Aggregate Report AR92-5

Aggregate Resources in the Rural Municipalities of Edward and Arthur

by H.D. Groom

Manitoba
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Winnipeg, 1993

Energy and Mines

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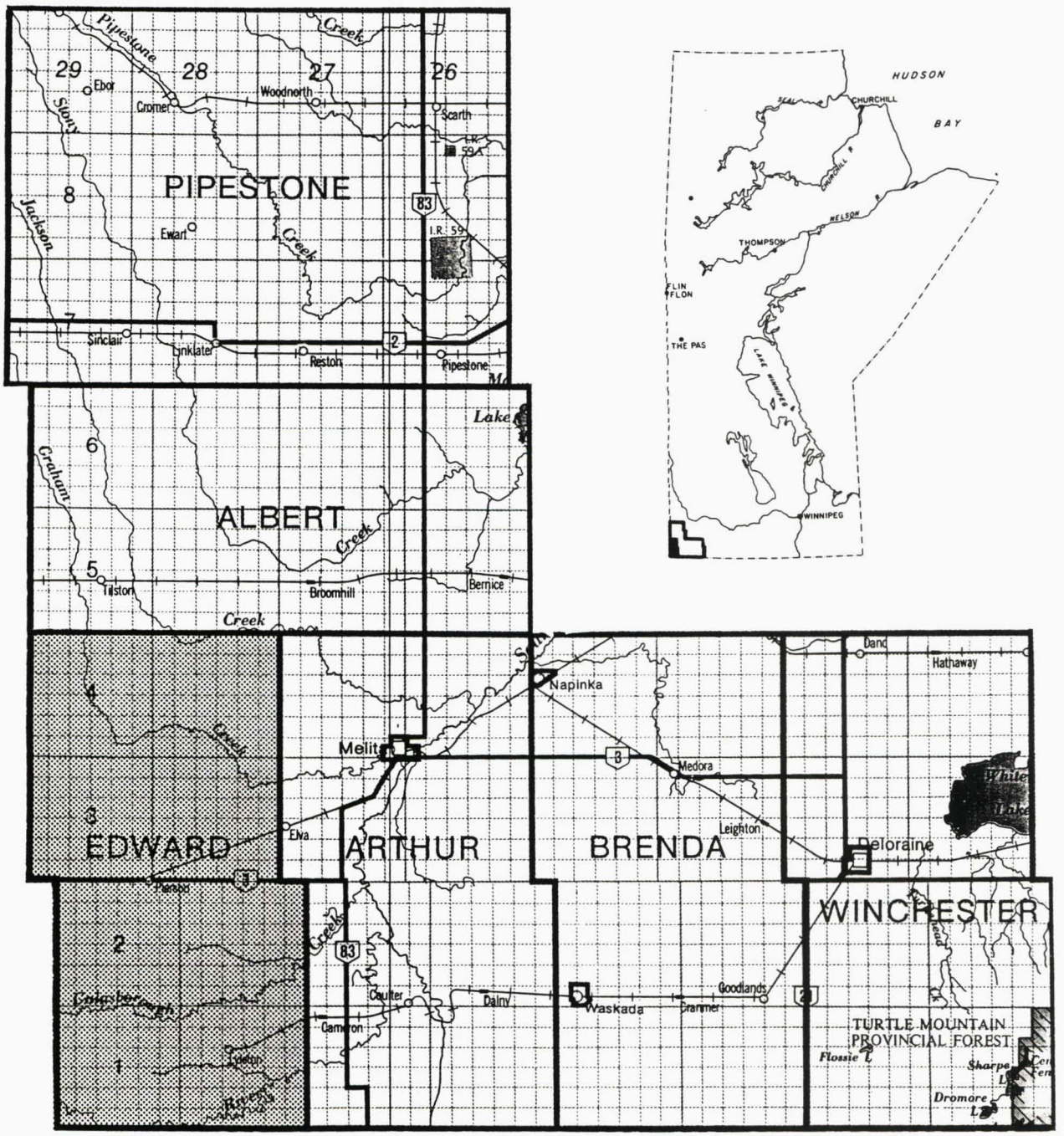

Figure 1: Location map of the R.M.s of Edward and Arthur.

INTRODUCTION

OBJECTIVES

An aggregate resource inventory was carried out during the summer of 1988 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 Edward-Arthur area encompasses 1 492 km^2 that lie within Townships 1-4 and Ranges 26-29W in southwest Manitoba (Fig. 1). It includes four 1:50 000 map sheets in NTS areas 62F/2, 3, 6 and 7.

The area is primarily a farming district. The town of Melita is the major service centre. Highway 83, and a network of gravelled Provincial Roads and section roads, provide good access to most parts of the area.

PHYSIOGRAPHY

The Rural Municipalities of Edward and Arthur are in the Souris Basin of the Saskatchewan Plain. The bedrock surface dips to the west and the overlying glacial sediments thicken correspondingly. The present day surface slopes gently to the north east. North to south along the Saskatchewan border, elevations fall from 495 m above sea level (a.s.l.) to 472 m a.s.l.; along the eastern boundary, elevations fall from 465 m a.s.l. in the south to 440 m a.s.l. in the north.

The topography is flat to gently rolling except in the area of the Souris Spillway. On the till plains and delta surfaces, linear ridges and circular rims around deprsessions rise 1 to <3 m high. Relief in the central part of the area, underlain by lake sediments, is generally 1 to <2 m. The walls of the Souris and Blind River valleys, however, are 10 to 20 m deep and hills within the spillway rise 10 to 20 m.

Major drainage channels are the Souris and Antler rivers and Jackson, Graham and Gainsborough creeks, all of which flow into the Souris River.

METHODOLOGY

Surficial deposits were delineated on 1:50 000 scale airphotos. Airphoto interpretation was based on surficial units outlined by Elson (1961) 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 3" (7.5 cm), 1½" (3.8 cm) and ¾" (1.9 cm) screens. The weights of the 1½", ¾" and <¾" fractions were recorded. Sieve analysis was done on a representative sample of the <¾" fraction. Sieve intervals are shown in Appendix A. Pebble counts of the ¾"-1½" 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 1:15 840 scale airphotos and transferred to 1:50 000 scale photos for use in production of the 1:50 000 scale maps accompanying this report (Map AR92-5-1 and AR92-5-2, 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

The surficial geology of the area was mapped at a scale of 1:126 700, and the glacial history outlined, as part of a regional study of southwestern Manitoba - southeastern Saskatchewan (Elson 1956, 1961). Studies of the spillways on the northern plains include the channel and lake basin that lie in the south eastern portion of the municipalities (Kehew, 1982; Kehew and Clayton, 1983; Kehew and Lord, 1986). The soils were mapped by Eilers *et al.* (1978) at a scale of 1:20 000. Drift thickness maps are included in ground water studies prepared by Betcher (1983) and Water Rsources Division (1968).

The bedrock geology was mapped by Wickenden (1945) and Bannatyne (1970), and the units were further described by McNeil and Caldwell (1981). A map of the regional bedrock topography, at a scale of one inch to eight miles, has been produced by Klassen *et al.* (1970). Klassen and Wyder (1970) discuss the location and fill of buried vallies.

ACKNOWLEDGEMENTS

JoAnn Mitchell provided able field assistance. Lise Villeneuve drafted the map and figures, D.A. Baldwin edited the manuscript and S. Weselak did the desktop publishing.

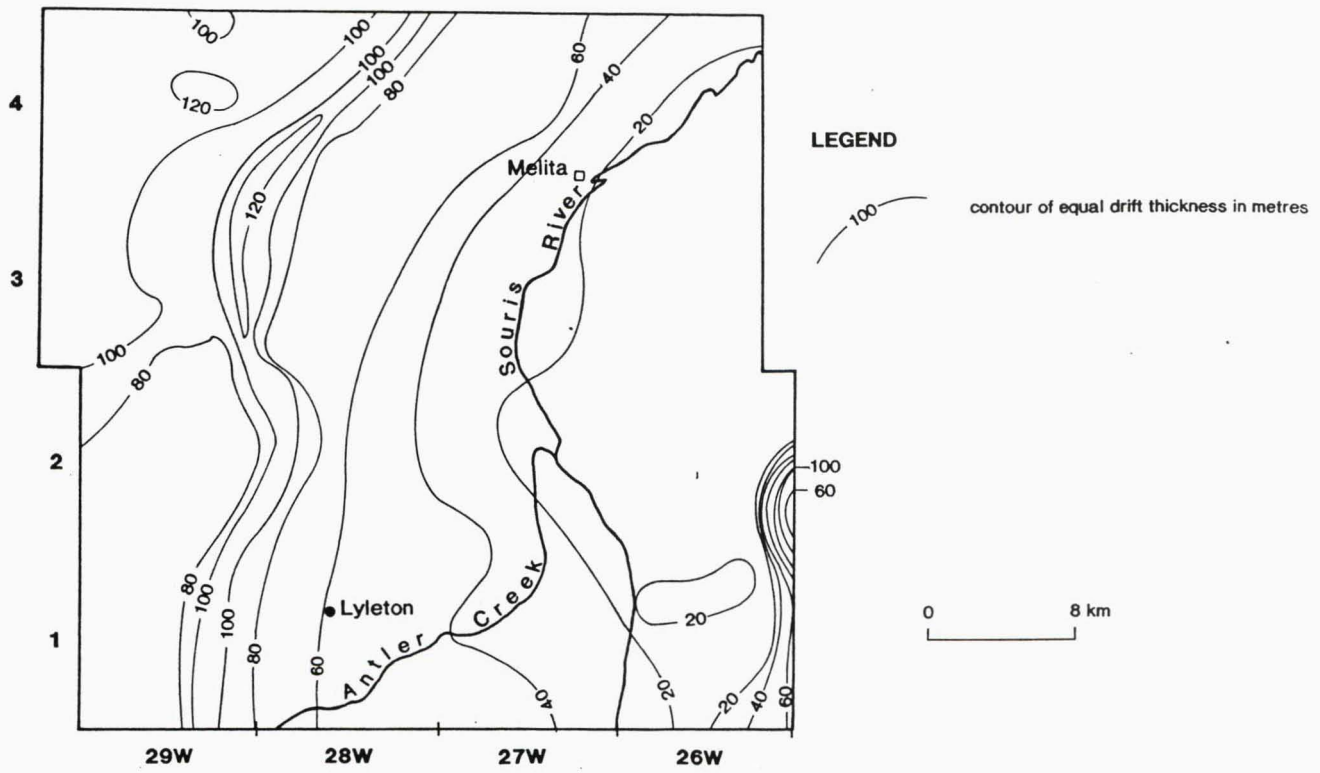

Figure 2: Drift thickness map (after Betcher, 1983).

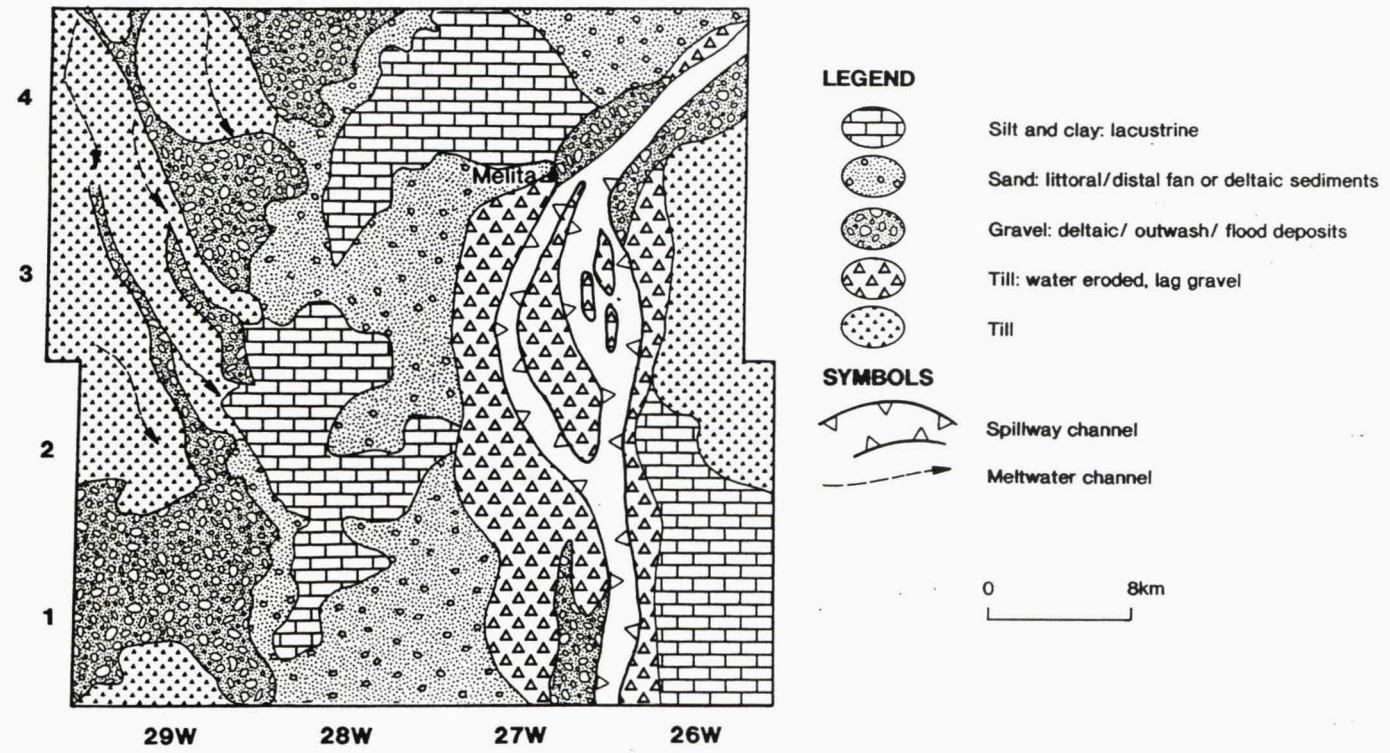

Figure 3: Surficial geology of the R.M.s of Edward and Arthur (modified from Elson, 1961).

GEOLOGY

BEDROCK GEOLOGY

The municipalities of Edward and Arthur are underlain by the Odanah Member of the Pierre Formation. Bannatyne (1970) assigned this unit to the Riding Mountain Formation, but work by McNeil and Caldwell (1981) resulted in a revised nomenclature that abandoned the use of the term "Riding Mountain Formation" and assigned its members to the Pierre Shale Formation.

The Odanah Member is a hard, grey siliceous marine shale with thin interbeds of soft, olive grey shale. Bentonite beds occur throughout the unit.

Bedrock in the Edward-Arthur area is overlain by 20 to >120 m of Quaternary sediments except along the Souris spillway channel (Fig. 2; Betcher 1983). Bedrock in the spillway channel is generally within 2m of surface.

Figure 2 also shows the location of the Pierson Valley, an early Pleistocene channel that lies within the preglacial Missouri River Valley (Klassen and Wyder, 1970).

LATE GLACIAL HISTORY

A generalized map of the surficial sediments in the region is shown in Figure 3. The sequence of the late Wisconsinan events, particularly the deglacial history of the area, is outlined in Elson (1956). The surface till was deposited by southeastward-flowing ice during the Late Wisconsinan. As the ice thinned during retreat, re-entrants formed around heights of land such as Turtle Mountain to the east and Moose Mountain to the west in Saskatchewan. Glacial Lake Souris formed at the ice front. Ice marginal channels and eskers carried sediments southeastward depositing a series of outwash fans and deltas along the north and west shores of the lake. The Pembina Trench was the northern outlet; as the trench deepened, Lake Souris shrank in size until it was entirely contained within the north basin. At this stage, Elson refers to the lake as Glacial Lake Hind. The Souris River and the Blind Souris spillway system carried water into the lake, depositing deltas at Melita and then Napinka as the lake receeded.

Recent work by Kehew (1982), Kehew and Clayton (1983) and Kehew and Lord (1986) indicate that the inlet channels to Lake Hind were formed during one short-lived, catastrophic flood. A sudden influx of water, probably from Glacial Lake Regina in Saskatchewan, caused Lake Souris, in North Dakota, to deeply erode its northern outlet and empty into Lake Hind. The eroding event must have occured near the end of the lakes' history as the channels are eroded to below the level of the floor of Lake Souris and the only depositional sediments in the spillway are alluvial deposits of the present-day underfit Souris River.

AGGREGATE RESOURCES

INTRODUCTION

The sand and gravel resources of the Edward-Arthur area are found as meltwater channel and deltaic deposits created as glacial meltwater flowed into Lake Souris.

Deposit and sample locations, as well as deposit production potential, are shown on Maps AR92-5-1 and AR92-5-2 (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 ¾"-1½" (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 municipalities and Appendix G is a glossary of relevant terms.

Table 1: Aggregate Deposits in the R.M.s of Edward and Arthur

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Estimated Reserves ('000s m^3)	Comments
11801	HM072 HM073 HB900s HB901 HB902 HB903 HB907 HB908		44	5 720.0	Material varies from shaley, coarse pebble gravel to pebbly sand. Shale content of the gravel is generally . >5%
11802	HB899			35.9	Shallow deposit; <1.5 m sandy fine pebble gravel overlying till
11803	HM137s	Inter.	40	80.9	New pit; deposit is a ridge of gravel on sand plain #Shale: low (2%).
11804	HM102s	Aband.	16	131.7	More than 3m of pebbly sand underlies pit floor; high shale and (5%) till balls in gravel
11805	HM096s HM099s	Aband. Aband.	47 49	867.5	Deposit is 3-4m pebble gravel to till floor; near depletion at north end. Shale: moderate to high (2-5%).
11806	HM098s HB904 HB905 HB906	Inter.	42	1 105.5	Deposit is highly variable from sandy pebble gravel to; sand HM098 is >7m pebble gravel while nearby backhoe testpits show sand. Shale content is variable; 1% at HM098.
11807	HM087s	Inter.	45	289.8	2-3m sandy pebble gravel; deposit near depletion Shale: high (12%).
11808	HM086	Aband.		24.9	Pit depleted; shaley, sandy material remains
11809	HM063s HM064 HM065s HB911 HB912	Aband. Aband. Inter.	48 55	306.0	Very shaley deposit (11-14%); near depletion in north
11810	HB913			72.9	Two metres shaley gravel

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Estimated Reserves ('000s m^3)	Comments
11811				76.0	About 1.5m sandy pebble gravel; deposit tested by Hwys. in 1949
11812	HM111	Aband.		31.0	About a metre of very fine gravel over till; shale: moderate
11813	HM112s	Aband.	44	81.6	Shallow deposit over till; material varies from sand to pebble gravel
11814	HM124s	Inter.	23	99.3	3m of gravel to till floor; deleterious = till balls Shale: low to moderate (3%).
11815	HM123s HB927 HB928	Aband.	20	131.7	3-4m fine pebble gravel and sand above water table; shaley. Shale: high (11%).
11816	HB924 HB925 HB926s		 37	307.5	Ridge in centre of deposit is >3m of sandy pebble gravel; flanks of deposit are shallow fine pebble gravel overtill. Shale: moderate but only (1%) in 5-10mm fraction
11817	HM115 HM117s	Aband. Aband.	 25	102.8	Deposit is 2-3m sandy pebble gravel over till; centre portion is untested. Shale: moderate to low.
11818	HM118	Aband.		6.7	Primarily sand
11819	HB922	Aband.		22.1	Gravel pit is 3m deep but backhoe pit at road is all till
11820	HM119s HM120	Inter. Aband.	32	294.0	North-west part of deposit is >4m sandy pebble gravel deposit shallows to south. Shale: moderate.
11821	HM061s HM062s HB915 HB916 HB917	Aband. Aband. Aband.	11 27	164.7	Mostly very shallow gravel over till; deepens to 2m in south-central portion. Shale: moderate to high (4-5%)
11822	HM110			34.3	Deposit is 2m sandy pebble gravel over water table.
11823	HM109s	Aband.	43	203.5	Pit is ~2m sandy fine pebble gravel; same material seems present in unopened part of deposit
11824	HM054s HM057	Aband. Aband.	39	97.5	Near depletion in south; some reserves to north Shale: moderate (5%).
11825	HM012 HM013 HM014s HM019 HM020s HM021s HM022s HM023 HM024 HM025	Aband. Aband. Inter. Aband. Aband. Inter. Inter. Aband. Aband. Aband.	 48 22 13 36	17 640.0	Deposit is generally 1-3m pebble gravel overlying sand or till. The gravel grades into pebbly sand along the eastern edge of the deposit. Shale content is low, usually less than 1%.

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Estimated Reserves ('000s m^3)	Comments
	HM026s	Inter.	37		
	HM027	Aband.			
	HM028	Aband.			
	HB833				
	HB834				
	HB835				
	HB836s		32		
	HB837				
	HB838				
	HB839				
	HB840				
	HB841				
	HB842				
	HB843				
	HB844				
	HB845				
	HB846				
	HB847				
	HB885				
	HB886				
	HB887				
	HB888				
	HB889s		20		
	HB890				
	HB891				
	HB892				
	HB893s		24		
11826	HM002s	Aband.	20	14 017.5	Deposit is 2-3m coarse pebble gravel over till in the northwestern portion; the gravel becomes finer, the beds less thick and the sand content increases to the south and east.Shale content is low, usually less than 1%.
	HM003s	Aband.	32		
	HM004				
	HM005	Aband.			
	HM007				
	HB849s		43		
	HB851				
	HB852				
	HB853				
	HB854				
	HB855				
	HB856				
	HB857				
	HB858				
	HB859s		40		
	HB860				
	HB861				
	HB862				
	HB863				
	HB864				
	HB865				
	HB867				
11827	HM083s		34	101.3	Dugout shows 2m sandy pebble gravel above the water table. Shale: moderate (4%).

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Estimated Reserves ('000s m^3)	Comments
11828	HM081s		36	215.3	Deposit is 1-2m fine pebble gravel to water table
	HM129	Inter.			Shale: low (<1%).
11829	HM030s		21	153.0	Shallow deposit of very sandy fine pebble gravel
	HM084s		20		Shale: low (1-2%).
	HM084A				
11830	HM085			141.8	More than 2m of good quality gravel but limited by water table
	HB830				
11831	HM093s	Aband.	37	258.1	Shallow deposit; 2-3m sandy fine pebble gravel over till
	HB828				Shale: low (<1%).
11832	HM094	Aband.		47.9	Pit shows 2.5m sandy fine pebble gravel
11833	HM095	Aband.		53.2	Dugout in base of pit shows gravel continues below water table
11834	HB896s		14	619.8	1-2m sandy pebble gravel over sand. Shale: low.
11835	HM105			74.2	2m of very sandy material
11836	HM046			335.0	Deposit shallows to the south east; m gravel over till
	HM136				at road
11837	HM033s	Aband.	33	36 429.3	Large deposit of variable material and depth. Material
	HM034s	Aband.	51		is generally 1-3m pebble gravel overlying till or clay.
	HM035s	Aband.	42		The gravel is usually fine and very sandy but there are
	HM036	Aband.			some areas of coarse pebble gravel. Shale content is
	HM037s		34		low (0-2%) at most sites but can be high; shale is 12%
	HM039s	Aband.	42		at HM044
	HM043				
	HM044s		13		
	HM045s		41		
	HM049s	Inter.	27		
	HM130				
	HM132s	Inter.	40		
	HB780				
	HB781				
	HB782				
	HB784				
	HB786s		33		
	HB787s		41		
	HB788				
	HB789				
	HB790				
	HB792s		17		
	HB794				
	HB796				
	HB797				
	HB798				
	HB799				
	HB800s		40		
	HB801				
	HB802				

Deposit Number	Site Number s=sample	Pit Status	Percent Stone (>#4) (>4.76mm)	Estimated Reserves ('000s m^3)	Comments
	HB803				
	HB804				
	HB805				
	HB806s		35		
	HB807				
	HB808				
	HB809				
	HB810s		43		
	HB811				
	HB812s		40		
	HB813				
	HB814				
	HB815				
	HB818				
	HB819				
	HB820				
	HB821				
	HB822				
	HB823				
	HB842				
		Total Reserves		**80 374.2**	

* Aband.=Abandoned; pit has not been used in several years, usually has begun to revegetate; not necessarily depleted
Inter.=Intermittant; pit is active or has been in recent use

Shale content based on visual estimate on site, percentage shale e.g.(5%) is percent by weight of the 5-10mm fraction

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 (<0.07mm)	Oversize on Site (> 6")
11801	HB900	44	51	5	-
11803	HM137	28	70	2	
11804	HM102	16	83	1	-
11805	HM096	47	49	4	-
	HM099	49	47	4	-
11806	HM098	42	54	4	-
11807	HM087	45	48	7	
11809	HM063	48	44	8	X
	HM065	55	40	5	X
11813	HM112	44	54	2	-
11814	HM124	23	76	1	-
11815	HM123	20	78	2	-
11816	HB926	37	60	3	-
11817	HM117	25	73	2	-
11820	HM119	32	67	1	X
11821	HM061	11	83	6	-
	HM062	27	66	7	-
11823	HM109	43	51	6	-
11824	HM054	39	56	5	X
11825	HB836	32	60	2	X
	HB889	20	77	3	-
	HB893	24	74	2	-
	HM014	48	56	3	X
	HM020	22	75	3	-
	HM021	13	82	5	-
	HM022	36	61	3	-
	HM026	37	60	3	-
11826	HB849	43	55	2	-
	HB859	40	59	1	-
	HM002	20	75	5	-
	HM003	32	65	3	-
11827	HM083	34	62	4	-
11828	HM081	36	59	5	-
11829	HM030	21	75	4	-
	HM084	20	73	7	-

Deposit Number	Sample Number	% Gravel (>#4) (>4.76 mm)	% Sand (4.76 mm-) (0.07 mm)	% Silt and Clay (<0.07mm)	Oversize on Site (> 6")
11831	HM093	37	61	2	-
11834	HB896	14	82	4	-
11837	HB786	33	65	2	-
	HB787	41	56	3	X
	HB792	17	82	1	-
	HB800	40	56	4	-
	HB806	35	47	18	-
	HB810	43	54	3	-
	HB812	40	57	3	X
	HM033	33	64	3	-
	HM034	51	46	3	-
	HM035	42	54	4	-
	HM037	34	63	3	-
	HM039	42	53	5	X
	HM044	13	83	4	-
	HM045	41	56	3	-
	HM049	27	70	3	X
	HM132	40	57	3	
NO DEPOSIT DEFINED					
	HM092	33	63	4	X
	HM067	3	90	7	-
	HM048	--	96	4	-
	HM040	38	57	5	-
	HM168	41	52	7	

AGGREGATE RESERVES

Much of the Edward-Arthur area is underlain by sand (map unit 5), pebbly sand (unit 4a) and sand and gravel (unit 4b). The sand and pebbly sand units have been shown on the map but are excluded from reserve calculations because they have limited economic value. As well, since the deltaic deposits were formed by rivers as they flowed into the lake, the boundaries between units are gradational and the lines on the map are ncessarily fairly arbitrary. The line between the gravel (4b) and sand (4a) portions of each deltaic deposit is a best fit based on field observations and testing; pockets of gravel occur in the 4a areas and there is much sand in the 4b portions.

Table 3: Aggregate Reserves in the R.M.s of Edward and Arthur

Rural Municipality	Production Potential High ('000 m^3)	Medium ('000 m^3)	Low ('000 m^3)	Total ('000 m^3)
Edward	17 640.0	50 446.8	1 999.6	70 086.4
Arthur	877.7	8 318.0	1 092.1	10 287.8
Total	18 517.7	58 764.8	3 091.7	80 374.2

There are 80 374.2 x 10^3 cubic metres of aggregate reserves in the Edward-Arthur area. Of these, 70 086.4 x 10^3 m^3 are in the R.M. of Edward and 10 287.8 x 10^3 m^3 in the R.M. of Arthur.

Table 3 shows aggregate reserve figures for deposits classified by production potential within each municipality. 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, land use pressures that may prevent gravel extraction and whether or not alternative sources are available. For example, the high percentage of shale in Deposit 11809 would indicate a low production potential; however, it has a high rating (and an active pit) due to the absence of any better, nearby sources. On the other hand, Deposit 11837, despite a large quantity of good quality gravel, has a moderate production potential because there is limited demand for aggregate in that area.

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

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
	Speciality Material	yes		no
	Aggregate Substitute	none	marginal	proximal

CONCLUSIONS

Aggregate reserves in the R.M.s of Edward and Arthur are found in deltaic and meltwater channel deposits scattered throughout the area. The deltaic deposits are generally the best sources of aggregate because they have greater depth and areal extent than the meltwater stream deposits. The meltwater stream deposits, however, are important for meeting local, small volume needs and most have pits in them.

The R.M. of Edward has by far the greater abundance of aggregate, concentrated primarily in the deltaic deposits (11825, 11826 and 11837). These deposits contain pockets of coarse gravel and have variable, but generally low, amounts of shale. There is little demand for aggregate, however, and currently there are only three active pits in the municipality.

The R.M. of Arthur, on the other hand, has much lower reserves, found in small deposits that are commonly very shaley. However, the town of Melita creates a high demand for gravel and despite the low quality, there are five active pits in the municipality.

REFERENCES

Bannatyne, B.B.

1970: The clays and shales of Manitoba; Manitoba Mines Branch, Publication 67-1, 107p.

Betcher, R.N.

1983: Groundwater availability map series, Virden area (62F); Manitoba Department of Natural Resources, Water Resources Branch, 1:250 000.

Eilers, R.G., Hopkins, L.A. and Smith, R.E.

1978: Soils of the Boissevain-Melita area; Manitoba Soil Survey, Soil Report No. 20, 204p.

Elson, J.A.

1956: Surficial geology of the Tiger Hills region, Manitoba, Canada; Yale University, Ph.D. Dissertation, 316p.

1961: Surficial geology, Virden, Manitoba and Saskatchewan; Geological Survey of Canada, Map 39-1961, 1:126 720.

Folk, R.L.

1974: Petrology of sedimentary rocks; Hemphill Publishing Company, Austin, Texas, 185p.

Hince, T.I., Vogel,C.G. and Barto, W.P.

1991: Crown Lands Handbook for Agro-Manitoba; Manitoba Department of Natural Resources.

Kehew, A.E.

1982: Catastrophic flood hypothesis for the origin of the Souris spillway, Saskatchewan and North Dakota; Geological Society of America Bulletin, v.93, p.1051-1058.

Kehew, A.E. and Clayton, L.

1983: Late Wisconsinan floods and development of the Souris-Pembina spillway system in Saskatchewan, North Dakota and Manitoba In Glacial Lake Agassiz, Teller, J.T. and CLayton, Lee, eds.; Geological Association of Canada Special Paper 26, p. 187-209.

Kehew A.E. and Lord, M.L.

1986 Origin and large-scale erosional features of glacial-lake spillways in the northern Great Plains; Geological Society of America Bulletin, v.97, p.162-177.

Klassen, R.W., Wyder, J.E. and Bannatyne, B.B.

1970: Bedrock topography and geology of southern Manitoba; Geological Survey of Canada, Paper 70-51, 1:500 000.

Klassen, R.W. and Wyder, J.E.

1970: Bedrock topography, buried valleys and nature of the drift, Virden map area, Manitoba; Geological Survey of Canada, Paper 70-56, 11p.

McNeil, D.H. and Caldwell, W.G.E.

1981: Cretaceous rocks and their foraminifera in the Manitoba escarpment; Geological Association of Canada Special Paper No.21, 439p.

Water Resources Division.

1968: Groundwater availability in the Milita area, Ground-water availability studies, Report No.1; Manitoba Department of Mines, Resources and Enviromental Management, 30p.

Wickenden, R.T.D.

1945: Mesozoic stratigraphy of the eastern plains, Manitoba and Saskatchewan; Geological Survey of Canada, Memoir 239, 87p.

APPENDIX A: GRAIN SIZE CLASSIFICATION AND SIEVE INTERVALS

APPENDIX B: DETAILED SIEVE RESULTS

Deposit Number		11801	11806	11804	11805	11805
Sample Number		HB900	HM098	HM102	HM096	HM099
Crushable on site		-	-	-	-	-
%	1½"	96	98	98	94	92
	¾"	83	89	94	78	77
P	⅜"	71	80	89	68	61
A	#4	56	58	84	53	51
S	#8	41	37	77	42	41
S	#16	27	26	67	32	33
I	#30	19	20	41	21	24
N	#50	13	9	7	9	13
G	#100	7	5	2	5	6
	#200	5	4	1	4	4

Deposit Number		11809	11809	11813	11814	11803
Sample Number		HM063	HM065	HM112	HM376	HM137
Crushable on site		X	X	-	-	-
%	1½"	89	92	98	98	97
	¾"	75	73	86	92	92
P	⅜"	64	57	70	85	83
A	#4	52	45	56	77	72
S	#8	41	37	42	65	55
S	#16	27	29	26	43	31
I	#30	17	15	13	22	17
N	#50	12	7	4	6	6
G	#100	9	6	2	2	2
	#200	8	5	2	1	2

Deposit Number		11815	11816	11817	11820	11821
Sample Number		HM123	HB926	HM117	HM119	HM061
Crushable on site		-	-	-	X	-
%	1½"	98	96	98	94	98
	¾"	92	90	92	86	96
P	⅜"	88	78	87	77	95
A	#4	80	63	75	68	89
S	#8	71	45	61	57	75
S	#16	53	28	46	41	49
I	#30	34	16	33	15	28
N	#50	8	6	9	4	13
G	#100	3	4	3	2	8
	#200	2	3	2	1	6

Deposit Number		11821	11823	11824	11825	11825
Sample Number		HM062	HM109	HM054	HB836	HB889
Crushable on site		-	-	X	X	-
%	1½"	98	97	97	92	98
	¾"	94	84	84	82	93
P	⅜"	84	69	74	74	87
A	#4	73	57	61	62	80
S	#8	59	45	44	50	72
S	#16	39	32	27	37	62
I	#30	19	19	13	19	45
N	#50	10	9	6	6	16
G	#100	7	6	5	3	5
	#200	7	6	5	2	3

Deposit Number		11825	11825	11825	11825	11825
Sample Number		HB893	HM014	HM020	HM021	HM022
Crushable on site		-	X	-	-	-
%	1½"	98	93	96	100	93
	¾"	95	82	91	100	77
P	⅜"	89	71	88	94	69
A	#4	76	59	78	87	64
S	#8	59	50	62	79	56
S	#16	38	31	36	66	42
I	#30	20	14	18	44	30
N	#50	8	6	10	16	14
G	#100	3	4	4	7	5
	#200	2	3	3	5	3

Deposit Number		11825	11826	11826	11826	11826
Sample Number		HM026	HB849	HB859	HM002	HM003
Crushable on site		-	-	-	-	-
%	1½"	100	91	100	96	100
	¾"	88	78	83	91	94
P	⅜"	75	68	71	87	81
A	#4	63	57	60	80	68
S	#8	52	47	49	72	53
S	#16	39	33	38	56	38
I	#30	23	19	23	33	25
N	#50	10	8	8	13	11
G	#100	5	3	3	5	5
	#200	3	2	1	4	3

Deposit Number		11827	11828	11829	11829	11831
Sample Number		HM083	HM081	HM030	HM084	HM093
Crushable on site		-	-	-	-	-
%	1½"	99	97	98	99	97
	¾"	90	88	93	93	87
P	⅜"	77	76	84	87	75
A	#4	66	64	79	80	63
S	#8	54	53	72	72	49
S	#16	41	40	63	60	36
I	#30	25	27	47	46	24
N	#50	11	15	16	20	9
G	#100	6	7	6	9	2
	#200	4	5	4	7	2

Deposit Number		11834	11837	11837	11837	11837
Sample Number		HB896	HB786	HB787	HB792	HB800
Crushable on site		-	-	X	-	X
%	1½"	99	99	93	99	99
	¾"	96	93	80	95	85
P	⅜"	91	80	71	91	70
A	#4	86	67	59	83	60
S	#8	79	54	44	72	49
S	#16	69	39	30	59	38
I	#30	51	17	17	34	25
N	#50	24	6	9	10	14
G	#100	6	3	4	3	6
	#200	4	2	3	1	4

Deposit Number		11837	11837	11837	11837	11837
Sample Number		HB806B	HB810	HB812	HM033	HB034
Crushable on site		-	-	X	X	-
%	1½"	97	95	92	98	93
	¾"	90	82	82	91	79
P	⅜"	78	70	73	82	65
A	#4	65	57	60	67	49
S	#8	51	43	45	51	37
S	#16	39	27	29	38	26
I	#30	33	17	16	26	14
N	#50	27	11	8	15	7
G	#100	20	5	4	6	4
	#200	18	3	3	3	3

Deposit Number		11837	11837	11837	11837	11837
Sample Number		HM035	HM037	HM039	HM044	HM045
Crushable on site		-	-	X	-	-
%	1½"	98	99	99	100	96
	¾"	86	91	86	98	83
P	⅜"	69	81	74	94	71
A	#4	58	66	58	87	59
S	#8	47	46	42	78	50
S	#16	34	22	30	64	35
I	#30	20	10	23	35	20
N	#50	8	7	11	13	7
G	#100	5	5	7	6	4
	#200	4	3	5	4	3

Deposit Number		11837	NODEP	NODEP	NODEP	NODEP
Sample Number		HM049	HM092	HM067	HM048	HM040
Crushable on site		X	X	-	-	-
%	1½"	99	96	--	--	1
	¾"	88	89	--	--	85
P	⅜"	84	79	98	--	74
A	#4	73	67	97	--	62
S	#8	60	54	96	98	48
S	#16	43	40	95	94	36
I	#30	25	23	93	80	24
N	#50	8	10	79	34	9
G	#100	4	5	29	7	4
	#200	3	4	7	4	5

Deposit Number		11837	11807	NO DEP
Sample Number		HM132	HM087	HM168
Crushable on site		X	X	X
%	1½"	98	92	92
	¾"	89	76	82
P	⅜"	77	66	68
A	#4	60	55	59
S	#8	42	43	49
S	#16	27	34	38
I	#30	17	21	25
N	#50	7	11	13
G	#100	5	8	8
	#200	3	7	7

APPENDIX C: % LITHOLOGY OF THE 3/4" - 1 1/2" FRACTION

Deposit Number	11806	11801	11804	11805	11805
Sample Number	HM098	HB900	HM102	HM096	HM099
% Sample encrusted	100	100	100	100	100
L Carbonates	58	63	60	62	51
I Pc crystalline	25	21	24	27	26
T Volcanics	2	1	4	1	4
H Greywacke,Argillite	-	-	1	-	-
O Gneiss,Schist	9	12	6	7	11
L Quartzite	1	1	1	1	2
O Sandstone,Arkose	-	-	-	-	1
G Chert, Concretions	1	1	2	1	1
Y Weathered	4	1	1	-	4
% SHALE (5-10mm fraction)	1	6	4	2	5

Deposit Number	11809	11809	11813	11814	11815
Sample Number	HM063	HM065	HM112	HM124	HM123
% Sample encrusted	100	100	100	100	100
L Carbonates	43	61	55	52	60
I Pc crystalline	38	19	25	30	27
T Volcanics	4	3	3	3	2
H Greywacke,Argillite	1	2	1	-	-
O Gneiss,Schist	13	14	12	10	8
L Quartzite	-	1	1	1	-
O Sandstone,Arkose	-	-	-	-	-
G Chert, Concretions	1	1	2	2	1
Y Weathered	1	-	1	2	1
% SHALE (5-10mm fraction)	11	14		3	11

Deposit Number	11816	11817	11820	11821	11821
Sample Number	HB926	HM117	HM119	HM061	HM062
% Sample encrusted	100	100	100	100	100
L Carbonates	57	58	52	65	65
I Pc crystalline	27	23	28	17	21
T Volcanics	2	2	3	2	2
H Greywacke,Argillite	-	-	2	1	-
O Gneiss,Schist	9	9	10	8	8
L Quartzite	1	1	2	-	2
O Sandstone,Arkose	-	1	-	2	-
G Chert, Concretions	3	2	1	2	1
Y Weathered	1	3	2	2	1
% SHALE (5-10mm fraction)	<1	1	3	5	4

Deposit Number	11823	11824	11825	11825	11825
Sample Number	HM109	HM054	HM014	HM020	HM021
% Sample encrusted	100	100	100	100	100
L Carbonates	63	47	58	47	50
I Pc crystalline	23	30	23	24	28
T Volcanics	4	4	4	2	-
H Greywacke,Argillite	-	1	-	-	-
O Gneiss,Schist	5	12	8	14	11
L Quartzite	2	2	2	8	6
O Sandstone,Arkose	1	1	1	4	6
G Chert, Concretions	1	2	1	1	-
Y Weathered	1	2	3	-	-
% SHALE (5-10mm fraction)	<1	5	-	<1	<1

Deposit Number	11825	11825	11825	11825	11825
Sample Number	HM022	HM026	HB836	HB889	HB893
% Sample encrusted	100	100	100	100	100
L Carbonates	55	53	57	49	61
I Pc crystalline	21	18	23	26	16
T Volcanics	4	5	2	3	4
H Greywacke,Argillite	1	-	-	1	1
O Gneiss,Schist	12	16	9	7	5
L Quartzite	2	3	1	1	5
O Sandstone,Arkose	5	5	1	-	1
G Chert, Concretions	-	-	1	1	3
Y Weathered	-	-	6	3	4
% SHALE (5-10mm fraction)	-	<1	1	1	<1

Deposit Number	11826	11826	11826	11826	11827
Sample Number	HM002	HM003	HB849	HB859	HM083
% Sample encrusted	100	100	100	100	100
L Carbonates	54	65	51	56	47
I Pc crystalline	26	11	18	23	45
T Volcanics	5	4	2	4	1
H Greywacke,Argillite	-	2	-	-	-
O Gneiss,Schist	7	9	10	10	6
L Quartzite	-	1	1	1	1
O Sandstone,Arkose	5	9	1	-	-
G Chert, Concretions	-	-	2	1	-
Y Weathered	3	-	5	5	1
% SHALE (5-10mm fraction)	<1	<1	<1	<1	4

Deposit Number	11828	11829	11829	11831	11834
Sample Number	HM081	HM030	HM084	HM093	HB896
% Sample encrusted	100	100	100	100	100
L Carbonates	55	45	51	54	49
I Pc crystalline	24	28	30	32	28
T Volcanics	1	4	1	1	5
H Greywacke,Argillite	2	-	1	1	-
O Gneiss,Schist	15	15	5	7	11
L Quartzite	-	3	-	1	1
O Sandstone,Arkose	-	2	-	1	1
G Chert, Concretions	-	-	-	2	3
Y Weathered	4	2	2	1	2
% SHALE (5-10mm fraction)	<1	2	1	<1	1

Deposit Number	11837	11837	11837	11837	11837
Sample Number	HM033	HM034	HM035	HM037	HM039
% Sample encrusted	100	100	75	100	100
L Carbonates	46	56	46	53	64
I Pc crystalline	34	31	28	28	13
T Volcanics	3	2	3	2	5
H Greywacke,Argillite	1	1	-	-	1
O Gneiss,Schist	7	6	21	10	13
L Quartzite	3	1	1	2	3
O Sandstone,Arkose	2	1	-	1	-
G Chert, Concretions	2	1	2	1	1
Y Weathered	2	1	1	3	-
% SHALE (5-10mm fraction)	-	-	-	-	1

Deposit Number	11837	11837	11837	11837	11837
Sample Number	HM044	HM045	HM049	HB786	HB787
% Sample encrusted	20	100	100	100	100
L Carbonates	33	53	49	49	50
I Pc crystalline	33	24	30	29	29
T Volcanics	-	2	3	4	2
H Greywacke,Argillite	4	-	1	-	1
O Gneiss,Schist	19	15	13	8	10
L Quartzite	4	1	1	3	3
O Sandstone,Arkose	4	-	1	2	-
G Chert, Concretions	-	1	-	1	2
Y Weathered	-	3	3	4	3
% SHALE (5-10mm fraction)	12	2	1	<1	<1

Deposit Number	11837	11837	11837	11837	11837
Sample Number	HB792	HB800	HB806	HB810	HB812
% Sample encrusted	100	100	100	80	100
L Carbonates	43	52	51	49	53
I Pc crystalline	24	26	27	32	28
T Volcanics	-	2	2	3	2
H Greywacke,Argillite	-	-	1	3	-
O Gneiss,Schist	13	12	12	9	9
L Quartzite	2	1	-	1	1
O Sandstone,Arkose	6	1	-	-	2
G Chert, Concretions	3	1	1	4	2
Y Weathered	9	5	6	1	3
% SHALE (5-10mm fraction)	1	1	<1	<1	2

Deposit Number	11837	11803	11807	NODEP	NODEP
Sample Number	HM132	HM137	HM087	HM040	HM092
% Sample encrusted	100	100	100	100	100
L Carbonates	37	35	50	49	51
I Pc crystalline	32	24	28	28	31
T Volcanics	2	3	2	4	2
H Greywacke,Argillite	11	9	4	1	-
O Gneiss,Schist	4	1	-	13	10
L Quartzite	1	7	5	3	1
O Sandstone,Arkose	4	11	1	2	-
G Chert, Concretions	2	4	2	-	2
Y Weathered	7	6	8	-	3
% SHALE (5-10mm fraction)	-	2	12	5	<1

APPENDIX D: AGGREGATE SITES and BACKHOE TEST PIT LOGS

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
11801	HM072	bulldozer test; <3 m sandy fine pebble gravel
	HM073	dug out; 2m sandy fine pebble gravel
	HB900s	0.0 - >2.9m interbedded sandy fine and sandy coarse pebble gravel; shaley.
	HB901	0.0 - >2.9m sandy pebble gravel fines down to coarse pebbly sand at base; high shale
	HB902	0.0 - >2.4m sandy fine pebble gravel interbedded with coarse pebbly sand high shale
	HB903	0.0 - 0.9m fine sand, massive 0.9 - >2.8 very sandy fine pebble gravel
11802	HB899	ditch: <1m sandy fine pebble gravel backhoe: >0.3 m sandy fine pebble gravel over till
11803	HM101	abandoned pit, depleted
11804	HM102s	pit, recently active at north end; >3m sandy fine pebble gravel and pebbly sand, till balls and abundant shale pebbles; backhoe in floor shows >3m pebbly sand
11805	HM096s HM099s	active pit; >3.5m sandy pebble gravel, moderate shale old, revegetated pits, till floored
011806	HM098s	very large old pit; 3-4m of variable material ranging from med. sand to coarse pebble gravel Backhoe at base: >2m of interbedded sandy fine pebble gravel and pebbly sand, abundant large shale pebbles
	HB904	0.0 - 2.6m sandy coarse pebble gravel, shaley >2.6 water table
	HB905	0.0->2.5m interbeds of fine sand, medium sand and granules >2.5 water table
	HB906	0.0 - 1.2m fine sand, stone free 1.2 - >2.0 coarse sand >2.0 water table
	HB907	0.0 - 1.3m fine sand, stone free 1.3 - >2.7 coarse sand with granules and pebbles
11807	HM087s	intermittant pit; sandy pebble gravel over till and water
11808	HM086	pit depleted; sand walls remain
11809	HM063s	abandoned pit; 2-3m deep, sandy coarse pebble gravel backhoe in floor shows <1 m sandy fine pebble gravel over till
	HM064 HM065s	abandoned pit; 2-3m to till floor; original material was shaley, sandy coarse pebble gravel active pit; 3-4m sandy fine to cobbly coarse pebble gravel, high shale
	HB911	0.0 - 0.6m sandy coarse pebble gravel, large shale clasts >0.6 till

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB912	0.0 - 2.5m sandy coarse pebble gravel; very shaley >2.5 till
11810	HB913	0.0 - 2.0m sandy pebble gravel, abundant shale cobbles
11812	HM111	abandoned pit, 1m sandy fine pebble gravel over till; low shale
11813	HM112s	pit depth 1-2m over till; material varies from coarse sand to clean, well sorted sandy pebble gravel
11814	HM124s	active pits; 3m sandy fine pebble gravel over till; backhoe in floor shows 0.8m sandy fine pebble gravel over clay
11815	HM123s	inactive pit; 2-3m sandy fine pebble gravel backhoe at base: 0.0 - 0.1m sandy fine pebble gravel 0.1 - >1.2 medium coarse sand >1.2 water table
	HB927	0.0 - >2.8m sandy pebble gravel, high shale sandier to base
	HB928	0.0 - >2.8m sandy pebble gravel, high shale
11816	HB924	0.0 - 0.8m sandy coarse pebble gravel >0.8 till
	HB925	0.0 - 1.4m sandy pebble gravel fining down to coarse sand and granules >1.4 till
	HB926s	0.0 - >3.0m sandy pebble gravel
11817	HM115	abandoned pits, shallow; originally sandy pebble gravel
	HM117s	large pit recently active in north; 2.5m interbedded pebbly sand and sandy pebble gravel, continues below water table
11818	HM118	small pit, material is medium fine sand
11819	HB922	abandoned pit, till floored
11820	HM119s	intermittant pit; <3m pebble gravel and pebbly sand, water table at 3m.
	HM120	abandoned pits, some pebble gravel left at north end
11821	HM061s	abandoned pit; 1.5m deep, sand floored backhoe in floor shows 0.2m sand over till
	HM062s	abandoned pit, 2m deep to till floor
	HB915s	0.0 - 1.0m sandy, shaley pebble gravel >1.0 till
	HB916	0.0 - 0.1m sandy fine pebble gravel >0.1 till

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB917	0.0 - 2.1m very coarse sand with pebbles >2.1 till, water table
	HB918	0.0 - 1.0m sandy fine pebble gravel 1.0 - 1.2 sand >1.2 till
11822	HM110	dugout; 2m sandy pebble gravel to water table; dugout north of road is <1m pebble gravel with clay at water table
11823	HM109s	revegetated pits; >2m sandy fine pebble gravel to sand floor
11824	HM054s	small pit, 2.5m to till floor; material varies from granules to coarse pebble gravel
	HM057	3m till over medium sand
11825	HM012	depleted pit, a little sandy fine pebble gravel remains
	HM013	small revegetated pit; 3m sandy coarse pebble gravel to gravel floor
	HM014s	active pit; 3m sandy coarse pebble gravel water table .5m below floor
	HM019	inactive pit; 3m pebbly coarse sand
	HM020s	inactive pit; material generally very sandy fine pebble gravel but some areas of coarse pebble gravel
	HM022s	inactive pits; 3-4m deep. Backhoe in floor shows 0.8m pebbly sand and then the water table
	HM023	old pit, very sandy fine pebble gravel
	HM024	abandoned pit, depleted
	HM025	abandoned pit; >2m sandy fine pebble gravel over till
	HM026s	small pit; 2m very sandy fine pebble gravel with coarse pebbly sand at base
	HM027	small pit; 2-3m sandy pebble gravel
	HM028	abandoned pit; waste pile of >2" on site
	HB833	0.0 - 0.3m fine sand 0.3 - 2.0 sandy coarse pebble gravel, up to small cobbles 2.0 - >2.2 coarse sand >2.0 water table
	HB834	0.0 - 2.0m sandy pebble gravel becoming sandier to base
	HB835	0.0 - 1.0m sandy coarse pebble gravel 1.0 - 2.5 interbeds of sandy fine pebble gravel and coarse sand
	HB836s	0.0 - 2.2m sandy coarse pebble gravel, up to small cobbles 2.2 - >2.9 coarse sand

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB837	0.8m very coarse pebble gravel over till
	HB838	3.3m sandy coarse pebble gravel
	HB839s	0.0 - 1.0m sandy pebble gravel 1.0 - 2.5 interbeds of pebbly coarse sand and sandy fine pebble gravel >2.5 coarse sand
	HB840	0.0 - 2.0m sandy coarse pebble gravel 2.0 - 2.3 pebbly sand >2.3 till
	HB841	floor of HM024: 0.0 - 2.0 coarse sand with pebbles >2.0 clay; water table
	HB842	0.0 - 0.8m sandy pebble gravel 0.8 - 1.9 sand and fine pebble gravel - caving
	HB843	0.0 - 1.2m sandy fine pebble gravel >1.2 till
	HB844	0.0 - 0.8m sandy fine pebble gravel 0.8 - >1.3 coarse sand >1.3 water table
	HB845	0.0 - >2.1m sandy fine pebble gravel, high amount of coarse sand - caving
	HB846	0.0 - 1.3m sandy coarse pebble gravel 1.3 - >2.3 coarse sand
	HB847	0.0 - 1.3m cobbly sandy coarse pebble gravel 1.3 - 2.4 coarse sand, pebbles 2.4 - >2.5 medium sand >2.5 water table
	HB885	0.4m silt over till
	HB886	0.0 - 1.0m very sandy fine pebble gravel 1.0 - >2.5 interbedded coarse sand and pebbly coarse sand >2.5 water table
	HB887	>2.0m medium sand
	HB888	0.0 - 1.5m very sandy fine pebble gravel 1.5 - >2.5 medium sand with some pebbles
	HB889s	0.0 - 1.0m sandy pebble gravel 1.0 - 1.5 sandy fine pebble gravel 1.5 - 2.9 sandy coarse pebble gravel >2.9 till
	HB890	0.0 - 1.8m very sandy pebble gravel >1.8 till

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB891	0.0 - 1.0m sandy fine pebble gravel 1.0 - >3.2 interbeds of coarse sand and very fine pebble gravel - caving
	HB892	0.0 - 2.1m medium sand with pebbles >2.1 stone-free sand
	HB893s	0.0 - 2.3m interbeds of very sandy fine pebble gravel, coarse sand and granules 2.3 - 2.4 till - olive, shaley >2.4 clay - black, stoney
11826	HM002s	abandoned pit; 3m deep to sand and gravel floor
	HM003s	abandoned pit; 2m deep to sand floor
	HM004	dugout; 2m sandy coarse pebble gravel above water
	HM005	depleted pit; till floored; stockpiles on site
	HM007	dugout; 2-3m very sandy fine pebble gravel
	HB849s	0.0 - 2.0m sandy coarse pebble gravel 2.0 - >2.6 sandy pebble gravel with high sand >2.6 water table
	HB850	0.0 - >2.8m sandy coarse pebble gravel >2.8 water table
	HB851	0.0 - 0.1m silty fine sand 0.3 - 1.3 sandy coarse pebble gravel 1.3 - >2.5 interbeds of coarse sand and pebble gravel >2.5 water table
	HB852	0.0 - 0.8m sandy coarse pebble gravel 0.8 - >2.0 medium coarse sand
	HB853	0.0 - 0.9m fine sand 0.9 - 1.7 coarse sand becoming pebbly to base >1.7 till
	HB855	0.0 - 1.5m sandy pebble gravel >1.5 till
	HB856	0.0 - 0.3 fine sand 0.3 - 0.6 cobbly coarse pebble gravel >0.6 till
	HB857	0.0 - 0.1m fine sand 0.1 - 1.9 very sandy fine pebble gravel >1.9 till
	HB858	0.0 - >1.7m very sandy pebble gravel >1.7 water table

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB859s	0.0 - 1.7m sandy pebble gravel 1.7 - >2.8 fine pebble gravel, high coarse sand >2.8 water table
	HB860	0.0 - >3.0m sandy coarse pebble gravel >3.0 water table
	HB861	0.0 - 1.4m very sandy fine pebble gravel 1.4 - 2.1 coarse sand, some pebbles >2.1 medium fine sand
	HB862	0.0 - 1.0m sandy fine pebble gravel 1.0 - >2.6 very sandy fine pebble gravel >2.6 water table
	HB863	0.0 - 1.0m sandy fine pebble gravel 1.0 - 2.0 pebble gravel, high coarse sand 2.0 - 2.8 medium sand >2.8 water, coarse sand and pebbles
	HB864	0.0 - 1.6m sandy coarse pebble gravel >1.6 till
	HB866	0.0 - 1.0m sandy fine pebble gravel 1.0 - 2.5 coarse pebbly sand grading down to stone free medium sand at base >2.5 water table
	HB867	0.0 - 1.5m very sandy pebble gravel 1.5 - 2.2 interbeds of coarse sand and pebbles >2.2 coarse sand
11827	HM083s	dugout; >2m sandy pebble gravel, low shale
11828	HM081s	dugout; <2m sandy pebble gravel
	HM129	revegetated pit; some sandy pebble gravel remains
11829	HM030s	ditch cut; 2m very sandy fine pebble gravel
	HM084s	dugout; 2m very sandy fine pebble gravel, low shale; dugout to north (HM084a) is 1.4m pebble gravel above water level
11830	HM085	dugout; 3m sandy fine pebble gravel
	HB830	0.0 - 1.0m sandy pebble gravel 1.0 - >2.2 very sandy fine pebble gravel >2.2 water
11831	HM093s	revegetated pit; 2m deep, very sandy fine pebble gravel
	HB828	ditch cut; 1.6m sandy pebble gravel over till
11832	HM094	revegetated pit; 2.5m deep, sandy fine pebble gravel

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
11833	HM095	revegetated pit; water table at base
11834	HM074	dugout; 2m sandy fine pebble gravel
	HB896s	0.0 - 1.7m sandy pebble gravel 1.7 - >3.2 sand; fines down from pebbly sand to fine sand at base
11835	HM105	ditch cut; 2m very sandy fine pebble gravel
11836	HM046	<1m interbedded pebble gravel and fine sand over till
	HM136	dugout; 2m sandy coarse pebble gravel above water table
11837	HM033s	large pit; 3m sandy pebble gravel; gravel and water table at base
	HM034s	revegetated pit; <2m deep, sandy coarse pebble gravel. Dugout east of road is 0.5m silty sand over 2m sandy fine pebble gravel; water table
	HM035s	very large pit; 2m sandy coarse pebble gravel; east end revegetated
	HM036s	several small pits, all revegetated
	HM037s	ditch cut; 1.5m sandy fine pebble gravel
	HM039s	abandoned pit; 0.5m fine silty sand over 2-3m sandy pebble gravel
	HM042	ditch cut; 1.5m very sandy fine pebble gravel
	HM044s	ditch cut; 3m very sandy fine pebble gravel over medium sand
	HM045s	ditch cut; 2m very sandy fine pebble gravel
	HM130	dugout; <2m sandy pebble gravel to water
	HM132	revegetated pit; sandy coarse pebble gravel over sand
	HB780	revegetated pit; 2.5m sandy pebble gravel.Backhoe test pit in base shows <1m sandy fine pebble gravel to water table
	HB781	0.0 - 1.3m sandy pebble gravel 1.3 - >2.5 sand-some stone in upper metre
	HB782	0.0 - 1.1m sandy pebble gravel 1.1 - >2.1 coarse sand >2.1 water table
	HB783	0.0 - 2.0 very sandy fine pebble gravel 2.0 - >2.4 very sandy fine fine pebble gravel >2.0 water table
	HB784	0.0 - 0.2m fine sand 0.2 - 1.3 sandy fine pebble gravel 1.3 - 2.8 coarse sand >2.8 stoney clay

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB786s	0.0 - 2.6m sandy fine pebble gravel >2.6 till; water table
	HB787s	0.0 - 0.2m fine sand 0.2 - 1.9 sandy coarse pebble gravel 1.9 - >2.1 medium sand
	HB788	0.0 - 1.5m sandy coarse pebble gravel 1.5 - >2.7 interbeds of very sandy fine pebble gravel and medium sand >2.7 water table
	HB789	0.0 - 1.0m pebbly sand >1.0 till
	HB790	1m sand with some pebbles
	HB791	0.0 - 0.8m fine sand 0.8 - 1.8 very sandy fine pebble gravel 1.8 - >2.3 sandy pebble gravel >2.3 water table
	HB792	0.0 - 0.2m sand 0.2 - 1.6 very sandy fine pebble gravel 1.6 - >2.5 medium sand >2.5 water table
	HB794	0.0 - 2.4m sandy coarse pebble gravel, cobbly to base >2.4 till
	HB795	>2.5m medium sand
	HB796	1.5m sandy fine pebble gravel over fine sand
	HB797	0.0 - 0.9m sandy coarse pebble gravel >0.9 clay
	HB798	0.0 - 2.0m sandy fine pebble gravel >2.0 sand
	HB799	0.0 - 2.3m fine sand 2.3 - >2.5 sandy pebble gravel - caving
	HB800s	0.0 - 0.2m fine sand 0.2 - >2.4 sandy coarse pebble gravel >2.4 water table
	HB801	0.0 - 0.5m fine sand 0.5 - >1.9 sandy fine pebble gravel fining down to pebbly sand by base >1.9 water table
	HB802	0.0 - 0.3m fine sand 0.3 - 2.2 interbeds of sandy fine pebble gravel and medium sand >2.2 water table, some boulders

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB803	0.0 - 0.5m fine sand 0.5 - 2.6 very sandy fine pebble gravel, some thin beds of medium sand >2.6 water table, caving
	HB804	0.0 - 0.5m fine sand 0.5 - 1.5 very sandy fine pebble gravel >1.5 clay
	HB805	0.0 - 1.8m fine sand >1.8 till
	HB806s	0.0 - 0.5m fine sand 0.5 - 2.3 sandy fine pebble gravel >2.3 till
	HB807	0.0 - 1.2m very sandy fine pebble gravel 1.2 - >2.4 pebbly sand
	HB808	0.0 - 0.5 fine sand 0.0 - >1.6 medium sand
	HB809	ditch wall is 1.5m very sandy fine pebble gravel ditch floor is: 0.0 - 0.5m sandy fine pebble gravel 0.5 - 1.2 coarse sand >1.2 till
	HB810s	ditch wall is 0.8m sandy pebble gravel ditch floor is: 0.0 - 1.6m sandy pebble gravel >1.6 water table
	HB811	0.0 - >2.1m very sandy fine pebble gravel >2.1 water table
	HB812s	>3.3m sandy coarse pebble gravel; low shale
	HB813	0.0 - 2.9m sandy coarse pebble gravel >2.9 till
	HB814	0.0 - 1.5m sandy pebble gravel >1.5 till
	HB815	0.0 - 0.8m very sandy fine pebble gravel 0.0 - >1.5 medium sand
	HB816	ditch wall is 0.9m sandy pebble gravel ditch floor is: 0.0 - 0.2m sandy pebble gravel 0.2 - >1.3 pebbly coarse sand >1.3 water table
	HB818	till; <0.3m silty fine sand at surface

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB819	0.0 - 1.7m sandy coarse pebble gravel, low shale 1.7 - >2.7 coarse sand, some pebble lenses >2.7 water table
	HB820	top of rim: 0.0 - 2.3m sandy fine pebble gravel; massive,poorly sorted with high, medium sand matrix 2.3 - 2.5 sand; medium, planar bedded >2.5 till
	HB821	0.0 - 0.6m silt and clay 0.6 - 1.1 silty clay, becoming stony to base 1.1 - >1.4 very sandy fine pebble gravel >1.4 water table
	HB822	rim bottom: 0.0 - 0.4m silty sand 0.4 - 0.7 coarse brown sand 0.7 - 1.3 grey silty clay 1.3 - >1.6 coarse sand with pebbles >1.3 water table
	HB823	rim top: 0.0 -2.7m sandy fine pebble gravel becoming sandier to base - hole stopped due to caving
BACKHOE PITS - NO DEPOSIT		
	HB793	0.0 - 1.8m fine sand >1.8 silty clay
	HB795	>2.5m medium sand,coarsening down to coarse sand and granules
	HB817	1m silt overlying till
	HB826	0.7m cobble lag over till
	HB827	0.5m sand over till
	HB829	1m coarse sand
	HB832	0.8m sandy fine pebble gravel over till
	HB854	0.0 - 0.5m fine sand 0.5 - >2.1 coarse sand, some pebble layers >2.1 water table
	HB869	1.8m sandy pebble gravel, disturbed, over bedrock (green sand over black sand)
	HB870	0.0 - 0.5m fine sand 0.5 - >2.8 lag sand and gravel at top then into coarse sand >2.8 water table
	HB871	2.6m sand then water table
	HB872	0.0 - 1.5m pebbly sand 1.5 - 2.2 medium-coarse sand - caving

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB873	1.7m coarse sand then water table
	HB874	0.0 - 1.5m pebbly sand 1.5 - 2.3 coarse sand >2.3 cobble lag over till
	HB875	0.0 - 0.3m fine sand 0.3 - 1.5 pebbly sand 1.5 - 1.6 silt, grey 1.6 - 2.5 medium coarse sand >2.5 clay, black, stony (till?)
	HB876	ditch wall: 1m very sandy fine pebble gravel ditch floor: 0.0 - 0.2m very sandy fine pebble gravel 0.2 - 1.0 pebbly sand 1.0 - >1.6 coarse sand >1.6 water table
	HB877	2.5m interbedded coarse sand and pebbly sand
	HB878	0.0 - 1.0m very sandy fine pebble gravel 1.0 - 3.2 sand, some pebbles 3.2 - >3.4 sandy fine pebble gravel >3.4 water table
	HB879	2.7m pebbly sand fines down to fine sand at base water table at 2.7m
	HB880	1.3m sandy fine pebble gravel over till
	HB881	0.0 - 2.5m pebbly sand/thin bed sandy fine pebble gravel 2.5 - 3.1 medium sand >3.1 pebble lag over till
	HB882	2.5m pebbly sand at top becomes medium sand in lower part
	HB883	pebble lag over medium sand
	HB884	2.4m fine to medium sand with a few lenses of coarse pebbly sand
	HB894	0.0 - 0.5 sandy fine pebble gravel 0.5 - 2.5 interbedded pebbly sand and coarse sand 2.5 - >2.7 clay; black, stony
	HB895	ditch wall: 0.5m very sandy fine pebble gravel ditch floor: 0.0 - 0.1m very sandy fine pebble gravel 0.1 - >1.5 coarse sand
	HB897	0.0 - 0.2m sandy fine pebble gravel 0.2 - 2.8 medium fine sand >2.8 water table; fine sand
	HB898	2.8m medium fine sand fining down to silty sand
	HB909	till

DEPOSIT NUMBER	SITE NUMBER s=sample	LOG
	HB910	0.5m sandy coarse pebble gravel over till
	HB914	ditch wall: 0.8m very sandy fine pebble gravel ditch floor: 0.0 - 0.3m very sandy fine pebble gravel 0.3 - 0.4 clay >0.4 till
	HB919	pebble lag over till
	HB920	pebble lag over till
	HB921	till
	HB922	till
	HB923	2m fine sand
	HM071	dug out; 2-3m medium sand; gravel below water table

APPENDIX E: INFORMATION FROM THE DEPARTMENT OF HIGHWAYS BLOCK FILES

Deposit Number	Sample Location	Inventory Type P=pit B=backhoe	Deposit Depth	Number of Samples	% Stone >#4	End Use
11802	NE24-4-26W	P	2.4	4	22-64	Bituminous
	NE24-4-26W	B	3.0	32	9-37	Traffic, C base
	NW24-4-26W	P	1.8	46	25-60	Pit run
11803	NW8-4-26W	P	1.8	1	35	
11804	NE8-4-26W	P	2.7	5	23-32	
11805	NE24-4-26W	B	2.5	32	30-72	
	NE24-4-26W	P	2.4	4	22-64	Bituminous,
	NW24-4-26W	P	1.8	46	27-70	Bituminous, Traffic, C Base Pit run
11806	SW36-4-26W	B	1.9	68	7-48	
11807	SW12-4-26W	B	1.8	36	4-75	Traffic gravel
	NW12-4-26W	B	1.5	56	1-60	Pit run
11808	SW4-4-26W	P	1.8	1	35	Traffic,Pit run
11809	NW29-3-26W	P	1.8	2	31-53	Bituminous,
	NE29-3-26W	P	2.5	8	39-65	Traffic gravel
	SE32-3-26W	P	3.1	6	35-53	Pit run
11811	SW32-4-26W	B	1.5	6	18-46	
11813	NW24-3-27W	P	2.0	8	19-56	
11815	NW36-2-27W	P	2.0	6	16-49	Traffic,Pit run
11817	NW22-2-27W	P	2.0	9	20-49	Pit run,Traffic
	NW28-2-27W	B	1.5	23	6-48	Base course
11820	SW12-2-27W	P	2.7	5	37-60	Traffic,Pit run
11821	NE7-2-26W	P	1.5	3	37-45	Traffic
	NW8-2-26W	P	1.5	3	15-25	
	SW17-2-26W	P	1.5	2	15-23	
	SE18-2-26W	P	1.8	3	20-34	
11822	NW14-1-27W	P	1.8	2	34	
11823	SE11-1127W	B	1.2	51	5-53	
11825	SE8-4-28W	P	2.5	7	5-38	Traffic gravel
	SE1-4-29W	P	2.0	7	14-26	Pit run
	SW1-4-29W	P	2.2	5	26-47	
11826	NE29-4-28W	P	0.8	3	15-28	
11828	NE20-3-29W	P	2.0	4	35-49	

Deposit Number	Sample Location	Inventory Type P=pit B=backhoe	Deposit Depth	Number of Samples	% Stone >#4	End Use
	SE29-3-29W	P	1.2	2	16-25	
11831	NE3-3-29W	P	2.0	7	4-28	Traffic
11832	SE3-3-29W	P	2.0	3	5-19	
11833	SW2-3-29W	P	0.9	3	28-50	
11834	NW5-3-28W	P	1.0	1	10	
11837	NW22-1-29W	P	3.0	5	40-45	A & C Base
	NW24-1-29W	P	3.0	6	14-23	Seal Coat
	SE28-1-29W	P	2.0	6	14-42	Traffic
	SW2-2-29W	P	3.0	5	25-35	
	SW3-2-29W	P	3.0	6	12-38	

APPENDIX F: LOCATION OF CROWN LANDS

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.