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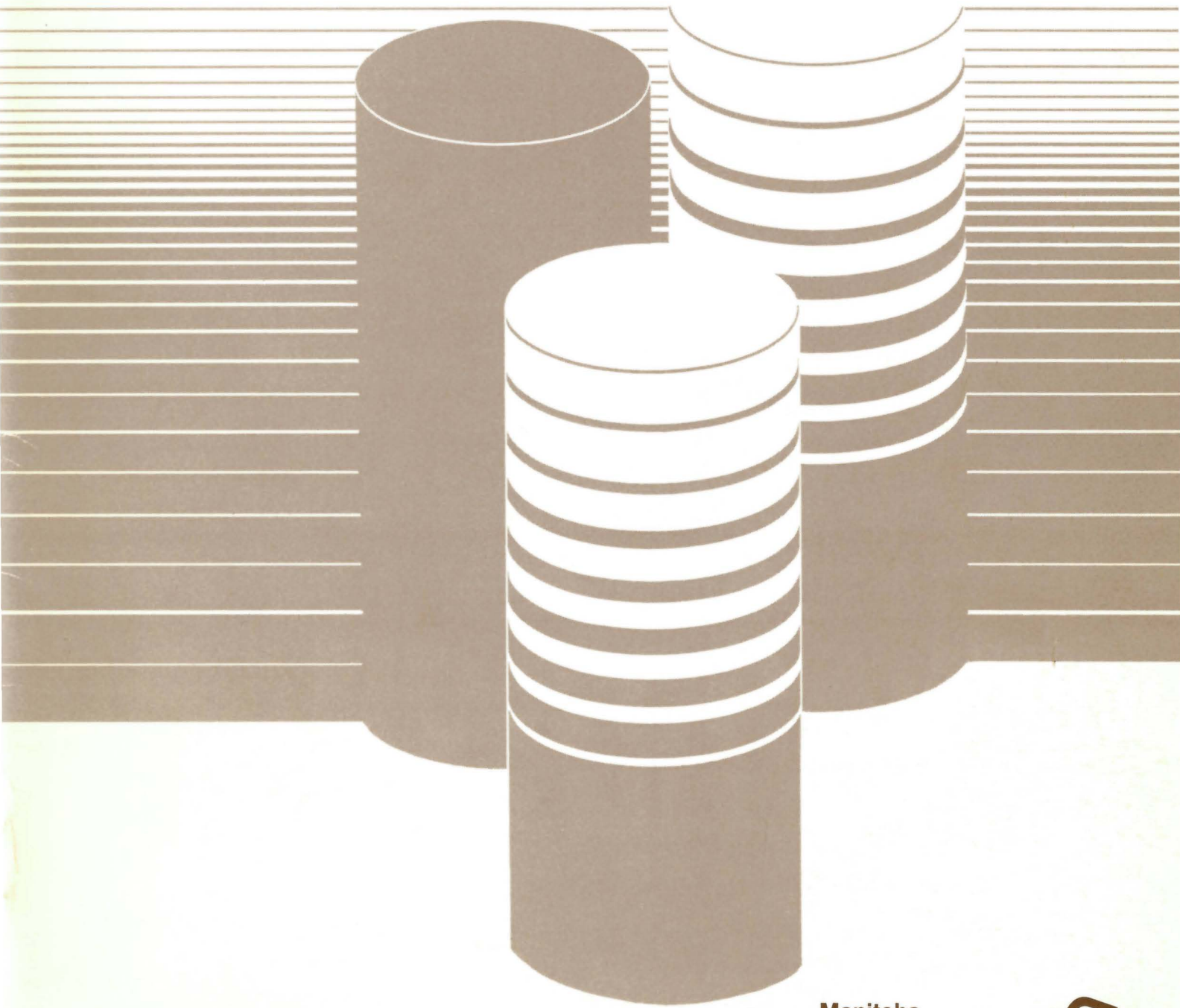
SAND & GRAVEL IN MANITOBA

by Peggy Large



Manitoba
Energy and Mines

SAND AND GRAVEL IN MANITOBA

Peggy Large

INTRODUCTION

Fifteen thousand years ago Manitoba was covered with an ice sheet, up to two miles thick in places. When this glacier moved over the Province, heading southward, it crushed and piled up ground materials in ridges ahead of it. Some of the material was frozen into the ice sheet and later, as the glacier was melting, meltwater rivers flowing at tremendous velocities picked up and carried along this debris. As river velocities decreased, the largest boulders settled out, then smaller cobbles, then pebbles and sand. The glacier melted and retreated northwards and literally tons of granular material were washed out in front of the ice. Meltwaters fed into glacial lakes and deltas formed where rivers flowed into the lakes. Beaches developed along the lakeshores as wave action sorted out gravel and sand and washed silt and clay away from the shorelines out to the lake bottom.

These processes are responsible for the formation of sand and gravel deposits in Manitoba. Sand and gravel are important raw materials in the construction industry. The purpose of this report is to illustrate the intensive use we make of these granular materials, and to enhance our appreciation of this non-renewable resource.

SOURCES OF SAND AND GRAVEL

A sketch map of glacial features in Manitoba (Fig. 1) shows the distribution of ridges (moraines), glacial rivers (eskers), outwash and beach deposits. These granular deposits are not evenly distributed throughout the Province. In the north are hundreds of eskers, characteristically running perpendicular to the former ice front. Morainic complexes (such as the one at The Pas) are commonly very large features traversing great distances. In the south, sources of granular materials are relatively less abundant. Large areas are covered by silt and clay which were deposited on the bottom of the glacial lake and now provide excellent agricultural soils. Some smaller eskers are evident, and some have well-developed deltas associated with them (Birds Hill, for instance). These, plus outwash deposits, beaches along the ancient lake's edge, and alluvium in river terraces, combine to provide Manitoba with supplies of natural sand and gravel.

The quality of these materials is by no means uniform. Deposits formed by river or wave action tend to be well sorted by size, and free of clay and organic material below the soil horizon. Beach ridges, deltas and eskers fall into this category. Morainic and outwash deposits, however, have been pushed up rapidly by ice or dumped from meltwater. Unless this material is reworked by wave action, little sorting or removal of silt, clay and organic material takes place. The unsorted deposits may contain everything from soil and clay to boulders. This unsorted material can be used directly for some purposes (generally as fill), but usually some form of processing is required before use. Processing involves washing, screening and crushing. These techniques will be discussed in more detail later.

USES

Listed here are the common uses of sand and gravel in Manitoba:

Road Construction
- sub-base
- base
- traffic (surface) gravel
- shoulders
- culvert fill
- maintenance (pit run)
- ice control

Concrete Aggregate
- road surfaces
- dams
- foundations
- buildings
- ready mix
- sidewalks
- pre-cast blocks, tiles
- mortar
- grout
- railway ties

Other Uses
- Portland Cement
- moulding sand

Mine Backfill

Asphalt Aggregate
- road surfacing
- parking lots

Railway Construction
- sub-base
- ballast

Silica Sand
- smelting flux
- sand blasting
- glass-making

Fill
- sewer and water pipe bedding
- septic field construction
- rip-rap
- dam construction

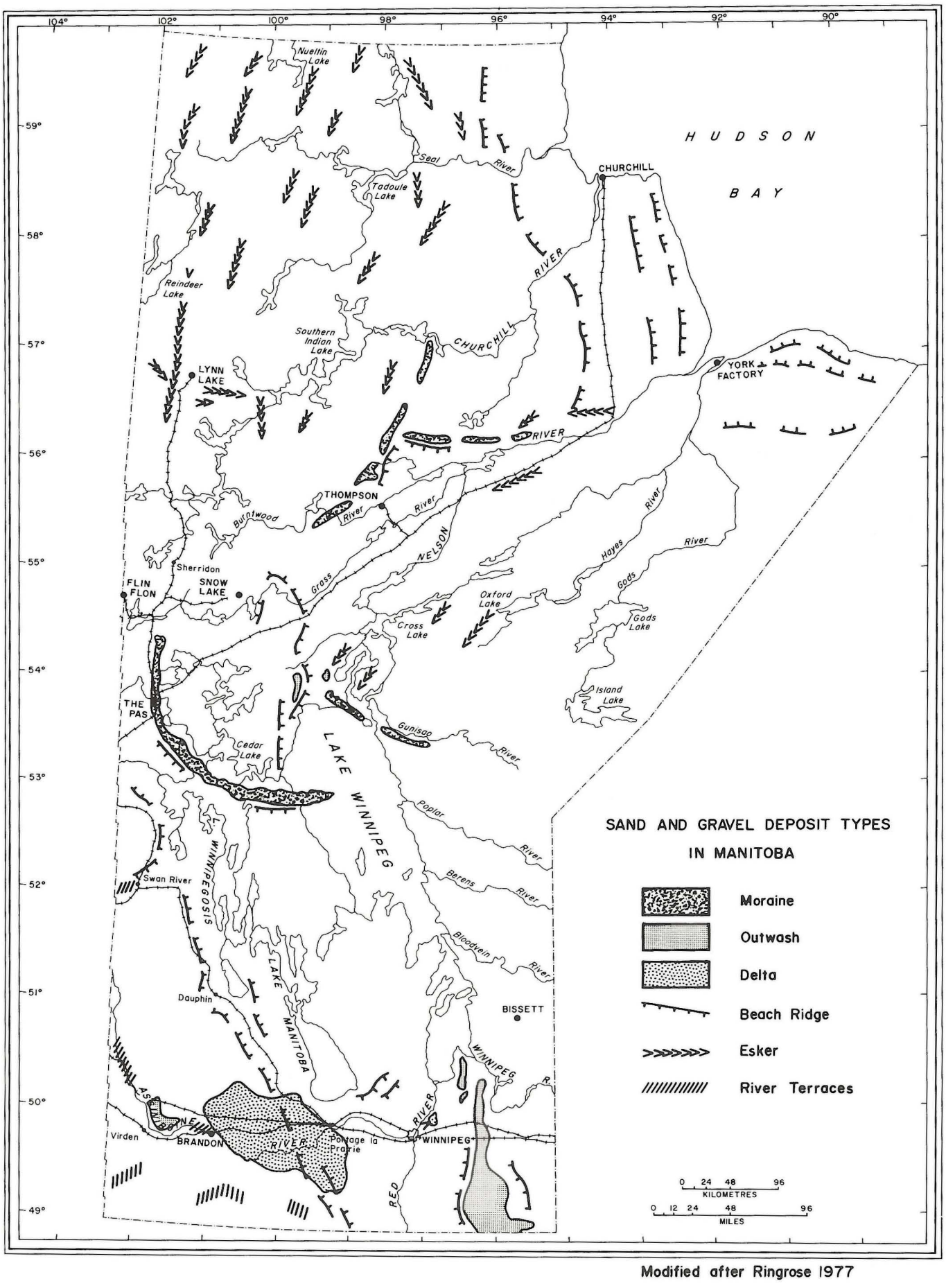


Figure 1. Sand and Gravel Deposit types in Manitoba

Sand and gravel are used in their natural state as a base for buildings, road and railroad construction. In many cases routeways, both road and rail, are located along the top or side of an esker or moraine because of natural drainage and accessibility of construction materials. Gravel is highly permeable; therefore, a base of a few inches to a few feet of granular fill is preferred under buildings to provide good drainage and avoid flooding which may result if an impervious clay base were used. This property of gravel also makes it useful as bedding for water and sewer pipes and in septic fields. Sand is commonly used in mining operations as backfill.

Processed granular material is used as aggregate that is mixed with cement to make concrete or with bitumen to make asphalt. Concrete is used in many aspects of building, either poured on site or previously formed. (Concrete blocks use a fine aggregate, whereas poured cement may require either coarse or fine material.) Both concrete and asphalt are commonly used in road surfacing, parking lots, driveways and sidewalks. Railway ballast is a specialized use of coarse gravel that has been crushed. Crushed rock makes a more stable base and is a preferred aggregate as the angular pieces of broken stone permit better compaction and provide a better binding surface than round stone. Sand, separated to certain sizes by screening away coarser material, is used as aggregate in masonry products (concrete blocks, mortar, grout), in the manufacture of Portland Cement, on winter streets for ice control and in foundries for moulding. Sand with a particularly high content of silica (which is extremely hard) is used in sandblasting, as a flux in smelting processes, and in glass-making (although no glass has been produced in Manitoba since 1913).

Figure 2 shows the proportional uses of sand and gravel in Manitoba.

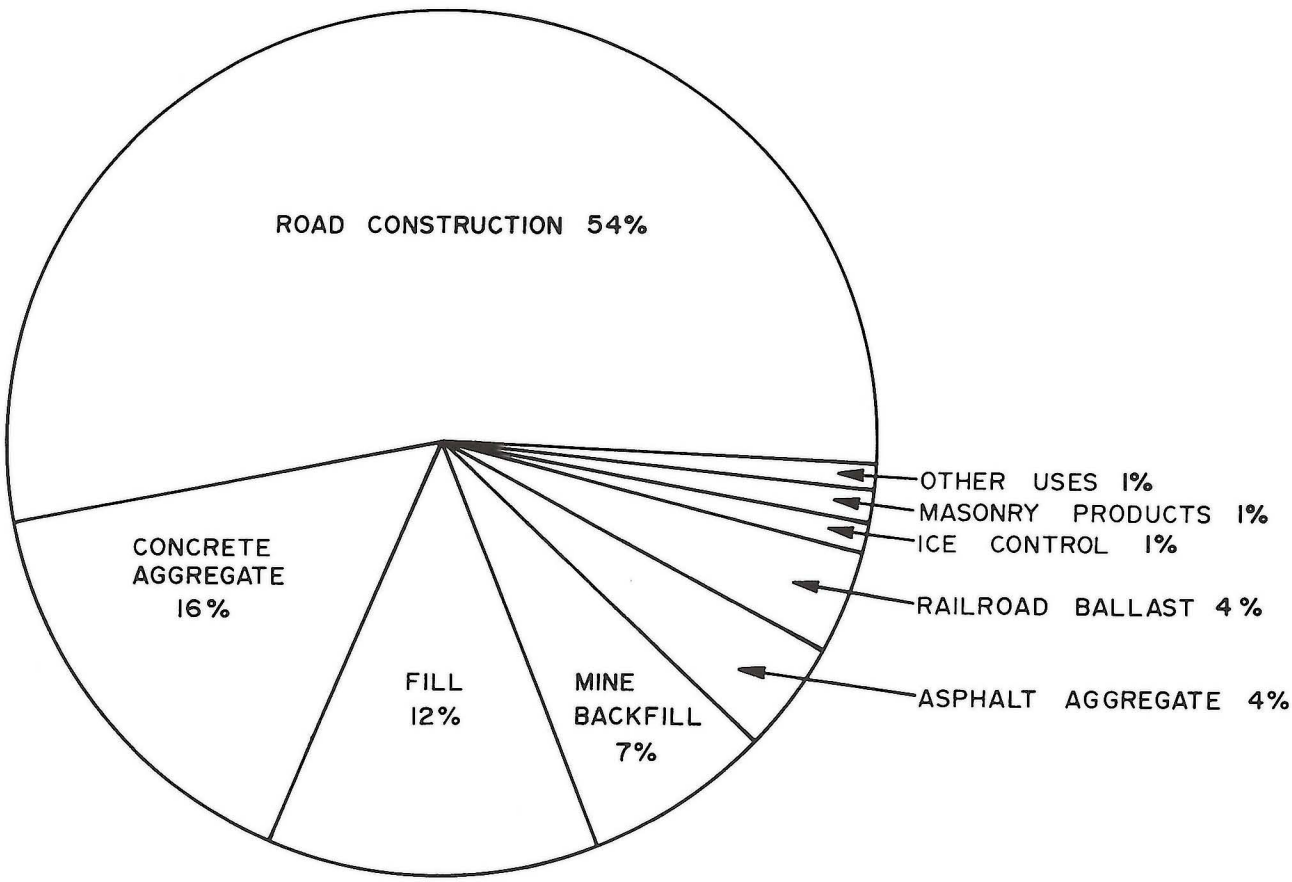


Figure 2. Uses of Sand and Gravel in Manitoba

PRODUCTION OF SAND AND GRAVEL IN MANITOBA

About 15 million tons of sand and gravel were extracted in 1976 in Manitoba for commercial use. Figure 3 shows the increase in production of sand and gravel in Manitoba over the past twenty-five years. This increase is in direct response to the Province's growing construction industry. The corresponding value of production is also shown on the graph. Manitoba has about twenty commercial sand and gravel producers employing about 225 people. This number, however, may not include many smaller contracting businesses which produce sand and gravel, but not on a regular basis.

QUARRYING AND PROCESSING

Gravel is a high bulk-low value material which costs almost as much to transport as it does to mine. As the distance between source and user increases, cost to the user increases significantly. Some of Manitoba's largest producers operate pits in the Birds Hill esker-delta complex located just a few miles northeast of Winnipeg. These producers (listed on Figure 4, an aerial photograph of the Birds Hill deposit) are able to supply much of the construction aggregate required in Winnipeg and the surrounding area from their plants located either in the city or at the pit itself. Photos 1 and 2 show the type of processing equipment that may be set up in large gravel pits. Other producers have portable plants which are set up in pits close to where the material is required (Photo 3). This is often the case for road-building projects.

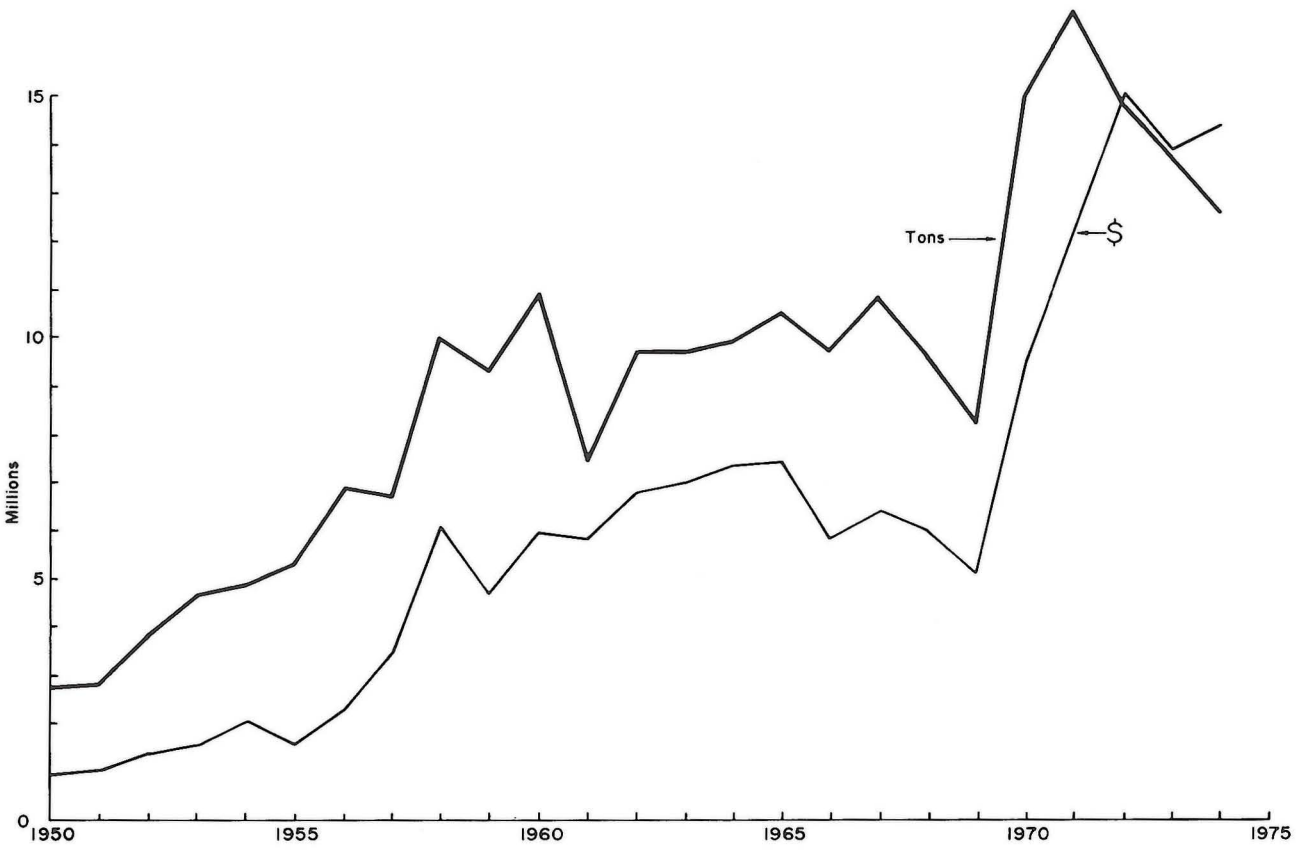


Figure 3. Sand and Gravel Production in Manitoba (Compiled from Statistics Canada data 1950-1975)

Outline of Esker-Delta Complex

Pit Operators:
- B: City of Winnipeg
- C: B.A.C.M.
- D: Fraser
- E: Mulder Bros.
- F: Smithson
- G: Favorite
- H: C.P.R.
- I: Selkridge
- J: R.M. Springfield
- L: McCurdy
- X: C.N.R.

Figure 4. Sand and Gravel Producers in Birds Hill

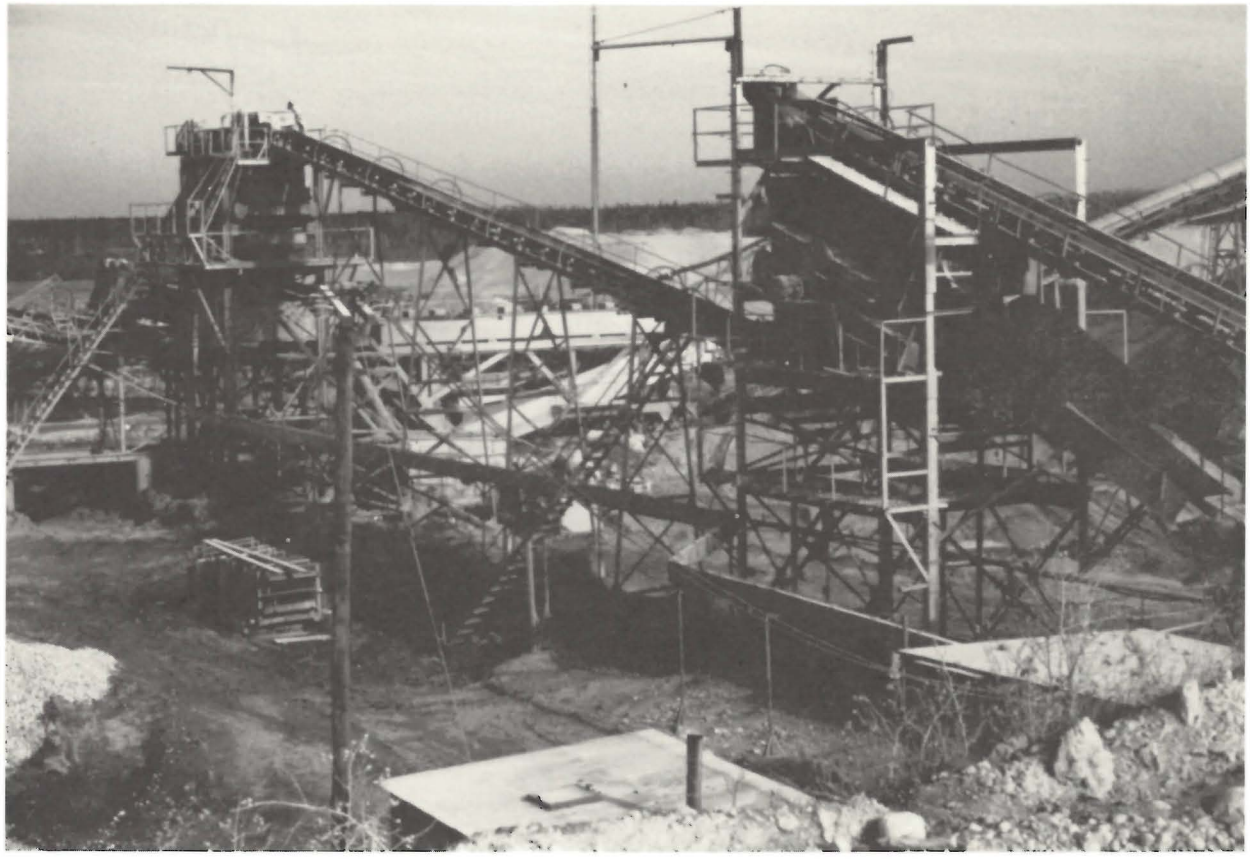


Photo 1. Processing plant in pit near Richer.

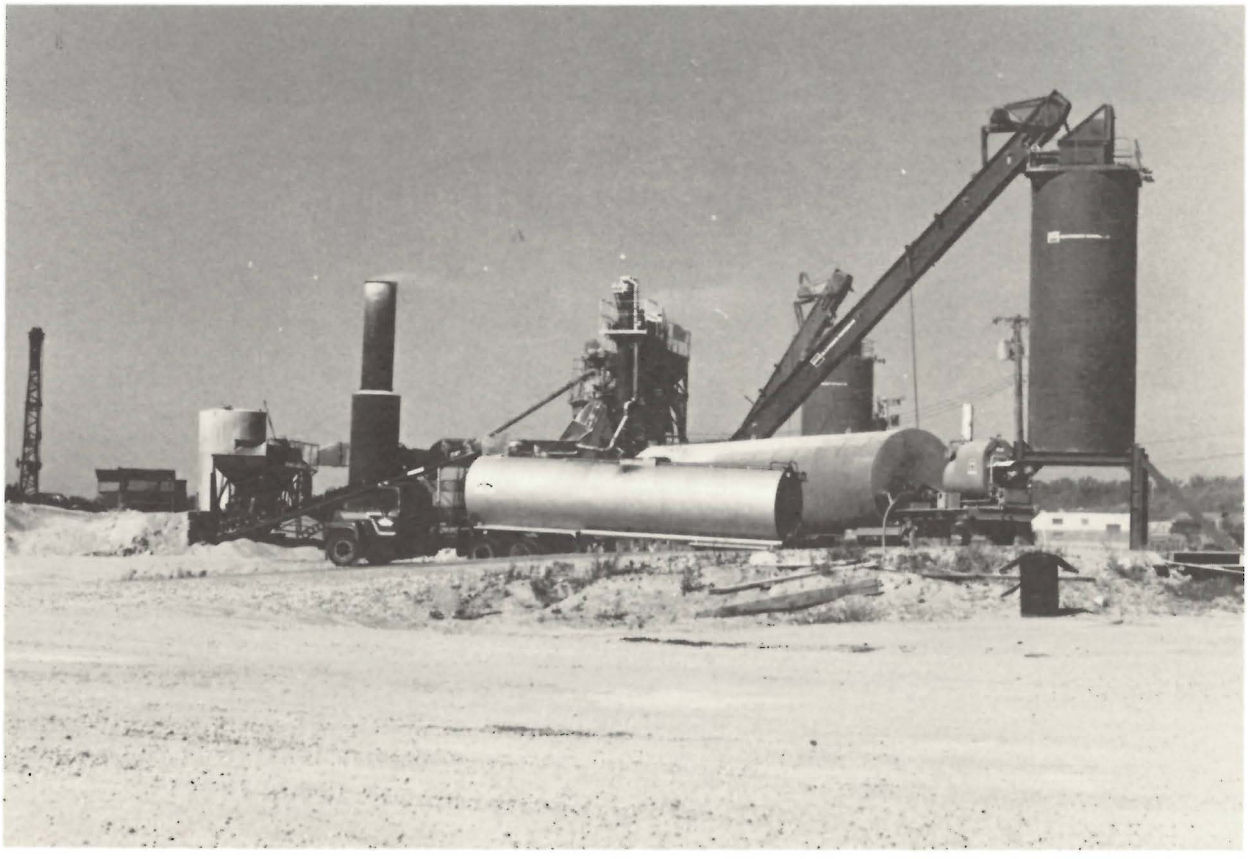


Photo 2. Asphalt plant in Birds Hill pit.

Photo 3. Portable screening-crushing plant at Leaf Rapids.

The mining of sand and gravel is a surface operation. Material is excavated by means of front-end loaders (Photo 4) or draglines (Photo 5). Draglines are required if digging goes much below the water table. The excavated material is loaded on trucks, stockpiled for later use, or processed. A flow diagram depicting the processing of sand and gravel to various sizes, typical of a large-scale operation, is shown in Figure 5.

Particle size is an important classifier of aggregate materials. Size of granular materials is determined by measuring the diameter or shortest axis of the particles. This measurement is made in either inches or millimetres. Since it is an unimaginable task to measure every pebble or grain of sand in a pit, a system of screening is used to sort out materials into sizes. The screens have holes of measured sizes, so that a two-inch pebble will sit on top of a one-and-a-half inch screen while sand will go through it to sit on sand-size screens (with openings of less than two millimetres).

Specifications for different products require that sand and gravel conform to certain sizes or proportionate mixtures of sizes. For example, aggregate used in a high grade asphalt is required to have 100% of the material passing through a ¾-inch screen, 95% to 100% passing through a ⅝-inch screen, 70% to 90% passing through a ⅜-inch screen, 50% to 70% passing a number 4 mesh screen (slightly smaller than ¼-inch) and so on down to a number 200 mesh screen through which only 2% to 8% of the material should pass. A 200 mesh screen is so-called because one square inch of the screen has 200 (equal sized) holes in it.

The following table relates mesh to millimetres and size to the common classification of sand, pebbles, cobbles and so on. Three "mixes" of different sized material, also in the table, show a typical batch of aggregate for asphalt, coarse concrete and fine concrete. These are by no means the only combinations of sizes that might be used.

Photo 4. Front-end loader excavation.

Photo 5. Drag-line excavation in Birds Hill.

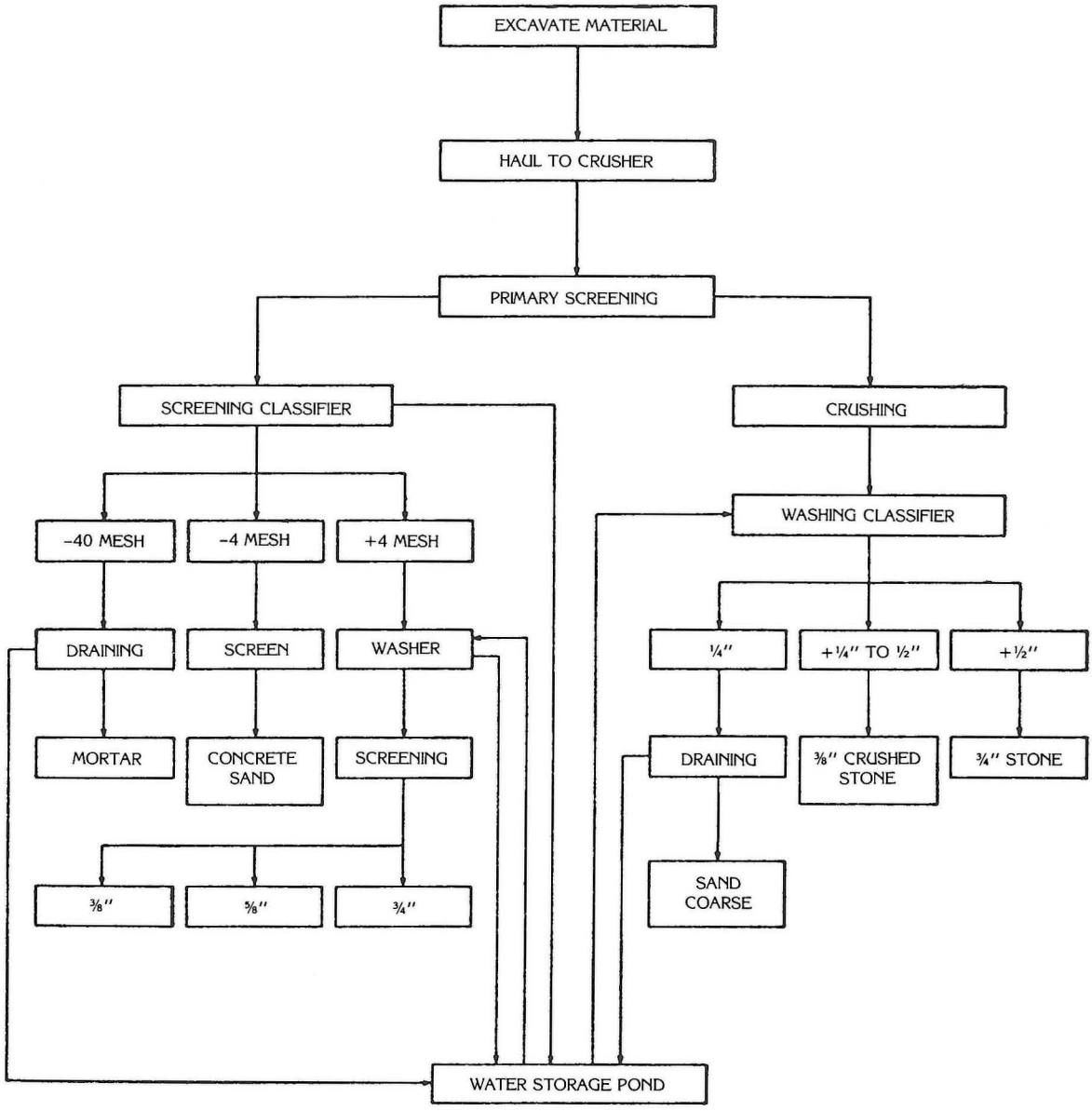


Figure 5. Flow diagram for Sand and Gravel operation (From Aggregate Resources of the Winnipeg Region, UMA 1976)

Table 1
SIZE CLASSIFICATION OF GRANULAR MATERIAL

Inches / Mesh	Millimetres	Size Class		Aggregate Sizes: Grade A Asphalt	Coarse Concrete	Fine Concrete
161"	4906					
40	1024	Boulder				
10	256					
2½	64	Cobble			0%	
2	50.8			0%		
1½	38.1				10%	0%
1	25.4				30%	
¾	19.1					
⅝	15.9	Pebble		5%	50%	
½	12.7			20%		
⅜	9.52					
¼"	6.35			20%	5%	10%
#4 mesh	4.76					
5	4.00					
6	3.36					
7	2.83	Granule		20%	5%	
8	2.38					30%
10	2.00					
12	1.68					
14	1.41	Very Coarse Sand				
16	1.19					
18	1.00					
20	0.84					
25	0.71	Coarse Sand		15%		
30	0.59					
35	0.50					40%
40	0.42					
45	0.35	Medium Sand				
50	0.30					
60	0.25					
70	0.210					
80	0.177	Fine Sand		15%		
100	0.149					
120	0.125					
140	0.105					20%
170	0.088	Very Fine Sand				
200	0.074					
230	0.0625					
270	0.053					
325	0.044	Silt		5%		
400	0.037					
	0.0039					
		Clay				

CONCLUSION

In the past the tendency has been to take sand and gravel for granted in Manitoba. There have always been abundant supplies for building, and the cost of transportation has not been excessive. However, as large deposits close to urban centres become depleted, the industry is having to travel farther to look for high quality material.

It would be difficult to imagine what would happen if no sand and gravel were available. Consider this as you walk along a city street or drive along a country road or take a train past a hydro-generating station, and appreciate how our standard of living relates directly and indirectly to our use of natural sand and gravel. Substitutes are not readily found, and it may soon be a resource not to be taken for granted.

Surveys are currently in progress to determine the extent and quality of Manitoba's sand and gravel resources, and to assist in formulating plans for the best use of this valuable material in the future.

REFERENCES

American Society for Testing and Materials
1970: Annual Book of ASTM Standards. Part 10: Concrete and Mineral Aggregate. Philadelphia.

Ringrose, S. M.
1977: Manitoba Pleistocene Geology Preliminary Map. Manitoba Mineral Resources Division. Winnipeg.

Statistics Canada
1950–1975: Mineral Industry Review, 26–201
Mineral Industries: Principal Statistics, 26–204
Sand and Gravel Pits, 26–215
Queen's Printer, Ottawa.

Underwood, McLellan & Associates
1976: Aggregate Resources of the Winnipeg Region.
Study done for the Manitoba Mineral Resources Division, Winnipeg.