Ontario
Ministry of Natural Resources

Hon. Leo Bernier
Minister

Dr. J. K. Reynolds
Deputy Minister

DIVISION OF MINES

GEOLOGICAL BRANCH

Open File Report

5218

Resources of Construction Aggregate in the Regional Municipality of Ottawa-Carleton

by

E.V. Sado and M.A. Vos

1976

OPEN FILE REPORTS

Open file reports are made available to the public subject to certain conditions. Anyone using them shall be deemed to have agreed to these conditions which are as follows:

> This report is udedited. Discrepancies may occur for which the Division does not assume liability.

Open file copies may be read at the following places:

> Mines Library, (Room W1603, Whitney Block),
> Ontario Ministry of Natural Resources,
> Parliament Buildings, toronto.
>
> The office of the Resident or Regional Geologist in whose district the area covered by this report is located.

A report cannot be taken out of these offices. Handwritten notes and sketches may be made from it. This particular report is on file in the Regional or Resident Geologist;s office located at:

South Boundary Road
Kemptville, Ontario
K0G 1J0

Open file reports cannot be handed out for office reading until a card, giving the name and address of the applicant, is filed with the Regional or Resident Geologist or Librarian.

A copy of this report is available for inter-library loan.

The Division cannot supply photocopies. Arrangements may be made for photocopying by an outside firm at the user's expense. The Librarian or Regional or Resident Geologist will supply information about these arrangements.

E.G. Pye,
Director, Geological Branch

RESOURCES OF CONSTRUCTION AGGREGATE IN THE REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

by

E. V. Sado[1] and M. A. Vos[2]

[1] Resource Geologist, Phanerozoic Geology Section, Geological Branch, Ontario Division of Mines.

[2] Geologist, Mineral Deposits Section, Geological Branch, Ontario Division of Mines.

Manuscript approved for publication by the Acting Chief, Phanerozoic Geology Section, November 19, 1976.

This report is published by permission of E.G. Pye, Director, Geological Branch, Ontario Division of Mines.

CONTENTS

..../2

CONTENTS....cont'd.

SECTION I

BEDROCK RESOURCES

Introduction

The Regional Municipality of Ottawa-Carleton occupies a triangular shaped area of approximately 1100 square miles. The triangular area has its base along the Ottawa River, from Arnprior in the west to Rockland in the east and its apex on the Rideau River, halfway between Kemptville and Smiths Falls. The population of this area in 1971 was 471,931. More than 300,000 people or 64% were living in Ottawa City.

The area of Ottawa-Carleton is underlain by Precambrian, Paleozoic and Quaternary rock formations. Precambrian bedrock underlying a 4-mile wide strip of land stretching 22 miles east-southeast of Arnprior has little potential as a source of construction aggregates and will not be considered in the present survey.

Paleozoic bedrock underlying a large part of the area is an important resource of construction aggregate. Its character and availability determine the potential supply of construction aggregate from bedrock resources. Bedrock resources are discussed in Section I of this report.

Surface deposits of Pleistocene and recent sands and gravels complement the supply of construction aggregates. Although historically a primary source of aggregate their depletion will necessarily emphasize more and more the importance of bedrock resources in the future. Sand and gravel will be discussed under Quaternary deposits in Section II.

The present survey does not include resources of clay, shale, lime and building stone. Brick is produced from shale deposits in the northwest part of Russell Township. The deposits extend into adjacent areas of the Regional Municipality. Nepean sandstone has been quarried extensively in the past for production of building stone. Lime is produced from marble in Ramsey Township just west of the study area. Production from these resources constitutes a minor part of the total mineral raw materials consumed in the construction industry.

SUMMARY

A survey of resources of construction aggregates, undertaken upon request of planning officials of the Regional Municipality of Ottawa-Carleton, was made in two parts. Section I is concerned with reserves from bedrock formations. A tonnage figure for these reserves is based on the area of suitable geologic formations occurring at, or within 25 feet of, the surface and an assumed average quarry depth of 60 feet.

The survey shows that there is an adequate supply of raw materials available and that proposed provisions will secure a supply of potential reserves sufficient for at least 200 years at present rate of population growth and aggregate consumption.

Geology of Paleozoic Formations

Paleozoic Formations of the Ottawa-Carleton area include dolomites, limestones and shales of the Ordovician Period underlain in some areas by sandstones of Ordovician or possibly Cambrian age. The following compilation is given in the legend of Geological Map No. 852A of the Ottawa-Cornwall area by Wilson (1946):

Table I

PALEOZOIC

ORDOVICIAN

RICHMOND

QUEENSTON FORMATION: red shale
RUSSELL FORMATION: interbedded grey shale and dolomite

DUNDAS-LORRAINE

CARLSBAD FORMATION: grey shale, sandy shale, some dolomite layers

COLLINGWOOD AND CLOUCESTER

BILLINGS FORMATION: black shale; minor brown shale

EASTVIEW FORMATION: dark grey limestone with shale bands

BLACK RIVER AND TRENTON

OTTAWA FORMATION: chiefly grey limestone, some dolomite, shale and sandstone in the lower part; 7a, Pamelia beds: limestone, dolomite, shale and thin-bedded sandstone; 7b, Lowville beds: chiefly shaley limestone; 7c, Leray beds: limestone; 7d, Rockland beds: limestone; 7e, Hull beds: limestone; 7f, Sherman Fall beds: thin-bedded limestone with some shaly partings; 7g, Cobourg beds: limestone

CHAZY

ST. MARTIN FORMATION: limestone, minor shale and dolomite

ROCKCLIFFE FORMATION: grey-green shale with lenses of grey sandstone

	BEEKMANTOWN	OXFORD FORMATION: grey limestone, magnesian limestone, and dolomite
		MARCH FORMATION: interbedded grey calcareous sandstone and blue-grey dolomite
	CAMBRIAN OR ORDOVICIAN	NEPEAN FORMATION; sandstone
PRECAMBRIAN		Crystalline limestone, quartzite, and gneiss of the Grenville series intruded by granite, syenite, and other rocks

Successful operations for the production of aggregate are conducted in two groups of rocks, the Beekmantown Dolomites and the Black River Trenton Limestones.

Beekmantown Dolomite

A major quarry area is located east of highway 31 approximately 5 to 5½ miles southeast of the Ottawa city limits. Quarries are operated by Armstrong Brothers Company Limited, Dibblee Construction Company Limited and Bertrand and Frere Construction Company Limited in lots 24, 25 and 27, Concession V, South Gloucester Township. Production is from the Oxford Formation of the Beekmantown Dolomite which, in this area, is

quarried to a depth of 30 to 50 feet.

A geological section (Map 852A) running north-south through the area indicates a thickness of Beekmantown Dolomite of more than 100 feet. However, irregularities in the topography of the underlying Precambrian surface and of the present erosion surface in areas of outcrop are likely to detract from the expected maximum thickness and for calculation of reserves 60 feet is assumed to be a realistic value for the average thickness of quarriable Beekmantown Dolomite.

Care must be taken in planning of quarries in the western part of the region. The Oxford Formation is here much thinner and near Arnprior it directly overlies the Precambrian, making it more susceptible to changes in thickness as well as quality. The Oxford and March Formations are here mapped as one unit by Livingstone et. al. (Map 1363A) under the heading: brown silty dolomite; minor grey sandstone in basal units.

Present operations produce both concrete and asphalt aggregate from Oxford Dolomite. The dolomite has a higher specific gravity than the limestones of the Ottawa Formation.

Black River - Trenton Limestone

Mid-Ordovician limestones in the Ottawa area equivalent to Black River-Trenton Limestones elsewhere, are classified as

Ottawa Formation by Wilson (Map 852A). The Ottawa Formation is subdivided into 7 units. The Formation is 700 feet thick, in Ottawa as well as Montreal, but it is probably thinner towards the northwest near Arnprior.

Present quarries produce from the lower units of the Ottawa Formation only. An abandoned quarry in Eastview, within Ottawa City Limits, formerly produced from Hull beds equivalent to Lower Trenton (Hewitt, 1960, p.80). These beds contain massive bedded, pure limestones which in Hull are quarried by Canada Cement Lafarge Limited for production of cement.

Two areas of Black River limestone near Ottawa support large quarries for production of aggregate. One quarry is located in lots 12 - 14, Concession II, Gloucester Township, $2\frac{1}{2}$ miles east of the city limits and south of highway 17. Opportunity for expansion of operations in this area is limited by the amount of overburden and by competing land uses.

The second area stretches east of Fallowfield where Middle Black River Limestone is exposed in lots 20 - 24, Concession IV and lots 23 - 26, Concession V, Nepean Township. North of this area faulting has brought older sandstones and dolomites of the March Formation near surface. No production is reported from these deposits. In directions south of the fault increasing overburden limits expansion of existing quarries.

Quarries in the Fallowfield area have reached a depth of approximately 60 feet.

Potential Reserves of Bedrock Aggregate

The following calculations attempt to evaluate the potential reserves of bedrock aggregate in the Regional Municipality of Ottawa-Carleton. The determination of actual reserves would involve quality testing of material over large areas.

Potential reserves are here defined as the volume of bedrock in geologically favourable formations accessible under present quarry practices. It is assumed that in favourable areas quarries will reach an average depth of 60 feet and that overburden in access of 25 feet rules out the opening of new quarries locally. Not considered is the fortuitous coincidence of aggregate potential in bedrock formations and surficial deposits alike, in areas of more than 25 feet of overburden.

Potential resources rather than reserves would include granite and shale, as possible sources of aggregate and lightweight aggregate respectively.

Information on favourable bedrock formations is available from existing quarry operations and from geological maps and reports. The Black River and Trenton Limestone equivalents have been combined for calculation purposes since

existing maps, particularly of the Arnprior area, do not allow separate treatment of the individual units. A tentative distinction suggests that approximately 35% of the total area of Black River-Trenton deposits is occupied by the less favourable Trenton Limestones (Units 7 d,e,f,g).

In the present calculations deposits within the Ottawa City Limits have been excluded. Elsewhere deposits underlying residential developments, e.g. south of Orleans and east of Stittsville, or institutional grounds e.g. the Animal Research Institute southeast of Bells Corners and the terrain of the Department of National Defence in the northwest corner of Nepean and adjacent area in March Townships, may have to be excluded also.

In order to convert volume into tonnage an average specific gravity of 2.75 was assumed for Beekmantown Dolomite and 2.70 for Black River-Trenton Limestones.

The following areas in order of Townships from north to south and east to west are considered:

area in sq. miles:

	Beekmantown Dol.	Black River-Trenton Lst.	(Trenton equivalent in brackets)
1) Cumberland Township			
a) area south of Cumberland		7.96	(5.30)
b) area east of Sarsfield		4.44	(4.44)
c) area southwest of Sarsfield (one quarry)		2.08	(2.08)
		14.48	(11.82)
2) Gloucester Township			
a) area north of Orleans (one quarry) (partially in Cumberland Tp.)		.25	
b) area south of Orleans (one quarry) (partially in Cumberland Tp.)		1.80	(.90)
c) area surrounding Francon Quarry		1.16	
d) area between Leitrim and South Gloucester (3 quarries)	6.00		
e) area west of Johnston Corners	.60		
f) area west of Limebank	1.16		
	7.76	3.21	(.90)
3) Osgoode Township			
a) area southwest of Greely	3.44		
b) area east of Greely	15.96		
c) area east & west of Metcalfe	12.50		
d) area south of Metcalfe	19.36		
e) area north & south of Marvelville	1.84		
f) area northeast of West Osgoode	0.32		
	53.42		

	area in sq. miles:		
	Beekmantown Dol.	Black River-Trenton Lst.	(Trenton equivalent in brackets)
4) Nepean Township			
a) area south of Bells Corners (partially in March and Golbourn Townships)	15.28		
b) Fallowfield area		3.8	
c) northwest corner of Township	4.10		
d) southwest corner of Township	.70		
	20.08	3.8	
5) North Gower Township			
a) along west boundary of Township	1.44		
6) Torbolton Township			
a) area east of Constance Creek		6.00	
b) area west of Constance Bay		10.36	(2.59)
c) area west of Dunrobin-Woodlawn	3.6		
d) area north of Dunrobin	.4		
	4.00	16.36	(2.59)
7) March Township			
a) area north of Constance Lake		4.00	
b) area surrounding Constance Lake	17.20		

	area in sq. miles:		
	Beekmantown Dol.	Black River-Trenton Lst.	(Trenton equivalent in brackets)
8) Fitzroy Township			
a) area north of Fitzroy Harbour		4.00	
b) area east of Fitzroy Harbour	2.50		
c) area west of Kinburn		.25	
d) area on Carp River northeast of Marathon		.80	
e) area south and southeast of Antrim (one quarry southwest of Marathon)		8.92	(2.97)
	2.50	13.97	(2.97)
9) Huntley Township			
a) area southwest of Marathon-Stittsville (one quarry 1½ miles west of Corkery)	3.40	58.60	(29.30)
10) Goulbourn Township			
a) area south and southwest of Stittsville including Munster (2 quarries)		40.28	(8.05)
b) area north and east of Stittsville		8.60	(1.72)
c) area south of the Jock River	24.52		
	24.52	48.88	(9.77)
11) Marlborough Township			
a) area northwest of the Rideau River	87.20		

Total potential reserves are:

	Beekmantown Dolomite	Black River-Trenton Limestone	Trenton Equivalent
area in sq. m.:	221.52	163.30	(57.35)
average s.g.:	2.75	2.70	
tonnage:	31.8 billion	23 billion	(8.08 billion)

TOTAL 31.8 + 23 billion = 54.8 billion tons.

Mineral Reserve Areas

In the draft plan for the region certain areas have been allocated as mineral reserve areas. They include the Francon Quarry area, an area southwest of Sarsfield, three areas north, southwest and east of Greely, the Fallowfield area, an area southwest of Bells Corners, an area south and west of Stittsville and an area north of Fitzroy Harbour. It is estimated that those areas combined consist of approximately 32 square miles of Beekmantown Dolomite and 28 square miles of Black River-Trenton Limestones of which about 5.5 square miles represent the Trenton equivalent. These potential reserves amount to 4.6 billion ton of Beekmantown Dolomite and 4 billion ton of Black River-Trenton Limestone of which approximately 750,000,000 ton consist of the Trenton equivalent.

If, in a period of 30 years, the population of the area increases to 1 million as suggested by the Draft Report for the Region and use of aggregates amounts to 20 ton per

capita, a figure comparable to figures used in the Proctor, Redfern Report, then the annual consumption of aggregates would be 20 million ton or approximately ¼% of present potential reserves of bedrock in mineral reserve areas.

Conclusion

The Regional Municipality of Ottawa-Carleton is blessed with ample resources of Bedrock aggregate. A calculation of potential reserves indicates a total of 54.8 billion tons accessible with present quarrying techniques. Availability of 8.6 billion tons or approximately 15½% of this supply in mineral reserve areas, according to the draft plan for the region, will secure an adequate potential supply of construction aggregates from bedrock resources alone for approximately the next 200 years at present rates of growth.

APPENDIX

The capability of limestone and dolomite formations as a source of aggregate depends on the quality of the stone. Approval according to specifications issued by the Ministry of Transportation and Communications determines the range of products to be obtained from a single quarry operation. Important physical parameters for concrete and asphalt aggregate are magnesium sulphate soundness, hardness, absorption characteristics and petrographic rating.

Comparison of test results of samples from different quarries in the Regional Municipality does not conclusively show a difference in the quality of the rock types concerned. Results of tests of 14 samples from 4 quarries in Beekmantown Dolomite and 21 samples from 6 quarries in Black River-Trenton Limestone show that little difference exists in the results of magnesium sulphate soundness and hardness tests except that a wider spread of hardnesses is found in the dolomites, whereas results of magnesium sulphate soundness tests are less consistent in the limestones. Both formations produce a large percentage of stone of satisfactory petrographic characteristics, favouring Beekmantown Dolomite for production of concrete aggregate.

The majority of samples show resistance to loss due to absorption, although here the percentage of samples meeting the more stringent specifications for asphalt aggregate is higher in the Black River-Trenton Limestones.

There are no test results at hand for comparison of other rock formations, but it is logical to assume that presently successful quarry operations have been established in the most favourable rock types.

Selected References

Hewitt, D.F.,
1960: The Limestone Industries of Ontario; O.D.M., Industrial Mineral Circular No. 5.

Livingstone, K.W., P.A. Hill and others,
1974: Map 1363A, Geology, Arnprior, Ontario; G.S.C., Ottawa.

Wilson, A.E.,
1964 Geology of the Ottawa-St. Lawrence Lowland, Ontario and Quebec; G.S.C., Memoir 241.

Wilson, A.E.,
1946: Map 852A, Ottawa-Cornwall; Canada Department of Mines and Resources, Ottawa.

Draft Report -
1974: Official Plan for the Regional Municipality of Ottawa-Carleton.

Drift Thickness - Unpublished information from Ontario Water Resources Division, Ministry of the Environment, Toronto.

Mineral Aggregate Study of the Central Ontario Planning Region - Proctor, Redfern Limited, March 1974.

Rock properties in the Ottawa Area - information received from Materials Testing Office, Ontario Ministry of Transportation and Communications.

Section II

Quaternary Resources

Summary

The consumption of Quaternary gravel is increasing with the construction industry's demand for cheap aggregate. Paleozoic limestones and dolostones provide a higher priced but quality controlled alternative. Pleistocene and Recent sands and gravels are utilized mainly in pit run form, specialized processing taking place within coarser deposits.

Road networks have stimulated cultural build up along prominent reserve areas. The recently introduced Mineral Resource Policy within the region will hold cultural development until after favourable reserve areas are exploited.

For the purposes of this study the areal extent of favourable Quaternary gravel deposits was calculated. Water well log data provided depth estimates. Field studies of existing exposures, local topographic and geologic features were undertaken to assess the continuity and distribution of underlying materials.

Aggregate potential is contained within ice-contact ridges, marine strand lines, and fresh water, estuarine and river channel deposits. Ice-contact materials were further subdivided into three aggregate probability ratings. Large reserves of marine, fresh water and eolian sands were outlined but not calculated within this study.

Sand reserves within the region are plentiful, gravel

reserves are in short supply and must be carefully managed to ensure maximum utilization.

Method

Office Work

Township base maps were prepared from the National Topographic Map Series at a scale of 1:50,000. The areas and locations of granular materials were obtained from yet unpublished Surficial Geology Maps prepared by Henry Richard of the Geological Survey of Canada. Water well logs obtained from the Ministry of the Environment supplied useful information on subsurface materials. The locations of sand and gravel pits within the region were obtained from records at the Ministry of Transportation and Communications, Downsview, Ontario.

The area of favourable gravel bearing units was calculated using a compensating polar planimeter. Thickness estimates relied heavily upon the existing pit depths and to a lesser degree on the inferred ground water table and well log data.

It was assumed that an area of one acre at a depth of one foot contained 2,420 tons of material. Thus a one acre area containing an average ten foot thickness of sand and gravel would contain 2,420 tons/one acre foot x 10 feet of sand and gravel or 24,200 tons of sand and gravel per acre.

Corrective compensation for areas already extracted and areas tied into cultural features and set backs was applied to each deposit. These corrections were derived

from field data and airphoto interpretation. A pictorial representation of the areas deleted is available at a scale of 1:25,000 for the large ice-contact aggregate reserve areas contained within Gloucester, Osgoode, Nepean and North Gower Townships. The data is presented in table form and is to be found in the appendix.

Field Work

Available exposures such as sand and gravel pits, road cuts, cultural excavations, surficial materials and test pits were examined in estimating the quality, continuity and thickness of the underlying materials. Local topography and geology were also considered.

Gravel bearing deposits were found within ice-contact materials, marine beach and bar complexes and estuarine and river channel deposits. Ice-contact materials were difficult to evaluate. Estimates of the probable gravel content within ice-contact features were based upon existing pit exposures. Areas of high ($\geq$ 35 percent gravel), medium ($<$ 35 percent but $>$ 15 percent gravel) and low ($\leq$ 15 percent gravel) probabilities were outlined on this basis.

It must be stressed that these are only probable reserves for which tonnage and grade values were computed partly from specific measurements and partly from projection for a reasonable distance on geological evidence. The

reliability of these probable reserves is directly related to the number of exposures and well log data. In many sites inspection and measurement was to widely or otherwise inappropriately spaced to outline the materials completely or to establish it's grade throughout. Because gravel pits are always located within the most favourable potential areas, inspection and measurement of these exposures will automatically bias the estimation of the surrounding reserves.

QUATERNARY HISTORY OF THE REGIONAL MUNICIPALITY

During Pleistocene time the region was invaded by several ice sheets advancing from the north. The pre-glacial land surface was modified by glacial erosion and the subsequent deposition of glacial till and other sediments. Well rounded, sorted and bedded glacial gravels, and sands were deposited along stagnant ice margins in the form of morainic ice-contact materials.

The weight of the advancing ice had depressed the area to below sea level, as the ice melted back the sea entered the Ottawa valley. In this sea, known as the Champlain Sea, thick deposits of sand, silt and clay were laid down. The gradual uplift (isostatic rebound) of the area caused the land surface to emerge out of the sea. Along it's shores and in shoals developed during it's recession, the Champlain Sea developed gravel beaches from glacial materials exposed to wave action, and shingle beaches from easily eroded local bedrock exposures. The glacial till surface was thus modified and in places up to 10 feet of coarse, poorly sorted lag gravels lie upon and grade downward into bedrock, till, or ice-contact materials. Marine sands were commonly deposited along the western flanks of the ice-contact ridges.

Large volumes of silt laden fresh water released from the Upper Great Lakes through the Fossmill and North

Mattawa Outlets discharged down through the Ottawa Valley. Broad ancestral channels of the present day Ottawa River were formed and contain deposits of alluvial sands.

Marine and fresh water sands, were reworked by wind action from the north west during a short period of arid post glacial climate. Eolian sand dunes were formed primarily within eastern Gloucester Township and south central Cumberland Township.

LOCATION AND CHARACTERISTICS OF AGGREGATE RESERVE AREAS

The Quaternary aggregate potential within the region is largely contained within morainic accumulations of ice-contact materials; the balance occurs along marine beach and bar deposits and fresh water estuarine and river channel deposits.

Ice-Contact Deposits:

Economically viable Quaternary aggregate is concentrated along four morainic ridges. Large reserves are contained in two deposits south of Ottawa. They are oriented sub-parallel to and on either side of the Rideau River.

A prime deposit, one mile east of Twin Elm is centered in Nepean Township south of the Jock River. Abrupt changes in the size, sorting and roundness of materials occur. South-east of this mass, a long, narrow ridge extends along Greenbank Road through Watterson Corners ending south of Kars in North Gower Township. Locally called the "Kars Esker" it is more likely a continuation of morainic materials. Well sorted and rounded very coarse gravels predominate along it's core; these are flanked by clean sands and fossiliferous gravelly sand beaches.

Southward from Uplands Airport, in Gloucester Township, a ridge of outwash with minor ice-contact material extends

to Greely in Osgoode Township, then continues south through Herbert Corners, West Osgoode and Reids Mills, entering Mountain Township in Dundas County. Well rounded, sorted and bedded boulders, cobbles and fine gravels are concentrated within sand materials. The beds wedge out laterally and/or longitudinaly due to facies changes, slumpage and cut and fill structures. Outwash materials are commonly masked by fossiliferous silts, sands and gravels of marine beach origin. The sedimentary pattern is such that local concentrations of boulders and cobbles occur in pockets within gravelly sand materials.

Small and scattered deposits of aggregate in Cumberland Township extend from Sarsfield south to Bearbrook. Coarse aggregate is flanked and in places capped by silty fine to fine sands. A small gravel deposit lies one mile north of and between Navan and Sarsfield. Coarse aggregate potential is highest within topographically elevated areas. Marine sands and gravels occur about the peripheries.

A morainic sand ridge begins two miles south of Carp and extends approximately 10 miles to the south beneath the route of Highway 5. Poorly sorted, bedded and subrounded gravelly sands are concentrated within the Stanley Corners segment. Northward, gravelly sands have been sterilized by urban proliferation.

Marine Beach and Bar Deposits:

Beach and Bar deposits, attributed to the Champlain Sea, occur in all the townships studied. They are concentrated in Marlborough, Goulbourn and Huntley Townships. Glacial materials and local bedrock, exposed to wave action during the recession of the sea developed gravelly sand beaches and shingle beaches respectively. Prominent ground moraine features, notably drumlinoid ridges, were modified to the extent that up to 10 feet of coarse poorly sorted lag gravels lie upon and grade downward into the underlying till. They usually average a 3 foot thickness. Thin shingle beaches developed upon exposed bedrock surfaces, average a thickness of 1 foot in Marlborough Township they thicken to between 1 and 8 feet further north.

These sometimes fossiliferous marine beach deposits occur between 325 and 675 feet present elevation (Gadd, 1963). Below 325 feet A.S.L. fresh water sands were deposited along ancestral channels of the Ottawa River.

Estuarine and River Channel Deposits:

Gravel bearing estuarine sands occur at the mouth of the Mississippi River in Fitzroy Township. Remaining deposits, concentrated along the Constance Creek and Mer Bleue Lowlands, contain negligable amounts of fine gravel.

Cumberland Township

Several small bodies of ice-contact material lie in Cumberland Township. Local concentrations of well rounded, sorted and bedded cobbles and fine gravels are contained within sandier materials. Fossiliferous fine gravelly sand beds are present along the flanks. Two pit run and crusher run operations, C-5 and R9-24, supply local aggregate needs, several other pits become activated as demand and quality dictates.

Marine, fresh water and eolian sands cover a large area within the township. Many haphazardly located, poorly worked sand borrow pits lie abandoned and overgrown within this area. It is recommended that several reserve areas be set aside to meet this demand. The rehabilitation of abandoned pits would be of benefit to the surrounding landscape.

Wave action has reworked local Queenston Shale bedrock south-west of Vars. Thin, poor quality gravels have resulted. A large borrow pit was opened for Highway 417 on Lots 27 and 28, Concession 8 within this deposit. Rehabilitation on this abandoned site is needed.

Excluding large scale local demands, such as for Highway 417, this agricultural area has adequate aggregate reserves for the future.

FITZROY TOWNSHIP

Gravel bearing deposits of marine beach and fresh water estuarine and river channel origin are present here. A probable 100,000 tons of fine gravel remains along a 3 foot deep beach deposit south of Antrim on Highway 17. Nine abandoned pits here have removed most of the flaggy local limestones.

Abandoned marine strand lines mask an ice-contact deposit within Lots 17, 18 and 19, Concession 6. One pit is active on demand within it, another lies abandoned.

Units A and B contain sand materials with some gravels. They are found within fresh water estuarine and river channel deposits at the mouth of the Mississippi River. Several deep pits have developed, only two remain in production, A5-8 and A5-11.

A mine tailings dump, (Kingdon Mine), on Morris Island, Lot 23, Concession 6, produces calcite chips, (4-10mm), for ornamental driveway and rock garden uses. The calcite is a by-product of lead zinc mining within two calcite veins cutting a Precambrian, marble host rock.

Gloucester Township

An elevated outwash-ice-contact deposit here is characterized by well rounded, sorted and bedded sands and gravels. Gently dipping beds contain foreset, and cut and fill structures; these are frequently dissected by channel cuts and truncated along slump faults. Abandoned marine strandlines mask the tops and sides with fossiliferous beds of silt, sand and fine gravel.

Uplands International Airport and features such as racetracks, highways, power lines, residential properties, etc., have neutralized the probability of extracting several hundred million tons of sand and gravel. Well logs imply a thickness exceeding one hundred feet of fine aggregate within this culturally sterilized zone. The coarse aggregate potential increases to the south-east. Pit sections within Unit A, commonly exceed 20 feet of bouldery and cobbly gravels. The extractable gravel thickness here is governed by the topographic elevation and the static ground water level. An estimated 70 percent of Unit A, has been extracted to an average depth of 25 feet. Excavations below this datum penetrate the ground water table. Substantial tonnages of coarse aggregate are known to exist below this level, in places 50 feet or more. Removal of this material would ultimately lower the ground water table in the immediate area and possibly admit contamination into the water system (as

this is a ground water recharge area).

Units B and C, isolated from the main outwash mass have largely been exploited; encroachment by cultural development makes future extraction unlikely. The two remaining beach deposits have already been diverted to other uses.

The five active pits within this area are all operated by major producers. Spratt Sand and Gravel maintains a large semi-permanent processing plant on Lots 29 and 30, Concession 4.

Several sand pits are found within the alluvial and eolian sands in eastern Gloucester Township. They are largely small, abandoned and overgrown as discussed in Cumberland Township.

Goulbourn Township

Economic reserves of Quaternary gravel are found within an ice-contact ridge extending south from within Huntley Township, along the route of Highway 5, through Stittsville and south of Stanley Corners. Rural and urban proliferation along this route has frozen the reserves in Units B and C.

Unit A, centered on Stanley Corners, contains poorly sorted and bedded medium to fine aggregate. Several abandoned pits occur along the roadside. Extraction is limited to two pits, GL-5 and GL-6, within Lot 22, Concession 7. They do not appear on MTC records.

Marine beach complexes contain numerous and widely scattered pits, either abandoned or active on demand. These deposits are identical to similar deposits described in Marlborough Township. Beaches here are thicker than those in Marlborough Township.

An average thickness has been assigned to each deposit from field observations. A sub-commercial deposit is located on Lots 4, 5 and 6, Concession 1. In places more than 10 feet of flaggy limestone has accumulated; the reserves are small.

Huntley Township

Quaternary coarse aggregate here occurs in a similar manner to that discussed in Goulbourn Township immediately to the south. Economic gravel reserves follow Highway 5 north to within 2 miles of Carp. Sand materials predominate, pebbly gravels have been outlined within Units A_2, B and C_1. The gravels are contained within a sand matrix, they are poorly bedded, sorted and subrounded. Spratt Sand and Gravel operates a permanent processing plant at K3-9, within Unit A_2. Reserves at this site are now nearly depleted, plans are underway to open a limestone quarry on the pit bed. Spratt also operates the Cowan Pit, Ø5-49, the only other major gravel producer in the area. Several sand pits are being actively worked along the west side of Highway 5 just south of the Village of Huntley.

A proliferation of estate and subdivision housing projects is underway in south central Huntley Township. Several small pit operations are being developed within local marine beach materials to supply this local demand.

March Township

Marginal beach deposits are present east of Constance Lake. Poor quality gravels overlie the Rockcliffe Formation Shales exposed along the lower limits of the Constance Creek Lowland. The gravel improves in quality and thickness to the east where it overlies a ridge of Black River and Trenton limestones.

Small quantities of sand are being extracted for local use within abandoned estuarine and river channel deposits found along the Constance Creek Lowlands.

Marlborough Township

Local limestones make up shingle beaches along the shores and shoals of the Champlain Sea. Scattered and thin the supplies are adequate for the small local requirements in Marlborough Township.

Beach materials here reflect the parent materials from and on which they have been developed. Where overlying glacial till, lag concentrates consist of sandy fine to coarse gravels, largely composed of local limestones; Precambrian rock types are also present. Well to poorly bedded, flaggy limestone gravels have developed over exposed limestone bedrock. Materials are always better sorted nearest the surface, and grade gradually downward into their respective parent materials.

Thin deposits of marine sands are found along the Rideau River concentrated within the eastern corners of the township.

Nepean Township

Gravel reserves in Nepean Township are divided into two categories: marginal and ecomonic. Marginal reserves are contained in beach and bar complexes of the Champlain Sea, and consist of 2 and 8 feet of flaggy local rock types. Although not commercially extractable, they are used locally.

A prominent ice-contact deposit is found 1 mile west of Twin Elm, south of the Jock River. Two topographic crests, Units B_1 and B_4, contain the greatest coarse aggregate potential. Cobbly gravels and sands are poorly rounded, sorted and bedded within Unit B_1; gravelly till-like sediments are also found. Flaggy accumulations of local limestone bedrock predominate along the north margin. Coarse aggregates are plentiful in Unit B_4, the gravels are well rounded, sorted and bedded. Till-like pockets sometimes truncate well sorted sediments. Unit B_3 is a transitional zone; pockets of cobbly gravels are contained within well sorted and bedded sands. Finely laminated sands in Unit B_2 occasionally bear small gravel percentages. Deposit B is flanked along its west and south margins by a marine sand plain.

Unit A extends southward into North Gower Township. Rounded but poorly sorted and bedded gravels are found here

within a sandy matrix.

Seven pits are active within Unit B. Burnside Sand and Gravel, (K3-58, K3-98 and K3-103), and Brazeau Sand and Gravel, (K3-82, K3-126), are the most active in the area. The Burnside Company operates a central processing plant within abandoned pits K3-55 and K3-59. Brazeau controls large reserves within Unit B_1 and a large tonnage of crushable aggregate north of pit K3-98 where a 35 foot face containing 80 percent cobbly gravels is exposed.

Thickness estimates used in calculating the probable reserves are based on the depths of existing pits. Small open ponds are present where operators have penetrated the ground water table, eg K3-98.

Scanty well log data indicates a thickness of 90 feet in places. Probable reserve estimates are restricted to deposits above the water table.

Nepean Township has recently started a large sanitary landfill operation within the abandoned site of pit K3-62. The high ground water recharge potential and porosity of such a deposit makes the storage of waste materials here unwise.

North Gower Township

Aggregate reserves are contained along a thin ice-contact ridge trending to the south. Locally referred to as the "Kars Esker", it is more likely an extension of the ice-contact materials found within Nepean Township to the north. Well rounded and sorted coarse gravels at the core, are flanked by clean sands and fossiliferous beach materials. A paved county road bisects this ridge, passing through Watterson Corners and Kars. Residential developments are rapidly spreading along this route.

Billie Construction operates two pits, K3-109 and K3-20, north of Watterson Corners. Pit run, screened and crushed aggregates are extracted by a portable plant. Good quality coarse gravels occur here but the reserves are small. Lloyd's Cartage hauls sand sized aggregate from the Rice Pit, K3-163; reserves here are large.

Marine beach gravels contribute small tonnages for local use; these deposits, developed upon till material, are only a few feet thick; the William's Pit, K3-36, Lot 10, Concession 1 is worked along a 10 foot face.

Small, local sand pits occur within marine sand deposits west of Watterson Corners and north along the Rideau River in south North Gower Township.

Osgoode Township

The outwash-ice-contact body described in Gloucester Township extends south through Osgoode Township. Thin, alternating beds of fossiliferous silts, sands and fine gravels have accumulated along marine strand lines. The thickness of this material varies from a few inches to several feet overlying the unfossiliferous outwash materials. Pit operations compete with residential properties along a paved road traversing the crest of the deposit. Few new pits have been opened along this route; existing exposures are generally abandoned, shallow and overgrown, prone to accumulating local scrap.

Fourteen pits are active within Osgoode Township. Production, mainly of pit run, fine gravelly sands is concentrated between the villages of South Gloucester and Herbert Corners.

Units F and J are difficult to evaluate, the exposure is poor and well log data inadequate. Seismic surveys may provide valuable information as to the character of underlying materials, their depth and the ground water level. Back hoe excavations, based upon the above data, could be used to spot check favourable zones.

Marine sands flank the western margin of the outwash ridge, and follow it south into Mountain Township (Dundas County).

Planning policies should discourage such situations as exist in South Gloucester. A subdivision housing project here covering one concession lot is flanked on three sides by 30 foot deep pits.

Torbolton Township

Marginal reserves of coarse aggregate are found along a small beach deposit within Lots 21, 22 and 23, Concession 1. Largely worked out by two now abandoned operations, probable reserves total 160,000 tons of pit run material along a variable 2 foot thickness.

Sand reserves are widespread along eolian and estuarine river channel deposits. Sand extracted from active on demand pits supplies local needs.

Conclusions

Deposits of Quaternary aggregate within the region are fine textured gravelly sands, they are for the most part uniformly graded and bedded. Pockets of coarser, poorly sorted and till-like ice contact materials do occur.

The finer aggregate is extracted in pit run or where larger clasts are present crusher run form. Specialized processing is often required, especially within the coarser ice-contact units outlined on the accompanying map in purple. Abundant reserves of Paleozoic rock types in the region supply the specific size and quality demanding markets.

Quaternary sands and gravels are largely inferior to a Paleozoic alternative, they are extracted however at a fraction the cost of the latter. This cheap non-renewable natural resource is in danger of being frozen by cultural expansion within the Municipality. Economic gravel aggregate reserves within the region roughly total 78 million tons at present. It is not probable that every gravel bearing acre will be extracted but areas where a high gravel potential does exist should not be wasted.

APPENDIX

GRAVEL AND SAND PIT LOCATIONS

WITHIN THE REGIONAL MUNICIPALITY

OF OTTAWA-CARLETON

listed per township

NOTE: Information obtained from the Ministry of Transportation and Communications, Downsview, Ontario

TERMINOLOGY:

*	Pit not listed with M.T.C.
M.T.C.	Ministry of Transportation and Communications
U.T.M.	Universal Transverse Mercator
Name	Pit name or name of owner or operator
Material	Sand or gravel, predominant material listed first
Status	(A) abandoned (A.O.D.) Active on demand

PIT LOCATIONS IN CUMBERLAND TWP.

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	R9-4	723352	Morris	4	3	snd,grvl	A
2	R9-5	730327	Leoul	9	3	snd,grvl	A.O.D.
3	R9-34	731300	Spence	13	4	snd,grvl	A.O.D.
4	R9-33	734289	Butenschon	15	4	snd,grvl	A
5	R9-35	735284	Coburn	16	4	grvl	A.O.D.
6	R9-6	736270	Rothwell	17,18	4	grvl,snd	A
7*	C-5	734274		18	5	grvl,snd	Active
8	R9-10	740264	Vial	19	4	grvl,snd	A
9	R9-9	735265	Rothwell	19	5	snd,grvl	A
10	R9-21	742243	Armstrong	23	5	snd,grvl	A
11	R9-20	743240	Nadon	23	5	snd,grvl	A
12	R9-3	683328	County	6	7	grvl,snd	A.O.D.
13	R9-24	687322	LeBlanc	8	6	grvl,snd	Active
14	R9-12	688325	Brown	7	6	snd,grvl	A.O.D.

NOTE: There are several sand pits developed within the alluvial and eolian sand deposits for which there are no records. Most are abandoned, some however supply fill material for local uses.

PIT LOCATIONS IN FITZROY TOWNSHIP

	MTC#	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	A5-67	071202	Cavanaugh	3	3	grvl	A
2	A5-25	069204	Curry	3	3	grvl	A
3	A5-24	069205	Hudson	3	3	snd,grvl	A
4	A5-49	063211	McCoy	4	3	grvl	A
5	A5-68	064210	Storey	4	3	grvl	A
6	A5-87	053212	Grainger	5	3	snd	A
7	A5-52	966307	Phillips	26	3	snd	A
8	A5-14	963308	Green	27	3	snd,grvl	A
9	A5-97	079208	Hammells	3,4	4	snd,grvl	A
10	A5-22	068212	M.T.C.	3,4	4	snd,grvl	A
11	A5-17	066209	Coulton	4	4	snd	A
12	A5-23	060217	Finer	5	4	snd,grvl	A
13	A5-8	997299	Blair	22	4	snd,grvl	Active
14	A5-72	993305	Stewart	23	4	snd,grvl	A.O.D.
15	A5-13	994302	Carss	24	4	snd	A
16	A5-108	988309	Carss	24	4	snd	A
17	A5-12	985305	James	24	4	snd	A
18	A5-18	054282	Yuck	14	6	grvl	A
19	A5-16	036296	Dickson	17,18	6	snd,grvl	A
20	A5-48	033301	Dickson	18	6	snd,grvl	A.O.D.
21	A5-11	027303	Riddell	19	6	snd,grvl	Active
22	A5-15	022036	Wilson	20	6	snd,grvl	A
23	A5-31	015311	Russell	21	6	snd	A

PIT LOCATIONS IN
GLOUCESTER TWP.

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	Ø5-38	456207	Dollar	4	2	snd	A
2	Ø5-87	456204	Hunt Club	5	2	snd	A
3	Ø5-39	456201	Foster	6	2	snd	A
4	Ø5-112	517154	Spratt	22,23	3	snd	A.O.D.
5	Ø5-17	501159	Billie	21	3	snd	Active
6	Ø5-1	517162	Duncan	21,23	3	snd	A
7	Ø5-58	522146	M.T.C.	25	3	snd,grvl	Active
8	Ø5-82	529288	Galoway	22	3	snd	A
9	Ø5-60	494219	Dollar	6	3	grvl,snd	A.O.D.
10	Ø5-61	528146	Grant	26	4	snd,grvl	Active
11	Ø5-35	530142	Dibblee	27	4	snd,grvl	Active
12	Ø5-54	543144	Nolan Pit	28	4	grvl	A
13	Ø5-66	537139	Pyper	29	4	snd	A
14	Ø5-77	545144	Pyper	29	4	snd,grvl	A
15	Ø5-69	542134	Quinn	30	4	grvl	A
16	Ø5-114	546139	Spratt	29,30	4	grvl	Active
17	Ø5-133	598304	Perrault	4	4	snd	A
18	Ø5-21	501223	Spratt	6	4	snd	A
19	Ø5-78	555294	Delaney	16	6	snd	A

NOTE: There are several sand pits developed within the alluvial and eolian sand deposits for which there are no records. Located in eastern Gloucester township, most are abandoned, some supply fill material for local purposes.

PIT LOCATIONS IN
GOULBOURN TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	K3-130	272948	Lyng	5	1	grvl	A.O.D.
2*	GL-19	279944		5	1	grvl	A.O.D.
3*	GL-18	280944		5	1	grvl	A.O.D.
4*	GL-20	275949		6	1	grvl	A.O.D.
5	C4-106	210985	Purdy	1	6	grvl	A
6	K3-63	309070	Patrick	22	6	grvl	A
7	K3-66	221013	Graham	5	7	grvl	A
8	K3-80	302074	Jenner	21,22	7	snd	A
9	K3-77	284056	Graham	18	7	grvl	A
10*	GL-5	300079		22	7	grvl	Active
11*	GL-6	299079		22	7	grvl	Active
12	K3-81	301077	Cathcart	22	7	snd,grvl	A.O.D.
13	K3-184	302075	Mulligan	22	7	snd,grvl	A
14	K3-67	304073	Cathcart	22	7	snd,grvl	A
15	C4-93	205007	Eynouf	3	8	grvl	A
16	C4-95	209012	MacDonald	4	8	grvl	A
17	K3-13	215020	Simpson	5	8	grvl	A
18	K3-65	222020	Emery	6	8	grvl	A
19	K3-149	237047	Crawford	11	8	grvl	A.O.D.
20	K3-64	262068	Healey	16	8	grvl	A
21	K3-15	297081	Cathcart	21	8	grvl,snd	A.O.D.
22	K3-129	292092	McCoy Const.	22	8	snd,grvl	A
23	K3-152	293088	Johnson	22	8	snd	A
24	C4-6	207037	Simpson	6	9	grvl	A.O.D.
25	K3-12	273094	Garden	20	9	grvl	A.1
26	K3-107	283091	Morley	21	9	grvl	A
27	K3-183	289095	Bradley	22	9	snd,grvl	A
28	K3-50	226068	McEvoy	11	10	snd,grvl	A
29	K3-53	253086	Davidson	16,17	10	snd	A
30	C4-96	165040	Lowe	1	11	grvl,snd	A

PIT LOCATIONS IN
GOULBOURN TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
31	K3-7	249107	James	18	11	snd	A
32	K3-45	251106	Grierson	19	11	snd	A
33	C4-29	193072	McFarland	6,7,8	12	snd	A
34	Ø5-21	245113	Folly	19	12	snd	A

PIT LOCATIONS IN
HUNTLEY TWP.

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	A5-44	213215	Gilchrist	14	1	snd	A
2	Ø5-9	248147	Spratt	2,3	2	snd,grvl	Active
3	Ø5-74	237164	Black	6	2	snd,grvl	A
4	Ø5-85	231136	Paul	3,4	4	snd	A
5	Ø5-130	217149	Cox	6,7	4	snd,grvl	A
6	Ø5-6	255134	Rothwell	1	3	snd,grvl	A
7	Ø5-2	255135	Spratt	1	3	snd	Active
8	Ø5-47	250140	Reed	2	3	snd	Active
9	Ø5-50	251140	Walker	2,3	3	snd	A
10	Ø5-53	247144	Burke	3,4	3	snd	Active
11	Ø5-46	246146	Rump	4	3	snd	Active
12	Ø5-63	239149	McCoy	4	3	snd	A
13	Ø5-118	241151	Redbourne	5	3	snd,grvl	A
14	Ø5-48	236154	Marshall	5	3	snd,grvl	A
15	Ø5-51	239152	Mulligan	5	3	snd,grvl	A.O.D.
16	Ø5-49	231158	Cowan	6	3	snd,grvl	Active
17	Ø5-101	221173	Irwin	9	3	snd	A
18	Ø5-120	218177	Francon	10	3	snd,grvl	A
19	A5-104	214181	Deugo	11	3	snd,grvl	A
20	A5-76	175228	Saddler	21	3	snd,grvl	A
21	Ø5-45	534291	N.C.C.	21	3	snd,grvl	A
22	Ø5-3	220120	Bova	3,4	5	grvl	A
23	Ø5-116	219130	Manchester	4	5	grvl	A
24	A5-88	191151	McGee	10	5	snd	A
25	A5-93	188156	Revtor	11	5	snd	A
26	A5-113	175163	Bayliss	12,13	6	grvl	A.O.D.
27	A5-82	165116	Shaw	13	6	grvl	A
28	A5-45	167159	Dolan	14	6	grvl	A
29	A5-27	179134	Howie	8,9	7	grvl	A
30	A5-6	158147	Diblee	13	7	grvl	A

PIT LOCATIONS IN
HUNTLEY TWP.

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
31	A5-95	157158	Scott	14	7	snd	A
32	A5-42	147166	Armstrong	16	7	snd	A
33	A5-79	124191	Green	23	7	grvl	A
34	A5-70	167116	Carter	8	8	grvl	A
35	A5-84	167119	Bassett	8	8	grvl	A.O.D.
36	A5-71	165125	Burke	9	8	grvl	A.O.D.
37	A5-85	163130	Howie	10	8	snd,grvl	A
38	A5-91	160139	Spratt	11	8	snd,grvl	A.O.D.
39	A5-110	120179	Lillie	21	8	grvl	A.O.D.
40	A5-19	113195	Green	23	8	snd,grvl	A
41	A5-86	167111	Carter	7	9	snd	A
42	A5-5	134146	Egan	15	9	snd	A
43	A5-4	114164	Brown	19	9	grvl	A
44	A5-89	107169	Burke	21	9	snd,grvl	A
45	A5-3	110170	Rayon	21	9	snd,grvl	A
46	A5-28	100179	Ryan	22,23	9	snd	A
47	A5-73	091197	Smith	26	9	grvl	A
48	A5-65	089199	Mongomery	26	9	grvl	A
49	C4-99	180075	Houston	1	10	grvl	A
50	A5-115	121134	Ballard	15	10	grvl	A
51	C4-10	139091	Mehan	8	11	snd,grvl	A
52	A5-2	104135	Carroll	17	11	snd	A.O.D.
53	A5-1	097131	Dept. of Defence	17	12	snd,grvl	A

PIT LOCATIONS IN MARCH TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	Ø5-125	292164	Teron	1	2	snd	A.O.D.
2	Ø5-146	254248	Murphy	14	4	snd	A

PIT LOCATIONS IN MARLBOROUGH TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	K3-113	438915	Mackey	4	3	snd,grvl	A
2	K3-46	438914	Brownlee	4	3	snd,grvl	A
3	K3-88	438918	Bartley	4	3,4	snd,grvl	A
4	K3-5	369956	Taylor	9	7	snd	A

PIT LOCATIONS IN
NEPEAN TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	K3-17	432077	Todd	2	3	snd,grvl	A
2	K3-110	434074	Stinson	2	3	snd,grvl	A.O.D.
3	K3-96	429080	Miller	4	3	snd,grvl	A
4	K3-34	435088	Barrett	4	2	snd,grvl	A
5	K3-16	428084	Barrett	4,5	3	snd,grvl	A
6	K3-102	400084	Johnston Pit	7	4	snd,grvl	Active
7	K3-165	400087	Brazeau	8	4	snd,grvl	A
8	K3-126	415093	Brazeau	8	3	snd,grvl	Active
9	K3-82	412094	Brazeau	9	3	snd,grvl	Active
10	K3-97	410097	Todd Pit	9	3	snd,grvl	A.O.D.
11	Ø5-28	368192	N.C.C.	34	3	snd	A
12	K3-92	402080	Miller	6,7	4	snd,grvl	A
13	K3-76	395079	Gamble	6,7	4	snd	A
14	K3-103	391081	Fallowfield Pit	8	4	snd,grvl	Active
15	K3-78	398091	Brazeau	8,9	4	snd,grvl	A
16	K3-33	395090	Nepean Twp	9	4	snd,grvl	Active
17	K3-62	393089	Nepean Twp	9	4	snd	Dump
18	K3-58	387095	Burnside	11	4	grvl	Active
19	K3-104	391096	Mitchell Pit	11	4	grvl	A.O.D.
20	K3-98	398095	Burnside	11,12	4	grvl	Active
21	K3-56	384098	Clark Pit	12	4	snd,grvl	A
22	K3-57	391105	Brophy	14	4	grvl,snd	A
23	K3-186	389080	Paul	7,8	5	snd	A
24	K3-127	386086	Moody	9	5	snd	A
25	K3-101	384089	Houlihan	10	5	snd	A
26	K3-94	385-088	Osgoode S&G	10	5	snd	A
27	K3-59	382095	Burnside	12	5	snd	Processi: Plant
28	K3-55	381098	Burnside	12,13	5	snd	Processing Plant

PIT LOCATIONS IN

NEPEAN TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
29	K3-48	393105	Smith	15	5	snd	A
30	K3-185	371106	McVicar	15	5	snd,grvl	A

PIT LOCATIONS IN NORTH GOWER TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	K3-19	440071	Finley	1	A	snd,grvl	A
2	K3-20	444070	Scharf	2	A	grvl	Active
3	K3-93	477033	Rasa	13	A	snd	A
4	K3-163	475033	Rice	13	A	snd	Active
5	K3-23	480024	Pratt	16	A	grvl,snd	A
6	K3-153	442062	Scharf	3	1	snd	A
7	K3-104	449056	Moffat	5	1	grvl	Active
8	K3-21	450055	Rutherford	6	1	snd,grvl	A.O.D.
9	K3-60	448051	Rutherford	6	1	snd	A
10	K3-72	455048	Wilson	7	1	grvl,snd	A.O.D.
11	K3-115	457047	Campbell	8	1	grvl	A.O.D.
12	K3-100	400045	Campbell	8,9	1	snd,grvl	A
13*	NG-13	462043	Campbell	9	1	snd,grvl	A
14	K3-116	464043	Wilson	9,10	A,1	snd,grvl	A
15	K3-36	446031	Williams	10	1	grvl,snd	A.O.D.
16	K3-117	463041	Desjardins	11	1,A	snd,grvl	A
17	K3-203	466016	Duhamel	16	1	grvl	A
18	K3-99	488003	Adams	21	1	snd	A
19	K3-25	493984	Lindsay	26	1	snd	A
20	K3-120	498978	Whalen	28	1	snd,grvl	A
21	K3-71	478031	Lewis	14	2	grvl	A
22*	NG-2	479979		25	2	grvl	A
23	K3-22	439996	Craig	17	3	grvl	A
24	K3-135	439995	Craig	17	3	grvl	A
25	K3-164	442991	McEwen	18	3	grvl	A
26	K3-160	450979	Willis	21,22	3	grvl	A
27	K3-52	463971	Dobson	24	3	grvl	A
28	K3-73	446961	Wallace	24	4	grvl	A
29	K3-24	450953	Township	27	4	grvl	A
30	K3-172	459921	Crowder	35	4	grvl	A

PIT LOCATIONS IN OSGOODE TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	K3-49	542000	Clelland	27	2	snd,grvl	A
2	K3-174	540003	Ferguson	27	2	snd,grvl	A
3	K3-26	545971	Choinacki	34	2	snd,grvl	A
4	K3-148	549970	Peterson	35	2	snd,grvl	A
5	K3-178	558940	Forbes	42	2	snd	A.O.D.
6	K3-177	553065	O'Rourke	17	3	snd,grvl	Active
7	K3-28	556048	McEvoy	20	3	snd,grvl	A
8	K3-196	556046	McEvoy	21	3	snd	A
9	K3-29	556040	McEvoy	21,22	3	snd	A
10	K3-30	555023	Taylor	25,26	3	grvl,snd	A
11	Ø5-88	543131	Brown Pit	1	4	grvl,snd	Active
12	Ø5-64	544129	Fagon Pit	2,3	4	snd,grvl	A.O.D.
13	K3-170	556080	Burns	14	4	snd,grvl	Active
14	K3-106	557076	Rankin Pit	15	4	grvl,snd	Active
15	K3-197	554071	Loughlin	15	4	grvl,snd	Active
16	K3-27	554069	Tierney	16	4	grvl,snd	Active
17	Ø5-44	550137	Eastview	1	5	snd,grvl	Active
18	Ø5-12	553134	Cahill	2	5	snd,grvl	Active
19	Ø5-32	555130	Stackpole	3	5	snd,grvl	A
20	Ø5-113	555127	McFarland	3	5	snd	A
21	Ø5-33	552124	Stanley	4	5	grvl,snd	A.O.D.
22	Ø5-39	601083	Morris	19	6	grvl	A
23	W7-1	621036	Logan	30	6	grvl	A
24	W7-20	621039	Osgoode Twp	31	6	grvl	A
25	W7-22	623049	Wallace	28	7	grvl,snd	A
26	R9-46	646121	Scharf	6	9	grvl	A
27 *	OS-38	556086	Pyper	14	4	snd	Active
28 *	OS-37	558099		11	4	snd	Active
29 *	OS-39	562086		11	4	snd,grvl	Active
30 *	OS-40	550033		23	3	grvl	A

PIT LOCATIONS IN
OSGOODE TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
31 *	OS-42	541104		7	4	snd,grvl	Active
32 *	OS-43	539102		7	3	snd,grvl	A
33 *	OS-44	542099		5	4	snd	Active
34 *	OS-49	554019		26	3	grvl,snd	Active
35 *	OS-50	552011		28	3	grvl,snd	A

PIT LOCATIONS IN

TORBOLTON TOWNSHIP

	MTC	UTM	NAME	LOT	CON.	MATERIAL	STATUS
1	A5-128	199299		1	3	snd	A
2	A5-127	207308	Younghusband	1	4	snd	A.O.D.
3	A5-119	201340	Murphy	4,5	5	snd	A.O.D.

AGGREGATE TONNAGES FOR
ELEVEN TOWNSHIPS WITHIN
THE REGIONAL MUNICIPALITY
OF OTTAWA-CARLETON

(refer to accompanying map)

LIST OF ABBREVIATIONS

UNIT:		unit on accompanying map
ACREAGE:		lateral extent of gravel bearing deposit
DEPTH:		average overall thickness of unit
TOTAL TONNAGE:		sum of depth and acreage
TONNAGE EXTRACTED:		amount of material removed from unit
%	:	areal percentage of unit extracted
TONNAGE CULTURAL SETBACKS	:	amount of material frozen due to cultural features and property boundaries
%	:	areal percentage of unit frozen
TONNAGE REMAINING:		amount of material remaining in unit after extracted and frozen tonnages have been subtracted
% Grvl	:	percentage of gravel by volume probably contained in unit
AVAILABLE GRAVEL TONNAGE	:	amount of gravel sized material probably contained within unit

Aggregate Within Cumberland Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Economic							
A	33	15	1,197,900	119,790	10	359,370	30	718,740	30	215,622
B	4	5	4,840		0	4,840	100	0	30	0
C	8	5	9,680		0	484	5	9,196	30	2,759
D	48	20	2,323,200	464,640	20	116,150	5	1,742,410	20	348,482
E	30	25	1,815,000	90,750	5	90,750	5	1,633,500	50	816,750
F	133	20	6,437,200	1,287,440	20	643,720	10	4,506,040	35	1,577,114
G	55	15	1,996,500		0	199,650	10	1,796,850	20	359,370
H	240	25	14,520,000	2,904,000	20	1,452,000	10	10,164,000	25	2,541,000
I	10	5	121,000	96,800	80	12,100	10	12,100	20	2,420
	561		28,425,320	4,163,420		2,879,423		20,582,836		5,912,304

Aggregate Within Fitzroy Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL.	AVAILABLE GRAVEL TONNAGE
			Economic							
A	130	25	7,865,000	2,359,500	30	1,179,750	15	4,325,750	25	1,081,437
B	152	10	3,678,400	183,920	5	183,920	5	3,310,560	20	662,112
C	405	20	19,602,000	1,960,200	10	2,940,300	15	17,641,800	15	2,946,270
D	162	3	1,176,120	823,284	70	117,612	10	235,224	40	94,089
	849		32,321,520	5,326,904		4,421,582		25,513,334		4,783,908
			Marginal							
Misc.	290		1,403,600	210,540	15	280,720	20	912,340	40	364,936
	1139		33,725,120	5,537,444		4,702,302		26,425,674		5,148,844

Aggregate Within Gloucester Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
A_1	993	25	60,076,500	42,053,550	70	6,007,650	10	12,015,300	40	4,806,120
A_2	341	20	16,504,400	2,475,660	15	2,475,660	15	11,553,080	20	2,310,616
A_3	80	5	968,000	96,800	10	145,200	15	726,000	15	108,900
A_4	55	20	2,662,000		0	2,662,000	100	0	25	0
A_5	3,246	25	196,383,000	1,963,830	1	176,744,700	90	17,674,470	5	883,724
B	62	20	3,000,800	2,400,640	80	450,120	15	150,040	40	60,016
C	180	25	10,890,000	7,623,000	70	3,267,000	30	0	15	
	4,957		236,484,700	56,613,480		191,752,330		42,118,890		8,169,376
			Marginal							
Misc.	187	3	1,357,620		0	1,357,620	100	0	35	0
	5,144		237,842,320	56,613,480		193,109,950		42,118,890		8,169,376

Aggregate Within Goulbourn Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	%	AVAILABLE GRAVEL TONNAGE
			Economic							
A	714	15	25,918,200	5,183,640	20	5,183,640	20	15,550,920	25	3,887,730
B	322	10	7,742,400		0	7,742,400	100	0	5	0
C	94	10	2,274,800		0	2,274,800	100		15	0
	1,130		35,985,400	5,183,640		15,250,840		15,550,920		3,887,730
			Marginal							
Misc	2,166	2	10,483,440	209,669	2	2,096,688	20	8,177,083	50	4,088,541
	875	3	6,352,500	317,625	5	1,270,500	20	4,764,375	50	2,382,187
	223	4	2,158,640	107,932	5	413,728	20	1,618,980	50	809,490
	647	5	7,828,700	391,435	5	1,565,740	20	5,871,525	45	2,642,186
	540	6	7,840,800	784,080	10	1,568,160	20	5,488,560	45	2,469,852
	360	8	6,969,600	1,393,920	20	2,090,880	30	3,484,800	45	1,568,160
	4,811		41,633,680	3,204,661		9,005,696		29,405,323		13,960,416
	5,941		77,619,080	8,388,301		24,256,536		44,956,243		17,848,146

Aggregate Within Huntley Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Economic							
A_1	446	20	21,586,400	4,317,280	20	3,237,960	15	14,031,160	10	1,403,116
A_2	124	15	4,501,200	3,600,960	80	225,060	5	675,180	20	135,036
B	478	10	11,567,600	578,380	5	2,313,520	20	8,675,700	20	1,735,140
C_1	142	10	3,436,400	171,820	5	412,368	12	2,852,212	30	855,663
C_2	354	10	8,566,800	428,340	5	1,028,016	12	7,110,144	5	355,522
	1,544		49,658,400	9,096,780		7,216,924		33,344,696		5,152,276
			Marginal							
Misc.	2,737	3	19,870,620	2,980,593	15	2,980,593	15	13,909,434	40	5,563,773
	4,281		69,529,020	12,077,373		10,197,517		47,254,130		10,716,049

Aggregate Within March Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Marginal							
A	273	3	1,981,980	39,640	2	495,495	25	1,446,845	25	361,711
B	105	3	762,300		0	152,460	20	609,840	25	152,460
C	25	2	121,000		0	84,700	70	36,300	25	9,075
D	74	3	537,240		0	188,034	35	349,206	25	87,302
E	24	2	116,160		0	69,696	60	46,464	25	11,616
Misc.	56	2	271,040		0	81,312	30	460,768	15	69,115
	557		3,789,720	39,640		1,071,697		2,949,423		691,279

Aggregate Within Marlborough Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Economic							
A	161	8	3,115,960	779,240	25	467,549	10	1,870,176	50	935,088
			Marginal							
Misc.	963	1	2,330,460	23,305	1	233,046	10	2,074,109	70	1,451,876
	236	5	2,855,600	571,120	20	428,340	15	1,856,140	60	1,113,684
	1,199		5,186,060	594,425		661,386		3,930,249		2,565,560
	1,360		8,303,020	1,373,665		1,128,935		5,800,425		3,500,648

Aggregate Within Nepean Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Economic							
A	180	15	6,534,000	1,306,800	20	1,960,200	30	3,267,000	35	1,143,450
B_1	292	25	17,666,000	3,003,220	17	1,766,600	10	12,896,180	35	4,513,663
B_2	683	15	24,792,900	4,958,580	20	3,718,935	15	16,115,385	10	1,611,538
B_3	434	20	21,005,600	3,150,840	15	3,150,840	15	14,703,920	20	2,940,784
B_4	472	35	39,978,400	11,993,520	30	3,997,840	10	23,987,040	50	11,993,520
	2,061		109,976,900	24,412,960		14,594,415		70,969,525		23,346,405
			Marginal							
C	56	5	677,600		0	101,640	15	575,960	40	230,384
D	496	5	6,001,600	120,000	2	1,200,320	20	4,681,280	45	2,106,576
E	62	2	300,080		0	60,016	20	240,064	40	96,025
F	37	2	179,080		0	152,218	85	26,862	60	16,117
G	62	2	300,080		0	45,012	15	255,068	40	102,027
H	99	3	728,640		0	728,640	100	0	40	0
I	93	2	450,120		0	450,120	100	0	40	0
J	49	3	360,640		0	36,064	10	324,576	25	81,144
	954		8,997,840	120,000		2,774,030		6,103,810		2,632,273
	3,015		118,974,740	24,532,960		17,368,445		77,073,335		25,978,678

Aggregate Within North Gower Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Economic							
A	105	15	3,811,500	762,300	20	1,334,025	35	1,715,175	35	600,311
B	37	15	1,343,100	201,465	15	537,240	40	738,705	35	258,546
C_1	229	10	5,541,800	277,090	5	1,108,360	20	4,156,350	10	415,635
C_2	105	20	5,082,000	1,016,400	20	1,270,500	25	2,795,100	25	698,775
D	74	7	1,253,560		0	125,356	10	1,128,204	15	169,230
E_1	248	10	6,001,600	600,160	10	1,800,480	30	3,600,960	5	180,048
E_2	12	10	290,400		0	29,040	10	261,360	20	52,272
E_3	18	10	435,600	87,120	20	43,560	10	304,920	20	60,984
F	130	10	3,146,000	786,500	28	943,800	30	1,415,700	10	141,570
	958		26,905,560	3,731,035		7,192,361		16,116,474		2,577,371
			Marginal							
G	24	3	174,240	34,848	20	130,680	75	8,712	15	1,307
H	31	3	225,060		0	213,807	95	11,253	15	1,688
Misc.	167	3	1,212,420	242,484	20	363,726	30	606,210	40	242,484
	222		1,611,720	277,832		708,213		626,175		245,479
	1,180		28,517,280	4,008,367		7,900,574		16,742,649		2,822,850

Aggregate Within Osgoode Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL.	AVAILABLE GRAVEL TONNAGE
			Economic							
A	348	8	6,737,280	336,864	5	1,347,456	20	5,052,960	10	505,296
B	47	4	454,960	0	0	181,984	40	272,976	50	136,488
C	75	5	907,500		0	45,375	5	862,125	10	86,212
D_1	31	5	375,100	37,510	10	56,265	15	281,325	45	126,596
D_2	124	10	3,000,800	300,080	10	600,160	20	2,100,560	15	315,084
E	31	5	375,100		0	93,775	25	468,875	15	70,331
F_1	757	25	45,798,500	3,663,880	8	11,449,625	25	30,684,995	25	7,671,248
F_2	956	10	23,135,200	1,156,760	5	5,783,800	20	16,194,640	20	3,238,928
F_3	31	5	375,100	7,502	2	187,550	50	180,048	10	18,005
G	229	8	4,433,440	221,672	5	1,551,704	35	2,660,064	25	665,016
H	198	6	2,874,960		0	1,724,976	60	1,149,984	30	344,995
I_1	229	25	13,854,500	831,270	6	3,463,625	25	9,559,605	40	3,823,842
I_2	267	15	9,692,100	387,684	4	2,423,025	25	6,881,391	25	1,720,348
I_3	316	10	7,647,200		0	1,147,080	15	6,500,120	10	650,012
I_4	248	15	9,002,400	2,250,600	25	1,350,360	15	5,401,440	20	1,080,288
I_5	198	5	2,395,800		0	479,160	20	1,916,640	5	95,832
J	378	15	13,721,400	960,498	7	3,430,350	25	9,330,552	10	933,055
K	105	20	5,082,000	3,557,400	70	1,016,400	20	508,200	35	177,870
K_2	440	15	15,972,000	5,590,200	35	6,388,800	40	3,993,000	25	998,250
K_3	173	6	2,511,960	175,837	7	326,555	13	2,009,568	10	200,957
	5,181		168,347,300	19,477,757		43,048,025		106,009,068		22,858,653

cont .....

Aggregate Within Osgoode Township (continued)

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL	AVAILABLE GRAVEL TONNAGE
			Marginal							
Misc.	288	3	2,090,880	41,818	2	418,176	20	1,630,886	30	489,266
	5,469		170,438,180	19,519,575		43,466,201		107,639,954		23,347,919

Aggregate Within Torbolton Township

UNIT	ACREAGE	DEPTH	TOTAL TONNAGE	TONNAGE EXTRACTED	%	TONNAGE CULTURAL SETBACKS	%	TONNAGE REMAINING	% GRVL.	AVAILABLE GRAVEL TONNAGE
			Marginal							
Misc.	56	2	271,040	108,416	40		0	162,624	40	65,050

TOTAL QUATERNARY AGGREGATE RESOURCES WITHIN THE REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

TOWNSHIP	TOTAL ACREAGE	TOTAL TONNAGE	TONNAGE EXTRACTED	TONNAGE MINUS CULTURAL SETBACKS	TOTAL TONNAGE REMAINING	AVAILABLE GRAVEL TONNAGE
Cumberland	561	28,425,000	4,163,000	2,879,000	20,583,000	5,912,000
Fitzroy	1,139	33,725,000	5,537,000	4,702,000	26,426,000	5,149,000
Gloucester	5,144	237,842,000	56,613,000	193,110,000	42,119,000	8,169,000
Goulbourn	5,941	77,619,000	8,388,000	24,257,000	44,956,000	17,848,000
Huntley	4,281	69,529,000	12,077,000	10,198,000	47,254,000	10,716,000
March	557	3,790,000	40,000	1,072,000	2,949,000	691,000
Marlborough	1,360	8,303,000	1,374,000	1,129,000	5,800,000	3,501,000
Nepean	3,015	118,975,000	24,533,000	17,368,000	77,073,000	25,979,000
North Gower	1,180	28,517,000	4,008,000	7,901,000	16,743,000	2,823,000
Osgoode	5,469	170,438,000	19,520,000	43,466,000	107,640,000	23,348,000
Torbolton	56	271,000	108,000	Negligable	163,000	65,000
GRAND TOTALS	28,703	777,434,000	136,361,000	311,840,000	391,706,000	104,201,000

ECONOMIC QUATERNARY AGGREGATE RESOURCES WITHIN THE REGIONAL MUNICIPALITY OF OTTAWA CARLETON

TOWNSHIP	TOTAL ACREAGE	TOTAL TONNAGE	TONNAGE EXTRACTED	TONNAGE MINUS CULTURAL SETBACKS	TOTAL TONNAGE REMAINING	AVAILABLE ECONOMIC GRAVEL TONNAGE
Cumberland	561	28,425,000	4,163,000	2,879,000	20,583,000	5,912,000
Fitzroy	849	32,322,000	5,327,000	4,422,000	25,513,000	4,784,000
Gloucester	4,957	236,485,000	56,613,000	191,752,000	42,119,000	8,169,000
Goulbourn	1,130	35,985,000	5,184,000	15,251,000	15,551,000	2,888,000
Huntley	1,544	49,658,000	9,097,000	7,217,000	33,345,000	5,152,000
March	0	0	0	0	0	0
Marlborough	161	3,116,000	779,000	468,000	1,870,000	935,000
Nepean	2,061	109,977,000	24,413,000	14,594,000	70,970,000	23,346,000
North Gower	958	26,906,000	3,731,000	7,192,000	16,116,000	2,577,000
Osgoode	5,181	168,347,000	19,478,000	43,048,000	106,009,000	22,859,000
Torbolton	0	0	0	0	0	0
TOTALS	17,402	691,121,000	128,785,000	286,823,000	332,076,000	77,622,000

Selected References

Gadd, N.R.,

1963: Surficial Geology of the Ottawa Map-Area, Ontario and Quebec; G.S.C., Paper 62-16.

Hewitt, D.F.,

1963: Sand and Gravel in Southern Ontario; O.D.M., Industrial Mineral Report No. 11.

Johnston, W.A.,

1917: Pleistocene and Recent Deposits in the vicinity of Ottawa, with a description of the soils; G.S.C., Memoir 101.

Minning, G.W.,

open file (map) 118 Surficial Geology, Arnprior, Ontario and Quebec, 31-F-8; G.S.C., open file (map) 1972, scale 1:50,000, Geology 1969, 1970.

Richard, S.H.,

Open File 366 (map) 1976 Surficial Geology, Ottawa, Ontario and Quebec, 31-G-5; G.S.C., open file 366 (map), scale 1:50,000, Geology 1957, 1970, 1971, 1972, 1973.

Richard, S.H., 1976
Open File 365 (map): Surficial Geology, Kemptville, Ontario, 31-G-4; G.S.C., open file 365 (map), scale 1:50,000, Geology 1970, 1971.

Richard, S.H.,
open file 364 (map) 1974: Surficial Geology, Winchester, Ontario, 31-G-3-W½; G.S.C., open file (map) 364, scale 1:50,000, Geology 1970, 1971, 1972.

Richard, S.H., 1976
Open File (Map) 361: Surficial Geology, Carleton Place, Ontario, 31-F-1-E½; G.S.C., open file 361 (map), scale 1:50,000, Geology 1970, 1971, 1972.

Richard, S.H., 1976
Open File 367 (map): Surficial Geology, Russell, Ontario, 31-G-6-W½; G.S.C., open file 367 (map), scale 1:50,000, Geology 1971, 1972.

Richard, S.H., 1976
Open File 362 (map): Surficial Geology, Arnprior, Ontario and Quebec, 31-F-8-E½; G.S.C., open file 362 (map), scale 1:50,000, Geology 1971, 1972, 1973, 1974.

Richard, S.H.,
unpublished map: Surficial Geology, Regional Municipality Ottawa-Carleton; G.S.C., unpublished map, scale 1:100,000, Geology 1970, 1971, 1972, 1973, 1974.