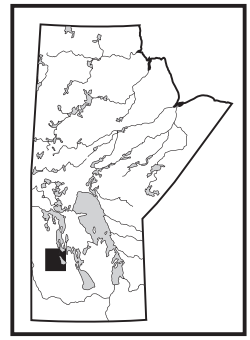
GS-15 Aggregate resources in the rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River, Manitoba (parts of NTS 62N1, 2, 7, 8, 9, 10, 62O4, 5, 12)

by H.D. Groom



Groom, H.D. 2008: Aggregate resources in the rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River, Manitoba (parts of NTS 62N1, 2, 7, 8, 9, 10, 62O4, 5, 12); *in* Report of Activities 2008, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 159–170.

Summary

The rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River were mapped this year as part of an ongoing project to update a 30-year old regional aggregate study (Gartner Lee Associates and Proctor and Redfern Limited, 1978). Field work by MGS (Groom 1999, 2001, 2006) confirmed the accuracy of the original deposit mapping by Gartner Lee Associates. This year, a pit inventory program was used, which allowed the updating of aggregate information of five municipalities to be completed in one field season. In the study area, sand and gravel resources are found in glaciofluvial and glaciolacustrine (beach ridge) deposits. These beach deposits contain very high quality aggregate that has been extensively mined in the past. Provincial Highway 10 is built on one of the highest quality beach ridges in the area. Locally, ironstone concretions and weathered Precambrian clasts lower the quality of the aggregate from the glaciofluvial deposits but it is still good quality aggregate that meets specifications for most end-uses. Bedrock quarries also provide an important component of the area's aggregate reserves. Aggregate demand in the area is relatively low compared to more populated areas of the province and there is an adequate supply of aggregate for the foreseeable future.

Introduction

The rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River form the western half of a regional aggregate study of ten municipalities surrounding the city of Dauphin (Gartner Lee Associates and Proctor and Redfern Limited, 1978; Figure GS-15-1). The Gartner Lee Associates (Gartner Lee) study is 30 years old and MGS has been updating the aggregate maps on a municipality by municipality basis over the past several years. The re-evaluation is usually provided as a response to regional needs for inclusion in municipal development plans but also as other needs arise. Aggregate deposits in the following rural municipalities have been remapped and sampled: Ochre River (Groom, 1999), Grandview (Groom, 2001) and Ste. Rose (Groom, 2006). There has also been extensive updating, including sampling, of deposits in Wildlife Management Areas and community pastures in the rural municipalities of Alonsa and McCreary over the last ten years (H.D. Groom, unpublished data). This work confirmed that the original deposit mapping done by Gartner Lee was very good and the decision was made to shift the focus away from remapping and resampling deposits to a pit inventory method of updating the aggregate maps. This less time consuming method allowed five municipalities to be updated in one field season.

Location

The five municipalities of this year's study area lie in western Manitoba and are situated on NTS sheets 62N1, 2, 7, 8, 9, 10 and 62O4, 5, 12. The study area covers approximately seventy townships contained within Twp. 23 to 35, Rge. 17 to 25, W 1st Mer. Riding Mountain National Park forms the southern boundaries of the rural municipalities of Dauphin, Gilbert Plains and Grandview (Figure GS-15-1). The area is accessed by Provincial highways 5, 10 and 20, numerous Provincial roads and a network of gravel section roads. The city of Dauphin is the major service centre but the town of Grandview and villages of Gilbert Plains, Ethelbert and Winnipegosis also provide amenities to local residents and tourists. Farming is the primary industry but tourism, due to the proximity to Riding Mountain National Park and Duck Mountain Provincial Park, along with logging and fishing are important contributors to the local economy.

Previous work

The bedrock of the area has been described in many regional studies, including those by Wickenden (1945), Bannatyne (1970, 1988), McNeill and Caldwell (1981) and Norris et al. (1982). Recently, a co-operative project between the MGS, Saskatchewan Industry and Resources and the Geological Survey of Canada incorporated new mapping and borehole data to refine and reinterpret crossborder correlations of the Phanerozoic formations in southern Manitoba and Saskatchewan (Bezys et al., 2004; Nicolas, GS-16, this volume). This has resulted in a revised nomenclature for some of the bedrock formations in the study area (Christopher et al., 2006). Detailed stratigraphic sections for several Cretaceous outcrops in the study area are described by Bamburak and Christopher in their fieldtrip guidebook (Bamburak and Christopher, 2004). The bedrock geology, areas of near-surface bedrock, and quarry locations in the Rural Municipality (R.M.) of Mossey River are included on the 1:250 000 scale maps that accompany Bannatyne's report on dolomite resources of southern Manitoba (Bannatyne,

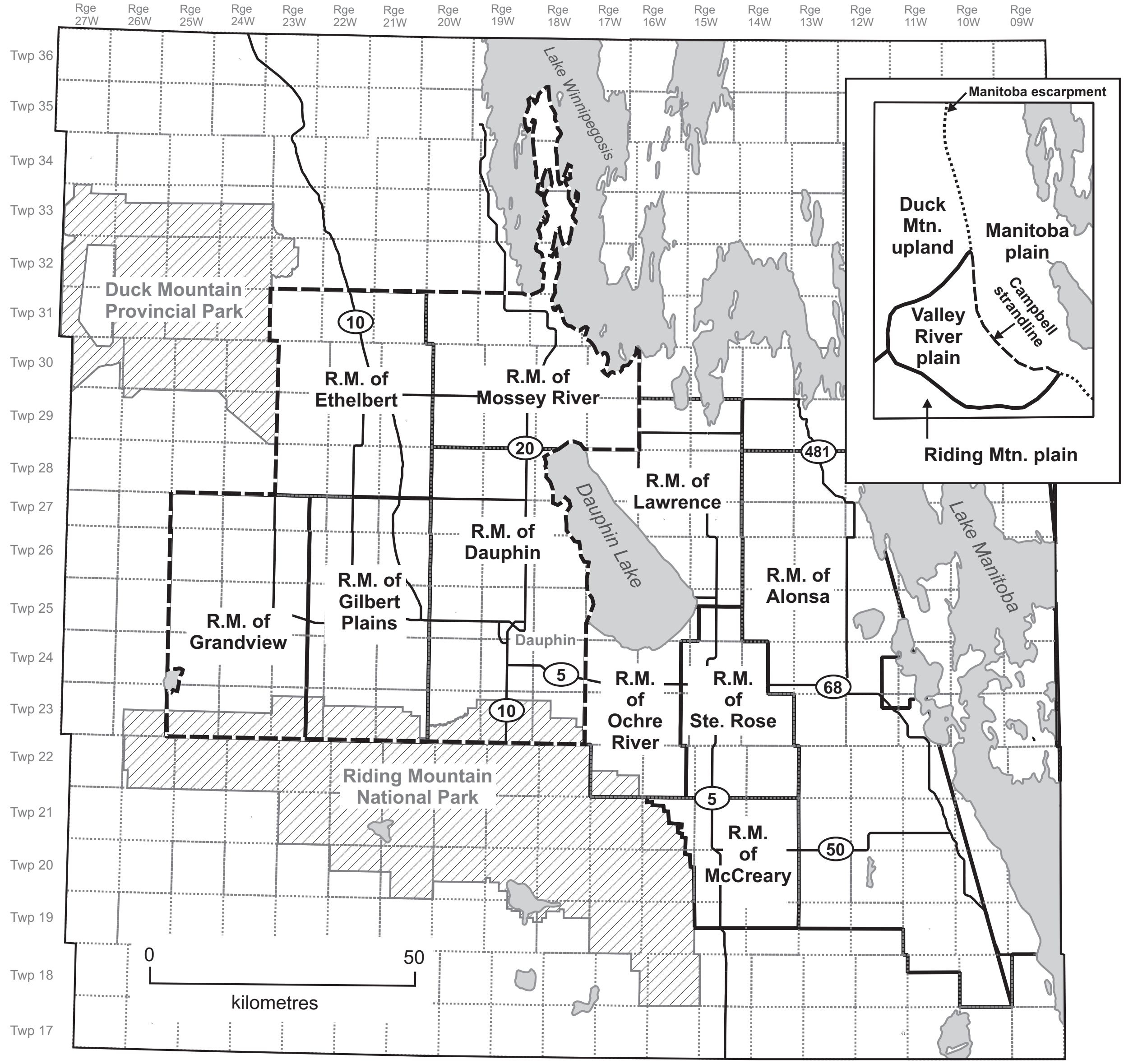


Figure GS-15-1: Location map of the ten municipalities of the Gartner Lee Associates and Proctor and Redfern Limited (1978) report. Dashed line indicates the five municipalities of the current study area: the rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River. Inset diagram shows major physiographic regions referred to in text.

1988). Bezys and Bamburak (2004) describe Devonian stratigraphy exposed in two quarries in the R.M. of Mossey River. Jones (1986) discusses the aggregate potential of bedrock formations in Manitoba; one of the quarries sampled is within the R.M. of Mossey River.

The study area is covered by two reports on groundwater availability: Duck Mountain area (NTS 62N; Little and Sie, 1976) and Dauphin Lake (NTS 62O; Betcher, 1987). These reports contain 1:250 000 scale maps of bedrock geology, surficial geology and overburden thickness as well as maps more directly related to water resources.

Klassen (1979) outlined the glacial history and mapped the surficial geology of NTS sheet 62N (Duck Mountain) at a scale of 1:250 000; all but the far eastern portion of the study area is included in that report. Nielsen (1988) mapped the surficial geology of the area immediately north of the study area at a scale of 1:100 000. His report includes diagrams of beach formation at successive stages as glacial Lake Agassiz receded from the area. The five municipalities of the study area were mapped at a scale of 1:50 000 as part of a surficial geology and aggregate mapping project that included ten municipalities (Gartner Lee Associates and Proctor and Redfern Limited, 1978). During that study, 165 aggregate sites were examined in the current study area; 70 of these were sampled. Bedrock quarries were not included in the report. The municipalities are also included on two recent

1:250 000 scale Surficial Geology Compilation Maps: SG-62N (Matile and Keller, 2004a) and SG-62O (Matile and Keller, 2004b). On these maps, the surface units have been draped over topographic relief maps and landforms are clearly shown.

Physiography and drift thickness

The area has three distinct physiographic regions: the Riding Mountain and Duck Mountain uplands, the Valley River plain and the Manitoba plain (Figure GS-15-1**)**. The upland areas are formed of thick deposits of hummocky stagnation moraine; there are up to 260 m of glacial sediments on Duck Mountain (Little and Sie, 1976). Elevations on Duck Mountain reach 831 m asl at Baldy Mountain, the highest peak in Manitoba. The upland areas are separated from the Manitoba plain by the Manitoba escarpment. The escarpment is steepest along the eastern edge of Duck Mountain where elevations rise from 427 to 640 m asl over a distance of 8 km. The area is characterized by alluvial fans and landslides. The Valley River plain is an area of gently rolling terrain between the two upland areas. Drift thicknesses range from >120 m in the west to <10 m in the area southwest of Dauphin. Elevations fall from 520 m asl in the western part of the plain to 335 m asl in the east. The western boundary of the Manitoba plain is not distinct. In the study area, the Manitoba escarpment and the Campbell strandline at the eastern edge of the Valley River plain, form an approximate boundary. The Manitoba plain is generally flat lying and poorly drained. It is marked by a series of south-southeast-trending gravel ridges with intervening organic deposits in the western part of the study area. Depth to bedrock is approximately 30 m in this area. In the extreme northeast of the study area, till ridges trend southwest; Quaternary sediments are thin and bedrock outcrop is common. Drainage on the plain is to the northeast. Valley River drains into Dauphin Lake, which in turn drains into Lake Winnipegosis by way of Mossy River. The elevation at Lake Winnipegosis is 252 m asl.

Geology

Bedrock geology

The majority of the study area is underlain by Cretaceous and Jurassic sedimentary rocks while Devonian carbonate strata underlie the northeastern part (Figure GS-15-2).

The Cretaceous formation nomenclature (Figure GS-15-3) used in this report follows that of McNeil and Caldwell (1981) but has been amended to include the changes proposed by Christopher et al. (2006). As a result of recent work, they concluded that the Boyne and Morden Shale members are eastern facies of the Carlile Formation and that the Niobrara Formation does not extend into Manitoba. The Cretaceous rocks, except for the Swan River Formation, are primarily marine shales and have been well described in the literature (Bannatyne, 1970; McNeill and Caldwell, 1981). In general, the shales are soft and were comminuted to clay during glacial transport. The exception to this is the Odanah Member of the Pierre Shale Formation. It is a hard siliceous shale. Clasts of Odanah Member shale are common in many gravel deposits of southwestern Manitoba although shale is not a major component of the gravels in the study area. The Pierre Shale Formation is the major source of ironstone concretions found in the local gravels. The Cretaceous shales are primarily noncalcareous. However, the Marco Calcarenite bed and the Laurier Limestone beds (McNeill and Caldwell, 1981) of the Favel Formation are very calcareous (Bannatyne, 1970). These beds are described at Stops 16 and 17 of Bamburak and Christopher (2004). Currently, there are quarry leases pending in the area southwest of Dauphin in order to further test these beds for their high-calcium potential. The Cretaceous Swan River Formation is primarily sand and sandstone; the sand contains a high percentage of silica (Watson, 1985) although it has not been a commercial source of silica sand. The Swan River Formation was not seen in outcrop in the study area.

Jurassic rocks were not seen in outcrop in the study area. However, shale of the Melita Formation and limestone beds of the underlying Reston Formation were both examined in outcrop in the R.M. of Ste. Rose (Groom, 2006).

Devonian strata of the Souris River and Dawson Bay formations underlie the northeastern part of the study area. These rocks have been reported on by many authors, most notably Norris et al. (1982) who present detailed lithological and stratigraphic descriptions and Bannatyne (1975, 1988) who studied the bedrock formations from an economic perspective, as sources of high-calcium limestone and dolomite. Both of these formations represent ‘evaporite cycles’ and include red shales, dolomite and limestone. Limestone, variously fossiliferous, is the predominant rock type. Both formations contain units of high-calcium limestone. Bannatyne (1975) reported $CaCO_3$ values reaching 99% for samples from the study area. There are quarry leases pending for high-calcium production over the Dawson Bay Formation strata in Twps. 29 and 30, Rge. 17, W 1st Mer.

Surficial geology and late glacial history

Surficial geology

The surficial sediments in the study area are primarily glacial till, glaciofluvial sand and gravel and glaciolacustrine gravel, sand, silt and clay. The units are shown on Figure GS-15-4**.** The following unit descriptions, with the exception of the aggregate deposits, are primarily from Klassen (1979).

There are two surface tills in the study area: a clay-rich shaly till on the upland areas and a silty till on the plains. The surface till on the uplands is part of the

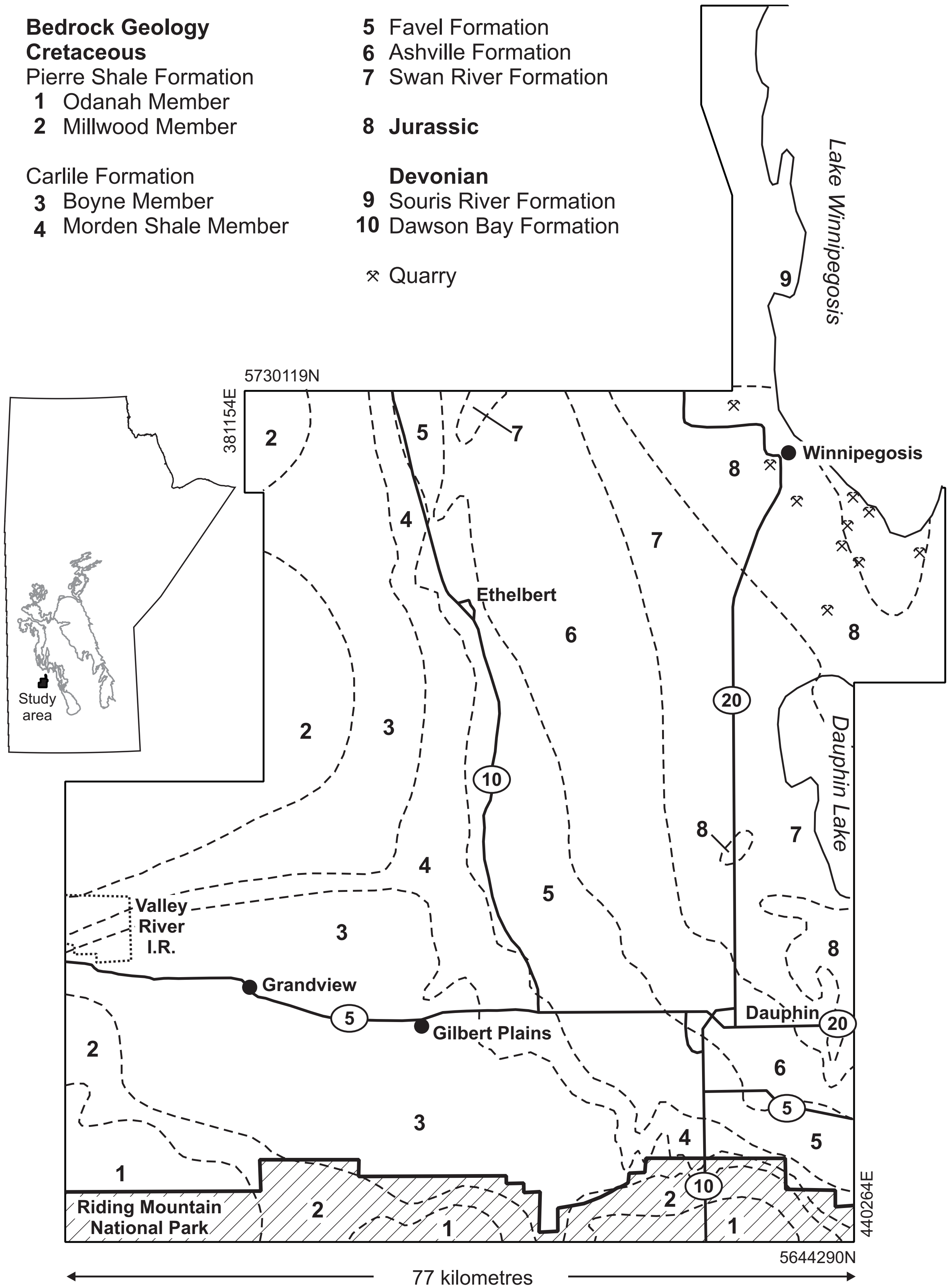


Figure GS-15-2: Bedrock geology of the rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River, showing quarry locations.

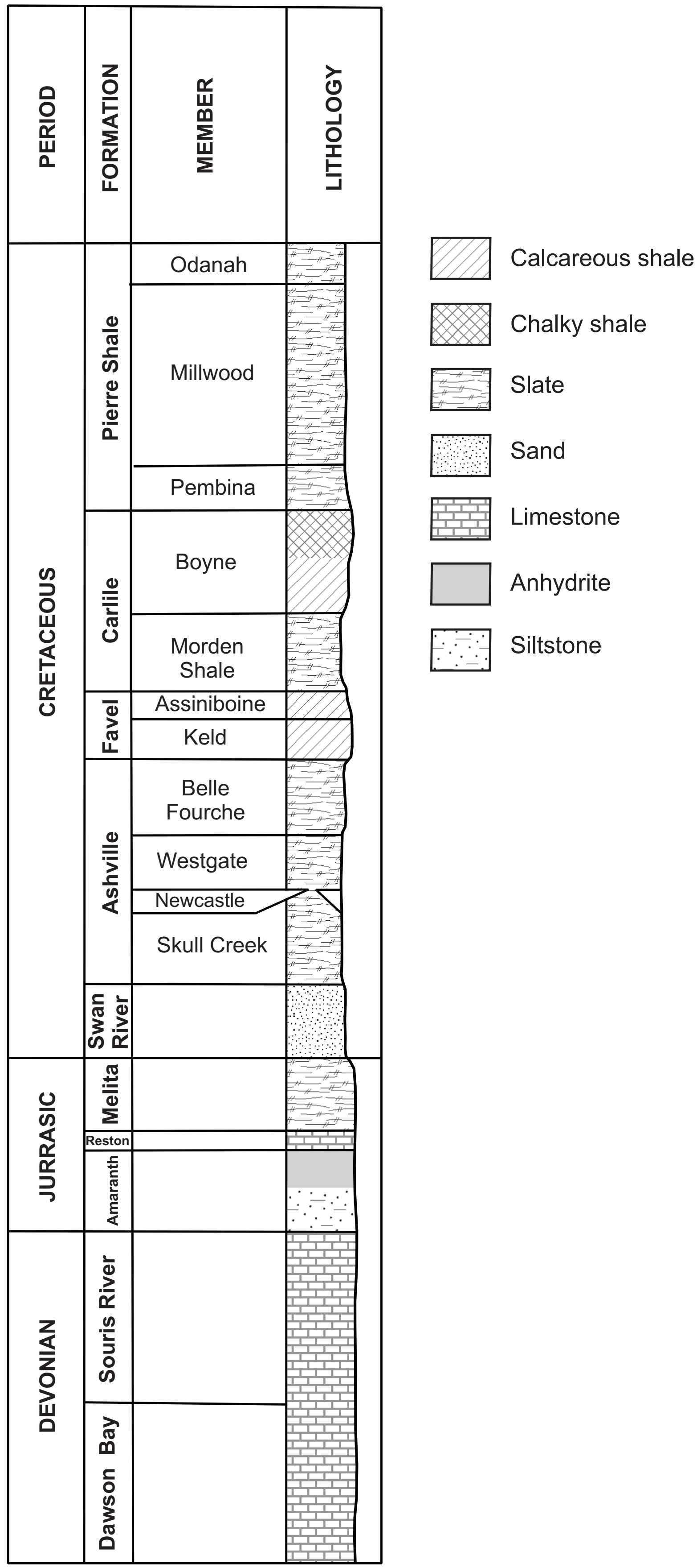


Figure GS-15-3: *Pre-Quaternary stratigraphy of the study area (*after *Nielsen,1988).*

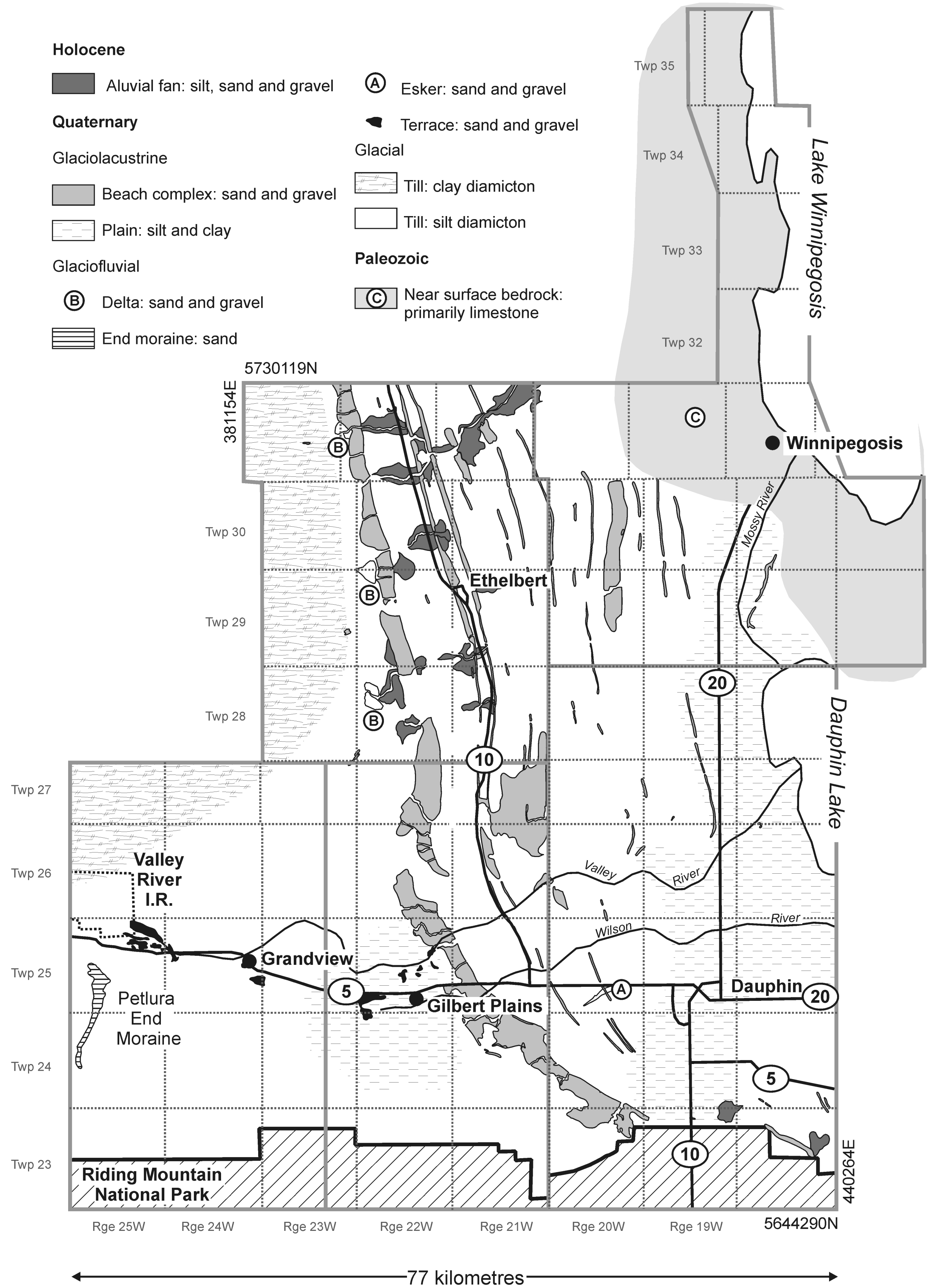


***Figure GS-15-4:** Surficial geology of the rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River (*after *Klassen, 1979).*

Zelena Formation. The till has a brownish clay-silt matrix with moderate carbonate content and contains a pebble lithology of shale, Precambrian and carbonate clasts. It is generally 3–15 m thick but locally can be much thicker (Klassen, 1979). The till forms a hummocky stagnation moraine with hummocks ranging between 5 and 15 m high. This till overlies the Early Wisconsinan Minnedosa Formation. The Minnedosa Formation till is an olive-brown, clayey till that is usually more compacted and less calcareous than the Zelena Formation. The surface till on the Manitoba plain is the Arran Formation. The till has a yellowish brown silty matrix that is 34–65% carbonate. Clast lithology is also primarily Paleozoic carbonate rocks. The till is normally 2–5 m thick but can be thicker locally. The Arran Formation till overlies Zelena Formation till in the Valley River plain.

Glaciofluvial sediments form a minor component of the area's surficial geology but they are a significant source of aggregate reserves. They are found mainly as terrace deposits along meltwater channels and as deltas along the escarpment. There is an end moraine on the Valley River plain. The Petlura end moraine, described and named by Klassen (1979), marks the western edge of the Arran Formation till in the Valley River plain (GS-15-4). The moraine is a north-trending ridge approximately 10 km long, 1 km wide and 15–30 m high. The material exposed in ditch sections is crossbedded, medium- to fine-grained sand although Klassen reports silt and gravel are also constituents of the moraine (Klassen, 1979, p. 26).

Deltaic deposits are present along the edge of Duck Mountain. They formed early in deglaciation when large amounts of meltwater were flowing off the upland areas into glacial lakes ponded between the escarpment and ice in the Manitoba plains. The deposits are 3 to >4 m of good quality aggregate with a wide range of grain sizes and low shale content.

There are several meltwater channels that flowed off the mountains; the largest are those that now contain the Valley and Wilson rivers. Most of the water that formed the Valley River channel came from the Duck Mountain uplands. Several creeks along the north side of Riding Mountain carried water to the Wilson River channel. There is potential for gravel deposits along all the meltwater channels but it is the Valley River channel that provides the largest terrace deposits in the area. See Groom (2001) for detailed descriptions of these deposits.

Glaciolacustrine sediments, primarily sand and gravel beach complexes and patchy areas of fine sand and/or silt and clay, overlie the till deposits, over much of the Manitoba plain below the escarpment and west of Dauphin Lake. The silt and clay deposits west of Dauphin Lake are up to 5 m thick in places but are usually much thinner. The beach complexes generally consist of a prominent sand and gravel ridge (or ridges) with a series of sandy offshore bars and intervening fine sand sediments. The ridges trend broadly southeast and record successively lower levels of glacial Lake Agassiz as it receded from the area. The largest beach ridges are up to 5 m high and they are the major source of aggregate for the area. Provincial Highway 10 (Hwy. 10), where it parallels Duck Mountain, is built on one of the highest quality beach ridges in the area. Large reserves of aggregate lie under the highway.

Late glacial history

During the Late Wisconsinan, glacial ice flowing from a north-northwesterly direction deposited the clayey Zelena Formation till over the uplands and Valley River plain while ice from a northeastern direction flowed down the Manitoba plain depositing calcareous till. As the Late Wisconsinan drew to a close, the ice on the uplands stagnated in place while the overall retreat of the northeastern ice sheet in the lowlands proceeded in a series of retreats and advances. The last glacial readvance deposited Arran Formation till on the Manitoba plain. This ice sheet advanced up the Valley River plain as far as the Petlura end moraine depositing Arran Formation till over Zelena Formation till.

During deglaciation, active ice continued flowing at the lower elevations while ice stagnated on the upland areas. The ice sheet on the Manitoba plains prevented meltwater from the stagnating upland ice from following its natural course and glacial lakes ponded between the ice margins and the higher upland elevations. As drainage became established on the uplands, meltwater channels carrying debris formed deltas where they entered these lakes (Nielsen, 1988). The largest meltwater channel, Valley River, formed as the Arran ice retreated downslope out of the valley. Initially, large amounts of meltwater from Duck Mountain flowed eastward in Valley River depositing the large gravel terraces west of Grandview. When drainage through the Shell River, west of the study area, became established, water volumes in Valley River decreased and the smaller terrace deposits east of Grandview and near Gilbert Plains were formed.

As the ice in the Manitoba plains retreated, glacial Lake Agassiz inundated the area, ponding between the retreating ice to the north and the height of land to the west. The lake left behind patchy, thin silt and clay deposits overlying till; the deposits are most extensive in the area west of Dauphin Lake. Beach ridges and wave-cut scarps formed discontinuously along the edge of glacial Lake Agassiz. As the ice retreated, the lake also retreated, with the resulting formation of beaches at successively lower elevations. Working in Manitoba and the adjacent parts of Saskatchewan and Ontario, Johnston (1946) took beach elevations around the former lake and, taking into account differential uplift, recreated shorelines at the various lake levels. Based on Johnston's work, Klassen (1979) identified several lake levels, the highest being the Norcross. Nielsen (1988) working immediately north of the study area, outlined the lake configuration during the Upper and Lower Campbell, McCauleyville, Ojata and Burnside levels of the lake. The development of Holocene organic deposits and alluvial fans along the escarpment followed the retreat of the lake from the area. The alluvial fans have formed at the base of the escarpment by present-day streams draining the uplands. Nielsen (1988) dated paleosols in a large alluvial fan north of the study area. The fan has been forming over the last 4000 years.

Aggregate inventory

Methodology

The methodology for this pit inventory project is similar to the procedure used for previous aggregate inventories (e.g., Groom, 2006). It was carried out in two stages: office compilation followed by fieldwork. Aggregate information was compiled from several sources:

1) pit and quarry locations – Mines Branch quarry database;
2) quarry lease and withdrawn locations – Mines Branch digital shapefiles;
3) pit and sample locations – Geological Survey Pleistocene database;
4) pit and sample locations – Department of Highways block files; and
5) existing aggregate maps and reports, primarily the Gartner Lee study.

The Mines Branch quarry database now has digital records of aggregate production from crown and private sources dating back to 1992. These records were compiled in the spring of 2008 when 2007 production forms had been completed. Sand and gravel pits and bedrock quarries were classified into three categories:

- active – any production from 2005 to 2007
- inactive – any production from 2000 to 2004
- pre-2000 – any production from 1992 to 1999

The term pre-2000, rather than depleted or abandoned, was chosen because an aggregate source may cease production for reasons other than depletion and/or rehabilitation. Bedrock quarries in particular can remain dormant for a long time between periods of production and large construction companies, through quarry lease or private ownership, often hold aggregate deposits in reserve for future projects.

Over the winter, all of the deposit boundaries and pit and site locations from the Gartner Lee study were digitized. This information, as well as the production activity and quarry lease shapefiles, were transferred onto 1:20 000 township photomosaics and a 1:100 000 photo base of each municipality created from 1998 orthophotos for use in the field. Information from the R.M. of Grandview (Groom, 2001) was incorporated into the mosaics of that municipality.

During the field season, emphasis was placed on visiting all pits and quarries from the Mines Branch production compilation although other pits, roadcuts and natural exposures were examined. Gravel pits were examined for type of material, pebble lithology and degree of depletion. Special note was taken of shale content as it can make a deposit unsuitable for certain end-uses (e.g., concrete) and land uses that would limit aggregate extraction were noted. Site locations were taken by GPS using UTM co-ordinates, as well as by section-township-range notation. Where a pit or quarry had expanded beyond what was visible on the photomosaics, the new perimeter was refined using GPS data points.

Aggregate resources

Aggregate in the study area is extracted from sand and gravel pits and bedrock quarries (Figure GS-15-5). The majority of the sand and gravel pits are privately held while the majority of the bedrock sources are crown owned and administered through quarry leases. To view the current locations, status and holders of the quarry leases, visit the MGS website at http://www.gov.mb.ca/stem/mrd/geo/gis and click on 'Mineral Dispositions'.

Bedrock quarries

There are ten bedrock quarries in the study area (Figure GS-15-2). All are located in the northeast part of the R.M. of Mossey River where Quaternary sediments are generally thin and bedrock outcrop is common. The quarries are all in the Devonian carbonate bedrock formations.

Two of the quarries are old and were described by Bannatyne (1975). The one in Sec. 9, Twp. 31, Rge. 18, W 1st Mer. (abbreviated 9-31-18-W1), known as the Winnipegosis quarry, is in the Souris River Formation and was originally opened for its high-calcium potential. Bezys and Bamburak (2004) found 6 m of fine-grained, dense limestone exposed in the quarry walls. Samples from this quarry were also tested for aggregate potential and the rock was found to meet specifications for most end-uses, including concrete and base course as well as surface road gravel (Jones, 1986). The quarry in 29-30-17-W1, known as Paradise Beach quarry, is in the Dawson Bay Formation. Samples tested were found to be almost chemically pure limestone (Bannatyne, 1975). However, it is presently held under quarry lease to produce aggregate.

The remaining eight quarries have all been opened for aggregate production. Five of these quarries are categorized as active, with production since 2005. However, the small quarry in 31-31-18-W1 (HD291), which was in continuous production from 1995 to 2005, has not been used since. It is flooded and would have to be dewatered for production to begin again. The other four active quarries are all currently producing aggregate. The quarry in 13-30-18-W1 (HD286) is the largest quarry in the area (approximately 0.3 by 0.3 km). There is ~1 m of silty till overlying >3 m of limestone. The material exposed in the walls is primarily a dense grey stromatalitic rock but a

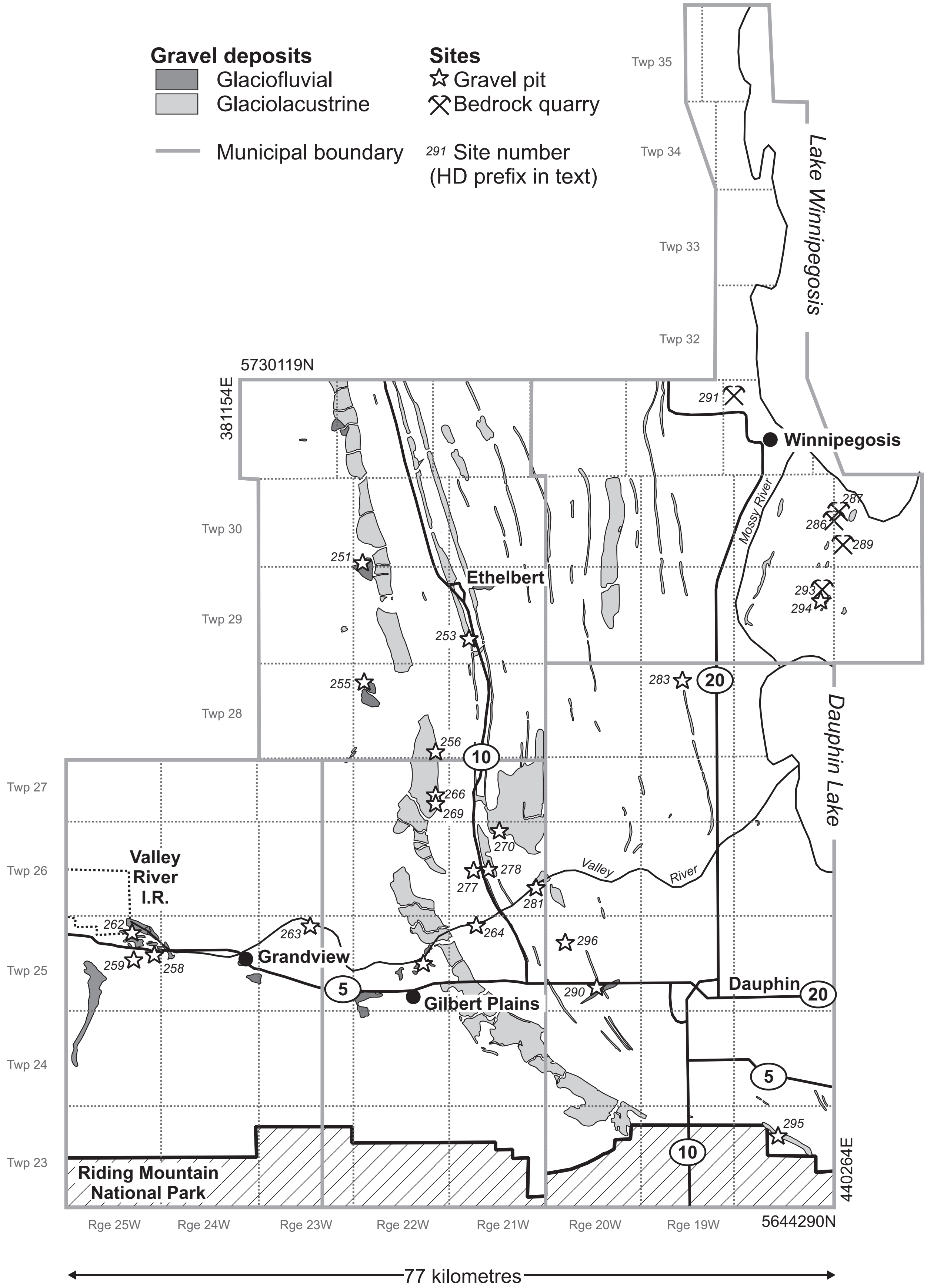


Figure GS-15-5: *Aggregate resources of the study area, showing active quarries and sand and gravel pits.*

soft yellow limestone overlies this in places. Large calcite crystals occur in the yellow strata at the southeast end of the quarry. The quarry in 19-30-17-W1 (HD287) is 2–3 m of rubbly, blocky limestone. Water is present at the west end of the quarry. The quarry in 7-30-17-W1 (HD289) exposes >2 m of grey limestone over yellow limestone beds. Deep water has flooded part of the quarry floor so the total quarry depth is unknown. The quarry walls in 25-29-18-W1 (HD293) expose >3 m of rubbly, blocky yellow limestone. The bedrock is overlain by ~1 m of sand and gravel and there is no water at the base of the quarry. The three inactive quarries, in 11-30-17-W1, 31-30-17-W1 and 34-30-18-W1, are all held under quarry lease and may be expected to resume production at some future date.

Sand and gravel pits

The sand and gravel pits of the area were extensively examined during the Gartner Lee study. In the five municipalities, 165 sites were logged and 70 samples taken for sieve analysis. Sites by rural municipality were: Dauphin, 25 sites and 7 samples; Ethelbert, 62 sites and 33 samples; Gilbert Plains, 44 sites and 17 samples; Grandview, 15 sites and 9 samples; Mossey River 19 sites and 4 samples. In addition, 44 sites were described and 12 samples taken in the R.M. of Grandview (Groom, 2001). Data from these studies are available on request from the MGS.

There are two main types of gravel deposits in the area: glaciofluvial and glaciolacustrine (Figure GS-15-5). The glaciofluvial deposits are primarily found in the western part of the study area. They were formed early in deglaciation from large volumes of meltwater eroding clayey Zelena Formation till deposits. The sand and gravel lithology is primarily Precambrian and limestone clasts with a surprisingly low amount of shale. Ironstone concretions form the major deleterious component. In general, the material in each deposit varies in depth and grain size over short distances. Grain size ranges from boulders to silt. The glaciolacustrine beach ridge deposits formed at the edge of glacial Lake Agassiz from sediments eroded from both Zelena Formation till along the escarpment and the carbonate-rich Arran Formation till on the Manitoba plain. The pebble lithology is approximately 40% Precambrian and 60% limestone clasts in the westernmost beach deposits. The limestone component increases eastward across the area, reflecting the increasingly dominant carbonate source of the sediments. There is virtually no shale in any of the beach deposits. The deposits, in general, are composed of 2–5 m of interbeds of sand and sand and gravel. The beds are usually uniform in grain size and continuous in extent, making them easy to mine. In addition, grain size rarely exceeds 12.5 cm (5 in.), which provides crushable material without having to screen off larger grain sizes. These deposits have been used as gravel sources since the earliest settler times and often can seem like one long gravel pit, only demarked by a fence line as land ownership changes. This is particularly true for the deposit along Hwy. 10 and the beach complex just west of it in the rural municipalities of Gilbert Plains and Ethelbert.

Sand and gravel pits in the area are too numerous to detail in this report. The discussion below centres on large active pits. Site descriptions of other gravel pits are available from the author.

R.M. of Dauphin

There are two large active pits in glaciolacustrine deposits in the R.M. of Dauphin. The pit (HD295) in 27-23-18-W1 and 28-23-18-W1 has been in operation for at least 15 years. It is owned and operated by the R.M. of Dauphin. Currently the municipality is clearing out old areas and removing aggregate from old waste piles. The pit is unusual for a beach deposit in that it contains a large cobbly coarse fraction. Given its position on the side of the Riding Mountain escarpment, there may be a glaciofluvial component under the beach sediments. The active beach pit (HD283) in 33-28-19-W1 has produced a large volume of aggregate in the last few years. However, it now appears that the remaining material is sand. The pit is 3–4 m deep with fine sand and silt exposed in the walls above the water table. There is a stockpile of crushed bedrock that has been brought onto site.

There are two glaciofluvial deposits that have been active recently. The pit (HD296) in NE-20-25-20-W1 is associated with Valley River. It is 3–4 m deep and contains sandy pebble gravel, as well as beds of cobbles and of silt. The lithology is 50% Precambrian and 50% limestone clasts. There is almost no shale despite the fact that shale bedrock is exposed in the floor at the northeast part of the pit. The other deposit is unique in the area. It is not associated with a meltwater channel and is either an esker or buried channel. The deposit, located in 10-25-20-W1, has been extensively mined; the pit (HD290) was active in 1978 when Gartner Lee mapped the rural municipality. It is depleted and revegetated over most of its length. Pit depths reach over 10 m in places. A minor amount of material was removed in 2006 but a backhoe on site seemed to be removing gravel from below the water table at one location although there was no sign of recent gravel piles there.

R.M. of Gilbert Plains

The R.M of Gilbert Plains has active pits in both glaciofluvial and glaciolacustrine deposits. The largest glaciofluvial pit (HD281) is located in NE-12-26-21-W1 along Valley River and has been in production since 1994. Pit depth varies from 1.5 to >4 m and the material is also very variable, ranging from fine sand through pebble gravel to cobbly gravel beds. Weathered Precambrian clasts and ironstone are the major deleterious factors. Two smaller pits along Valley River, in 15-25-22-W1 and in 32-25-21-W1 (HD264), have produced minor amounts of aggregate recently.

There are four active pits in beach deposits. The pit (HD270) in NE-34-26-21-W1 is <1.5 m deep and the remaining material is fine sand with pebbles. The pit (HD266) in SW-24-27-22-W1 is a continuation of the one (HD269) in NW-13-27-22-W1. The portion of the pit in Sec. 13 is near depletion and extraction activity is now at the north end of the pit in Sec. 24. The deposit is 1.5–2.5 m of sandy pebble gravel. The pit is owned and operated by the municipality and there are large stockpiles of traffic gravel on site. There are two active pits along Hwy. 10 in 26-21-W1. The one (HD277) in SW-21-26-21-W1, west of the highway, has been operating for over fifteen years and current extraction is at the north end where the pit is very sandy and there is water on the pit floor. The pit, visited in previous field trips, was 2–3 m deep and the material was well sorted beds of sandy pebble gravel with pebbles up to 7.5 cm (3 in.). The depleted parts of the pit now contain stockpiles of screened material and old asphalt. A narrow, sandy pit (HD278) along the east side of Hwy. 10, also in SW-21-26-21-W1, was only active in 2007.

R.M. of Grandview

The aggregate resources in the R.M. of Grandview are all in glaciofluvial deposits, primarily terrace deposits along Valley River. The major deposit, in 25-25-W1, was described fully by Groom (2001). Currently, there are two main active pits in the deposit. The pit in NE-24-25-25-W1 (HD258) exposes 3 m of sandy pebble gravel; the one in SE-23-25-25-W1 (HD259) is 1.5–2 m deep. Both pits contain good quality gravel with a good proportion of crushable size material. Ironstone and dispersed rust are the major deleterious factors. The pit in NW-26-25-25-W1 (HD262) was active in 2006 but there is a high amount of sand in the remaining reserves. A new pit (HD263) has been opened recently along Valley River, east of the town of Grandview in NW-27-25-23-W1. The material is 1.5 m pebble gravel overlain by fine sand. The water table will be the limiting factor for gravel extraction in this pit.

R.M. of Ethelbert

There are two large glaciofluvial pits that occur in deltaic deposits along the escarpment. The large pit (HD251) in 6-30-22-W1 contains crown-owned gravel and is administered by the Mines Branch under casual quarry permit. The pit is 3 m deep and the material is primarily pebble gravel with high sand content. There is very little shale and weathered Precambrian clasts are the major deleterious factor. The other pit (HD255), located in SE-30-28-22-W1, is privately owned. The pit exposes 3–4 m of high quality sandy pebble gravel. The material meets concrete specifications, one of the most restrictive end-use categories (gravel operator, pers. comm., 2008). The pit contains large stockpiles of pebbly sand that are being removed for road use by the R.M. of Ethelbert. A third glaciofluvial deposit occurs further east on the Manitoba plain. The pit (HD253), in NW-8-29-21-W1, is 3.5–4 m deep and exposes a wide range of grain size in the sediments. There are stockpiles of crushed traffic gravel on site.

There is one active pit in beach deposits in the municipality. The pit is part of a long series of old pits in the deposit; most are shallow and water filled. The pit (HD256) in SW-1-28-22-W1 has been reactivated and it appears gravel is being removed from below the water line. There are small piles of pebbles and cobbles on site.

R.M. of Mossey River

While there are several beach deposits in the R. M. of Mossey River, there is only one active gravel pit. The pit (HD294) is in SE-25-29-18-W1. It is a shallow gravel deposit overlying bedrock. The pit appears to be depleted although the deposit is still under quarry lease. The holder last reported production in 2006. A quarry lease in NE-9-30-18-W1 reported gravel production in 2006 but was not visited this year due to impassable roads.

Aggregate regulations

Aggregate extraction is regulated through the Quarry Minerals Regulation (Manitoba Regulation 65/92) under *The Mines and Minerals Act* of Manitoba, through policies under *The Planning Act* and through municipal development plans and their zoning by-laws. Policy #9 under *The Planning Act* is designed to protect high quality mineral resources from conflicting land uses until the resource has been extracted. Most development plans include maps showing high quality aggregate deposits. Zoning by-laws identify where extraction is allowed or excluded; the by-laws may set strict land-use controls on mining.

The *Quarry Minerals Regulation* sets standards for such things as safety slopes, setbacks from adjacent property lines and waterways, noise levels and location of petroleum storage, etc. It also provides for the Pit and Quarry Rehabilitation program. Under this program, landowners can apply to have depleted or abandoned gravel pits and quarries rehabilitated to a standard that is "safe, environmentally stable and compatible with adjoining lands." For further information visit the MGS website (http://www.gov.mb.ca/stem/mrd/mines/acts/index.html).

Economic considerations

The value of aggregate reserves in any specific area depends on three things: abundance of the resources, the demand for the resources and the quality of the aggregate. Aggregate is a high-bulk, low-value commodity so haulage costs are an important factor that can cause a lower quality deposit to be used over a more distant higher quality deposit.

The five rural municipalities have a large volume of aggregate that is spaced out across the area. The beach deposits contain very high quality aggregate and they have been extensively mined in the past. Ironstone concretions and weathered Precambrian clasts lower the quality of the glaciofluvial deposits but they can still provide good quality aggregate that meets specifications for most end-uses, particularly traffic gravel. Bedrock quarries are an important component of the area's aggregate reserves. They are a source of crushed stone and, additionally, as the pebble fraction in the beach deposits is depleted, the remaining sand can be blended with crushed bedrock to meet end-use specifications.

Aggregate demand in the area is relatively low compared to more populated areas of the province and centres mainly on highway and section road construction and maintenance.

Acknowledgments

J. Bamburak and M. Nicolas are thanked for assistance with the revised nomenclature of the bedrock formations.

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