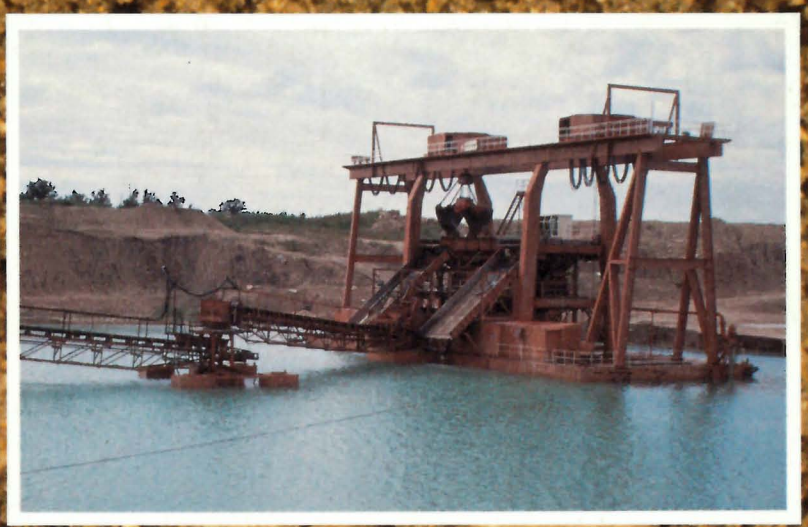
MINERAL EDUCATION SERIES



Sand And Gravel In Manitoba

Manitoba
Energy and Mines

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ACKNOWLEDGEMENTS

This publication was originally prepared by Peggy Large, and has been revised and expanded by Robert Young, with the assistance of many of the staff at Manitoba Energy and Mines.

Message From The Minister Of Energy And Mines

Manitoba's abundant mineral resources form a vital part of our province's rich natural resource heritage. It is almost impossible to spend even a day in our province without using some item which contains a tiny part of this heritage. Your home or workplace, no doubt, has concrete which includes our abundant sand and gravel. Or perhaps it uses building stone from one of Manitoba's quarries. Somewhere in your home there is likely to be copper pipe or wire which may well have originated from a northern Manitoba mine. The same mines produce the zinc which is used to galvanize much of the metal in your car to retard rust. You probably sit down to dinner with stainless steel cutlery which require nickel — one of Manitoba's richest mineral resources. Your car may use gasoline refined from Manitoba oil. You may even use Manitoba's gold when you exchange rings on your wedding day.

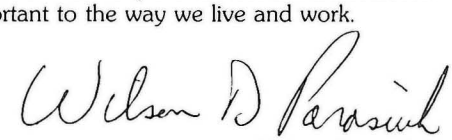
In getting these resources out of the ground and into your life, Manitoba's mining, quarrying and oil industries create thousands of jobs for Manitobans, including everything from clerks to miners to executives. These people, in turn, spend their salaries on goods and services which provide the lifeblood for countless more employees and businesses. In total, these industries and their spin-off benefits make a major contribution to Manitoba's prosperity and stability.

These resources also provide a significant source of income for the provincial government. Royalties and taxes ensure that revenues from our natural resource heritage contribute to maintaining the level of services Manitobans expect. These revenues help pay for the quality schools, hospitals and roads which make Manitoba a fine place to live.

In the Mineral Education Series, we hope to increase Manitobans' awareness of the wealth and variety of our mineral resources and their importance. Each booklet in the series explains one aspect of our mineral industry, describing the mineral resources, the history of its development in Manitoba and the industry today. We hope the series will convey some of the importance and excitement of exploiting Manitoba's mineral resource heritage.

Sand and Gravel in Manitoba explores a part of our mineral history which is often taken for granted. Manitoba has been blessed with rich sand and gravel deposits throughout the province. These aggregate resources play such an important part in our daily lives that it is easy to forget they are non-renewable and must be developed with care and respect. Yet without these resources, and the men and women who quarry them, society as we know it could not exist.

Manitoba Energy and Mines is working actively with producers and consumers to ensure a sensible use of our aggregate resources. In **Sand and Gravel in Manitoba** Robert Young, a geologist with our department's Aggregate Resources Section, examines the formation of our sand and gravel deposits and how they are explored for, quarried and used. I would like to thank him and all the staff of the department for this introduction to a resource which is so important to the way we live and work.



Wilson Parasiuk
Minister
Energy & Mines

Sand And Gravel In Manitoba

Introduction

Fifteen thousand years ago Manitoba was covered by an ice sheet, over 3 kilometres thick in places. As the glacier advanced southward over the province, it crushed and piled up bedrock and surface materials in its path (Fig. 1). Much of this frozen debris was incorporated into the glacier as it advanced. Later, as a changing climate began to melt the glacier, massive meltwater rivers, flowing at tremendous velocities, picked up and carried along much of this glacial debris. As river velocities decreased, first the largest boulders settled out, then smaller cobbles, then pebbles and sand. Thousands of tons of granular material were washed out to the front of the ice as the glacier retreated northward. Melt water rivers fed into glacial lakes, forming deltas as they deposited the remaining debris. Beaches developed along the lakeshores as wave action sorted out the gravel and sand, washing silt and clay away from the shorelines to settle in the lake bottoms. By far the largest of these glacial lakes is Lake Agassiz.

These processes formed the sand and gravel deposits found in Manitoba today. The purpose of this booklet is to illustrate the intensive use we make of these granular materials, and to enhance our appreciation of this non-renewable resource. While some use of technical terms is unavoidable, they have been kept to a minimum and a Glossary of Terms is included at the back.

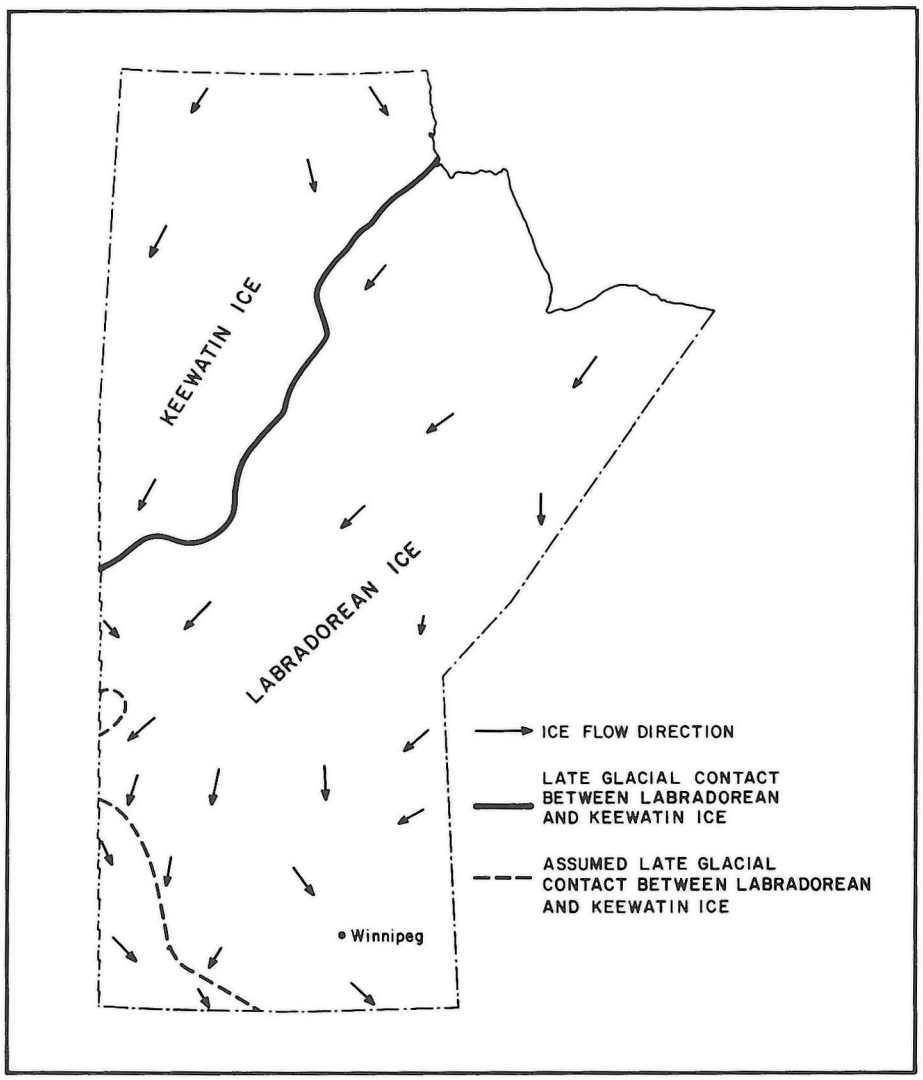


Figure 1:
Speculative ice flow directions and glacial contacts for Manitoba

(Manitoba Mineral Resources Division Map 81-1).

Sources of Sand and Gravel

A sketch map of glacial features in Manitoba (Fig. 2) shows the distribution of ridges (moraines), former glacial rivers (eskers), river deposits (terraces), 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 (Figs. 3 and 4) 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 glacial lakes and now provide excellent agricultural soils. Some smaller eskers are evident (Figs. 5 and 6) and some, such as Birds Hill, have well developed deltas associated with them. These, plus outwash deposits, glacial lake beach ridges, ancient inland Hudson Bay beaches (Fig. 7), and terraces along old meltwater channels, provide Manitoba with supplies of natural sand and gravel.

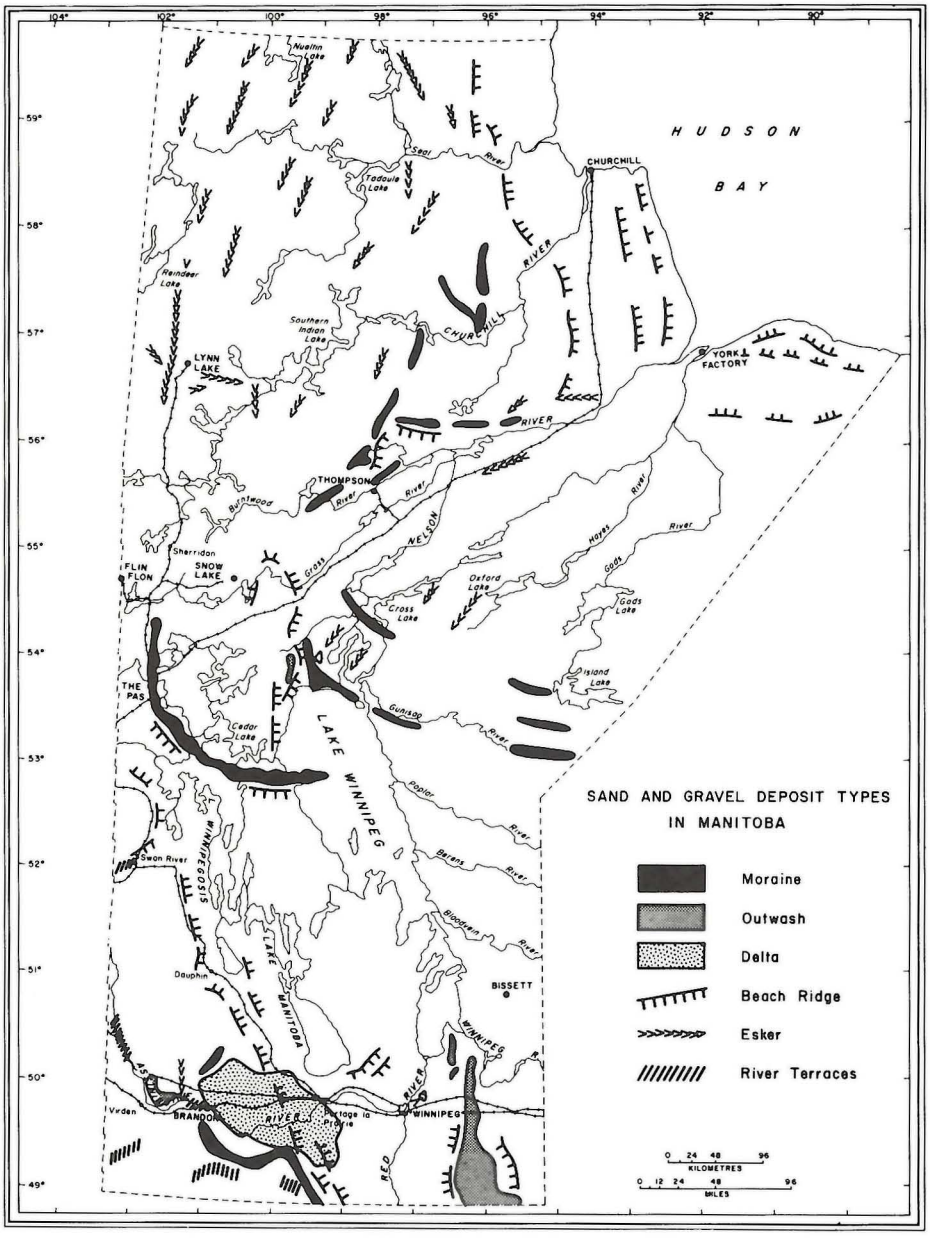


Figure 2:
Sand and gravel deposit types in Manitoba.

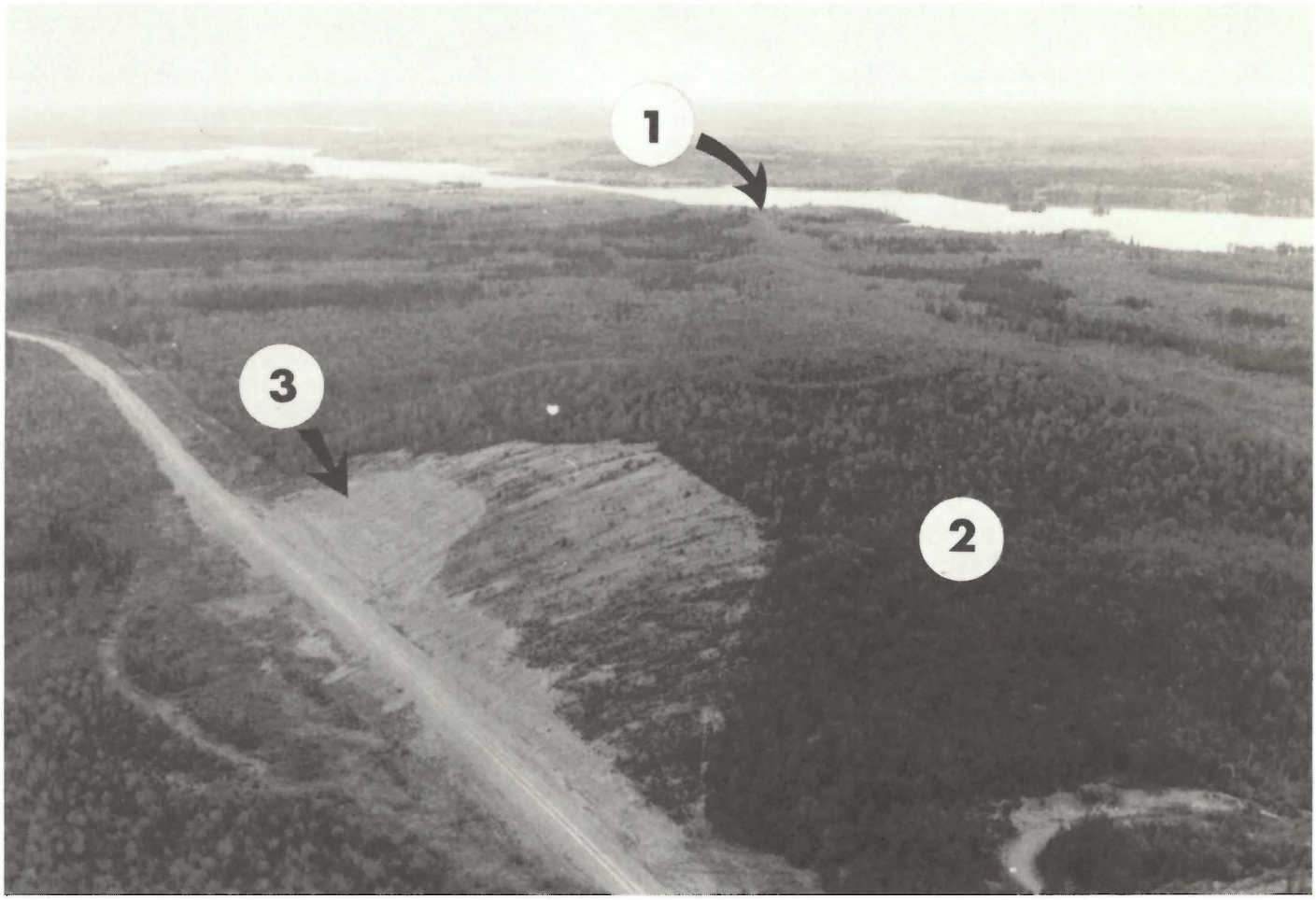


Figure 3:
A kame moraine complex north of Thompson. The aerial view illustrates (1) an esker ridge terminating at (2) a kame. A close-up view of (3) a roadcut through the kame is shown in Figure 4.

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. 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 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 can involve washing, screening and crushing. These techniques will be discussed in more detail later.

Figure 4:
View of the roadcut through the kame deposit. The kame is comprised of cobbly coarse sand and gravel.

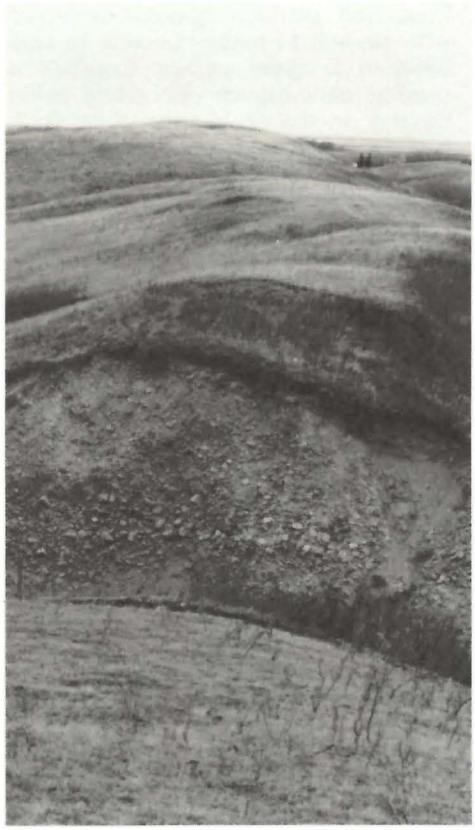


Figure 5:
Roadcut across the crest of an esker north of Oak Lake. The esker is comprised of shale-rich sand and gravel.

Figure 6:
Side view of the esker shown in Figure 5. Landforms similar to this are easily recognized on aerial photographs as potential sources of sand and gravel.

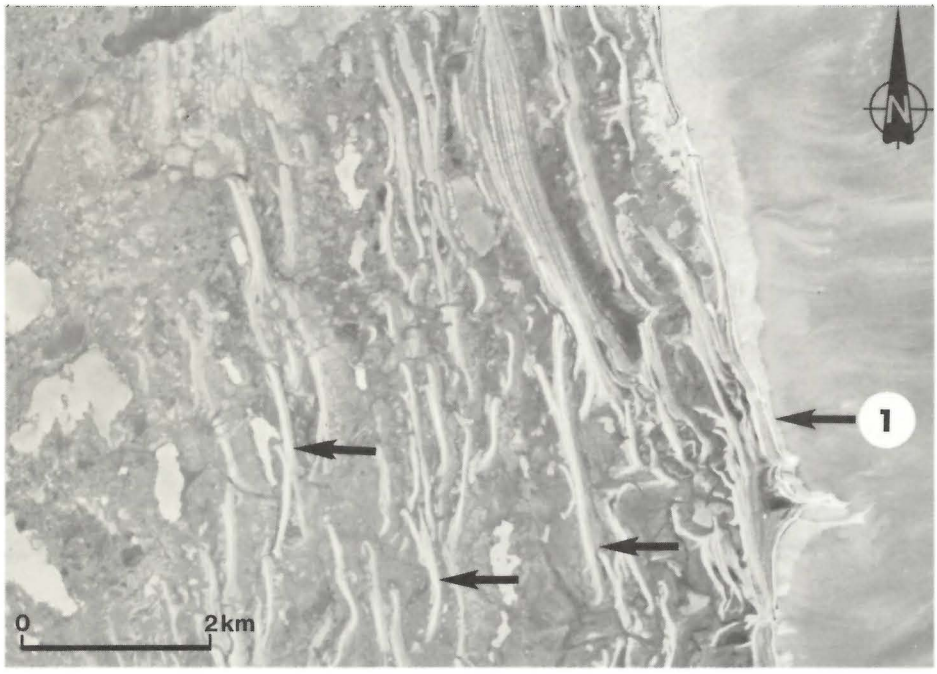


Figure 7:
Arrows on airphoto illustrate a successive series of ancient inland marine beaches adjacent to Hudson Bay. Active beach forming processes are occurring along the shoreline of Hudson Bay at (1).

Figure 8:
Arrows on airphoto illustrate a series of ancient glacial lake beach ridges 28 kilometres northwest of Dauphin. Highway 10 is built along a portion of one of the beach ridges at (1).

Uses

Common uses of sand and gravel in Manitoba are listed here:

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

Mine Backfill

Asphalt Aggregate
- road surfacing
- parking lots

Railway Construction
- sub-base
- ballast

Silica Sand
- smelting flux
- sand blasting
- glass sand

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

Other Uses
- Portland Cement
- moulding sand

Sand and gravel are used in their natural state as a base for buildings, road and railroad construction. Routeways, both road and rail, are often located along the top or side of an esker, moraine or beach (Fig. 8), to take advantage of natural drainage and the accessibility of construction materials. Gravel is highly permeable; therefore, a base of a few inches to a few feet of granular fill is ideal under buildings to provide good drainage and to avoid the flooding which can result if an impervious clay base is 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 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 as finished products such as bricks or tile. 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 (Figs. 9 & 10), parking lots, driveways and sidewalks. Railway ballast is a specialized use of coarse gravel derived from crushed rock. Crushed rock makes a more stable base and is a preferred aggregate as the angular pieces of broken stone permit better compaction and

Figure 9:
Stockpiled gravel is blended to form concrete at a portable concrete plant, then is loaded and trucked to the work site.

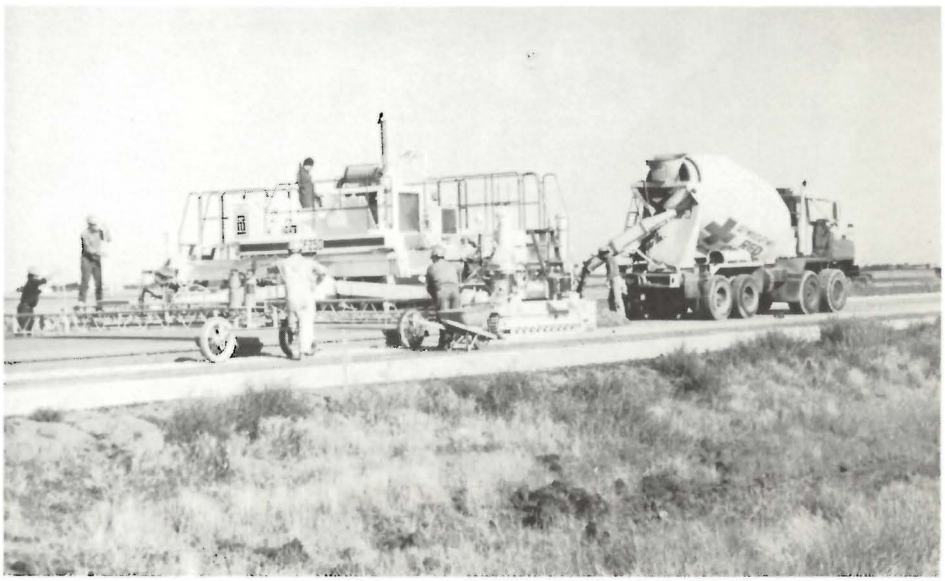


Figure 10:
Concrete is poured and spread on a gravel base for a new highway.

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 such as concrete blocks, mortar and 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 1930).

Figure 11 shows the proportional uses of sand and gravel in Manitoba.

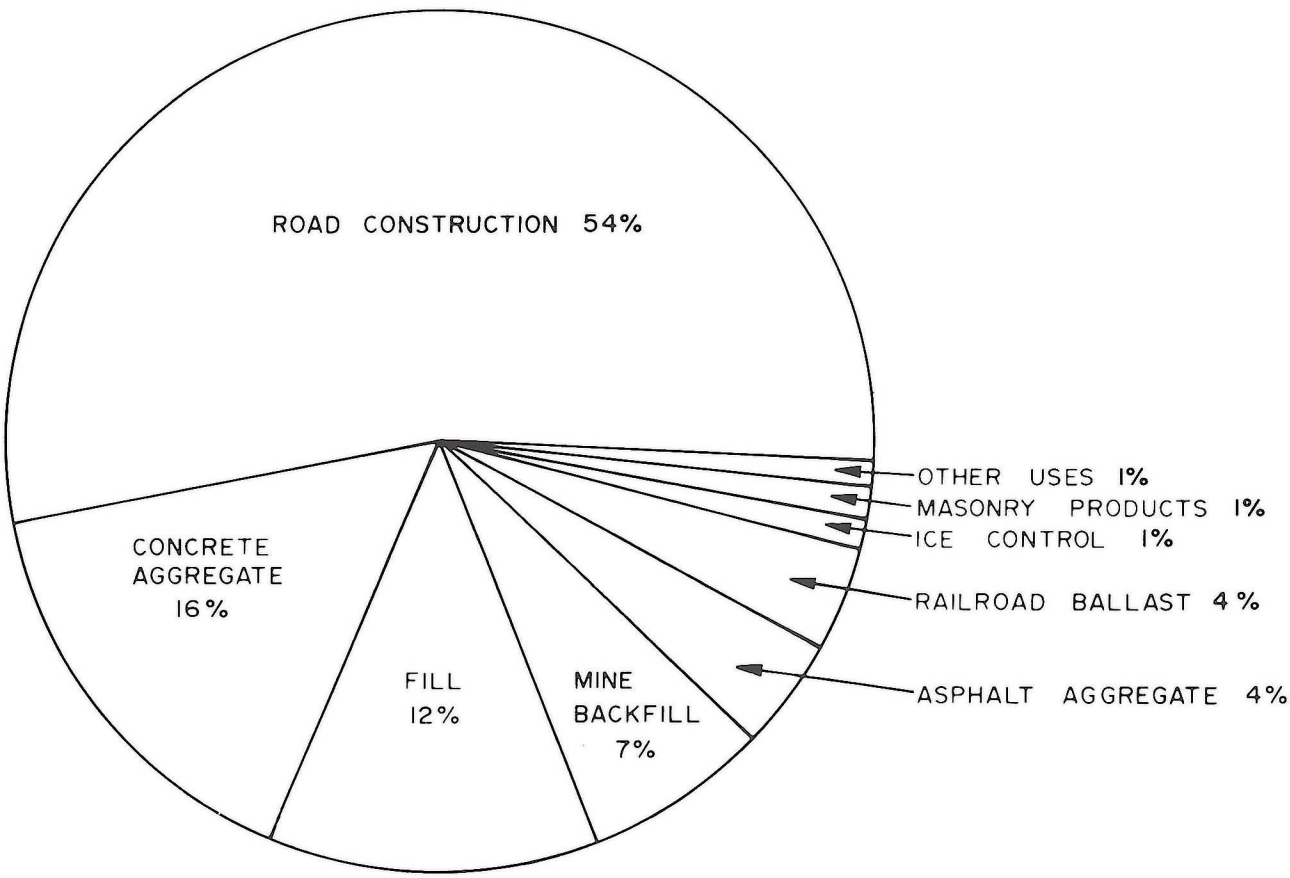


Figure 11:
Uses of sand and gravel in Manitoba.

Production Of Sand And Gravel

From 1975 to 1984 sand and gravel production has averaged over 13 million tonnes annually, for an average dollar value of 26.7 million dollars per year (Fig. 12). Manitoba has approximately twenty commercial sand and gravel producers employing about 225 people. This number, however, may not include many smaller contractors who produce sand and gravel, but not on a regular basis.

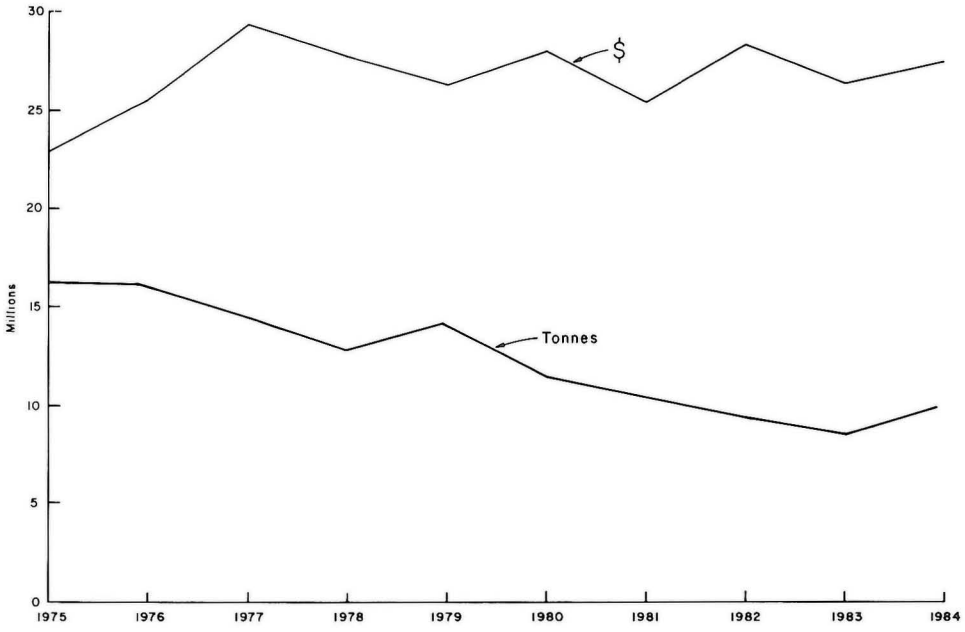


Figure 12:
Sand and gravel production in Manitoba. (Mineral Resources Division Annual Reports, 1975-1984).

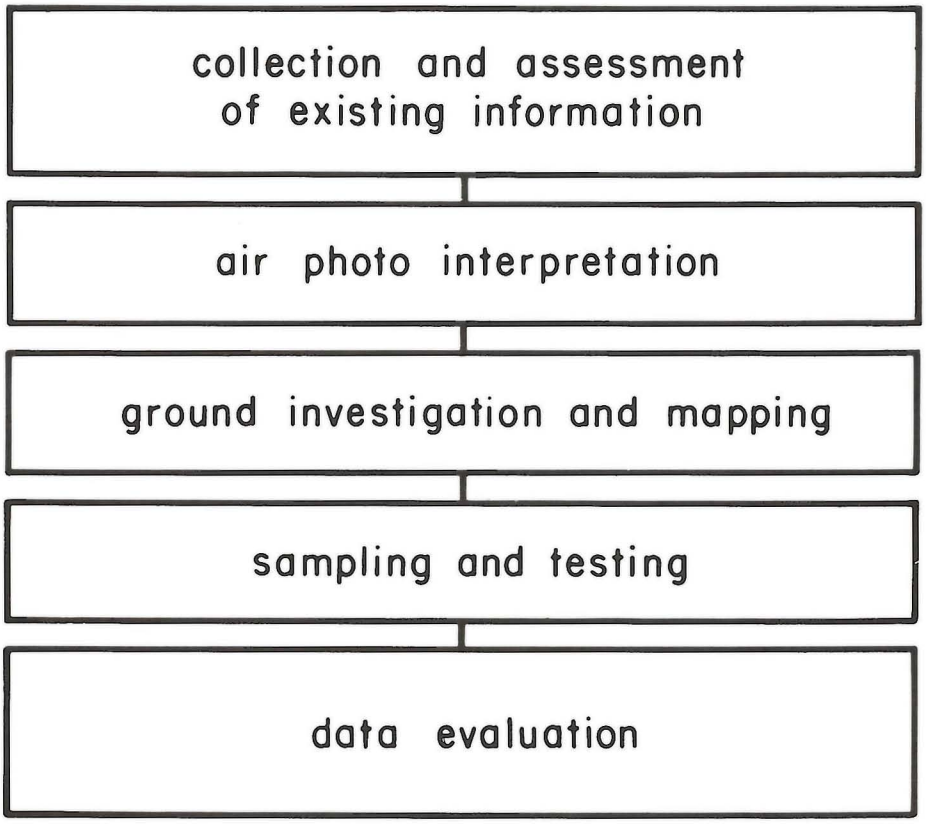


Figure 13:
Exploration phases for sand and gravel. *(Modified after Van Dine, 1984).*

Exploration Techniques

In Manitoba, sand and gravel is a quarry mineral that is removed, or mined from an open excavation. It is important to know the quantity, quality and distribution of this mineral resource. This type of data is useful for a variety of purposes including:

1. reduction of quarry mineral exploration and development costs;
2. resource planning, utilization and management;
3. pit planning, development and rehabilitation; and
4. project planning including cost estimation.

Sand and gravel resources are not evenly distributed throughout the province. To best utilize this non-renewable resource, we need to know the location, accessibility, distribution, and quality of the resource. Exploration programs are carried out to obtain this information. The procedures normally followed are shown on Figure 13.

Prior to any field investigation, it is necessary to collect and assess existing data.

Figure 14:
Testing a potential sand and gravel source with a backhoe.

Geological information is available for many areas of the province and can be used to assist the geologist in finding sand and gravel. A review of existing information will usually include bedrock geology reports, water resource studies, soils maps, academic theses, reports by consultants and a review of water well records. These studies often make reference to surficial deposits containing sand and gravel.

The next step involves a stereoscopic airphoto interpretation of the area under study. Various airphoto scales are used to identify landforms which may contain sand and gravel. Airphotos, when viewed stereoscopically, show specific landforms and changes in vegetation which may indicate the presence of sand and gravel. Airphotos also aid in defining the extent of potential deposits.

Depending upon the purpose of the study, ground investigations can be very detailed or of a reconnaissance nature. Each potential sand and gravel deposit previously identified from the airphoto interpretation is visited in the field to confirm the presence of sand and gravel. Existing pits, roadcuts and natural exposures are examined to confirm the limits of a deposit. Sand and gravel samples are usually taken. Testing with mechanical or geophysical methods is useful in defining the depth and boundary of the deposit. Shallow deposits are usually tested with the use of a resistivity meter or backhoe. The use of a backhoe provides a visual confirmation of the material and provides samples (Fig. 14). Deeper subsurface exploration may require the use of large diameter auger drills. To determine the feasibility of developing a deposit for production, factors such as depth to water table, variations of material with depth, sand and gravel ownership, accessibility of the deposit, depth of overburden and surface land uses may also be recorded in the field.

Sand and gravel samples are collected to define the quality of the deposit. Samples should be representative of the material in the deposit. They can be taken by making a vertical channel with a shovel and collecting sand and gravel from bottom to top. Usually material greater than 15 centimetres in diameter is not collected but is noted as potential crushable material.

Particle size determinations, also called mechanical or sieve analyses, are conducted on each sample. Size of granular materials is determined by measuring the width of the particles. This measurement is made in either inches or millimetres. Since it is impossible to measure every pebble or grain of sand in a pit, a system of screening is used to sort materials according to size. Each screen has holes of measured sizes which allow particles smaller than a specific screen size to pass through the screen while the screen retains the larger particles. The entire sample is passed through a series of screens and the weight of particles on each screen size is recorded.

After sieving, a representative sample of the pebble size is usually retained to determine the rock type. Rock types which are chemically or physically unsuited for use as a construction or road-building gravel are identified and counted. Certain rock types, such as shale, chert, clay lumps, carbonate or iron oxides, may deteriorate rapidly when exposed to traffic or other environmental conditions.

Sand and gravel data storage and retrieval systems can be either manual or computer assisted. Computerized systems allow the retrieval of data for specific uses in an easily accessible form, such as by geographical areas or from a specific site. Sand and gravel resource data are usually made available as a report which also includes maps illustrating all data points and an assessment of sand and gravel quality. Additional relevant data usually includes estimated reserves, mineral ownership and surface land use.

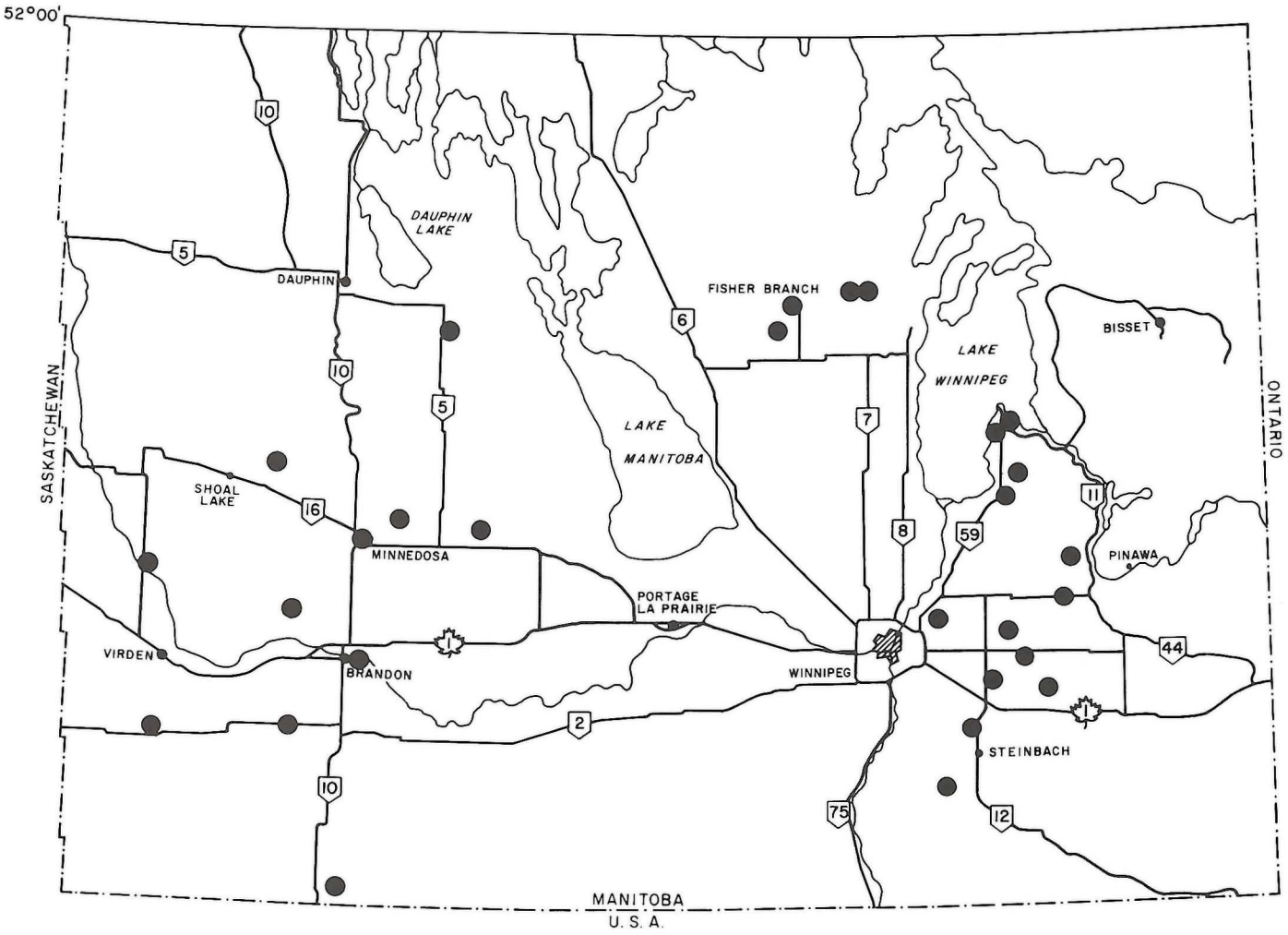


Figure 15:
Major sand and gravel producing areas of southern Manitoba.

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 gravel pits in the Birds Hill esker-delta complex located just a few kilometres northeast of Winnipeg. This area is able to supply much of the construction aggregate required in the Winnipeg region, from processing plants located either in the city or at the pit itself. Figure 15 shows the major sand and gravel producing areas in southern Manitoba.

Figure 16 shows 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. Front end loaders are usually used to excavate the aggregate. Special equipment is required to extract sand and gravel below the water table (Figs. 17 and 18).

The excavated material is loaded on trucks, stockpiled for later use, or processed. The flow diagram in Figure 19 outlines the processing of sand and gravel to various sizes, in a typical large-scale operation.

The essential elements of processing involve separating the aggregate into the various sizes, crushing of large aggregates to produce crushed rock and, for some products, washing to remove unwanted material. A flow diagram depicting the processing of sand and gravel to various sizes, typical of a large-scale operation, is shown in Figure 19.

Figure 20 relates mesh size to millimetres, and to the common classification of sand, pebbles, cobbles and boulders. 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 2% to 8% of the material should pass.

Figure 16:
Portable crushing and screening operation in a gravel pit. The processed gravel is hauled to the work site by truck.

Figure 17:
Dragline excavating gravel from below the water table in the Birds Hill gravel deposit.

Figure 18:
A floating twin clam-shell excavator in operation in the Birds Hill gravel deposit. The sand and gravel is excavated from depths of up to 20 metres and transported to shore for final processing by a floating conveyor system.

FLOW DIAGRAM FOR SAND AND GRAVEL OPERATION

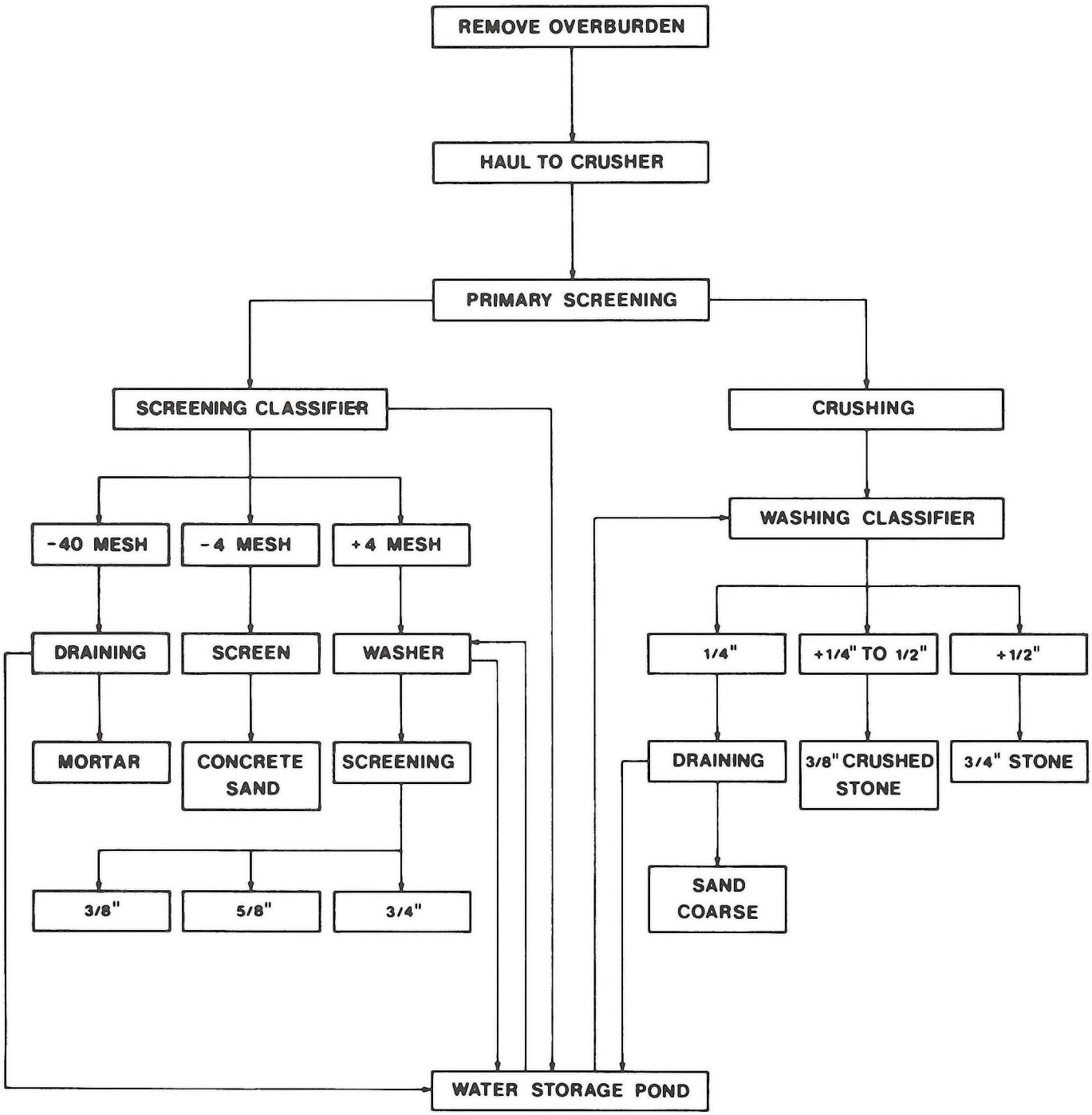


Figure 19:
Flow diagram for a sand and gravel operation.

(Underwood McLellan Ltd., 1975)

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	GRAVEL	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	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	MUD	5%		
400	0.037					
	0.0039					
		Clay				

Figure 20:
Size classification of granular material.

Conclusion

Because we have rich, easily accessible deposits, we have become accustomed to plentiful, inexpensive supplies of this resource. But sand and gravel are non-renewable resources, and must be explored for, developed and conserved with the same care due to all non-renewable resources.

It would be difficult to imagine what would happen if plentiful sand and gravel were not available. Think of the concrete and gravel base on city streets and country highways; the country roads and railway roadbeds; the concrete dams which help generate our electricity; the foundations and walls of our homes, offices and factories. Thinking of these, we realize the vital role that sand and gravel play in our standard of living. 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 formulate plans for the best use of this valuable material in the future. The Aggregate Resources Section of the Mines Branch of Manitoba Energy and Mines produces detailed aggregate resource inventories and quarry mineral land-use recommendations. Most of southern Manitoba and selected areas of the north have been inventoried. All data is computerized and is available on request. Published aggregate reports and maps are also available. The Aggregate Resources Section supplies inventory data and resource management proposals to all three levels of government and private sector users. In all of these functions, the section is actively co-operating with the industry to ensure that Manitoba's future needs for this essential resource are met.

Manitoba Energy And Mines

Manitoba Energy and Mines is continually working to increase our understanding of Manitoba's geology and its mineral resource base. Energy and Mines fieldworkers and analysts, working with private industry and their federal counterparts, have amassed a wealth of technical reports. More detailed information on sand and gravel in Manitoba can be obtained by contacting:

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Glossary

backfill — Waste sand or rock used to support a mine roof after removal of ore.

beach ridge — A continuous mound, usually consisting of sand and gravel, deposited by the waves of current or ancient lakes.

bitumen — Various solid and semi-solid hydrocarbons.

cement — A dry powder which hardens when mixed with water and used as an ingredient in concrete.

concrete — A mixture of sand, gravel, cement and water which hardens when dry.

esker — A sinuous ridge consisting of sand and gravel deposited by glacial meltwater.

flux — A substance used to promote fusing of minerals or metals.

geomorphology — The study of topographic features which are the result of either erosion or deposition.

kame — Mounds of poorly sorted sand and gravel deposited by glacial meltwater in depressions on the glacier surface or at its margin.

meltwater channel — A channel eroded by glacial meltwater either under the glacier or along its side.

moraine — A landform consisting of an accumulation of glacial debris deposited from a glacier's terminus, sides or bottom.

outwash — Sand and gravel transported away from a glacier by meltwater streams.

overburden — Material of any nature that covers a deposit of useful material or minerals.

resistivity meter — A portable instrument which measures the conductivity of a magnetic field through various surface materials. Used to determine the presence of material such as sand and gravel.

river terrace — An accumulation of river deposits along the sides of a river valley deposited by previous higher river levels.

silica sand — Sand having a high percentage of silicon dioxide.

stereoscope — An optical instrument in which each eye views one of two photographs producing an illusion of depth.

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