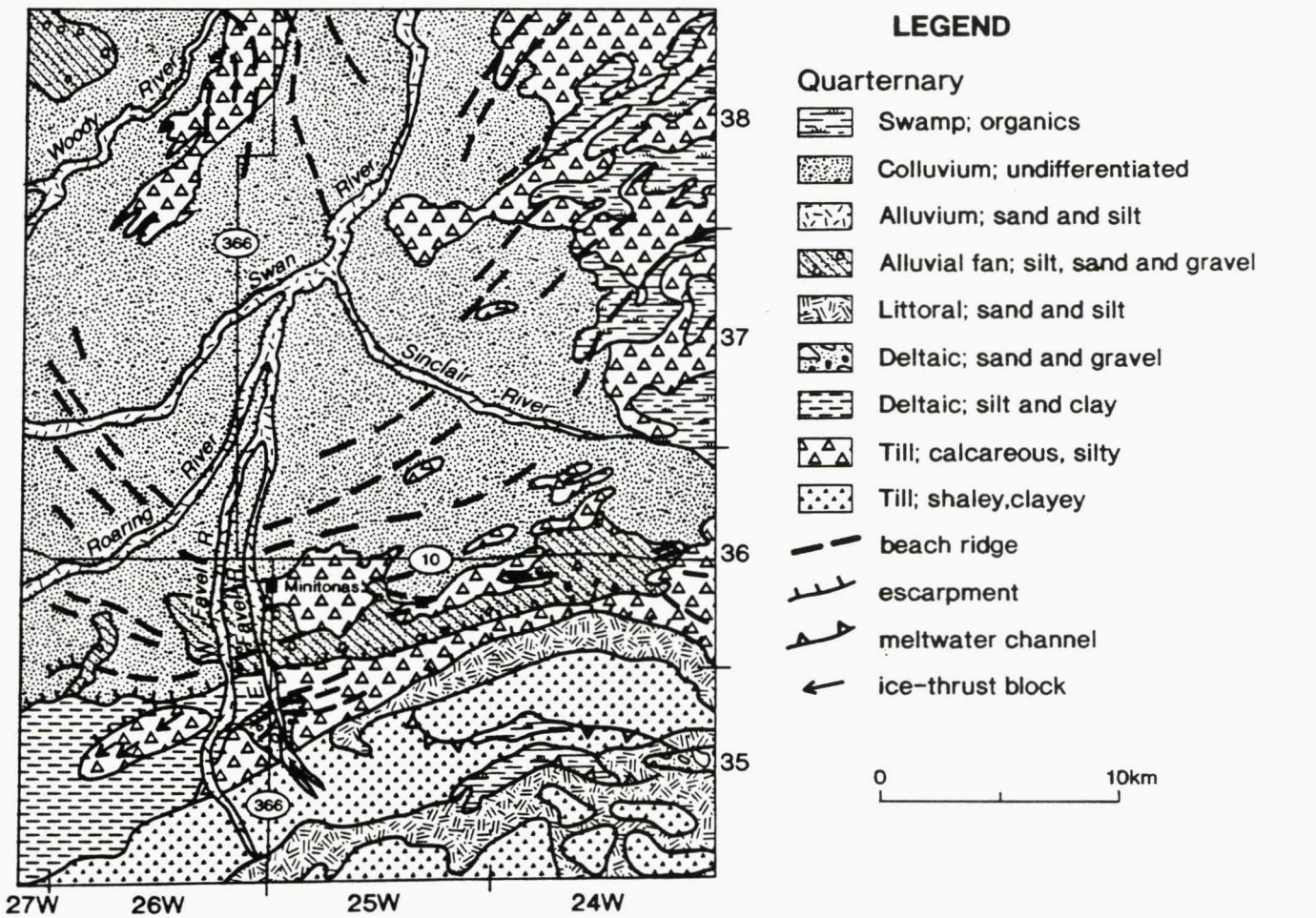

Figure 4: Surficial geology of the R.M. of Minitonas (from Nielsen, 1988).

AGGREGATE RESOURCES

INTRODUCTION

Sand and gravel resources of the R.M. of Minitonas occur in ice-contact, deltaic and beach deposits located primarily in the south and east part of the area.

Deposit, production potential and sample locations are shown on Map AR92-4 (in pocket). Information about the deposits is presented in summary tables in the text and in detail in the appendices.

Table 1 summarizes pit status, material type, 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 logs of the backhoe test pits. Appendix E summarizes aggregate information contained in Manitoba Department of Highways Block Files. Appendix F contains maps showing the location of crown lands in the municipality and Appendix G is a glossary of relevant terms.

Table 1: Aggregate Deposits in the Rural Municipality of Minitonas

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Oversize 3-6"/>6"	Backhoe Pit Log Summary*	Estimated Reserves ('000s m^3)	Comments
14601						11.2	Untested; under crop
14602	HM450s	Int.*	34	S/-		66.8	~1 m gravel in ridge, flanked by sand. Pit is small removal site in ditch.
	HA343s		47	S/-	1.4 scpg/t		
	HA344			S/S	1 scpg/t		
	HA345			-/-	1.3 scpg/t		
	HA346s		40	S/-	.6 scpg/t		
	HA347			S/-	.6 scpg/cl		
	HA348s		40	-/-	1 sfpg/cl		
	HA349			-/-	.9 sfpg/cl		
	HA350			-/-	.8 spg/cl		
14603	HM424s	Int.	42	S/-		141.3	Beach deposit, mostly depleted in north. Some recent activity at (HM424) and 1-2 m pebbly sand or fine pebble gravel in south.
	HM425	Ab.*					
	HM426	Ab.					
	HA335			-/-	sa/.2 sfpg/cl		
	HA336s		35	S/-	1.5 sa & sfpg/cl		
	HA337			-/-	>1.7 sa & p.sa		
	HA338s		29	-/-	.2 pg/1 p.sa/cl		
	HA339s		26	-/-	1 pg/.8 p.sa/cl		
	HA340			-/-	1 sfpg/cl		
	HA341			-/-	1.1 p.sa/cl		
	HA342			-/-	1.5 sfpg/cl		
14604	HM427s	Ab.	52	M/S	2 spg/t	53.9	Beach deposit; depleted around pits, maybe 1-2 m sandy pebble gravel in unopened portion.
	HM428	Ab.			<1 spg/t		
	HM429	Ab.		M/S	<1.5spg		
14605	HM449s	Ab.	44	-/-	<1 sfpg/sa	37.4	Unopened portion of ridge is very sandy, surface strewn with very fine pebbles.
14606	HM431	Ab.		S/-	<1 spg/sa&cl	18.1	Some recent bulldozer tesats show <1 m sandy pebble gravel over clay in west part of deposit.
14607	HM430	Ab.		S/-		10.1	Depleted on west side of road; some sandy pebble gravel left on east side.

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Oversize 3-6"/>6"	Backhoe Pit Log Summary*	Estimated Reserves ('000s m^3)	Comments
14608	HM495s	Int.	42	S/-		28.3	Shallow beach, mostly in depleted; some reserves central portion.
	HM497	Ab.		- / -			
	HM502	Ab.		-/-			
14609	HM503	Ab.				0.3	Depleted, shallow beach deposit.
14610A	HM433A	Int.	17	-/-	>5p.sa&cse sa	1646.1	Deposit is primarily coarse sand and pebbly sand. Gravel occurs at south end and along river. Sand , in some areas is of concrete or plaster grade.
	HM433B		3				
	HM434	Int.		S/-	<1.5 spg/t		
	HM435	Ab.		S / -			
	HM436	Ab.					
	HA362s		55	M/S	1scpg/sa/cl		
	HA363			S/-	.8cpg/sa/cl		
	HA364			M/S	1scpg/cl		
	HA365			M/S	1scpg/si		
	HA366s		45	M/S	1.3scpg/cl		
	HA367			-/-	1.3sa&spg/cl		
	HA368s		24	-/-	2.5sfpg/sa		
	HA369s		2	-/-	2sa		
	HA370			-/-	1sfpg&sa/cl		
	HA371A		9	-/-	1.2p.sa/sa		
	HA371B		17	-/-			
14610B	HM496	Int.		A/M	3spg	630.0	Deposit primarily sand; some pockets of gravel.
	HA372			-/-	2vsfpg/sa		
	HA373s		23	-/-	3vsfpg/sa		
	HA374			-/-	1spg/sa		
	HA375			-/-	.4vsfpg/sa		
	HA376			-/-	1.2vsfpg/sa		
	HA377			-/-	sand		
	HA378			-/-	p.sand		
14611	HA381s		35	S/S	1.2scpg/cl	45.6	Small deposit but nice sized gravel.
	HA382s		33	-/-	1sfpg/cl		
	HA383			S/-	1scpg/sa/cl		
	HA384			-/-	1spg/cl		
	HA385			-/-	1spg/sa/cl		
	HA386			-/-	1spg/sa/cl		
	HA387			-/-	.3spg/t		
	HA388			-/-	1vsfpg/cl		
	HA389			-/-	.5scpg/cl		
14612	HM437s	Int.	55	M/S		123.3	Ice-contact deposit, largely depleted. Depth variable to >8m; material varies from clay to cobble gravel. Southeast part untested, under lease to R.M.
	HM438s		39	S/S			
	HM442s	Ab.					
14613	HM420s	Ab.	33	-/-		240.9	Shallow beach deposit;depleted in pit area, sand with minor gravel in south; unopened portion is variable sand to pebble gravel.
	HA351			-/-	.7psa/.5fg/sa		
	HA352			-/-	1psa/sa		
	HA353			-/-	.3pea g/psa/cl		
	HA354			-/-	sand		
14614						25.2	Untested beach ridge; sand in roadcuts.

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Oversize 3-6"/>6"	Backhoe Pit Log Summary*	Estimated Reserves ('000s m^3)	Comments
14615	HM504					22.3	Untested beach in community pasture. Pebbly sand and some small cobbles on surface.
14616	HM421s	Ab.	41	S/-		34.5	Shallow beach deposit, largely sterilized by road.
	HM422	Ab.					
14617	HM505			-/-		2.3	Ditch shows sandy fine pebble gravel.
14618	HM506			-/-		32.9	Sterilized by road; material varies from pebbly sand to coarse pebble gravel over till.
14619	HM423s	Int.	45	A/-		322.4	Pit 2-3m deep, coarse pebble gravel over sand; deposit under quarry lease.
14620	HM444	Ab.				95.6	Beach deposit; mostly shallow gravel or sand over till.
	HA355			-/-	sand/t		
	HA356			-/-	1sfpg/t		
	HA357			-/-	.5sfpg/t		
	HA358			-/-	1psa/t		
	HA359			-/-	.5sand/t		
	HA360s		18	-/-	2.5sfpg&psa/cl		
	HA361			-/-	sand		
14621	HM507			-/-		16.9	Very thin pebble gravel over clay; ridge runs south under crop; sand at road.
14622	HM448	Ab.				204.7	Buried deposit, depleted at south; cobble under water table at Hwy 10.
	HM499	Int.		A/A			
14623	HM500	Ab.		M/S		145.8	Deposit depleted to west, nice pebble gravel to east but fibre optic cable sterilizes part of this area.
14624	HM445s	Int.	26	S/-		95.5	Pits are about 2.5m deep; high sand content but, for this area, relatively abundant large pebbles and small cobbles.
	HM446s	Int.	31	S/-			
	HM447As	Int.	59	M / M			
	HM447Bs		47	M/M			
14625	HM451					181.8	Untested road; mostly sand but some shallow gravel in areas.
				Total Estimated Reserves		**4 233.2**	

* Aband. = Abandoned; pit is usually revegetated
Inter. = Intermittent; pit generally has been in recent use, portions of pit may be revegetated
Backoe summary: all depths in metres
scpg = sandy coarse pebble gravel
sfpg = sandy fine pebble gravel
p.sa = pebbly sand
sa = sand
cl = clay
t = till
/ = overlying

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)	Oversize on Site (3-6"/>6")
14602	HA343	47	48	5	S/-
	HA346	40	38	22	S/-
	HA348	49	43	8	-/-
	HM450	34	55	11	S/-
14603	HA336	35	62	3	S/-
	HA338	29	69	2	-/-
	HM339	26	72	2	-/-
	HM424	42	57	1	S/-
14604	HM427	52	44	4	M/S
14605	HM449	44	55	1	-/-
14608	HM495	42	57	1	S/-
14610A	HA362	55	39	6	M/S
	HA366	45	51	4	M/S
	HA368	24	70	6	-/-
	HA369	2	91	7	-/-
	HA371A	9	78	13	-/-
	HA371B	17	80	3	-/-
	HM433A	17	79	21	-/-
	HM433B	3	94	3	-/-
14610B	HA373	23	73	4	-/-
14611	HA381	35	60	5	S/S
	HA382	33	64	3	-/-
14612	HM437	55	41	4	
	HM438	39	58	3	
14613	HM420	33	64	3	-/-
14616	HM421	41	58	1	S/-
14619	HM423	45	52	3	A/M
14620	HA360	18	78	4	-/-
14624	HM445	26	69	5	S/-
	HM446	31	67	2	S/-
	HM447A	59	36	5	M/M
	HM447B	47	46	7	M/M

A - Abundant
M - Moderate
S - Sparse

AGGREGATE RESERVES

There are 4 233.2 x 10^3 cubic metres of aggregate reserves in the R.M. of Minitonas, most of which is sand.

Table 3 shows aggregate reserve figures by production potential and type of material within the deposits.

Table 3: Aggregate Reserves in the R.M. of Minitonas

Primary Material	Production Potential High ('000 m^3)	Medium ('000 m^3)	Low ('000 m^3)	Total ('000 m^3)
Sand & Gravel	586.8	475.6	263.1	1 325.5
Sand	2 276.1	240.9	390.7	2 907.7
Total	2 862.9	716.5	653.8	4 233.2

Production potential not only depends on quantity and quality of the aggregate in the deposit but also on factors such as hauling distance to the job site, whether or not alternative sources are available and land use pressures that may prevent gravel extraction.

For example, Deposit 14619 has a high production potential, despite its isolated location, because it contains the coarse material that more accesible deposits lack; a road has been built and there is an active pit in the deposit.

Table 4 shows the criteria taken into consideration when assigning production potential.

Each of the deposit types (beach, delta, ice-contact) has different characteristics.

The beaches are usually 1 to 2 m of interbedded sand and sandy pebble gravel overlying clay or till. Most have been extensivly mined and only Deposits 14619 and 14624 are currently major sources of gravel.

The deltas have an area of coarse stone at the apex but are primarily formed of sand. Deposit 14610 has been nearly depleted of its coarse gravel but it is still economically important because in some areas the sand is of concrete and plaster grade.

The ice-contact deposits contain relatively abundant amounts of crushable size stone. Deposit 14612 has been a major producer of stone for the municipality but it is becoming depleted in the eastern part of the deposit and the extent of material in the west is unproven. Deposit 14622 contains 3 to 6 m of cobbly coarse gravel but it is not a major producer because all the reserves are below the water table.

CONCLUSIONS

Aggregate resources in the R.M. of Minitonas are found in beach, deltaic and ice-contact deposits scattered throughout the area.

These deposits contain 4.2 million m^3 of reserves. However, almost 3 million m^3 of these reserves are in deposits that are primarily sand with only minor amounts of gravel.

Despite the large reserve figure, there is a shortage of gravel in the municipality. At present, Deposits 14619 1nd 14624 are meeting local needs but the municipality will be importing gravel within the forseeable future.

Table 4: Aggregate Quality and Development Potential Criteria

	Criteria	HIGH	MEDIUM	LOW
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 DEVELOPMENT POTENTIAL	Aggregate Quality	high	medium	low
	<6"	abundant	moderate	minor
	>6"	minor	moderate	abundant
	Overburden	<2 m	2-4 m	>4 m
	Binder	yes	minor	none
	Water Table	>5 m	2-5 m	<2 m
	Geological Potential	good	moderate	low
	Verification	proven	limited	untested
	Local Access	0-1 km	1-5 km	>5 km
	Quarrying Status	active	intermittent	inactive
	Transportation Diff.	high	medium	low
	Planning Constraints	none	conditional	sterilized
	Specialty Material	yes		no
	Aggregate Substitute	none	marginal	proximal

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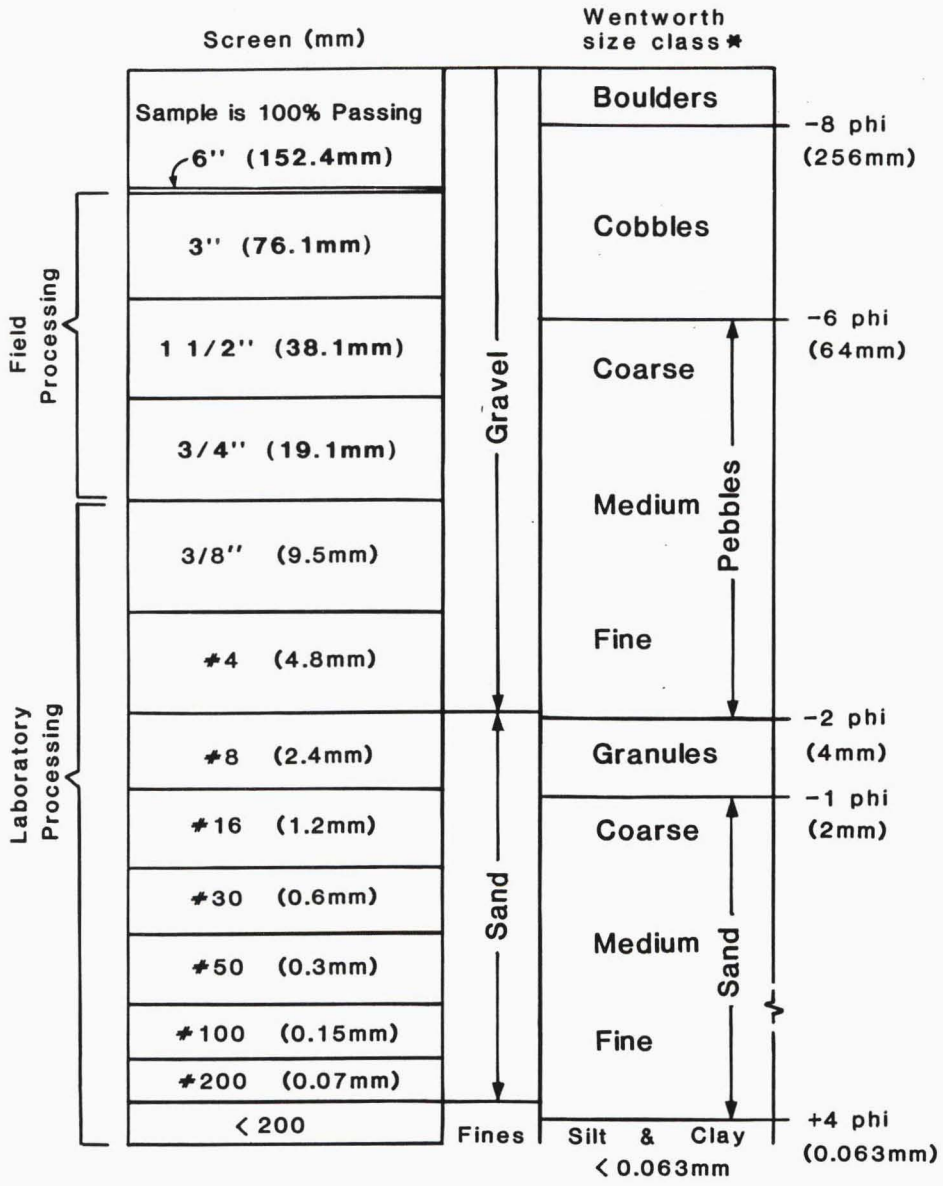
APPENDIX A: GRAIN SIZE CLASSIFICATION AND SIEVE INTERVALS



* modified from Folk, 1974

APPENDIX B: DETAILED SIEVE RESULTS

Deposit Number		14602	14602	14602	14602	14603
Sample Number		HA343	HA346	HA348	HM450	HA336
3"-6" / 6"		S/-	S/-	-/-	S/-	S/-
	3"	100	100	100	100	100
%	1½"	85	84	95	97	99
	¾"	72	75	79	92	90
P	⅜"	62	67	65	79	82
A	#4	53	60	51	66	65
S	#8	43	54	40	55	56
S	#16	33	48	33	44	51
I	#30	23	41	27	34	46
N	#50	11	33	14	19	30
G	#100	7	27	9	13	4
	#200	5	22	8	11	3

Deposit Number		14603	14603	14603	14604	14605
Sample Number		HA338	HA339	HM424	HM427	HM449
3"-6" / 6"		-/-	-/-	S/-	M/S	-/-
	3"	100	100	100	100	100
%	1½"	100	98	98	91	98
	¾"	88	92	88	79	85
P	⅜"	80	85	72	61	73
A	#4	71	74	58	48	56
S	#8	63	62	48	38	46
S	#16	55	52	40	28	38
I	#30	47	42	33	18	30
N	#50	30	22	18	10	19
G	#100	4	3	2	6	3
	#200	2	2	1	4	1

Deposit Number		14608	14610A	14610A	14610A	14610A
Sample Number		HM495	HA362	HA366	HA368	HA369
3"-6" / 6"		S/-	M/S	M/S	-/-	-/-
	3"	99	95	99	100	100
%	1½"	91	79	90	99	100
	¾"	80	61	75	93	100
P	⅜"	69	52	64	85	98
A	#4	58	45	55	76	98
S	#8	47	39	47	67	96
S	#16	38	34	37	57	94
I	#30	30	27	26	46	88
N	#50	16	19	14	30	68
G	#100	2	11	7	14	25
	#200	1	6	4	6	7

Deposit Number		14610A	14610A	14610A	14610A	14610B
Sample Number		HA371A	HA371B	HM433A	HM433B	HA373
3"-6" / 6"		-/-	-/-	-/-	-/-	-/-
	3"	100	100	100	100	100
%	1½"	100	100	99	100	97
	¾"	100	99	95	100	90
P	⅜"	97	92	89	99	85
A	#4	91	83	83	97	77
S	#8	84	74	75	92	68
S	#16	76	64	66	84	57
I	#30	67	49	54	72	44
N	#50	49	25	30	38	26
G	#100	25	7	11	12	10
	#200	13	3	4	3	4

Deposit Number		14611	14611	14612	14612	14613
Sample Number		HA381	HA382	HM437	HM438	HM420
3"-6" / 6"		S/S	-/-	M/S	S/S	-/-
	3"	99	100	93	100	100
%	1½"	91	98	80	98	99
	¾"	81	88	66	89	90
P	⅜"	75	79	56	78	78
A	#4	65	67	45	61	67
S	#8	58	52	36	47	52
S	#16	46	35	25	33	33
I	#30	36	25	16	18	20
N	#50	19	17	9	8	3
G	#100	6	5	6	5	3
	#200	5	3	4	3	3

Deposit Number		14616	14619	14620	14624	14624
Sample Number		HM421	HM423	HA360	HM445	HM446
3"-6" / 6"		S/-	A/M	-/-	S/-	S/-
	3"	100	96	100	97	97
%	1½"	97	82	100	94	94
	¾"	88	71	98	90	88
P	⅜"	75	63	91	84	78
A	#4	59	55	82	74	69
S	#8	44	49	73	58	57
S	#16	33	44	64	32	38
I	#30	28	37	54	14	20
N	#50	19	20	35	8	10
G	#100	2	6	9	7	3
	#200	1	3	4	5	2

Deposit Number Sample Number 3"-6" / 6"		14624 HM447A M/M	14624 HM447B M/M
	3"	100	98
%	1½"	80	95
	¾"	58	80
P	⅜"	47	70
A	#4	41	53
S	#8	38	38
S	#16	33	23
I	#30	23	15
N	#50	13	12
G	#100	8	9
	#200	5	7

APPENDIX C: PEBBLE LITHOLOGY AND DELETERIOUS CONTENT OF SAMPLES

Deposit Number	Sample Number	Precambrian crys	Precambrian vol	% Lithology of 3/4" - 1 1/2" fraction: Carbonate	Sandstone	Chert	Silt/ Shale	Ironstone/ Concretions	Weathered	Encrust/ Cemented
14602	HA343	17	61	20	-	-	-	-	1	16
	HA346	7	55	19	-	-	18	-	1	8
	HA348	20	51	25	-	-	4	-	-	5
	HM450	20	46	32	-	-	-	-	2	42
14603	HA336	24	53	22	-	-	-	-	1	23
	HA338	27	52	17	-	-	-	-	4	14
	HA339	17	42	39	-	-	-	2	-	21
	HM424	21	37	39	-	-	-	-	3	36
14604	HM427	29	50	14	-	-	-	-	7	21
14605	HM449	36	42	18	-	-	-	-	4	32
14608	HM495	15	62	20	-	-	-	3	-	24
14610A	HA362	29	45	23	-	-	-	1	2	-
	HA366	32	46	18	-	-	-	1	3	-
	HA368	19	53	24	-	-	-	2	2	9
	HM433	20	25	52	-	1	-	1	1	15
14610B	HA373	28	52	20	-	-	-	-	-	5
14611	HA381	19	52	24	-	-	2	-	3	-
	HA382	19	67	12	-	-	2	-	-	-
14612	HM437	23	57	17	-	-	-	2	1	-
	HM438	34	50	9	4	-	-	1	2	-
14613	HM420	70	15	15	-	-	-	-	-	-
14616	HM421	6	12	68	10	-	1	2	1	9
14619	HM423	20	34	34	-	-	-	11	1	-
14620	HA360	56	38	6	-	-	-	-	-	-
14624	HM445	1	20	70	-	-	6	1	1	-
	HM446	35	31	34	-	-	-	2	-	75
	HM447A	30	50	18	-	-	-	2	-	-
	HM447B	49	30	19	-	-	2	-	-	-

APPENDIX D: BACKHOE TEST PIT LOGS

DEPOSIT NUMBER	SITE NUMBER s=sample		LOG
14602	HA343s	0.0 - 0.4M	SOIL
		0.4 - 1.8	SANDY COARSE PEBBLE GRAVEL (M=7CM)
		>1.8	TILL
	HA344	0.0 - 0.3M	SOIL
		0.3 - 1.4	SANDY COARSE PEBBLE GRAVEL (M=20CM)
		>1.4	CLAY
	HA345	0.0 - 0.2M	SOIL
		0.2 - 1.5	SANDY COARSE PEBBLE GRAVEL
		>1.5	TILL
	HA346s	0.0 - 0.5M	SOIL
		0.5 - 1.1	SANDY COARSE PEBBLE GRAVEL
		>1.1	TILL
	HA347	0.0 - 0.2M	SOIL
		0.2 - 0.6	SANDY COARSE PEBBLE GRAVEL (M=20CM)
		>0.6	CLAY,SILTY
	HA348s	0.0 - 0.1M	SOIL
		0.1 - 1.3	SANDY FINE PEBBLE GRAVEL; COARSE SAND MATRIX
		>1.3	CLAY; STONY, GREY, SILTY
	HA349	0.0 - 0.1M	SOIL
		0.1 - 1.0	SANDY PEBBLE GRAVEL; M=5CM)
		>1.0	CLAY; STONY, GREY, SILTY
	HA350	0.0 - 0.1M	SOIL
		0.1 - 0.9	SANDY PEBBLE GRAVEL
		>0.9	CLAY; STONY, GREY, SILTY
14603	HA335	0.0 - 0.1M	SAND; MEDIUM, OXYDIZED
		0.1 - 1.0	SAND; MED-FINE, BEIGE, SOME PEBBLES
		1.0 - 1.2	SANDY FINE PEBBLE GRAVEL
		>1.2	CLAY
	HA336s	0.0 - 0.2M	SOIL
		0.2 - 0.5	SAND, COARSE
		0.5 - 1.1	SANDY FINE PEBBLE GRAVEL; WELL SORTED
		1.1 - 1.7	SAND, MED-COARSE, WITH PEBBLES
		>1.7	CLAY
	HA337	0.0 - 0.1M	SOIL
		0.1 - 0.3	SANDY GRANULES
		0.3 - 0.7	PEBBLY SAND
		0.7 ->1.7	INTERBEDS OF THIN GRANULE BEDS AND THICK BEDS OF MED-FINE SAND WITH PEBBLES
	HA338s	0.0 - 0.2M	SOIL; 10CM OF PEBBLE GRAVEL AT SURFACE
		0.2 - 1.5	PEBBLY COARSE SAND
		>1.5	CLAY, SILTY

DEPOSIT NUMBER	SITE NUMBER s=sample		LOG
	HA339s	0.0 - 0.1M	PEBBLE GRAVEL
		0.1 - 1.	PEBBLE GRAVEL, MEDIUM SAND MATRIX
		1.0 - 1.0	PEBBLY COARSE SAND
		>1.8	CLAY, SILTY, MOTTLED
	HA340	0.0 - 0.3M	SOIL
		0.3 - 1.0	VERY SANDY, FINE PEBBLE GRAVEL, WET
		>1.0	CLAY, SILTY
	HA342	0.0 - 0.3M	SOIL
		0.3 - 1.8	VERY SANDY FINE PEBBLE GRAVEL
		>1.8	CLAY, STONY
14601A	HA362s	0.0 - 0.1M	HUMUS
		0.1 - 1.0	SANDY COARSE PEBBLE GRAVEL WITH COBBLES (M=30CM)
		1.0 - 1.5	SAND,STONY AT TOP THEN PASSING INTO MED-FINE,STONE-FREE SAND
		>1.5	CLAY, SILTY
	HA363	0.0 - 0.1M	HUMUS
		0.1 - 0.9M	SANDY COARSE PEBBLE GRAVEL
		0.9 - 1.2	SAND, COARSE
		>1.2	SILTY CLAY
	HA364	0.0 - 0.1M	HUMUS
		0.1 - 1.0	SANDY COARSE PEBBLE GRAVEL
		1.0 ->1.4	CLAY, SILTY
	HA365	0.0 - 0.1M	HUMUS
		0.1 - 1.2	SANDY COARSE PEBBLE GRAVEL (M=20CM)
		1.2 ->1.8	CLAYEY SILT, ORANGE
	HA366s	0.0 - 0.1M	HUMUS
		0.1 - 1.4	SANDY COARSE PEBBLE GRAVEL (M=25CM)
		1.4 ->1.8	SILTY CLAY, MOTTLED
	HA367	0.0 - 0.1M	HUMUS
		0.1 - 0.4	SAND, FINE, SILTY
		0.4 - 1.4	SANDY PEBBLE GRAVEL AT TOP, FINING DOWN TO SAND
		1.4 ->2.0	CLAYEY SILT, WET
	HA368s	0.0 - 0.5M	SOIL, IN SILTY SAND
		0.5 - 2.9	SANDY FINE PEBBLE GRAVEL, SOME INTERBEDS OF FINE SAND; MATERIAL BECOMES FINER WITH DEPTH
		>2.9	SAND, FINE, SILTY
	HA369s	0.0 ->2.0M	SAND, MEDIUM TO MEDIUM-FINE
	HA370	0.0 - 0.4M	SOIL (IN FINE SAND)
		0.4 - 1.4	INTERBEDS OF VERY SANDY FINE PEBBLE GRAVEL AND COARSE SAND
		1.4 ->2.0	SAND, MED-FINE, STONE FREE
	HA371s	0.0 - 1.2M	COARSE PEBBLY SAND
		1.2 - 3.0	SAND, FINES DOWN
		3.0 ->5.5	SAND (OWNER REPORTED)

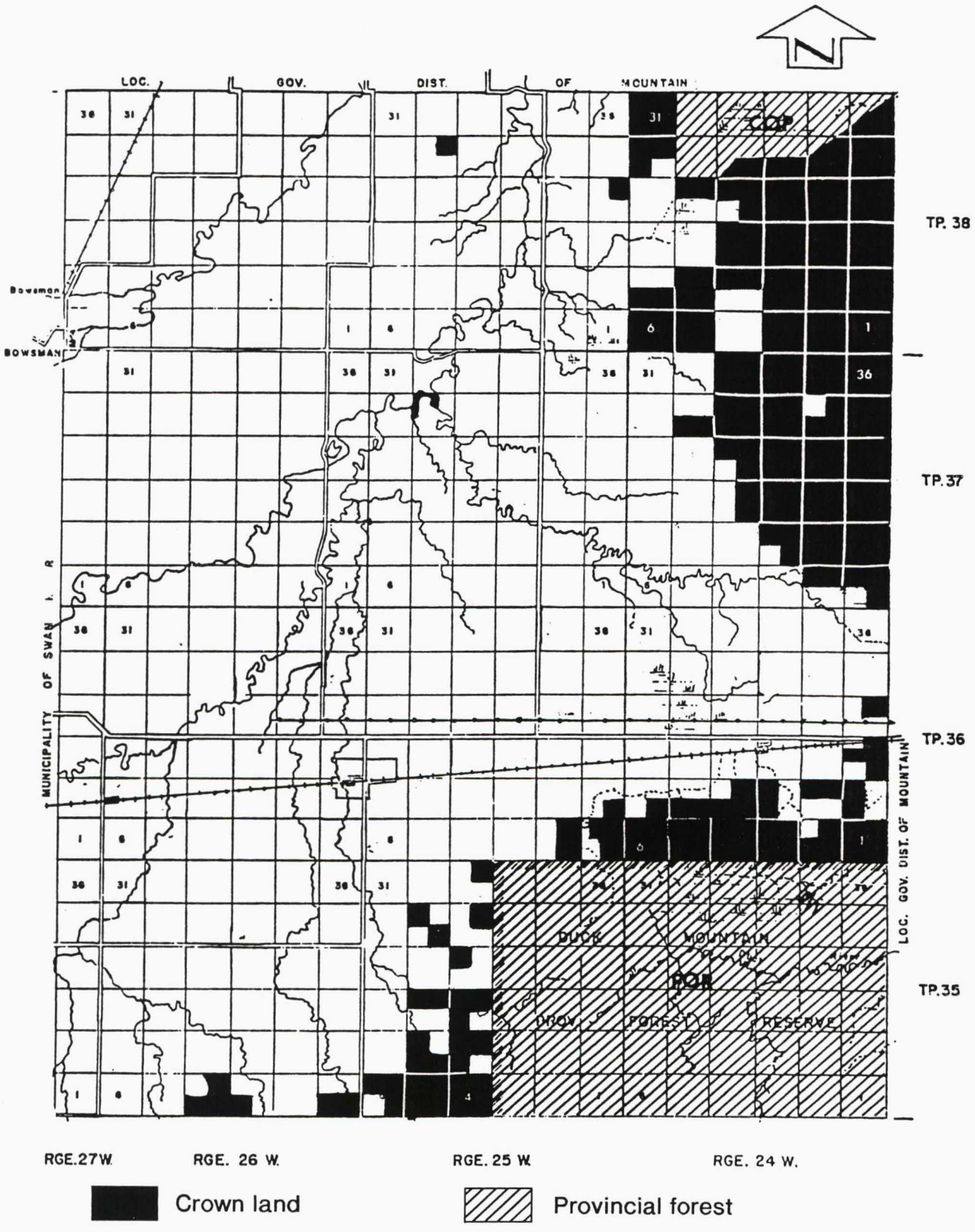
DEPOSIT NUMBER	SITE NUMBER s=sample	LOG	
14610B	HA372	0.0 ->2.0M	VERY SANDY FINE PEBBLE GRAVEL; FINES DOWN TO PEBBLY SAND
	HA373s	0.0 - 3.0M	VERY SANDY PEBBLE GRAVEL, FINING DOWN TO PEBBLY SAND
		>3.0	FINE SAND AND SILT
	HA374	0.0 - 0.3M	SOIL (IN FINE SAND)
		0.3 - 1.4	SANDY PEBBLE GRAVEL, HIGH COARSE SAND MATRIX
		1.4 ->1.6	SAND, FINE
	HA375	0.0 - 0.3M	SOIL, (IN FINE SAND)
		0.3 - 0.7	VERY SANDY FINE PEBBLE GRAVEL
		0.7 ->1.2	SAND,FINE
	HA376	0.0 - 0.2M	SOIL
		0.2 - 1.4	VERY SANDY, FINE PEBBLE GRAVEL
		1.4 ->1.6	SAND, FINE
	HA377	0.0 ->1.0M	MED-FINE SAND,STONE FREE; SURFACE PEBBLE STREWN
	HA378	SAND,MED-COARSE, SOME PEBBLES	
14611	HA291s	0.0 - 0.2M	SOIL
		0.2 - 1.4	SANDY COARSE PEBBLE GRAVEL WITH SOME SMALL COBBLES
		1.4 ->1.8	CLAYEY SILT
	HA382s	0.0 - 0.1M	SOIL
		0.1 - 1.1	SANDY FINE PEBBLE GRAVEL (AM=1 1/2")
		1.1 ->1.6	CLAYEY SILT
	HA383	0.0 - 0.1M	SOIL
		0.1 - 1.1	SANDY COARSE PEBBLE GRAVEL
		1.1 - 1.5	SAND, SOME STONE
		>1.5	SILTY CLAY
	HA384	0.0 - 0.3M	SOIL
		0.3 - 1.0	SANDY FINE PEBBLE GRAVEL GRADING DOWN TO PEBBLY SAND
		1.0 - 1.2	LAYER OF COBBLES AND PEBBLES
		>1.2	CLAY, SILTY, STONEY, MOTTLED
	HA385	0.0 - 0.1M	SOIL
		0.1 - 1.0	SANDY PEBBLE GRAVEL
		1.0 - 1.5	SAND,MEDIUM TO MEDIUM-COARSE
		>1.5	CLAY, SILTY
	HA386	0.0 - 0.1M	SOIL
		0.1 - 0.8	SANDY PEBBLE GRAVEL
		0.8 ->1.5	CLAY, SILTY
	HA387	0.0 - 0.3M	SANDY PEBBLE GRAVEL
		0.3 ->0.6	TILL
	HA388	0.0 - 0.2M	SOIL
		0.2 - 1.1	VERY SANDY PEBBLE GRAVEL
		1.1 ->1.3	SILTY, STONEY LAYER, THEN INTO CLAY, BLACK, BLOCKY, STONEY AND HEAVY

DEPOSIT NUMBER	SITE NUMBER s=sample		LOG
	HA389	0.0 - 0.5M	SANDY COARSE PEBBLE GRAVEL
		>0.5	CLAY, STONEY, BLACK, WITH TILL RIP-UP CLASTS
14613	HA351	0.0 - 0.1M	SOIL
		0.1 - 0.7	PEBBLY SAND
		0.7 - 1.2	PEA GRAVEL
		1.2 ->2.0	SAND, MEDIUM FINE, STONE FREE
	HA352	0.0 -<1.0M	PEBBLY FINE SAND
		>1.0	SILTY FINE SAND
	HA353	0.0 - 0.2M	SOIL
		0.2 - 0.5	CLEAN PEA GRAVEL,FINES UP TO GRANULES
		0.5 - 1.0	PEBBLY SAND
		>1.0	CLAYEY SILT
	HA354	0.0 - 0.1M	SOIL (IN FINE SAND); PEBBLE AND GRANULE LAG ON SURFACE
		0.1 ->1.0	SAND, MEDIUM TO MEDIUM-FINE, OCCASIONAL PEBBLES
14620	HA355	<0.8M	FINE SAND OVER TILL
	HA356	<1.0M	FINE PEBBLE GRAVEL OVER TILL
	HA357	<0.5M	SANDY COARSE PEBBLE GRAVEL OVER TILL
	HA358	0.0 - 1.3M	SAND, MED-FINE;SOME PEBBLES (<1") THROUGHOUT
		1.3 - 1.5	COBBLE LAG
		1.5 ->1.7	TILL
	HA359	<0.5M	MED-FINE SAND AND PEBBLES OVER TILL;PEBBLE LAG AT CONTACT
	HA360s	0.0 - 2.5M	INTERBEDS OF PEBBLY SAND, SANDY FINE PEBBLE GRAVEL,
		>2.5	COARSE SAND AND CLAY, STONY, GREY-BLACK, LAMINATED
	HA361	>1.2M	MEDIUM-FINE SAND, A FEW PEBBLES THROUGHOUT
NO DEPOSIT DEFINED			
	HA379		COBBLE AND BOULDER LAG OVER TILL
	HA380	0.0 - 0.3M	SAND,FINE, RUSTY-BROWN
		>0.3	COBBLES AND BOULDERS; LAG(?), A VERY COMPACTED,STONY SAND (TILL?) IN LOWER PORTION
	HA390		HOLE DEPTH IS 1.2M;BOULDER AND COBBLE LAG OVERLIES COMPACTED SILTY SAND; TILL AT BASE
	HA391	0.0 - 0.2M	VERY SANDY, VERY FINE PEBBLE GRAVEL
		0.2 - 0.4	SAND
		>0.4	CLAY

APPENDIX E: INFORMATION FROM DEPARTMENT OF HIGHWAYS BLOCK FILES

Deposit Number	Block File Number	Location	Inventory Type P=pit B=backhoe	Number of Holes	Samples	% Stone >#4	Comments/ End Use
14603	109	NW23-38-26W	P	2	2	10,13	
	109	SW26-38-26W	P	1	1	36	
14604	109	NE 4-38-26W	P	1	1	64	
14606	97	SW31-35-26W	P	2	2	54,32	
14607	97	SE31-35-26W	P	3	3	64,72,54	
14608	97	N34-35-26W	P	2	2	50,46	
	97	NW35-35-26W	P	2	2	39,59	
14612	98	SW2-36-26-25W	P	6	5	64-80	A & C Base
14613	110	SE30-38-24W	P	5	5	32-60	D Base
14624	98	N11-36-24W	P	5	5	42-78	

APPENDIX F: LOCATION OF CROWN LANDS



Crown lands in the R.M. of Minitonas; modified from Hince et al, 1987.

APPENDIX G: 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.