Ontario Geological Survey
Aggregate Resources Inventory Paper 46

AGGREGATE RESOURCES INVENTORY OF THE TOWN OF HALTON HILLS
Regional Municipality of Halton
SOUTHERN ONTARIO

by
Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1983

Ministry of Natural Resources
Ontario

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ISSN 0708-2061
ISBN 0-7743-5224-8

This report was prepared by: Staff of the Aggregate Assessment Office, Engineering and Terrain Geology Section of the Ontario Geological Survey, Ontario Ministry of Natural Resources, 77 Grenville Street, Toronto, M5S 1B3. Telephone (416) 965-1182.

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The Mineral Resources Staff of Cambridge District, Central Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

Ontario Geological Survey
1983: Aggregate Resources Inventory of the Town of Halton Hills, Regional Municipality of Halton; Ontario Geological Survey, Aggregate Resources Inventory Paper 46, 37 p., 6 tables, 3 maps, scale 1:50 000.

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ABSTRACT

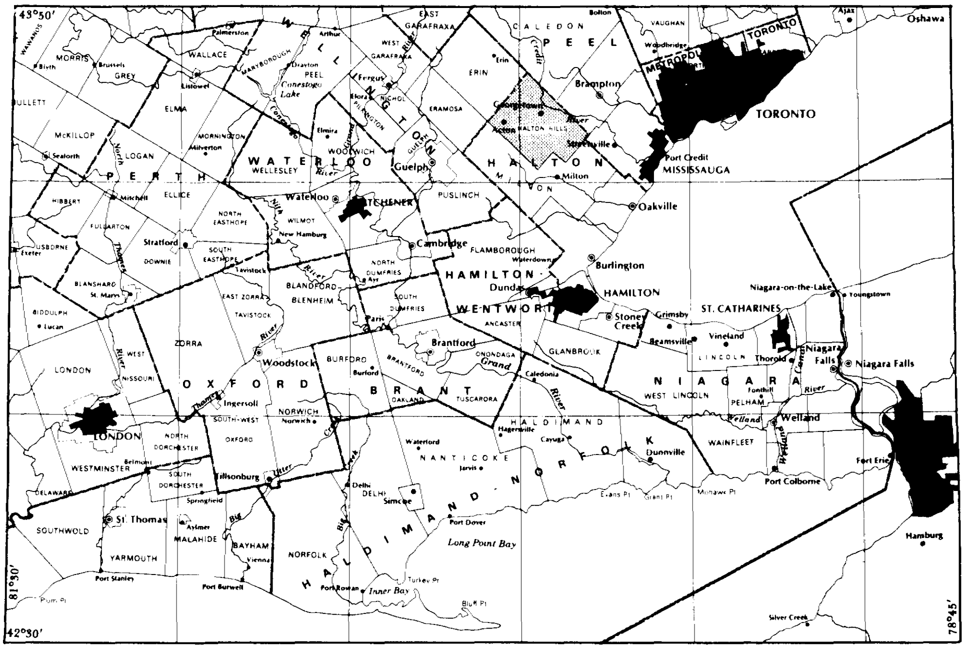

Figure 1 - Key Map Showing Location of the Town of Halton Hills, Scale 1: 1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Town of Halton Hills. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

In the Town of Halton Hills four areas containing sand and gravel have been selected as Resource Areas of Primary Significance. The Selected Sand and Gravel Resource Areas occupy a total of 3550 acres (1440 ha), exclusive of licenced areas. An estimated 1750 acres (710 ha) are currently available for extraction, containing possible resources of 84 million tons (76 million tonnes). The available portions of the selected areas represent 15 percent of the total area occupied by sand and gravel deposits in the township and 14 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1 is an outwash deposit located at the edge of the Niagara Escarpment. The deposit contains an estimated 34 million tons (31 million tonnes) of sand and gravel. Selected Resource Areas 2 and 4 are also outwash deposits located at the edge of the Escarpment. They contain an estimated 19 million tons (17 million tonnes) and 13 million tons (12 million tonnes), respectively. Selected Sand and Gravel Resource Area 3 is an ice-contact deposit containing an estimated 18 million tons (16 million tonnes) of aggregate. Five deposits, an ice-contact and four outwash deposits have been selected as Resource Areas of Secondary Significance.

Generally, the Town of Halton Hills has possible resources of sand and gravel which may be sufficient for local uses in the near future, but may not be suitable for high-specification aggregate, or for long-term supply. The material is generally suitable for Granular Base Course A, B and C with some mixing required.

The Town of Halton Hills is underlain by bedrock of the Clinton and Cataract Groups and the Amabel and Queenston Formations. There are six Selected Bedrock Resource Areas with an area of 24,300 acres (9800 ha), exclusive of licenced properties. An estimated 16,900 acres (6800 ha) are currently available for extraction, containing resources of 3300 million tons (3000 million tonnes).

Selected Bedrock Resource Area 1 occupies the entire extent of the Amabel Formation overlain by less than 25 feet (8 m) of drift. An estimated 2410 million tons (2190 million tonnes) of crushed stone resources are available in this area.

Selected Resource Areas 2a and 2b contain the Whirlpool Formation, which is suitable for building stone. The Areas have combined resources of approximately 18 million tons (16 million tonnes).

Selected Resource Areas 3, 4, 5 and 6 are in the Queenston Formation which is well suited for the manufacture of structural clay products such as brick and tile (Guillet 1967). An estimated 890 million tons (810 million tonnes) of shale are available for extraction.

It is important to note that the availability of possible resources in the Selected Sand and Gravel Resource Areas and the Selected Bedrock Resource Areas may be constrained by designations set through the Niagara Escarpment Planning exercise.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE TOWN OF HALTON HILLS[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1979, the total tonnage of mineral aggregates extracted was 144 million tons (131 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1980).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief Engineering and Terrain Geology Section, May 3, 1982.
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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Wherever possible, field examination of potential resource areas was also undertaken to confirm interpretations made in the office. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-size fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Air photos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

In the office, the pit data were supplemented by information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot thick layer of sand and gravel, one acre in extent, assuming an average density of 110 pounds per cubic foot.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2).

Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas lying outside of licenced properties that have previously been extracted (e.g. wayside pits are included in this cateogry). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favourable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot thick section of dolostone, one acre in extent, assuming a bulk density of 165 pounds per cubic foot).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot or approximately 3200 tons per acre. Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompny the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

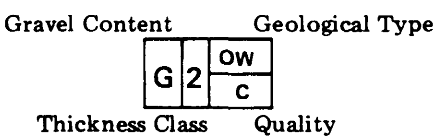
PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from the existing surficial geology maps of the area or from air photo interpretation where surficial mapping is incomplete. It shows the extent of sand and gravel deposits within the study area and serves as a base for the calculation of the total sand and gravel resources.

Map 1 presents a summary of all available information related to the quantity and quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbol which identifies each deposit. The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

The other information presented on Map 1 is designed to give an indication of the present level of extractive activity in the study area. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating under authority of a permit) are also identified and numbered on Map 1 and described in Table 2.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a medium-grey tone on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light grey tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no grey tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extraction development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent crushable gravel are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Exesss "fines" or high silt and clay content may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fine content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" particles (those greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C" "O" or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical well data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the labelled bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three tones. The darkest tone indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance due to their easy access. The medium tone indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest tone indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and use of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Three factors support this approach. Quality and quantity variations are gradual. The areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material. Since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wider range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intensive land use competition. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWN OF HALTON HILLS

LOCATION AND POPULATION

The Town of Halton Hills occupies an area of 68,166 acres (27 587 ha) in the Regional Municipality of Halton. The town is bounded by Erin Township to the north, the towns of Caledon and Brampton to the east and the Town of Milton to the south and west. It is shown on portions of the Brampton (30 M/12) and Guelph (40 P/9) map sheets of the National Topographic System at a scale of 1:50 000.

Georgetown and Acton, located in the east-central and northwestern portions of the town, respectively, are the main population centres and foci for local trade and retail activity. The population of the town as a whole was 34 397 in 1980 and figures indicate that the population has increased by seven percent since 1973 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Most of the recent growth has occurred in the vicinity of these two population centres in the northern portion of the town.

Access within the Town of Halton Hills is provided by King's Highway 25 which runs in a north-south direction and Highway 7 which connects the northern population centres. King's Highway 401 forms part of the town's southern boundary. The town is also served by a well developed grid of gravel-surfaced roads and paved regional roads. Rail access is provided by two lines of the Canadian National Railways in the central portion of the town.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of surficial material in the Town of Halton Hills, including the sand and gravel deposits shown on Map 1, are the result of glacial activity which took place in the Late Wisconsinan Substage of the Pleistocene Epoch. This period of time, which lasted from approximately 23 000 to 10 000 years ago, was marked by the repeated advance and melting back of massive, continental ice sheets.

The Niagara Escarpment dominates the physiography of the town and greatly influenced the pattern of glaciation in the region. The Escarpment, formed by erosion over millions of years, is a high relief bedrock scarp which trends to the north through the central part of the town. To the west, on the upper surface of the Escarpment, hummocky morainic ridges deposited by glacial ice form part of the Horseshoe Moraines physiographic region (Chapman and Putnam 1966). To the southeast below the Escarpment, is a smooth glacial till plain partially bevelled by lacustrine action, which forms part of the South Slope and Peel Plain physiographic regions (Chapman and Putnam 1966).

After the time of the maximum glacial extent much of southern Ontario, including the Town of Halton Hills, was covered by a submass of the ice sheet known as the Ontario lobe (Karrow 1968), which had advanced to the northwest out of the Lake Ontario basin and overtopped the Niagara Escarpment. The terminal position of the lobe was beyond the western boundary of the Town of Halton Hills at this time.

During its melting back, the margin of the Ontario ice lobe halted several times and built a series of morainic ridges in the western part of the town. The ridges form part of the Horseshoe Moraines physiographic region. The moraines have rolling to hummocky, irregular topography and local relief is 50 to 100 feet (15 to 30 m). In places the moraines are composed of the sandy silty Wentworth Till (Karrow 1968), although much of the material is ice-contact stratified drift deposited in large kames. The till has little value as aggregate because of its high fines content, but the ice-contact stratified drift deposits contain large amounts of sand and some crushable gravel.

The margin of the Ontario lobe eventually retreated back to the Lake Ontario basin. It then made a strong re-advance to the northwest depositing Halton Till below the Escarpment throughout the town. The lobe reached but did not go beyond the Escarpment. Meltwaters flowing off the ice margin deposited sand and gravel in ice-marginal meltwater channels, several of which are located just below the Escarpment in the north-central part of the town. These deposits are the best aggregate sources in the town and they have been selected for possible resource protection.

EXTRACTIVE ACTIVITY

The Town of Halton Hills has sand and gravel resources in ice-contact stratified drift deposits and outwash deposits in the northern portion of the town. Also there are large possible resources of crushed stone derived from the Amabel Formation, building stone and flagstone from the Whirlpool Formation and shales for use in structural clay products from the Queenston Formation.

Large scale sand and gravel extraction has been virtually restricted to the outwash channel deposits at Limehouse, Glen Williams and Silver Creek. Large ice-contact stratified drift deposits in the municipality may also contain considerable resources of sand and crushable gravel. More than 30 pits have been developed in these deposits.

Since the designation of the town under The Pits and Quarries Control Act, 1971, many of these sources have become inactive. Presently eight sources are licenced for extraction. The total licenced area is 447.7 acres (181.2 ha). These pits and surrounding deposits contain sand and gravel suitable for a variety of aggregate products.

The extraction of bedrock for crushed aggregate is concentrated in the Amabel Formation in the western part of the town. Two large quarries licenced for extraction in the Amabel have a combined area of 759.0 acres (307.2 ha).

Four quarries are licenced for extraction in the Clinton and Cataract Groups in the face and at the base of the Niagara Escarpment. Three quarries are worked to extract the Whirlpool Sandstone, an important source for building stone and flagstone. These licenced sources have a combined area of 226.6 acres (91.7 ha). Other bedrock formations of the Clinton and Cataract Groups may also be available for extraction in these quarries.

There is one licenced area of 8.0 acres (3.2 ha) in the Queenston Formation.

Production figures of all material extracted from licenced sources for the Town of Halton Hills are maintained by the Cambridge District Office of the Ministry of Natural Resources. The average annual production for licenced properties between 1976 and 1979 has been 2,168,887 tons (1 967 614 tonnes) and the average annual production for wayside properties between 1977 and 1979 has been 669,722 tons (607 572 tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS

Three outwash deposits located at the face of the Niagara Escarpment and a large ice-contact stratified drift deposit located above the Escarpment at Acton have been selected as Resource Areas of Primary Significance. An ice-contact deposit and four outwash deposits have been selected as Sand and Gravel Resource Areas of Secondary Significance.

The Selected Sand and Gravel Resource Areas of Primary Significance available for extraction occupy a total of 1750 acres (710 ha) with estimated resources of 84 million tons (76 million tonnes). The selected resource areas occupy 15 percent of the total area of sand and gravel in the town, and represent 14 percent of the total resource tonnage. The selected areas contain most of the town's possible resources of crushable gravel. It is important to note that the availability of possible resources in the selected sand and gravel resource areas may be constrained by designations set through the Niagara Escarpment Planning exercise.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is an outwash deposit which occupies a meltwater channel developed at the brow of the Niagara Escarpment. The deposit consists of an area of level topography at the brow of the Escarpment, connected to a channel down the partially buried face of the Escarpment. The geological boundaries shown on Map 1 and 2 are partially interpretive, based on the location of sand and gravel pits, and on water well data. They differ in some respects from the published map of the area (Hewitt 1969).

Pits developed in Area 1 are numerous and are scattered throughout the deposit. One pit (pit no. 2) is presently licenced. Faces in the pits range in height from 5 to 25 feet (2 to 8 m) and expose moderately stratified sand and gravel suitable for Granular Base Course (G.B.C.) A, B and C. Selection and sand control are often required because of the predominantly sandy texture of the material and the presence of Queenston shale particles which frequently coat the gravel. The material is unsuitable for asphalt and concrete uses because of quality limitations.

Selected Resource Area 1 has a total unlicenced area of 1550 acres (630 ha), of which 750 acres (305 ha) are presently available for extraction. Residential development at Silver Creek and along King's Highway 7 has substantially reduced the availability of the aggregate. Assuming an average thickness of 18 feet (6 m), possible resources of sand and crushable gravel are estimated to be 34 million tons (31 million tonnes). This material is well suited to supply local aggregate needs. The Area is accessible by King's Highway 7 and a line of the Canadian National Railways.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is an outwash deposit and is located below the brow of the Niagara Escarpment at Limehouse. A large part of the Area is presently under licence in pit no. 1. Faces in the pit expose 20 to 30 feet (6 to 9 m) of sand and gravel suitable for production of crushed aggregate although selection and sand control are required.

Much of the remaining aggregate in Area 2 is unavailable for extraction because of residential development. Of the total unlicenced area of 600 acres (243 ha), 375 acres (152 ha) are presently available for extraction. Assuming an average deposit thickness of 20 feet (6 m), possible sand and gravel resources are estimated to be 19 million tons (17 million tonnes). Area 2 is well situated for local demand and is accessible by a variety of roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

A small portion of the ice-contact stratified drift deposit in the northern portion of the town has been selected as an Area of Primary Significance. Testing is required to warrant further selection of the deposit at the primary level. The deposit is part of the Galt and Moffat moraines of the Horseshoe Moraines physiographic region. The deposit has characteristic high relief and hummocky irregular topography. Data obtained from the Ministry of Transportation and Communications revealed the material consists of well graded sand and crushable gravel. One licenced pit and one unlicenced pit have been developed in the deposit (pit nos. 8 and 31), with face heights ranging from 10 to 25 feet (3 to 8 m).

The total unlicenced area is 740 acres (300 ha), of which 370 acres (150 ha) are available for extraction. Assuming an average deposit thickness of 20 feet (6 m), possible sand and gravel resources are estimated to be 18 million tons (16 million tonnes). The Area is well situated for local needs and is accessible by a variety of roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 is also an outwash deposit, situated just below the Escarpment in the northern part of the town. This deposit has been a traditional aggregate source and has seen extensive extraction. At least six pits have been opened in the Area, three of which are presently licenced for extraction (pit nos. 4, 6 and 7). Faces in the pits expose 15 to 25 feet (5 to 8 m) of sandy gravel best suited for select subgrade aggregate such as G.B.C. B and C.

Much of the aggregate in Resource Area 4 has been removed or is unavailable for extraction. The total unlicenced area is 650 acres (265 ha), of which 255 acres (103 ha) are available for extraction. Assuming an average thickness of 20 feet (6 m), possible resources of sand and gravel are estimated to be 13 million tons (12 million tonnes). This material is useful for local needs and is well situated with respect to local markets and transport routes.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Five deposits, an ice-contact and four outwash deposits, have been chosen as Sand and Gravel Resource Areas of Secondary Significance.

The large ice-contact stratified drift deposit in the northern portion of the town has been selected at the secondary level. Water well information indicates a deposit thickness between 20 and 45 feet (6 to 14 m). The resource area has a large potential, although much of the western half of the deposit is unavailable for extraction because of the residential development at Acton. Although detailed information concerning texture and thickness of the deposit is lacking, large amounts of aggregate suitable for most local needs are probably available.

Two secondary outwash gravel deposits are located in the southwestern and northeastern portion of the town. The material is suitable for crushed aggregate, although in the latter deposit selection and sand control may be required.

The outwash sand deposits in the northeast and southwest portions of the town are felt to be important resource areas, although detailed information concerning quality is lacking.

BEDROCK GEOLOGY

The Town of Halton Hills is underlain by Ordovician shales of the Queenston Formation, east of the Niagara Escarpment and by Silurian dolostones of the Amabel Formation, west of the Escarpment. The Escarpment face exposes a complex succession of shales, sandstones, limestones and dolostones of the Clinton and Cataract Groups. Figure 2 illustrates the stratigraphic relationships between the formations.

Red shales of the Queenston Formation underlie the eastern half of the town and are generally covered by more than 50 feet (15 m) of glacial sediments, predominantly the Halton Till. There are several areas of thin drift cover south of Georgetown. The Queenston shales have very low bearing strength and are not suited for any load-bearing aggregate. However, they are well suited for the production of structural clay products such as brick and tile and are a resource of provincial significance for these products (Guillet 1967). Four areas of the Queenston Formation covered by thin drift have been selected for possible resource protection in the central and southeastern part of the town.

The succession of several formations which form the Clinton and Cataract Groups overlie the Queenston Formation and make up the face of the Niagara Escarpment. They have generally restricted lateral extent and are covered by more than 25 feet (8 m) of drift except for an area of outcrop and thin drift in the northern and central part of the town. A few of the formations have been extracted in the past for a variety of construction products. Four sources are presently licenced for extraction and in three of these the Whirlpool Formation is being worked.

The Whirlpool Formation is the lowermost unit of the Cataract Group. The formation has a thickness of only 10 to 15 feet (3 to 5 m) (Hewitt 1969) and consists of thin-to massive-bedded, medium-to fine-grained calcareous quartzose sandstone. The formation forms a low terrace at the base of the Escarpment, and south of Limehouse the terrace is over 1 mile (1.6 km) wide (Telford 1976). The sandstone is suitable for building stone and flagstone and has been extracted at several quarries in the area. The stone is commercially known as the "Credit Valley Sandstone" and has been used in the construction of such buildings as the main block of the Ontario Parliament Buildings and the Royal Ontario Museum (Hewitt 1969). However, it is not generally suitable for the production of crushed aggregate and has no history of such use. Other formations which form the Clinton and Cataract Groups have little potential for use as crushed aggregate.

The brow and upper surface of the Niagara Escarpment are formed by the tough, erosion-resistant Amabel Formation, which also forms the bedrock surface throughout the western half of the town. The Amabel Formation consists of medium- crystalline, fossiliferous, medium-to massive-bedded dolostone and is well suited for the production of road-building and construction aggregate. The Amabel is considered to be a resource of provincial significance for these products (Telford 1976). More than 700 acres (285 ha) of land along the brow of the Escarpment have been licenced to two operators for extraction of the Amabel Formation. The bedrock is thinly drift covered throughout the western half of the town and additional quarries might be established at numerous locations. All of the areas where the bedrock is covered by less than 25 feet (8 m) of drift in the western half of the town have been selected for possible resource protection.

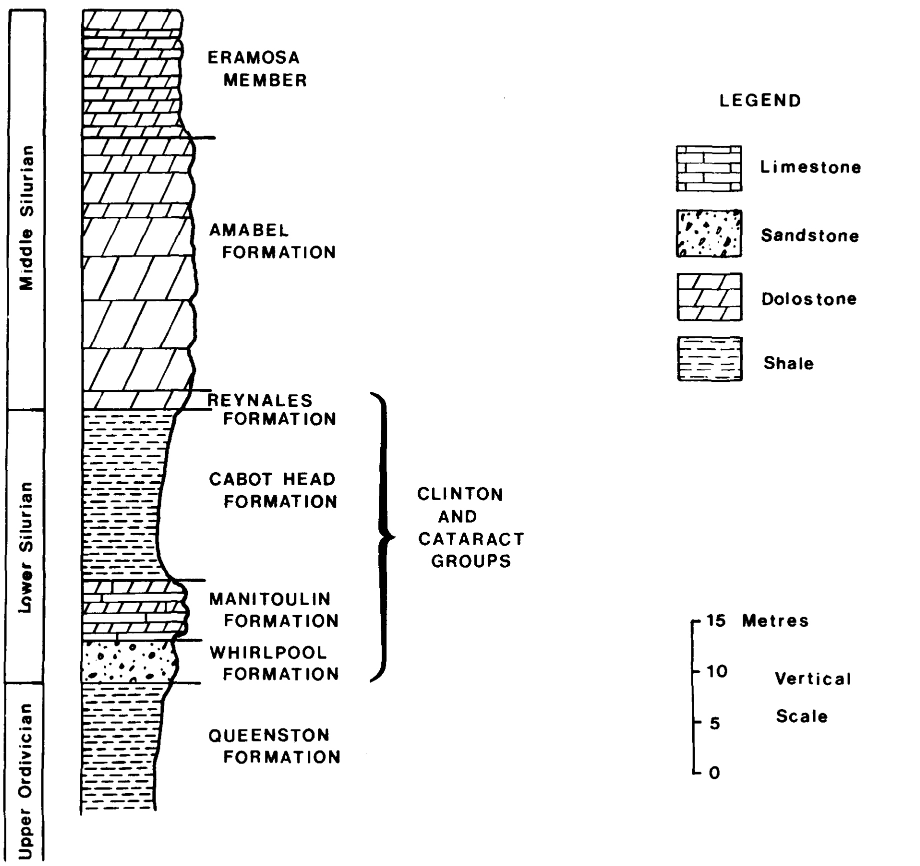


Figure 2: Stratigraphy of the Niagara Escarpment, Georgetown Area

Adapted from Telford 1978, Figure 4

SELECTED BEDROCK RESOURCE AREAS

Portions of the Amabel, Queenston and Whirlpool Formations have been selected for possible resource protection. Of the three formations, only the Amabel Formation is suited for the production of road-building and construction aggregate. The availability of possible resources in the Selected Bedrock Resource Areas may be constrained by designations set through the Niagara Escarpment Planning exercise.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 consists of all those areas where the Amabel Formation is overlain by less than 25 feet (8 m) of glacial sediments. The eastern limit of these areas is defined by the brow of the Niagara Escarpment which trends north-south through the central part of the town. Most of the land surface is thinly drift covered, except for a northeast-trending ridge of thick sediment near Acton. This ridge is composed of till and ice-contact stratified drift of the Horseshoe Moraines physiographic region.

Much of Resource Area 1 has been identified by Vos (1969, p. 46) as an area "for future quarry development" on the basis of drift thickness, material quality and proximity to markets and transport routes.

Two large quarries are presently licenced for extraction in the Resource Area (quarry nos. 1 and 2). The northern quarry is operated by Indusmin Limited. Prior to 1930, the quarry was operated for the production of dolomitic lime, but now produces crushed aggregate (Hewitt and Vos 1972). The stone exposed in the quarry is light grey, fine- to medium-crystalline, medium- to thick-bedded dolostone of uniformly high quality (Hewitt and Vos 1972). The Dufferin Quarry is located at the brow of the Escarpment just north of King's Highway 401 and exposes similar stone to that of the Indusmin Quarry.

Selected Bedrock Resource Area 1 has a total unlicenced area of 14,800 acres (6000 ha), of which 11,200 acres (4550 ha) are presently available for extraction. Assuming an average workable thickness of 60 feet (18 m) throughout the Area, possible resources of crushed stone are estimated to be 2410 million tons (2190 million tonnes). Quarries could be established at numerous locations in the generally sparsely populated area, especially south of Acton. The glacial sediments which overlie the bedrock consist predominantly of Halton Till which should not pose serious stripping problems. However, the irregularity of the bedrock surface in the reefal portions of the formation may hinder stripping (Vos 1969).

Road access to parts of the Resource Area is provided by paved regional roads and by King's Highway 25 which has a direct connection to Highway 401. Rail access is provided by a line of the Canadian National Railways. The Indusmin Quarry has direct access by way of a siding to the CN line and is only 35 miles (56 km) by rail from downtown Toronto (Vos 1969). The Resource Area is thus well situated with respect to the regional transport network in southern Ontario, and is in a position to supply high-quality aggregate throughout the areas of highest demand.

SELECTED BEDROCK RESOURCE AREAS 2a AND 2b

Selected Bedrock Resource Area 2a is located at Limehouse and extends for some distance to the north and south at the base of the Niagara Escarpment. Selected Bedrock Resource Area 2b is located in the northeastern part of the town. Although the Resource Areas are shown on Map 3 as containing both the Clinton and Cataract Groups, the Whirpool Formation of the Cataract Group is the only bedrock formation of economic interest within either group. The limited thickness and lateral extent of the formation prevent it from being mapped as a single unit. Four quarries (quarry nos. 3, 4, 5 and 8) are presently licenced for extraction in the two Areas and are working the Whirlpool Formation for building stone.

The available resources for the Selected Areas are difficult to estimate for the following reasons:

1) more detailed mapping is required to properly define the overburden thickness and outcrop of the Whirlpool Sandstone;

2) in addition to unconsolidated material the Whirlpool Sandstone may be covered by up

to 80 feet (24 m) (Telford 1976) of overlying bedrock of the Clinton and Cataract Groups;

3) sandstone quarrying is usually a labour intensive hand operation therefore using 25 feet (8 m) of overburden as a limiting factor may not be realistic.

Using an estimated thickness of 5 feet (2 m) for the Whirlpool Formation gives resource tonnages of 15 million tons (14 million tonnes) and 3 million tons (3 million tonnes), respectively, for Resource Areas 2a and 2b. In light of the three factors noted above, however, the actual tonnage of the Whirlpool available under current economic and technological conditions may be lower.

There are areas where the sandstone is known to be close to or at the surface. The most accessible areas are:

1) Selected Area 2a in the vicinity of Oakville Creek where Century Quarries Limited, Rice and McHarg Quarries Limited and W.R. Barnes Company Limited are presently located;

2) Selected Area 2b where unlicenced quarry no. 12 is located, although much of the resource has already been extracted.

Access to the Resource Area is provided by Regional Road 20 which has direct connection to King's Highway 7, and by a line of the Canadian National Railways which traverses the Resource Area.

SELECTED BEDROCK RESOURCE AREAS 3, 4, 5 AND 6

Selected Bedrock Resource Areas 3, 4, 5 and 6 are irregular, thinly drift-covered areas of the Queenston Formation in the central and eastern part of the town. There are no surface exposures of the bedrock in the Areas and their boundaries have been established from drift thickness contours based on water well data. One licenced quarry (quarry no. 6) has been established in the Queenston Formation. Quarries elsewhere in the region have produced material used in the manufacture of structural clay products from the Queenston and it is considered to be a resource of provincial significance. The Queenston has no potential for the production of crushed, road-building or construction aggregate.

Resource Areas 3, 4, 5 and 6 total 7700 acres (3100 ha), of which 4650 acres (1880 ha) are presently available for extraction. Assuming an average workable thickness of 60 feet (18 m) in all four Areas, possible resources of stone suitable for structural clay products are estimated to be 890 million tons (810 million tonnes).

Access is provided by Regional Roads 3 and 10 which have direct connection to King's Highways 401 and 7, respectively.

SUMMARY

The Town of Halton Hills has possible sand and gravel resources in three outwash deposits and an ice-contact deposit which have been selected for possible resource protection at the primary level. Care should be taken to ensure the continuing availability of as much of these resources as possible.

The town has very large possible resources of crushed stone derived from the Amabel Formation, most of which has been selected for resource protection. Quarries may be established at numerous locations in the resource area and opportunities for optimum resource management strategies are present. Other selected bedrock resource areas in the Clinton and Cataract Groups and Queenston Formation are important for building stone and structural clay products, respectively. The availability of possible resources in the Selected Sand and Gravel Resource Areas and the Selected Bedrock Resources Areas may be constrained by designations set through the Niagara Escarpment Planning exercise.

Enquiries regarding the Aggregate Resources Inventory for the Town of Halton Hills should be directed to the Ontario Ministry of Natural Resources either at the Cambridge District Office, Box 2186, Cambridge, Ontario, N3C 2W1 (Tel. (519) 658-9356) or to the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWN OF HALTON HILLS

1 **CLASS NO.**	2 **DEPOSIT TYPE** (see Appendix C)	3 **AREAL EXTENT** Acres (Hectares)	4 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
1	G-IC	5500 (2230)	345 (315)
	G-OW	1480 (600)	74 (67)
2	G-OW	1740 (700)	78 (71)
	S-OW	1690 (680)	60 (54)
3	G-IC	740 (300)	15 (14)
	G-OW	300 (121)	6 (5)
	S-OW	75 (30)	2 (2)
4	G-IC	75 (30)	1 (1)
	G-OW	5 (2)	<1 (<1)
	S-OW	60 (24)	1 (1)
		11,700 (4750)	580 (530)

N.B. Minor variations in above table are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF HALTON HILLS

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1		J.C. Duff Ltd.	23	5	85.5 (34.6)	20-30 (6-9)	60
2		J.C. Duff Ltd.	E½ 26 & 27	7	104.9 (42.4)	15-20 (5-6)	50 gravel & sand bands
3		H.D. Campbell	W½ 23	9	43.0 (17.4)	30-35 (9-11)	50
4		C.G. Bishop	23	10	75.0 (30.4)	15-25 (5-8)	40
5		Springbank Sand & Gravel Ltd.	21	10	16.3 (6.6)	15-25 (5-8)	sand
6		David T. Anderson	24	11	15.5 (6.3)	15-20 (5-6)	35-40 partially overgrown
7		Eric Leslie	E½ 25	11	12.0 (4.9)	15-25 (5-8)	35-40 partially overgrown
8		J.C. Duff Ltd.	Pt. 24	5	195.5 (79.1)	10-25 (3-8)	25-35
					447.7 (181.2)		
UNLICENCED PITS*							
9		Standard Industries Ltd.	E½ 32	11		3 (1)	40-50 sloped and overgrown
10		D. Arbic	32	9		5 (2)	10 overgrown
11	B12-74	Sheridan Tree Nurseries Ltd.	W½ 24	11		35-40 (11-12)	35-40 overgrown
12		Sheridan Tree Nurseries Ltd.	E½ 24	10		10-15 (3-5)	35-40 overgrown

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
13		A. Spence	24	10		10-15 (3-5)	40 overgrown
14	B12-49	W. Shaw	W½ 22	10		5-15 (2-5)	overgrown
15	B12-55	Hunter	22	10		15-35 (5-11)	5 overgrown
16		Sheridan Tree Nursery Ltd.	E½ 21	10		15 (5)	sand overgrown
17		Delrex Development Ltd.	E½ 15	8		15-25 (5-8)	5 sand overgrown
18		C. Pickett	W½ 5	8		10-20 (3-6)	till overgrown
19		R. Rice	W½ 11	4		5-20 (2-6)	sand overgrown
20		Glengate Farms Ltd.	E½ 11	2		15 (5)	10 overgrown
21	B12-20	G.S. Hume	E½ 12	3		8-10 (2-3)	30 sand & gravel bands
22		R. Vincent	Pt. 18 & 19	6		5-10 (2-3)	50
23	B12-118	Ordorico	E½ 19	6		5-10 (2-3)	40-50
24		Ordorico	E½ 19	6		15 (5)	overgrown
25	B2-115	Pilutti	W½ 19	7		20-25 (6-8)	50 gravel & sand bands
26	B12-117	Spitzer	21	6		15-18 (5-6)	35-40 partially overgrown

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF HALTON HILLS

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
27	B12-60	J. Jennings	E½ 22	6		5-15 (2-5)	overgrown
28		G. Scholz	E½ 24	6		5-18 (2-6)	25
29	B12-136	L. McEnery	W½ 26	7		5-10 (2-3)	40-50 partially overgrown
30		E. Cassac & E. Morris	W½ 28	5		3-5 (1-2)	overgrown
31		Duenck	25	5		15-20 (5-6)	60
32	B12-35	W. Cohoon	W½ 22	5		8-12 (2-4)	overgrown
33		J. Donovan	E½ 28	1		8-15 (2-5)	30 overgrown

* Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWN OF HALTON HILLS

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	1550 (630)	600 (243)	200 (81)	750 (305)	18 (6)	34 (31)
2	600 (243)	195 (79)	30 (12)	375 (152)	20 (6)	19 (17)
3	740 (300)	345 (140)	25 (10)	370 (150)	20 (6)	18 (16)
4	650 (265)	305 (123)	90 (36)	255 (103)	20 (6)	13 (12)
	3550 (1440)	1440 (580)	345 (140)	1750 (710)		84 (76)

N.B. Minor variations in above table are due to rounding of data.

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, TOWN OF HALTON HILLS

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3 (0-1)	Amabel	60 (18)	510 (206)	110 (100)
3-25 (1-8)		60 (18)	15,800 (6400)	3400 (3100)
25-50 (8-15)		60 (18)	5200 (2100)	1120 (1020)
			21,500 (8700)	4650 (4200)
0-3 (0-1)	Clinton and Cataract Groups	60 (18)	144 (58)	28 (25)
3-25 (1-8)		60 (18)	2280 (920)	440 (400)
25-50 (8-15)		60 (18)	1460 (590)	280 (255)
			3900 (1580)	750 (305)
0-3 (0-1)	Queenston	60 (18)	1020 (415)	196 (178)
3-25 (1-8)		60 (18)	7100 (2850)	1360 (1230)
25-50 (8-15)		60 (18)	9300 (3750)	1790 (1620)
			17,400 (7000)	3350 (3050)
			43,000 (17 400)	8800 (8000)

N.B. Minor variations in above table are due to rounding of data.

TABLE 5 | QUARRIES, TOWN OF HALTON HILLS

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
LICENCED QUARRIES						
1		Dufferin Materials & Construction Ltd.	Pt. 8, 9 & 10	1	184.0 (74.5)	50-70 (15-21)
2		Indusmin Ltd.	Pt. 22 & 23 Pt. 21, 22 23 & 24	3 4	575.0 (232.7)	60-80 (18-24)
3		Century Quarries Ltd.	22	5	4.8 (1.9)	3-5 (1-2)
4		Rice and McHarg Quarries Ltd.	21	5	8.4 (3.4)	3-5 (1-2)
5		W.R. Barnes Co. Ltd.	W½ 19	5	100.0 (40.5)	10 (3)
6		Amos C. Martin	Pt. W½ 23	8	8.0 (3.2)	5-10 (2-3)
7		Smithson Quarries	E½ 26	8	100.0 (40.5)	5 (2)
8		Rice and McHarg Quarries Ltd.	21	5	13.4 (5.4)	
					993.6 (402.1)	
UNLICENCED QUARRIES *						
9	B12-123	B. Pattison	W½ 27	8		8-10 (2-3) above water table
10	B12-107	R. Souther	E½ 26	9		5-10 (2-3) overgrown
11		Industrial Sand & Gravel Co. Ltd.	E½ 26	9		15-20 (5-6)

TABLE 5 | QUARRIES, TOWN OF HALTON HILLS

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
12		Hilltop Quarry	26	10		15-25 (5-8) above water table overgrown
13		K. Galbraith	27	10		15-20 (5-6) overgrown water-filled
14		G. Harry	E½ 28	10		8-10 (2-3) overgrown
15		J. Prucyk	W½ 24	7		15-20 (5-6) 5-10 (2-3) above water table
16		R. Vincent	18	6		5-8 (2) overgrown
17		Standard Industries Ltd.	E½ 13	2		5-10 (2-3) overgrown

* Abandoned quarries or wayside quarries operating on demand under authority of a permit.

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWN OF HALTON HILLS

1 **DEPOSIT NO.**	2 **DEPTH OF OVERBURDEN** Feet (Metres)	3 **UNLICENCED AREA** Acres (Hectares)	4 **CULTURAL SETBACKS** Acres (Hectares)	5 **EXTRACTED AREA** Acres (Hectares)	6 **AVAILABLE AREA** Acres (Hectares)	7 **ESTIMATED WORKABLE THICKNESS** Feet (Metres)	8 **AVAILABLE RESOURCES** Millions of Tons (Tonnes)
	Amabel Fm.						
1	0-3 (0-1)	425 (172)	40 (16)	10 (4)	375 (152)	60 (18)	81 (74)
	3-25 (1-8)	14,400 (5800)	3550 (1440)	10 (4)	10,800 (4350)	60 (18)	2330 (2110)
	Whirlpool Fm.						
2a	3-25 (1-8)	1500 (610)	560 (227)	15 (6)	920 (370)	5 (2)	15* (14)
	Whirlpool Fm.						
2b	0-3 (0-1)	130 (53)	25 (10)	50 (20)	55 (22)	5 (2)	1* (1)
	3-25 (1-8)	140 (57)	15 (6)	0 (0)	125 (51)	5 (2)	2* (2)
	Queenston Fm.						
3	0-3 (0-1)	1000 (405)	445 (180)	0 (0)	560 (227)	60 (18)	108 (98)
	3-25 (1-8)	1400 (570)	630 (255)	0 (0)	770 (310)	60 (18)	148 (134)
	Queenston Fm.						
4	3-25 (1-8)	2490 (1010)	1000 (405)	0 (0)	1490 (600)	60 (18)	285 (260)
	Queenston Fm.						
5	3-25 (1-8)	1900 (770)	680 (275)	0 (0)	1220 (495)	60 (18)	234 (212)

TABLE 6 SELECTED BEDROCK RESOURCE AREAS, TOWN OF HALTON HILLS

1 **DEPOSIT NO.**	2 **DEPTH OF OVERBURDEN** Feet (Metres)	3 **UNLICENCED AREA** Acres (Hectares)	4 **CULTURAL SETBACKS** Acres (Hectares)	5 **EXTRACTED AREA** Acres (Hectares)	6 **AVAILABLE AREA** Acres (Hectares)	7 **ESTIMATED WORKABLE THICKNESS** Feet (Metres)	8 **AVAILABLE RESOURCES** Millions of Tons (Tonnes)
	Queenston Fm.						
6	3-25 (1-8)	950 (385)	360 (146)	0 (0)	590 (239)	60 (18)	113 (102)
		24,300 (9800)	7300 (2950)	85 (34)	16,900 (6800)		3300 (3000)

N.B. Minor variations.in above table are due to rounding of data.

* Actual resource tonnage of the Whirlpool Formation may be lower. Refer to the description of these Resource Areas in the text for a detailed explanation.

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ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CAMBRIAN

The first Period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a large rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A Period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DIRT

See fines.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder		>-256 mm
Gravel	cobble	64-256 mm
Gravel	pebble	4-64 mm
Gravel	granule	2-4 mm
Sand	coarse	.5-2 mm
	medium	.25-.5 mm
	fine	.074-.25 mm
Silt, clay		<.074 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE)

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early peiod of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago. The Paleozoic Era (or Ancient Life Era) is subdivided into six geologic Periods, of which only four (Cambrian, Ordovician, Silurian, and Devonian) can be recognized in southern Ontario.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE

Estimates of mineral aggregate material based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples of measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SILURIAN

An early Period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Winsconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 7000 to 85 000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain-size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. They vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amount of crushable aggregate in alluvial deposits in low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

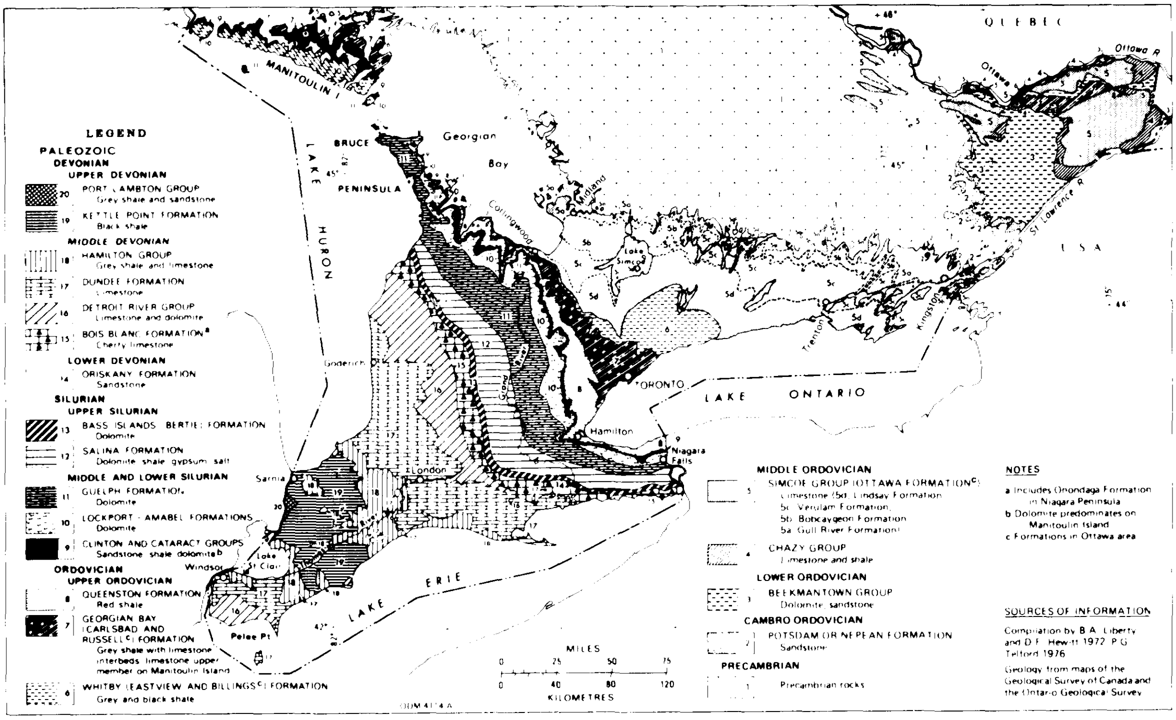


Figure 3 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11-18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion

Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Watertown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, and building stone throughout their area of occurrence, and are a valuable aggregate resource. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliffe Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Falls Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES.

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change). Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic- to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. It is quarried at Glen Christie and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular, weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point, Colborne, and Bowmanville for lime. It is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200-300 feet (61-91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for lime. It is unsuitable for crushed stone due to clay impurities and many clayey interbeds, low abrasion resistance. High soundness losses and poor freeze-thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas). Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Five producers in Metro Toronto and Cooksville produce brick and structural tile (Guillet 1967). Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The Group has six formations. Only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are 12 large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa (Guillet 1967). All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

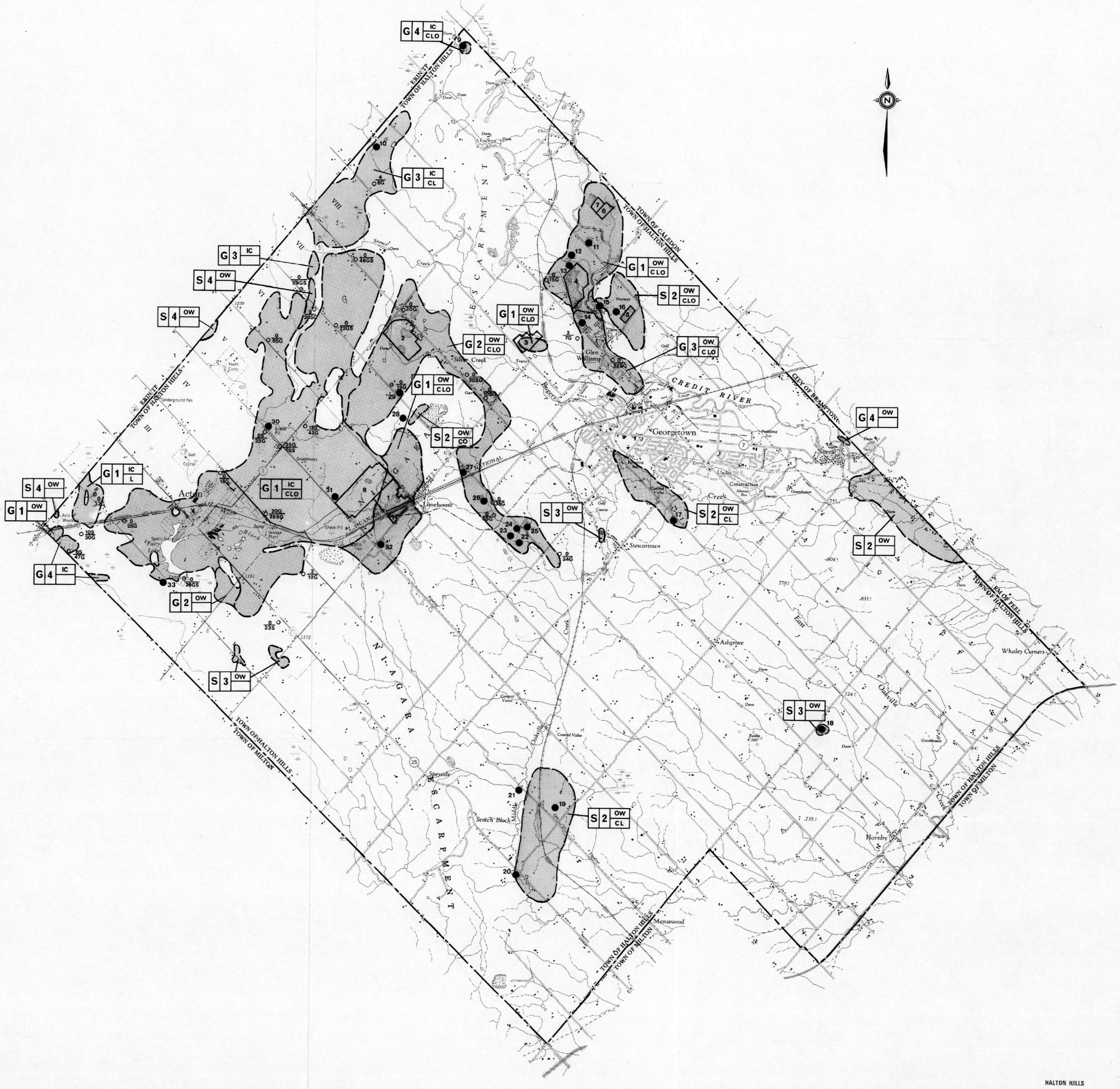
Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto). Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.



Ontario
Ministry of Natural Resources
Hon. Alan W Pope
Minister
W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

TOWN OF HALTON HILLS

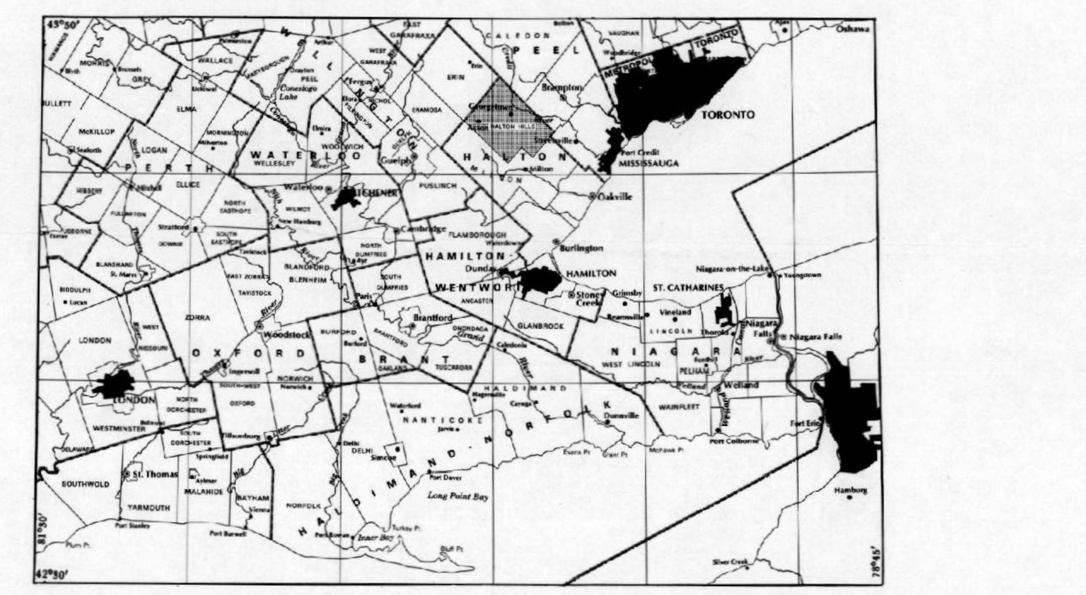
REGIONAL MUNICIPALITY OF HALTON

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 30M/12, 40P/9



SYMBOLS

(Some symbols may not apply to this map)

Geological and aggregate thickness boundary. Shading indicates deposit area.

S 1 IC/CLO Deposit symbol: see below.

3 Licenced property boundary; Property number: see Table 2.

● 4 Unlicenced sand or gravel pit*; Property number: see Table 2
*Abandoned pit or wayside pit operating on demand under authority of a permit.

O 6/23 Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet). (Note: S - sand, G - gravel, T - till)

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

DEPOSIT SYMBOL (Continued)

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (>112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500-25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12,500 (<28 000)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
EM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

Quality Indicators

If blank, no known limitations present

C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: D.F. Hewitt, 1969
P.F. Karrow, 1968

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

Issued 1982.

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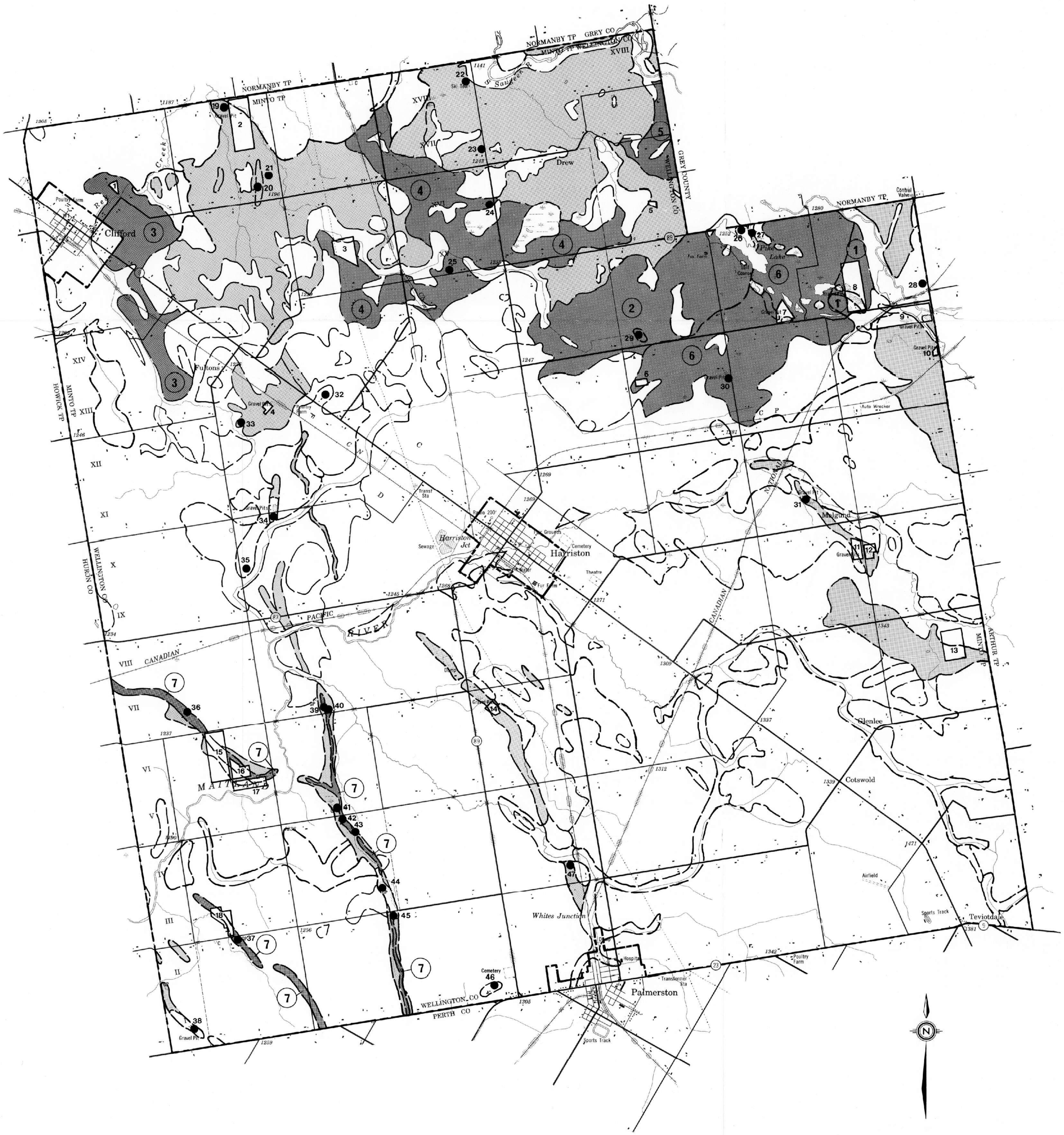
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 46.



MINTO

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

MINTO TOWNSHIP
WELLINGTON COUNTY

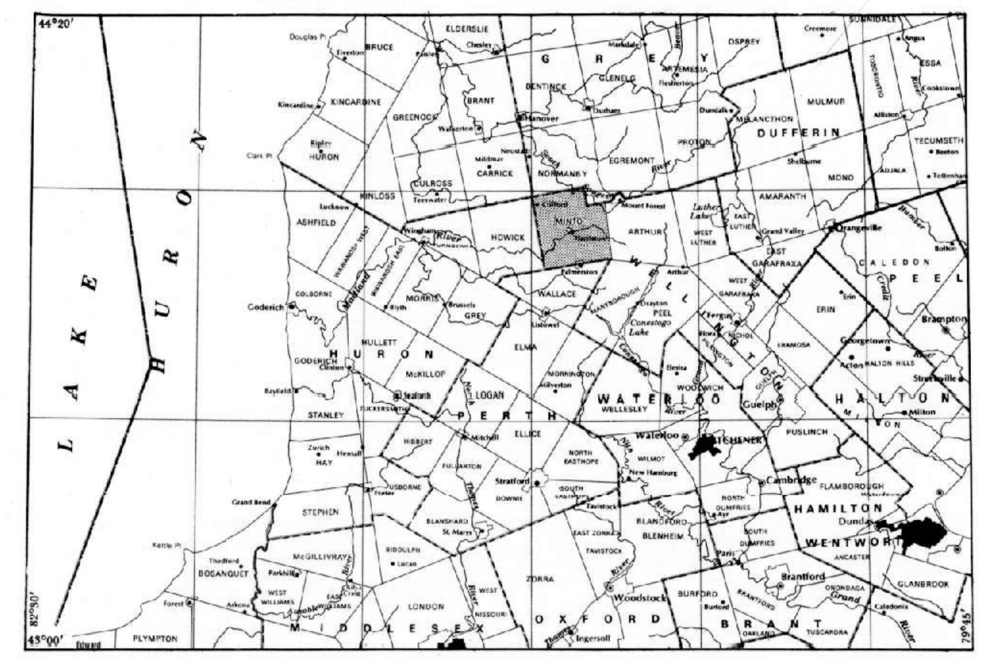
MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale: 1:50,000

Mile 1 — 0 — 1 Mile

Metres 1000 — 0 — 1 Kilometre

NTS Reference: **40 P/15, 41 A/2**



SYMBOLS
(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- Licenced property boundary; Property number: see Table 2.
- Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.
- Municipal boundary.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: W.R. Cowan, 1979.
D.R. Sharpe and D.C. Broster, 1977.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

Issued 1981.

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This map is to accompany O.G.S. Aggregate Resources Inventory Paper 44.

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

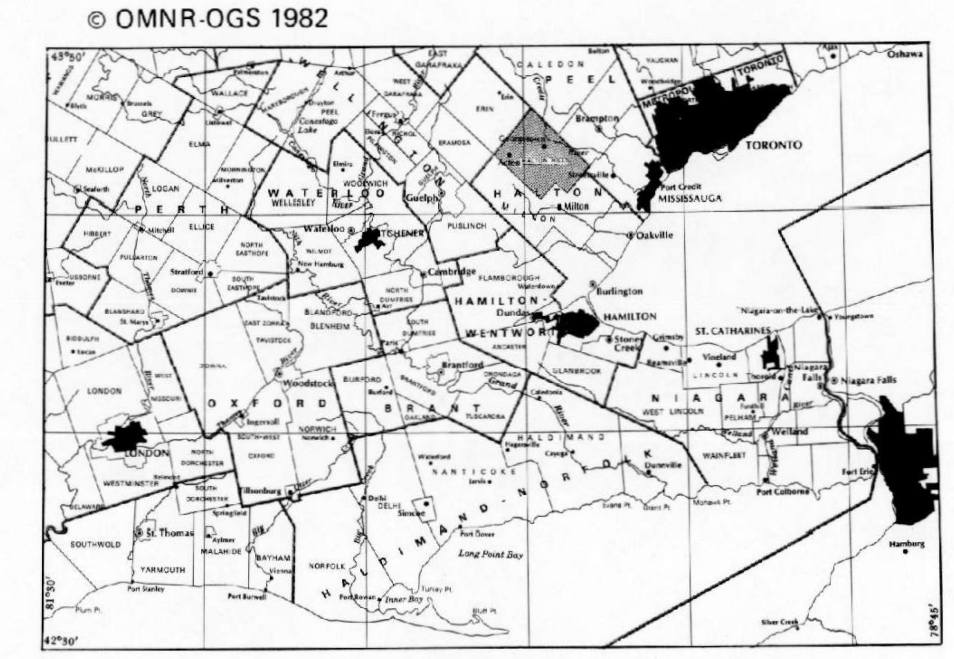
TOWN OF HALTON HILLS
REGIONAL MUNICIPALITY OF HALTON

MAP 3
BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 30M/12, 40P/9



LEGEND

PALEOZOIC
SILURIAN

MIDDLE AND LOWER SILURIAN
AMABEL FORMATION
Dolostone
CLINTON AND CATARACT GROUPS
Sandstone, shale, dolostone

ORDOVICIAN

UPPER ORDOVICIAN
QUEENSTON FORMATION
Red shale

SYMBOLS
(Some symbols may not apply to this map.)

- Geological boundary.
- 25 Drift thickness contour line (25 foot (8 m) interval).
- x Isolated bedrock outcrop.
- Bedrock within 3 feet (1 m) of surface: see Table 4.
- Bedrock covered by 3 to 25 feet (1 m to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 m to 15 m) of overburden: see Table 4.
- 1 Selected bedrock resource area; Deposit number: see Table 6.
- Q3 Licenced quarry boundary; Property number: see Table 5.
- ●Q4 Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- ○27 Selected drilling location indicating reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: I.J. Bond, B.A. Liberty and P.G. Telford, 1976
P.G. Telford, 1976

Compilation and drafting by: Staff of the Aggregate Assessment Office.

Issued 1982.

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