MANITOBA

DEPARTMENT OF ENERGY AND MINES

MINERAL RESOURCES DIVISION

GEOLOGICAL REPORT

GR82-4

QUATERNARY GEOLOGY AND AGGREGATE RESOURCE INVENTORY OF THE THOMPSON AREA

by

R.V. Young

1982

MANITOBA
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ABSTRACT

A Quaternary geology and aggregate resource inventory was carried out in the Thompson area to map the surficial geology, inventory aggregate resources and to interpret glacial events. Field investigations included airphoto interpretation, helicopter reconnaissance and sampling of surficial deposits. Bedrock striae indicate the area lies in a zone of confluence between the Keewatin and Labradorean sectors of the Laurentide ice sheet. The zone of confluence is marked by the Settee and Burntwood Interlobate Moraines. The moraines consist of subaqueous outwash and ice contact ridges. There are sufficient accessible reserves of high quality sand and gravel within the moraines to supply current sand and gravel requirements within the area.

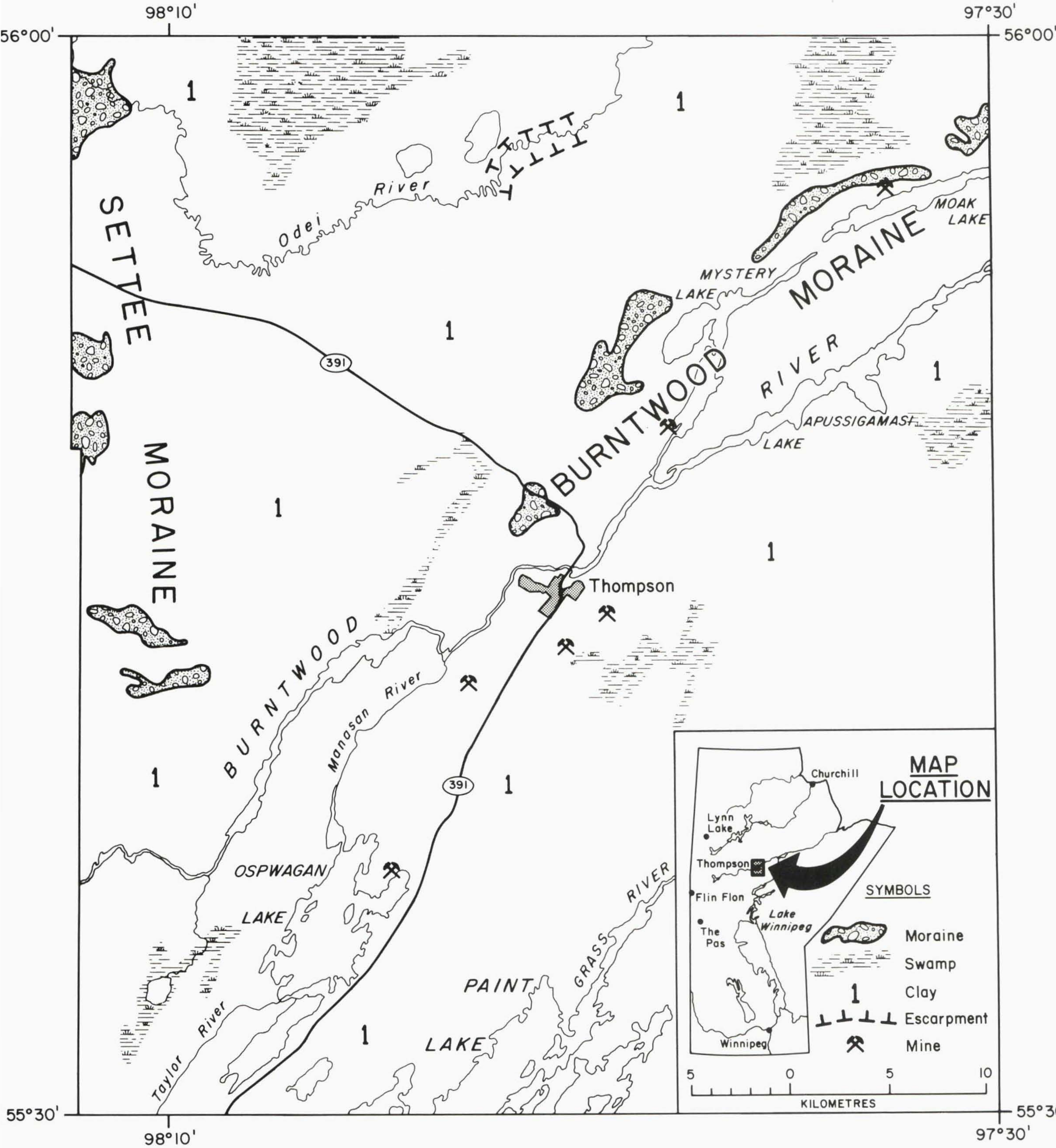

FIGURE 1. Location and surficial geology of the Thompson map area.

INTRODUCTION

OBJECTIVES

Surficial geology mapping was carried out in the Thompson area. The objectives of this study were to:

1. Map the surficial geology at a scale of 1:50 000 for a 24 km radius of Thompson;
2. Inventory and evaluate economically viable sand and gravel deposits; and
3. Describe Quaternary events in the Thompson area.

ACKNOWLEDGEMENTS

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The author thanks Inco Metals Company, specifically D.J. Browne, Chief Mines Geologist and M.A. Hallam, Supervising Engineer, for their assistance in providing drill log data and aggregate consumption data used in this report.

Maps and figures accompanying this report were drafted by C. Sandy under the direction of R. Sales.

LOCATION AND ACCESS

The map area includes a 29 km radius of Thompson encompassing 2665 km^2 in central Manitoba between 55° 20′ to 56° 00′ north latitude and 97° 30′ to 98° 15′ west longitude (Fig. 1). The only townsite is the City of Thompson with a population of 14 000.

Road access includes Provincial Road 391, which is paved south from Thompson and continues as a gravel road northwest from Thompson to Leaf Rapids. A second access road is northeast from Thompson to Split Lake. The City of Thompson is accessible by air service from Winnipeg and by Canadian National Railway.

PHYSIOGRAPHY AND DRAINAGE

Thompson is located within the Kazan Upland physiographic subdivision of the Precambrian Shield, Bostock (1968), and is within the Boreal Forest Region, Ehrlich et al., (1959). White spruce and moss covers much of the better drained terrain, with jack pine often found on the higher better drained bedrock hills and moraine deposits. Black spruce, tamarack and peat are found within the low-lying poorly drained areas.

Klassen and Veillette (1976) reported discontinuous permafrost beneath and low-lying terrain. They reported the active layer to be less than 0.6 m thick, with the maximum depth of permafrost reaching depths of 15 m.

Local relief seldom exceeds 22 m and consists of bedrock ridges and knolls separated by flat to gently irregularly shaped basins. The most prominent landforms are the Burntwood and Settee Moraines (Fig. 1). The Burntwood Moraine is an interlobate moraine system (Klassen, 1982) comprised of ice-contact glaciofluvial sand and gravel (Fig. 2). This series of hills and ridges rise 30 to 38 m above the surrounding clay plain. A second prominent ridge, the Settee Moraine west of Thompson rises 23 m above the surrounding terrain (Fig. 3).

Drainage is from southwest to northeast. The central portion of the map area is drained northeast via the Burntwood River system which widens at several locations forming lakes (Birch Tree, Mystery and Apussigamasi). South of Thompson, the Manasan River flows from Ospwagan Lake and enters the Burntwood drainage system southwest of Thompson. The meandering Odei River drains the northern area and the Grass River drains the southern portion.

FIGURE 2. Burntwood Interlobate Moraine north of Thompson. The prominent ridges are ice-contact sand and gravel deposits.

PREVIOUS WORK

Early geological reconnaissance were conducted by R. Bell (1880) and Tyrrell (1902). A large greenstone belt in the Ospawagan Lake area was mapped by Alcock (1921) and later described by McInnes (1930). Wright (1931) described the bedrock and mineral deposits in the Thompson-Moak Lake area, and this area was later mapped by Dawson (1952). The bedrock geology of the Thompson-Moak Lake area was further described by Harrison (1951), Wilson and Brisbin (1961), and Patterson (1963). The Paint Lake area was mapped by Cranston (1970).

C.K. Bell (1971) summarizes the boundary geology between the Superior-Pikwitonei-Churchill Provinces in the Upper Nelson River area. The geology of the Thompson Nickel Belt is summarized by Coates *et al.*, (1972) and preliminary maps of the nickel belt have been published by Scoates *et al.*, (1977). The nickel bearing sulphide deposits of the Thompson area are described by Gale *et al.*, (1980) and Theyer (1980). A summary of the geology and mineral deposits of the Thompson area are presented by Gale *et al.*, (1982).

Early Quaternary geology studies in northern Manitoba were of a reconnaissance nature. Tyrrell (1896) recorded southwest trending glacial striae in the Sipiwisk Lake area. Alcock (1920, a, b), reported ice movement towards the southwest at South Indian Lake and reported extensive surficial clay deposits along the Burntwood and Ospawagan Lakes. Along the Nelson River, McInnes (1930) described well striated bedrock with ice movement originating from the east. Locations and successive culminations of ice centres and rates of ice recession in Manitoba were presented by Antevs (1931) who also indicated ice flow from the east in the Thicket-Portage-Pikwitonei region.

In the Grand Rapids area two distinctive tills are interpreted by Klassen (1966) as representing two intervals of glaciation. The most prominent recorded ice flow direction is from the northwest forming southeast trending grooves followed by an advance from the north to northeast. Klassen and Veillette (1976) describe, in detail, landforms and surface materials in the Thompson area. Several testholes show the presence of discontinuous permafrost. Discontinuous permafrost along P.R. 391 in the Paint Lake area was also recorded by Manitoba Department of Highways (1979). The Quaternary geology and gravel resources of the Leaf Rapids area are described by Ringrose and Large (1977) who recorded early ice advances from the north-northwest, with the last advance from the northeast. Klassen and Netterville (1978) mapped the surficial geology of the Thompson area at a scale of 1:250 000.

PRESENT STUDY

Geological field investigations were carried out during June, 1981. Map units were determined in the field and delineated from air photographs at a scale of 1:56 000. Field investigations included traverses to deposits from existing roads, and remote sites were examined by helicopter reconnaissance. Hand dug test pits were used to examine and sample remote deposits. Available road cuts, natural exposures and gravel pits were also examined.

International Nickel Company exploration drill logs were used to assist with stratigraphic interpretation. The logs of drill sites used for this study are shown in Appendix I.

Laboratory analysis of sand and gravel samples included determining the grain size distribution and pebble lithologies. Grain size analysis included sieving the sample between 0.074 and 101.6 mm sizes. Sizes less than 0.074 mm were recorded as the combined silt-clay fraction. Sizes greater than 150 mm were not sampled but recorded in the field as crushable material. The 4 to 16 mm pebble clasts were retained to determine pebble lithologies and pebble roundness values.

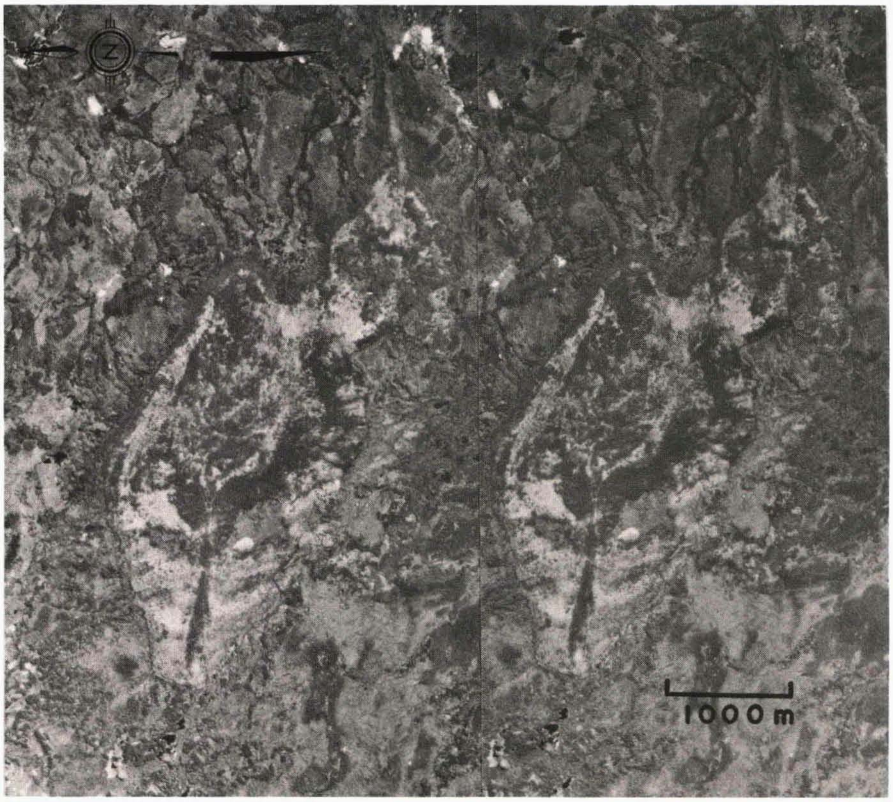

FIGURE 3. Stereopair airphotos (A24996-196, 197) of the wave-washed portion of the Settee Interlobate Moraine, deposit 32016.

BEDROCK GEOLOGY

The Precambrian Shield in Manitoba is divided into the Superior and Churchill Structural Provinces. The Superior Province is comprised of rock of Archean age, whereas, the Churchill Province contains rocks of Aphebian and Archean age. The Churchill-Superior boundary trends in a northeast-southwest direction through the map area, passing through Thompson.

The western portion of the map area lies within the Kisseynew sedimentary gneiss belt of the Churchill Province. The belt is comprised of metasedimentary and metavolcanic rocks with minor intrusive rocks. The dominant rock types are metagreywacke and/or greywacke-mudstone derived gneiss, metatexite and diatexite with minor ultramafic intrusive rocks (McRitchie *et al.*, 1979).

The Churchill-Superior boundary zone includes the Thompson Nickel Belt. The northern margins of the boundary zone are in fault contact with the Churchill Province, and the southern contact grades into the Pikwitonei Granulite Domain of the Superior Province. The bedrock consists of felsic to mafic gneiss, bands of metasedimentary and metasedimentary-metavolcanic rocks, and felsic, mafic and ultramafic intrusions. The metasedimentary assemblages include siliceous, calcareous, pelitic and ferruginous rocks, and the metavolcanic rocks comprise metabasaltic flows and ultramafic bodies. The mafic and ultramafic intrusions occur in the gneiss, metasedimentary rocks and metavolcanic rocks (Gale *et al.*, 1982). Nickel sulphide deposits are associated with the ultramafic and metasedimentary rocks of the Ospwagan Group.

The Pikwitonei Region of the Superior Province is located south of the Thompson Nickel Belt. Rocks of the Pikwitonei Region comprise a variety of hornblende granulite to pyroxene granulite facies gneisses, hypersthene granites, and mafic granulites (Coates *et al.*, 1972).

QUATERNARY GEOLOGY

SURFICIAL GEOLOGY

Four distinct surficial geology units are recognized; bedrock, kame moraines, glaciolacustrine silts and clays and swamp deposits. Minor till deposits have been found overlying bedrock outcrops. The surficial geology is shown on Maps GR82-4-1 to GR82-4-4 which accompany this report.

EXPOSED BEDROCK

Bedrock is exposed where the overlying drift cover is thin or absent (unit 1). Exposures are either prominent ridges and knolls, or minor surfaces exhibiting polished striated stoss slopes often with plucked or quarried lee slopes resulting from glacial overriding. Striation measurements indicate that the earliest ice flow direction was towards the southwest followed by a more westerly ice flow. Along the Odei River south of Jock and Hunter Lakes is a prominent bedrock escarpment and a series of clay veneered bedrock exposures.

SAND AND GRAVEL

Sand and gravel deposits are confined to the Burntwood and Settee Interlobate Moraines (unit 2). The Burntwood Moraine is an extensive morainic ridge trending parallel to Moak and Mystery Lakes. Along the upper portion of the ridge are a series of ice-contact sand and gravel esker and kame deposits (unit 2b). Morphologically the eskers and kames are a series of sinuous ridges and conical hills above the surrounding clay plain (Fig. 2). Sand and gravel deposits 32001 and 31012 inclusive are located along the Burntwood Moraine. The second source area of sand and gravel is the Settee Moraine west of Thompson and includes deposits 32013 to 32017 inclusive (Fig. 3). The moraine is flat-topped with abandoned strandlines along the flanks resulting from successive lowering of Lake Agassiz (unit 2a). Exposed bedrock adjacent to deposits 32017 and 32015 at elevations between 228 and 266 m and a bedrock exposure within deposit 32013 at 259 m suggests the moraine was deposited on bedrock.

GLACIOLACUSTRINE SEDIMENT

DEEP BASINAL SEDIMENT

The glaciolacustrine sediment found throughout the map area has been described by McInnes (1913), Antevs (1931) and Klassen and Veillette (1976). Deep basinal sediment up to 44 m deep (Appendix I) of varved silt and clay (unit 3c) can be divided into a lower grey clay unit and an upper brown clay unit. The brown clay varies in thickness from 0 to 7 m and the underlying grey clay varies from 0 to 15 m in thickness. Bell (1978) reported the maximum number of varves from one section in this area to be 200.

The sediment consists of fine textured silty clay transported by lacustrine currents and deposited from suspension in the deep Grass River basin of Lake Agassiz. The lower grey unit is slightly finer textured than the overlying brown unit which may indicate a gradual lowering of the level of Lake Agassiz (Fig. 4). This is consistent with the colour change from grey to brown. The grey colour is probably derived from the erosion of shaley and calcareous tills to the south and southwest of the Grass River basin, and the sediment transported into the Lake Agassiz basin by the Saskatchewan and Churchill Rivers. The brown clays are thought to have been derived from the erosion of brown tills which outcrop east of the Grass River basin.

GLACIOLACUSTRINE VENEER

Silt and clay sediments mantle bedrock exposures as a thin veneer (unit 3b) less than 3 m thick. Post depositional erosion has removed much of the veneer from the crests of many bedrock ridges. A thin veneer less than 1 m thick also mantles morainic sand and gravel (Fig. 5) along the Burntwood Interlobate Moraine (unit 3a).

SWAMP SEDIMENT

Standing water and organic deposits are designated as swamps (unit 4). Swamp deposits include bog and fen which cover the surficial silt and clay in low-lying areas. There are two areas of extensive swamp, one area northwest of Jock and Hunter Lakes and the second area north of Moak Lake.

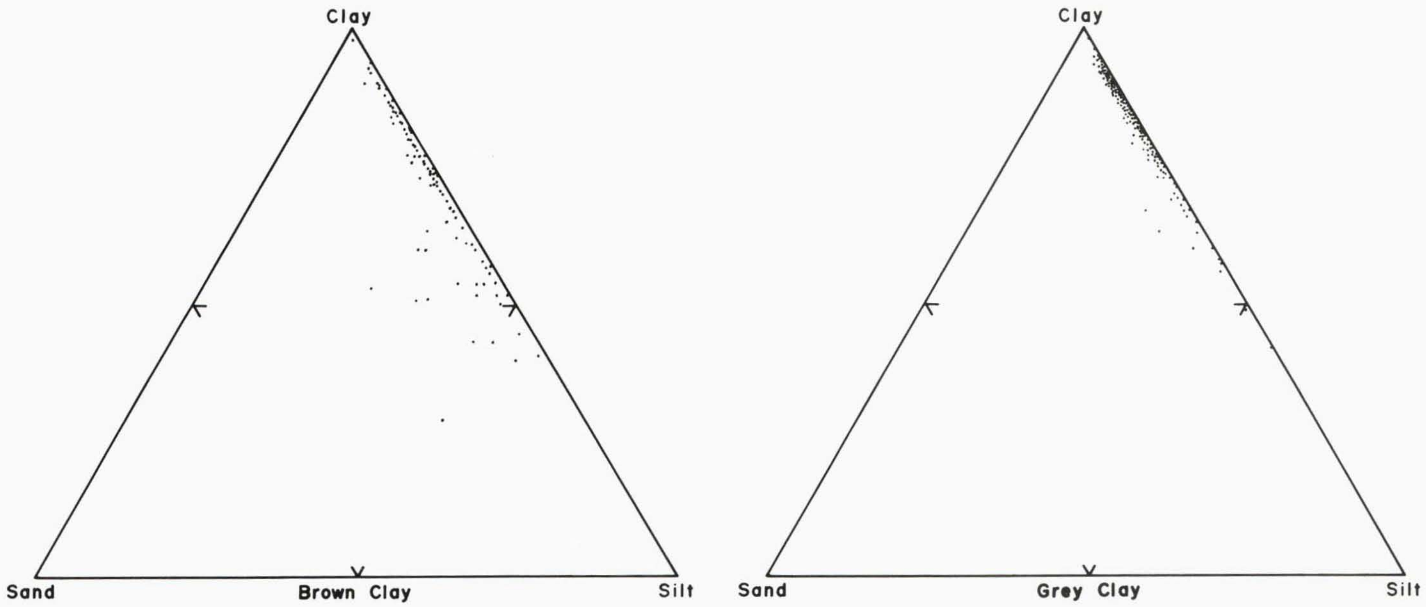

FIGURE 4. Grain size variation of deep water lacustrine sediments from the Grass River basin. Data from Manitoba Department of Highways, Materials and Research Branch, 1979.

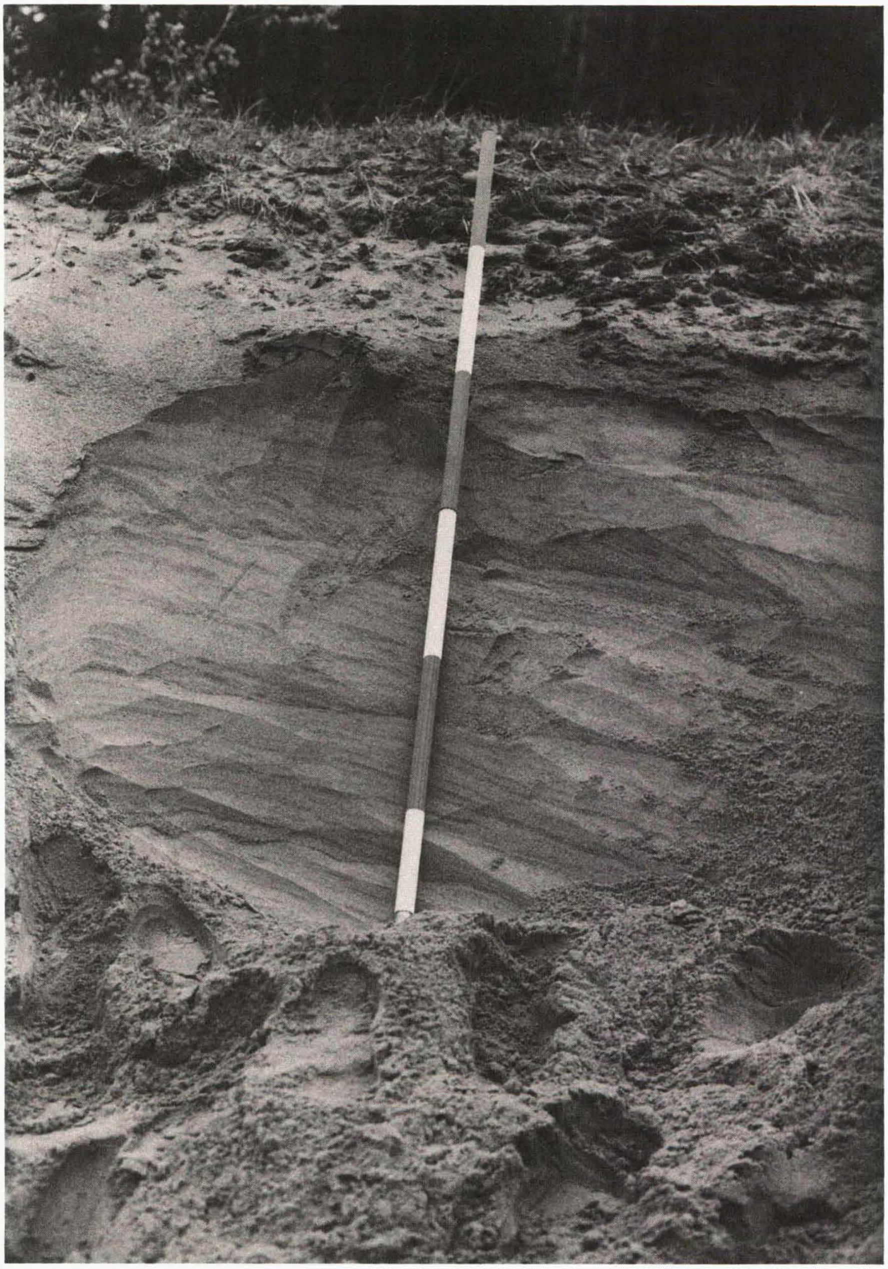

FIGURE 5. Fine to medium grained bedded sand at road cut station 7. A clay veneer overlies the sand but is not present in the photograph. Survey pole is divided in 1 foot units.

NEARSHORE DEPOSITS

Nearshore lacustrine sediment deposited during the regression of Lake Agassiz consists of sand and silt laid down in the offshore as the result of erosion and scarp formation along the Burntwood and Settee Interlobate Moraines north, west and southwest of Thompson. Beach deposits record the successive levels of Lake Agassiz in this area. Prominent terrace levels west and southwest of Thompson and their correlation are indicated in Table 1.

Klassen (1982) recognized the Ponton and Fidler phases of Lake Agassiz prior to the final drainage of the lake. The correlation of the lake levels in the map area is difficult but it appears that they are primarily associated with the Ponton phase.

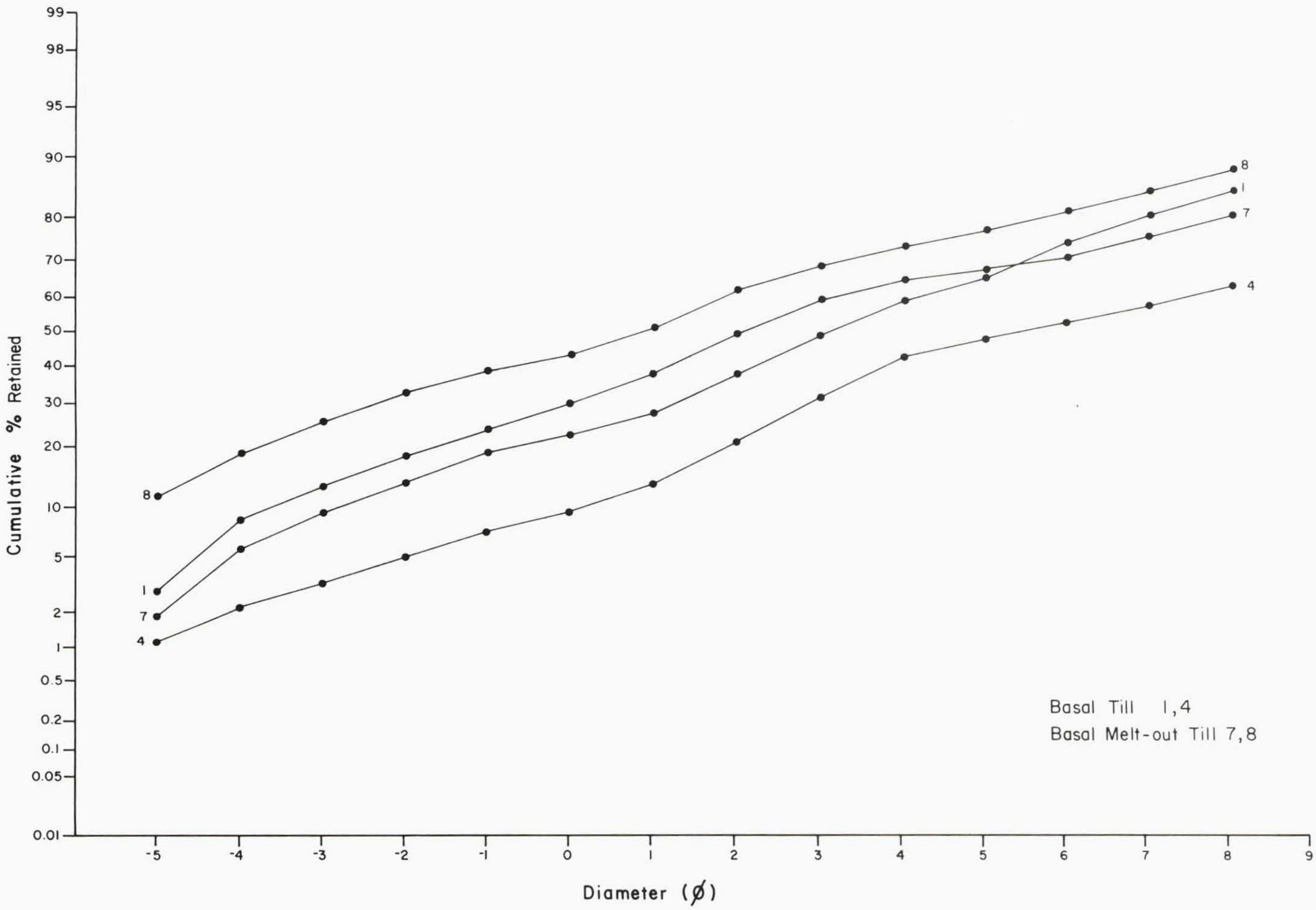

FIGURE 6. Grain size distribution of basal and basal melt-out tills.

TABLE 1. LEVELS OF LAKE AGASSIZ IN METRES RECORDED IN THE THOMPSON AREA

WATER PLANE	BURNTWOOD MORAINE		SETTEE MORAINE
Ponton	344*		
	329*		
	304*		
	295*		
	288		
	279*		
		274	
			270*
			268*
			265
			257*
Fidler		253*	253
			231

*indicates well developed terrace levels.

TILL

Till is exposed in a few road cuts but nowhere does it outcrop at the surface. The till directly overlies the striated bedrock surface and is in turn overlain by fine textured lacustrine sediment. The till shows homogeneous basal till facies on the more level surfaces and stratified lee-side or melt-out till facies on the down-ice side of bedrock obstructions. The grain size distribution of these two till types is shown in Figure 6. Both till types are characteristically amodal with only a minor increase in the sand fraction in 0.25-0.125 mm range. The lee-side till contains less silt and clay than the basal melt-out till.

The petrographic composition of the 4-16 mm size fraction of the till is shown in Table 2. Omarolluk greywacke clasts from Hudson Bay are notably present in the basal till and are completely absent from basal melt-out till. This would suggest the basal melt-out till is of more northern provenance and may be related to the ice flow recorded by the early southwesterly striae.

TABLE 2. PETROGRAPHIC COMPOSITION OF TILLS FROM THE THOMPSON AREA*

SAMPLE NO.	ORIGIN	N	% PRECAMBRIAN CLASTS	% CARBONATES	% OMAROLLUK GREYWACKE
Th 1	Basal	300	96	3	1
Th 4		300	97	2	1
Th 7	Basal melt-out	685	100	-	-
Th 8		650	99	1	-

*4-16 mm size of fraction

LATE GLACIAL HISTORY

The ice-flow directions suggested from superimposed bedrock striae indicate the area lies in a zone of confluence between two ice lobes. The crossing striae suggest fluctuations in the ice-flow direction of the lobes during deglaciation. The earliest ice-flow was towards the south-southwest at a time when ice from the Keewatin sector of the Laurentide ice sheet was dominant. This was followed by much stronger ice-flow from the Labradorean sector of the Laurentide ice sheet which was the last ice lobe to cover this area. The Settee and Burntwood Interlobate Moraines in the Thompson area mark the contact between the Keewatin and Labradorean ice sheets at the time of the final deglaciation of the area (Nielsen, *et al.*, 1981). The moraines were deposited proglacially as subaqueous outwash and englacial ice contact ridges along the ice margin between the Keewatin and Labradorean ice lobes.

Lake Agassiz covered the Thompson area as the ice front retreated to the north and northeast. The area probably became ice free about 9000 yrs. B.P. (Klassen, 1982) and Lake Agassiz drained from the area prior to 7700 yrs. B.P. (Nielsen and Kroker, 1982).

SAND AND GRAVEL RESOURCES

ANALYSIS OF SAND AND GRAVEL

A total of 17 sand and gravel deposits were identified and 12 samples were analyzed from nine different deposits. All the deposits are located on either the Burntwood or Settee Interlobate Moraines (Figs. 7, 8, 9 and 10). The grain size, pebble lithologies and shape for each sample are shown in Tables 1 and 2, Appendix II. Lithologically, the pebble clasts are predominantly Precambrian crystallines with secondary carbonate between 0 and 4 per cent. On the Powers (1953) scale of roundness the pebble clasts are predominantly subangular.

QUALITY OF SAND AND GRAVEL

The quality of each sampled deposit is based upon the number of potential industrial uses and the percentage gravel (sizes greater than 2.0 mm). The quality of deposits not sampled are based on location, morphology, genesis and airphoto signature.

The type of industrial uses for which the sample is suited is related to the grain size distribution. Although processing methods can modify the sediment to accommodate a variety of potential uses, the industrial uses are based on the natural (unprocessed) characteristics of the deposit. A computer program developed by the Aggregate Resources Section of the Mineral Resources Division correlates specification requirements of size distribution data derived from laboratory testing of each sample. The computer results include individual ratings (suitable, marginal, or not suitable) for each correlation, and a positive or negative indication of whether screening is required; whether it is necessary to remove silt or clay from the deposit; whether crushable material is available on site; or whether it is necessary to add fines to meet the specification for a particular use.

Table 3, Appendix II summarizes the potential uses of each deposit sampled. The industrial usage laboratory specifications for each of the 48 industrial uses are presented in Table 1 of Appendix III.

From Table 3, Appendix II, three categories of relative suitability are indicated:

i) Those materials which meet specifications exactly (indicated by an X);
ii) Those materials which require minimal processing, screening or addition of some size fractions (indicated by an 0); and
iii) Those requiring crushing to meet specifications and crushable material is available on site (indicated by a -).

The industrial usage assessment shows that except for coarse aggregate for highways and concrete, all sampled deposits are suited for a variety of industrial uses.

Size fractions greater than 8 cm were normally not included within the deposit sample. Size fractions greater than 15 cm are recorded in the field and referred to as crushable material. Due to the complexity of sampling the coarse size fractions (cobbles and boulders) this fraction was not included with the grain size distribution and is reflected in the absence of suitabilities for the coarse aggregate specifications. All sampled deposits contained material greater than 15 cm, and therefore meet coarse aggregate specifications.

FIGURE 7. Aerial view of deposit 32003 on the Burntwood Moraine. Moak Lake is in the background and road to Split Lake in the foreground.

FIGURE 8. Road cut through a portion of deposit 32003. The deposit is 300 m long and 100 m high. Person for scale.

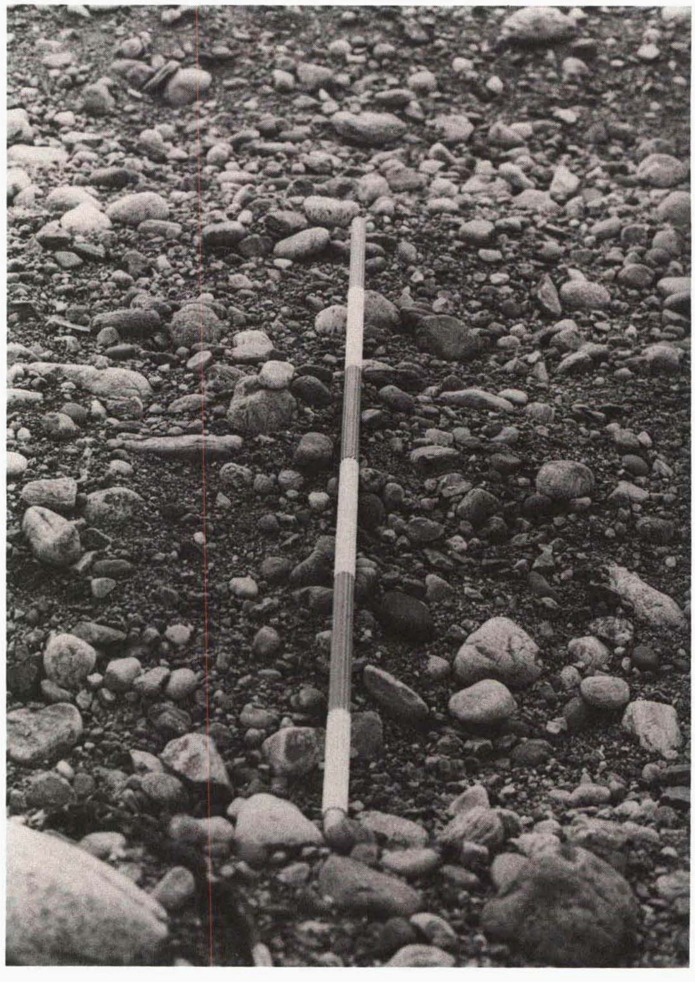

FIGURE 9. Close-up of cobbly coarse pebble gravel of deposit 32003. Survey pole is divided into 1 foot units.

FIGURE 10. Cobbly coarse pebble gravel of deposit 32007. Shovel for scale.

RESERVES OF SAND AND GRAVEL

Each identified sand and gravel deposit is plotted on the maps accompanying this report. The depth of each deposit was estimated based on topographic relief, generalized stratigraphy and site inspections. The surface area of each deposit was determined by planimetering using 1:50 000 maps. Reserve estimates were calculated by multiplying the deposit surface area by the average deposit depth. The morphology of many of the deposits are conical hills, and the deposit depth is the average depth of sand and gravel.

Estimated reserves of sand and gravel are shown in Tables 3 and 4. Total estimated reserves of sand and gravel equal 551.2 million cubic metres of which an estimated 50.0 million cubic metres are accessible within 1.0 km of an existing road.

DEMAND FOR SAND AND GRAVEL

The demand for sand and gravel is based on a review of applications for mineral dispositions and quarry returns on file with the Mineral Resources Division for the five-year period, 1977-1981. This data is shown in Table 5 and shows the estimated annual demand for sand and gravel to be 220 900 cubic metres. Continued road and highways maintenance by the City of Thompson and Department of Highways and Transportation Services consumes an estimated 18 400 cubic metres annually. The largest consumer of sand and gravel is Inco Metals Company which consume 202 500 cubic metres annually.

TABLE 3. ESTIMATED RESERVES OF SAND AND GRAVEL BY QUALITY (millions cubic metres)

QUALITY		ESTIMATED RESERVES
High		1.551
Medium High		18.267
Medium		146.432
Medium Low		251.847
Low		133.127
	TOTAL	551.224

TABLE 4. ESTIMATED RESERVES OF ACCESSIBLE SAND AND GRAVEL BY QUALITY (millions cubic metres accessible within 1.0 km of an existing road)

QUALITY		ESTIMATED RESERVES
High		1.551
Medium High		18.267
Medium		17.666
Medium Low		—
Low		12.579
	TOTAL	50.063

The Department of Highways and Transportation Services acquires sand and gravel from deposit 32012 (Fig. 11) for the maintenance of Provincial Road 391, and from deposits 32001 and 32002 for maintenance of the Thompson-Split Lake road. Inco Metals Company obtains sand and gravel from several quarry leases held on deposit 32012. Due to its proximity to the Thompson market deposit 32012 currently supplies most of the sand and gravel requirements for the town.

With a current annual demand for sand and gravel at 220 900 cubic metres, the estimated accessible reserves of 50.0 million cubic metres are sufficient for about 226 years. This estimate assumes present demand to remain constant. Deposit 32012 supplies most sand and gravel requirements. At current rates of consumption, the 15.4 million cubic metres of sand and gravel within deposit 32012 should be consumed in 69 years.

TABLE 5. ESTIMATED ANNUAL DEMAND FOR SAND AND GRAVEL WITHIN THE THOMPSON STUDY AREA (cubic metres)

USE		ESTIMATED ANNUAL DEMAND
Road Maintenance		18 400
Unspecified		86 200
Screened Sand		6 700
Flux Sand		85 000
Pit-Run Sand		5 400
Rip-rap		19 200
	TOTAL	220 900

FIGURE 11. Sand and gravel extraction on the Burntwood Moraine north of Thompson, deposit 32012.

SUMMARY

Deep basinal silt and clay are the predominant surficial sediments within the Thompson area. Glacial striae and the petrographic composition of tills indicate that the map area was within a zone of confluence between the Keewatin and Labradorean ice sheets.

Sand and gravel deposits are vital for an expanding mining industry. Expanding urban construction and maintenance and upgrading of provincial roads will also require an adequate and continuing supply of sand and gravel. Deposit 32012 should continue to supply requirements for the City of Thompson for the next 70 years. Deposit 32012 should be protected from land uses which would restrict or prohibit mineral extraction. Deposits along the Burntwood Interlobate Moraine should also be protected for mineral extraction as alternate sites will be required after depletion of deposit 32012.

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APPENDIX I

INCO BOREHOLE DATA
(elevation and depth in metres)

B.H. 1 (220.9 m a.s.l.)

0.0 -	3.0	Clay
3.0 -	60.9	Sand and gravel

B.H. 2 (213.3 m a.s.l.)

0.0 -	18.2	Overburden, not defined
18.2		Bedrock, not defined

B.H. 3 (182.8 m a.s.l.)

0.0 -	44.1	Clay
44.1 -	88.3	Gravel
88.3		Bedrock, not defined

B.H. 4 (205.7 m a.s.l.)

0.0 -	19.8	Clay
19.8 -	51.8	Sand and gravel
51.8		Bedrock, not defined

B.H. 5 (236.2 m a.s.l.)

0.0 -	30.4	Sand and gravel, includes boulders
30.4		Bedrock, not defined

B.H. 6 (220.9 m a.s.l.)

0.0 -	132.5	Overburden, not defined
132.5		Bedrock, not defined

APPENDIX II

SAND AND GRAVEL SAMPLE ANALYSIS

TABLE 1. SAND AND GRAVEL RESOURCES

Deposit	Sample	Area (hectares)	Average Depth (metres)	Lithology % Precambrian Crystallines	% Carbonate	Roundness[1]	Available Aggregate (million cubic Metres)	Estimated[2 3] Quality
32001	12	10.9	13.3	100	0	3	1.551	High
32002	11	17.4	13.0	98	2	3	2.239	Medium
32003	10	38.7	18.3	100	0	3-4	7.218	Medium High
32004		5.6	4.0				0.224	Medium High
32005	9	48.5	5.0	96	4	3	3.252	Medium High
32006	13	23.7	9.3	99	1	2-3	2.418	Medium High
32007	39	13.5	13.3	99	1	3	1.795	Medium High
32008		19.5	16.2				3.360	Medium High
32009	38	45.2	21.2	100	0	2-3	10.968	Low
32010		114.8	8.3				1.228	Low
32011		15.4	8.3				0.383	Low
32012		193.3	12.6				15.427	Medium
	1			99	1	3		
	22							
	24			98	2	3		
	25			96	4	3		
32013		994.0	22.7				251.847	Medium Low
32014		237.7	8.3				19.729	Low
32015		538.9	15.4				100.819	Low
32016		520.3	14.9				92.238	Medium
32017	40	193.1	16.3	100	0		36.528	Medium
	TOTAL						551.224	

1. Roundness Scale (Powers, 1953)
   1. Very Angular
   2. Angular
   3. Subangular
   4. Subrounded
   5. Rounded
   6. Well Rounded

2. Estimated Quality — Per Cent Gravel
   80-100 High
   60-80 Medium High
   40-60 Medium
   20-40 Medium Low
   0-20 Low

3. Industrial Usage Assessment

TABLE 2. GRAIN SIZE DISTRIBUTION PER CENT PASSING — PER CENT RETAINED

DEPOSIT	32001		32002		32003		32005		32006		32007	
SAMPLE	12		11		10		9		13		39	
SIEVE SIZE	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED
4 IN	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0
3½ IN	100.00	0.0	100.00	0.0	88.98	11.02	100.00	0.0	100.00	0.0	100.00	0.0
2 IN	100.00	0.0	100.00	0.0	89.98	11.02	100.00	0.0	100.00	0.0	100.00	0.0
2½ IN	90.50	9.50	100.00	0.0	89.98	11.02	100.00	0.0	100.00	0.0	100.00	0.0
2 IN	90.50	9.50	93.62	6.38	88.98	11.02	100.00	0.0	100.00	0.0	94.31	5.69
1½ IN	88.76	11.24	81.11	18.89	84.16	15.84	87.30	12.70	100.00	0.0	89.95	10.05
1 IN	80.93	19.07	75.34	24.66	76.76	23.24	77.29	22.71	86.63	13.37	84.91	15.09
¾ IN	71.89	28.11	72.75	27.25	70.46	29.54	73.16	26.84	78.80	21.20	78.24	21.76
⅝ IN	63.81	36.19	70.25	29.75	66.38	33.62	68.54	31.46	73.16	26.84	75.19	24.81
½ IN	55.83	44.17	68.66	31.34	61.31	38.69	65.36	34.64	70.19	29.81	70.08	29.92
⅜ IN	46.55	53.45	65.71	34.29	55.24	44.76	60.59	39.41	66.42	33.58	61.87	38.13
¼ IN	34.60	65.40	61.33	38.67	48.64	51.36	52.32	47.68	60.71	39.29	51.84	48.16
# 4	25.24	74.76	57.60	42.40	44.08	55.92	46.48	53.52	54.71	45.29	46.48	53.52
# 8	13.74	86.25	46.90	53.10	32.83	67.17	28.57	71.43	41.17	58.83	31.30	68.70
# 10	11.52	88.48	42.63	57.37	28.94	71.06	23.34	76.66	36.18	63.82	26.55	73.45
# 16	8.44	91.56	29.20	70.80	19.82	80.18	14.85	85.15	26.22	73.78	16.48	83.52
# 30	6.08	93.92	11.16	88.84	10.83	89.17	10.10	89.90	18.30	81.70	8.12	91.88
# 40	5.16	94.84	7.10	92.90	7.48	92.52	8.60	91.40	15.57	84.43	5.37	94.63
# 50	4.44	95.56	5.55	94.44	5.41	94.59	7.56	92.44	13.65	86.35	3.88	96.12
# 80	3.58	96.42	4.33	95.67	3.40	96.60	5.48	94.52	11.21	88.79	2.53	97.47
# 100	3.33	96.67	3.98	96.02	2.92	97.08	4.70	95.30	10.46	89.54	2.23	97.77
# 200	2.41	97.59	2.82	97.18	1.62	98.38	2.47	97.53	7.99	92.01	1.42	98.58
< 200	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00

	32001	32002	32003	32005	32006	32007
% Cobbles	9.50	0.0	11.02	0.0	0.0	0.0
% Pebbles	65.25	42.40	44.90	53.52	45.29	53.52
% Granules	13.73	14.97	15.13	23.14	18.53	19.92
% Sand	9.10	39.82	27.33	20.87	28.20	25.14
% Silt/Clay	2.41	2.82	1.62	2.47	7.99	1.42
Fineness Modules	6.32	5.26	5.85	5.67	4.90	5.61

TABLE 2. GRAIN SIZE DISTRIBUTION PER CENT PASSING — PER CENT RETAINED (Cont'd)

32009		32012		32012		32012		32012		32017	
38		1		22		24		25		40	
PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED	PER CENT PASSING	PER CENT RETAINED
100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0
100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0
100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0
100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0
100.00	0.0	100.00	0.0	89.39	10.61	100.00	0.0	100.00	0.0	100.00	0.0
93.42	6.58	91.23	8.77	85.29	14.71	100.00	0.0	89.98	10.02	97.92	2.08
93.42	6.58	80.74	19.26	75.10	24.90	95.95	4.05	82.18	17.82	91.52	8.49
91.46	8.54	74.84	25.16	70.42	29.58	92.68	7.32	76.73	23.27	85.76	14.24
91.46	8.54	68.07	31.93	67.76	32.24	88.77	11.23	72.08	27.92	82.00	18.00
91.46	8.54	62.46	37.54	66.15	33.85	84.94	15.06	67.15	32.85	78.98	21.02
90.20	9.80	57.66	37.54	62.22	37.78	78.51	21.49	61.42	38.58	74.45	25.55
89.44	10.56	50.78	49.22	58.71	41.29	69.62	30.38	54.51	45.49	68.83	31.17
88.81	11.19	44.77	55.23	55.73	44.27	63.01	36.99	50.30	49.70	65.58	34.42
86.58	13.42	32.31	67.69	49.43	50.57	51.71	48.29	40.66	59.34	54.84	45.16
85.42	14.58	28.65	71.35	46.71	53.29	57.86	52.14	37.61	62.39	51.33	48.67
82.20	17.80	21.30	78.70	38.36	61.64	38.00	62.00	30.88	69.12	40.52	59.48
76.32	23.68	14.54	85.46	25.47	74.53	24.85	75.15	23.33	76.67	16.42	83.58
71.32	28.68	11.40	88.60	17.37	82.63	19.56	80.44	18.68	81.32	7.48	92.52
65.93	34.07	8.75	91.25	11.37	88.63	15.22	84.78	13.99	86.01	4.42	95.58
51.51	48.49	5.62	94.38	5.93	94.07	10.47	89.53	6.40	93.60	2.69	97.31
43.96	56.04	4.84	95.16	4.78	95.22	9.22	90.78	4.84	95.16	2.37	97.63
15.02	84.98	2.91	97.09	1.84	93.16	5.79	94.21	1.32	98.68	1.52	98.48
0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00	0.0	100.00

0.0	0.0	0.0	0.0	0.0	0.0
11.19	55.23	44.27	36.99	49.70	34.42
3.38	16.11	9.01	15.15	12.69	14.25
70.40	25.74	44.87	42.08	36.29	49.81
15.02	2.91	1.84	5.79	1.32	1.52
1.81	5.50	4.97	4.27	5.08	4.58

TABLE 3. INDUSTRIAL USAGE ASSESSMENT*

Deposit	Sample	Asphalt A	Asphalt B	Asphalt C	Base Course A	Base Course B	Base Course C	Sub-Base, Base and Surface Course A	B	C	D	E	F	Traffic Gravel A	B	C	D	Seal Coat A	B	C
32001	12				O	O	O	O	O	O				O	O	O	X	—	O	O
32002	11	—	—		—	O	O	—	—	—	O	O	O		—	—	—		—	O
32003	10	O	X		O	O	O	O	O	O	O	O		—	O	O	X		—	X
32005	9	O	O		O	O	O	X	O	O	O	O		—	O	O	X		—	X
32006	13	O	O		X	X	X	—	X	X	O	O		—	X	O	X		—	O
32007	39	O	O		O	O	O	—	O	O		O		O	O	O	X		X	X
32009	38			O			—					O	O							
32012	1	O	X		O	O	O	X	O	O	O	O		O	O	O	X		—	O
	22	—	—		—	O	O	—	—	—	O	O	O		—	—	—		—	O
	24	X	X		O	X	X	—	—	—	O	X	O	—	—	X	X		—	O
	25	O	O		O	O	O	O	O	O	O	O		—	O	O	X		—	O
32017	40	—	—		—	O	O		—	—	O	O	O		—	—	—		—	X

Deposit	Sample	Standard Sizes Coarse Aggregate (for highways and concrete) 1	224	3	357	4	467	5	56	57	6	67	68	7	78	8	89	9	10	Fine Concrete A	Aggregate I	II	Mortar	Portland Cement	Built-up Roofs	Airfield Runways	Pit Run	Septic Fields	Shoulders
32001	12												—				O									O	X	—	X
32002	11																		O	O			O	O		—	X	—	X
32003	10																		O	O			O			X	X	—	X
32005	9																		O							X	X	—	X
32006	13																		O	O			O			X	X	—	X
32007	39																		O				O			X	X	—	X
32009	38																										—	—	—
32012	1																		O	O			O			X	X	—	X
	22																		O	O	O	O	O	O		—	X	—	X
	24																		O	O		O	O	O		X	X	—	X
	25																		O	O	O	O	O	O		X	X	—	X
32017	40																		O	O	O	O	O	O		—	X	—	X

X Material meets specifications exactly.

O Some (minimal) processing required to meet specifications.

— Crushing required and material on site.

*Refer to Table 1, Appendix III for Industrial Use Specifications.

APPENDIX III

INDUSTRIAL USAGE ASSESSMENT

TABLE 1. INDUSTRIAL USE — LABORATORY TESTS

ASPHALT A (P. OF M.)
ASPHALT B (P. OF M.)
ASPHALT C (P. OF M.)
BASE COURSE A (P. OF M.)
BASE COURSE B (P. OF M.)
BASE COURSE C (P. OF M.)
SUB-BASE/BASE COURSE A (ASTM D1241)
SUB-BASE/BASE COURSE B (ASTM D1241)
SUB-BASE/BASE/SURFACE COURSE C (ASTM D1241)
SUB-BASE/BASE/SURFACE COURSE D (ASTM D1241)
SUB-BASE/BASE/SURFACE COURSE E (ASTM D1241)
SUB-BASE/BASE/SURFACE COURSE F (ASTM D1241)
TRAFFIC GRAVEL A (P. OF M.)
TRAFFIC GRAVEL B (P. OF M.)
TRAFFIC GRAVEL C (P. OF M.)
TRAFFIC GRAVEL D (P. OF M.)
SEAL COAT A (P. OF M.)
SEAL COAT B (P. OF M.)
SEAL COAT C (P. OF M.)
COARSE AGGREGATE 1 (ASTM C33, D448)
COARSE AGGREGATE 2 (ASTM C33, D448)
COARSE AGGREGATE 24 (ASTM C33, D448)
COARSE AGGREGATE 3 (ASTM C33, D448)
COARSE AGGREGATE 357 (ASTM C33, D448)
COARSE AGGREGATE 4 (ASTM C33, D448)
COARSE AGGREGATE 467 (ASTM C33, D448)
COARSE AGGREGATE 5 (ASTM C33, D448)
COARSE AGGREGATE 56 (ASTM C33, D448)
COARSE AGGREGATE 57 (ASTM C33, D448)
COARSE AGGREGATE 6 (ASTM C33, D448)
COARSE AGGREGATE 67 (ASTM C33, D448)
COARSE AGGREGATE 68 (ASTM C33, D448)
COARSE AGGREGATE 7 (ASTM C33, D448)
COARSE AGGREGATE 78 (ASTM C33, D448)
COARSE AGGREGATE 8 (ASTM C33, D448)
COARSE AGGREGATE 89 (ASTM C33, D448)
COARSE AGGREGATE 9 (ASTM C33, D448)
COARSE AGGREGATE 10 (ASTM C33, D448)
FINE CONCRETE AGGREGATE A (P. OF M.)
FINE CONCRETE AGGREGATE I (ASTM C33, C404)
FINE CONCRETE AGGREGATE II (ASTM C33, C404)
MORTAR (ASTM C144)
PORTLAND CEMENT (P.C.A.)
BUILT-UP ROOFS (ASTM D1863)
AIRFIELD RUNWAYS (P. OF M.)
PIT RUN (P. OF M.)
SEPTIC FIELDS (U.M.A.)
SHOULDERS (P. OF M.)

TABLE 1. INDUSTRIAL USE — LABORATORY TESTS (Cont'd)

P. OF M.	MANITOBA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION SPECIFICATIONS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
P.C.A.	PORTLAND CEMENT ASSOCIATION
U.M.A.	UNDERWOOD MCLELLAN AND ASSOCIATES