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DEPARTMENT OF MINES

PLEISTOCENE GEOLOGY
OF THE
THORNHILL AREA

By

P. F. KARROW

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Abstract

The Thornhill area is located at the north edge of Metropolitan Toronto, on the north side of Lake Ontario. Although only 35 square miles in area, it has a surface relief of 500 feet, and bedrock relief of over 500 feet; drift thickness generally ranges from 100 to 300 feet, with a minimum of 50 feet and a maximum of nearly 800 feet. The buried Laurentian River valley is cut into Ordovician shale and limestone down nearly to sea level. Pleistocene deposits consist of a subsurface complex of tills and fossiliferous sediments probably ranging in age from Illinoian, through Sangamonian and Early Wisconsinan, to Late Wisconsinan. Surface deposits consist of the drumlinized silty to sandy Leaside Till, of Port Huron age, ice-marginal clay and silt, and deltaic sand. A succession of temporary glacial lakes formed during the retreat of the Ontario ice lobe at approximately 800-825, 750, 680, 600, 550, 465-475, and 420-435 (Lake Iroquois) feet elevation. Deposits of economic interest include glaciolacustrine clay and till-capped sand and gravel.

PLEISTOCENE GEOLOGY OF THE THORNHILL AREA

by

P. F. Karrow[1]

INTRODUCTION

Location and Access

The Thornhill area is situated on the northern edge of Metropolitan Toronto, north of Lake Ontario. It comprises the northern two thirds of the 1:25,000 Thornhill sheet (30 M/14d) of the National Topographic Series, and has an area of about 35 square miles. It is also covered by sheet 30 M/14 West Half (Markham) at a scale of 1:50,000. Portions of the townships of Vaughan and Markham, in York County, are included in the area.

The area extends from longitude 79 degrees 22'30" W. to 79 degrees 30'00" W. and from the northern boundary of the township of North York, and of Metropolitan Toronto, to latitude 43 degrees 52'30" N.

Numerous roads, many of which are paved, cross the area. Provincial highways 7 and 11 cross the area east-west and north-south respectively, and limited access highway 401 lies within three miles of the southern boundary of the area.

Two north-south lines and the new east-west Toronto bypass line of the Canadian National Railways cross the area.

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Manuscript received by the Director, Geological Branch, 10 Jan. 1969. Accepted for publication by the Chief, Industrial Minerals Section, 22 Oct. 1969.

Population and Industry

Located as it is on the edge of Metropolitan Toronto, with a 1967 population of 1,873,012, the area is feeling the growing influence of suburban housing development. Several unincorporated settlements are located in the vicinity of Concord, in the southwest corner of the area, and east of Thornhill, in the southeast. Others are grouped along Yonge St. (highway 11) between Thornhill and Richmond Hill.

Urban communities within the area are Thornhill[1] (population 1,123), Concord[2] (1,061), Richvale[2] (3,392), Langstaff[2] (1,153), and Richmond Hill[2] (19,437).

About a third of the area is thus covered by urban development, the remainder being still rural. Industrial development is as yet slight.

Climate

Climatic data for Woodbridge, obtained from the Meteorological Branch of the Canada Department of Transport are as follows (annual averages):

Precipitation (inches)			Temperature (Fahrenheit)		
Total	Rain	Snow	Maximum	Minimum	Mean
30.07	25.08	49.9	54.4	34.7	44.5

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1. Ontario Dept. of Municipal Affairs statistics, 1967.
2. 1961 Census.

Topography

The highest elevation in the area is 960 feet above sea level, in the northwest corner; the lowest is 475 feet in the southeast along the East Don River. Thus the maximum relief is nearly 500 feet. Most of the area is of low relief, generally about 10 to 20 feet, with greatest local relief of 50 to 100 feet to be found in the northern part of the area and along the East Don River in a strip extending diagonally across the area from northwest to southeast. Elevations generally range from 700 to 800 feet in the north down to 600 or 650 feet in the south.

Drainage

All the area is drained by streams flowing into Lake Ontario. Most of the drainage is tributary to a single stream, the Don River.

The most important stream is the East Don River, which rises in springs in morainic sands southwest and northwest of Richmond Hill. Some of the headwaters are in the map-area, while others are to the north of it. The East Don River has an average gradient of 70 feet per mile in the area, having a very steep slope in its headwaters, but levelling out to a slope of only 25 feet per mile by the time it leaves the area southeast of Thornhill.

The West Don River enters the area from the west at an elevation of 640 feet, and with an average gradient of 18 feet per mile leaves the area at an elevation of 590 feet.

The northeast corner of the area is drained by the Rouge River and one of its tributaries, Beaver Creek, which enters the area from the north at an elevation of 700 feet and leaves it on the eastern edge at an elevation of 620 feet, for an average gradient of 40 feet per mile.

All the streams flow across a partly-drumlinized till plain which is modified in part, by a covering of clay, to lake plain. The northwesterly flowing ice created a broadly-grooved surface which has controlled the development of a parallel consequent stream pattern.

Previous Work

An extensive bibliography on the geology of the Toronto region has recently been published (Karrow, 1967). Many studies, particularly of the Pleistocene geology, have been made in the Toronto district, but very little study specifically on the Thornhill area has been made previous to this one.

Areas adjacent to the Thornhill area which have been recently mapped are: the Bolton area to the west (White, 1964, and in preparation), North York Township to the south (Watt, 1957), and the Scarborough area to the east (Karrow, 1967). The mapping of the Thornhill area was undertaken to fill a gap in coverage and link these prior studies more firmly. A preliminary map of the Thornhill area has been issued (Karrow, 1964).

Important earlier work on the Pleistocene geology of the Toronto area include that of Hinde (1878), Coleman (1933), Watt (1954), and Dreimanis and Terasmae (1958). General physiography has been treated by Chapman and Putnam (1966) and soil mapping for York County has been reported by Hoffman and Richards (1955).

Studies of the bedrock geology by Caley (1940), Liberty (1964a and 1964b, and 1969), Sanford (1961) and Sanford and Quillian (1959) have included the Thornhill area.

Field Work

Mapping of the area was carried out in the summer of 1964. All available cuts, excavations, sand and gravel pits, and river bank exposures were examined, and numerous auger holes and test pits were made by hand. All water and gas wells for which information was available were field-checked for location to derive information on the bedrock topography. Some supplementary information on subsurface materials was obtained from test-borings for water and engineering purposes. Updating of water well data by office compilation was carried out in January, 1968.

Acknowledgments

Helpful field assistance was provided by R. A. Fisher and W. D. Morrison.

Information and assistance received from the following was much appreciated: Ontario Water Resources Commission, Ontario Fuel Board, Geological Survey of Canada, International Water Supply, Department of Highways of Ontario, Canadian National Railways, Metropolitan Toronto Region Conservation Authority, the Township of Vaughan, the Township of Markham, and the town of Richmond Hill. Numerous individuals helpfully provided access to private land.

Laboratory analyses were carried out by the Laboratory Branch, Ontario Department of Mines.

PALEOZOIC GEOLOGY

Ordovician

Although bedrock does not outcrop anywhere in the Thornhill area, it is known from regional relationships and wells drilled to bedrock that the area is mostly underlain by shale of Upper Ordovician age.

The nearest outcrops of the local shale are to be found to the west, south, and east of the Thornhill area. To the west about five miles, in the vicinity of Woodbridge, interbedded limestone and shale of the Georgian Bay Formation are exposed in the banks of the Humber River. The same rocks are exposed along the Don River north of Danforth Avenue in the city of Toronto, about 10 miles south of the area. Twenty miles to the east, along the Rouge River in the Scarborough area, the next older rock unit, the Whitby Formation, is exposed; it consists of dark gray to black shale (Liberty, 1964b; Karrow, 1967). The contact between the Georgian Bay Formation and the Whitby Formation is believed to lie close to the Rouge River in the Scarborough area.

Underlying the shales of the Georgian Bay and Whitby formations are the Middle Ordovician (Trentonian) limestones of the Lindsay Formation (Liberty, 1964a). The nearest outcrops of the Lindsay are a considerable distance north and east of the Thornhill area (e.g. near Oshawa). The Whitby-Lindsay contact is a relatively prominent one, readily recognizable in the surface and subsurface. Comparison of the bedrock topography and structure contours on the top of the Lindsay, as interpreted from gas wells in and near the area, indicates that limestone extends as a subcrop along the bottom of a deep buried valley west of Thornhill. Indeed, the buried valley must be cut down into the limestone in this vicinity 100 feet or more. One can further conclude that the limestone subcrop probably extends south into North York township to the vicinity of highway 401; this represents an extension of the Lindsay subcrop southward some ten miles farther than previously shown (Liberty, 1964a).

By using the top of the Lindsay as a reference datum, the Whitby-Georgian Bay contact can also be located approximately, 290 feet above the Lindsay, and is shown on the accompanying map where it can be seen to cross the area.

Gas wells which have been used to reconstruct the Whitby-Lindsay-Georgian Bay contacts are given in the accompanying table:

Name	Location	Ground elev.	Rock elev.	Top of Lindsay	Year
Henderson-Ash No. 1	Vaughan tp. C.III,L.11	648	450	128	1923
Sir D. Mann	Vaughan tp. C.III,L.13	694	404	134	1933
Page No. 1	Vaughan tp. C.I,L.33	680	39		1908
Page-Ogletree	Vaughan tp. C.I,L.33	653	53		1932
Bond-Cockwell	Markham tp. C.IX,L.4	536	333	156	1949
Durham No. 1	Whitchurch tp. C.I,L.64	975	315	275	1926

All but the two wells on the Page farm encountered shale over limestone; the Page wells, located as they are along the trend of a deep buried bedrock valley, can be inferred to have penetrated limestone directly. The special importance of the old Page well, both because of its excessive depth to rock and the buried wood encountered at depth, was pointed out by Coleman (1933). Because of this special importance, extra care was taken to locate the well in the field on the basis of inquiry from local residents. The writer feels the location so determined is reliable; independent confirmation of the deep valley is provided by the second Page well located near Bathurst Street. B. V. Sanford, of the Geological Survey of Canada, showed the author sample cuttings from the old Page well and confirmed the inference that the well entered limestone directly, instead of passing through shale first. Mr. Sanford has provided the following log of the Ordovician sequence from the rock cuttings of this well:

0-641	Pleistocene and Recent.
	<u>Trenton Group</u> - <u>Cobourg Formation</u>:
641-725	Limestone, medium, grayish-brown, slightly argillaceous, aphanitic; contains interbeds of light tan, bioclastic limestone and calcarenite; few gray shale partings. Limestone is oolitic at base.
	<u>Sherman Fall Formation</u>:
725-775	Limestone, light gray-tan and blue-gray, coarsely bioclastic and fragmental; minor interbeds of medium gray calcareous shale.
775-800	Limestone, medium grayish-brown, argillaceous, finely crystalline; fair number of dark gray shale interbeds; scattered zones of light tan and dark gray mottled fragmental limestone.
	<u>Kirkfield Formation (?)</u>:
800-845	Limestone, medium grayish-brown, aphanitic, minor interbeds of light gray-tan, coarsely crystalline bioclastic limestone.
845-900	Limestone, light gray-tan and brown mottled, coarsely bioclastic; contains abundant interbeds of dark gray calcareous shale.
900-1031	Limestone, medium brown, aphanitic, and limestone, gray-tan and brown mottled, coarsely bioclastic; minor interbedded dark gray calcareous shale.
	<u>Black River Group</u> - <u>Coboconk Formation</u>:
1031-1070	Limestone, light brown, finely crystalline to aphanitic. (Much of sample is composed of light gray, finely crystalline dolomite containing numerous imbedded quartz grains - lithology identical to basal part of Black River section; consequently some of this sample material may be out of stratigraphic sequence.)
	<u>Gull River Formation</u>:
1070-1100	Limestone, medium grayish-brown, finely crystalline to aphanitic, slightly argillaceous here and there.

1100-1160	Limestone, medium grayish-brown and tan, finely crystalline to aphanitic, the latter slightly argillaceous here and there.
	Shadow Lake Formation:
1160-1190	Dolomite, calcitic, light gray to bluish-gray, finely crystalline, containing scattered well-rounded sand to pebble size quartz grains imbedded; minor interbeds of medium brown, aphanitic limestone.
	Precambrian:
1190-1200	Granite.

The log of the Pleistocene section from this well has been given by Coleman (1933, p. 27).

Bedrock topography

An interpretation of the bedrock topography, gained by contouring rock elevations from water and gas wells, is shown on the accompanying map. The dominant pattern is that of a deeply dissected rock plateau with relief of about 500 feet. Deep main valleys trend northwest-southeast through the area, with smaller tributary valleys at right angles to them.

Bedrock uplands generally range from 400 to 500 feet above sea level, with the highest parts being in the north-central part of the area. Information on rock elevations to the north of the area is very sparse, but suggests a gradual rise to the northeast. Recent information indicates a general rise westward toward the Niagara Escarpment in the Bolton area. All available information, however, indicates a continuation of the relatively high-relief rock surface in all directions beyond the area (Deane, 1950; Dreimanis, 1953; Watt, 1957; Rogers, Ostry, and Karrow, 1961; Karrow, 1967; White and Morrison, 1968).

The most prominent buried valley is the one west of Thornhill, which is believed to be a portion of the so-called Laurentian River valley (Spencer, 1888). This valley has been interpreted as a major segment of the pre-glacial drainage system of the Great Lakes region, carrying water from the upper Great Lakes basin via Georgian Bay to Lake Ontario. In the Thornhill area, the valley is cut nearly to sea level and is believed to enter the area from the northwest near Maple (White and Morrison, 1968), trend southeast between Concord and Thornhill to Steeles Avenue, and swing abruptly east to join the deep valley shown by Watt (1957) and Rogers, Ostry, and Karrow (1961) along the course of the present Don River valley; to the southeast it probably reaches Lake Ontario in western Scarborough. The part reaching down almost to sea level west of Thornhill may have been scoured more deeply by glaciation, since it parallels the flow direction of ice of the Ontario lobe in this vicinity. Several tributary valleys at right angles to this seem much smaller and may have remained relatively protected from glacial scour. Also, other portions of the Laurentian valley may have somewhat higher basal elevations if they did not trend parallel to regional ice movement direction.

Two other prominent valleys trending northwest-southeast are situated west of Concord (corresponding approximately to the present West Don valley) and in the northeast part of the area between Richmond Hill and Beaver Creek.

PLEISTOCENE GEOLOGY

Drift thickness

Drift thickness is recorded directly from water and gas wells that reach rock, and is inferred from comparison of bedrock topography and ground surface topography. The thickest drift occurs along the deep, buried Laurentian valley where measured depths of over 600 feet occur west of Thornhill. Farther northwest along this buried valley, for instance near Maple, inferred depths of 700 or 800 feet are encountered. Along the buried valley west of Concord, depths to rock as great as 380 feet occur.

The shallowest depths to rock have been recorded where modern valley bottoms are situated away from the ancient buried valleys. Thus in the southeast part of the area, a few wells have gone only 50 to 75 feet to strike shale bedrock.

Generally however, drift thickness is between 100 and 300 feet. Rock is therefore generally of no interest for engineering purposes but is often encountered in deeper water wells. Because of the relatively high bedrock and surface relief, drift thickness is unusually variable.

GEOMORPHOLOGY

General

As might be expected from its small size, there are only a few types of landforms present in the Thornhill map-area; they are dominantly forms associated with glaciation. The area includes parts of three of Chapman and Putnam's physiographic regions - viz. Oak Ridges, South Slope, and Peel Plain. Most of the area is included in the Peel Plain.

Drumlins

Most of the area consists of till plain, modified in part to form elongate hills known as drumlins, and partly modified by the former presence of shallow glacial lakes to bevelled till plain and lacustrine clay plain. All the drumlins are formed of the youngest till sheet, the Leaside Till.

In all, about 16 drumlins have been noted in the area. Many of these are poorly developed; some, more rounded hills, have not been included. The drumlins of this area are a westward continuation of those described in the Scarborough area (Karrow, 1967). They are not found further to the west however, one in the southwest corner of the area at the intersection of Steele's Avenue and Keele Street being the westernmost of the group. Indeed, the Thornhill area forms a transitional zone between the nearly level clay-veneered plain to the west, and the more prominently drumlinized till plain to the east. A few more drumlins of this field also occur to the south in North York township (Watt, 1957).

The long axes of drumlins lie parallel to the direction of motion of the ice which formed them. The drumlins of the Thornhill area have a uniform trend of about north 45 degrees west; this is regarded as the trend of flow of the Ontario ice lobe as it flowed northwest out of the Lake Ontario basin.

Because of the irregularity and ill-defined form of many of the drumlins in the area, and because of modification of the till surface by later stream dissection, it is not easy to describe the sizes of drumlins present. However, they are most commonly 1/2 or 3/4 mile in length, 1/4 mile wide, and 20 to 50 feet high. Their shape is well shown by the 10-foot contours on the topographic base map of the area.

End Moraine

A small portion of the spur of kame moraine, extending southwest from the main Oak Ridges interlobate moraine, crosses the northwest corner of the area. It consists of thick masses of fine sand, with some patches of gravel, capped by silt till.

Because of active commercial exploitation of the deposit, it is not now known for certain how extensive the till cover was before it was disturbed by man. Certainly in many places the till had been eroded off by natural processes. Relationships in this map-area, and those observed by reconnaissance in the Richmond Hill map-area to the north suggest that much of the roughness of the topography is erosional rather than the result of glacial deposition. A closely spaced series of gulleys cut by consequent streams flowing southeast down the steep south slope of the moraine mass is very evident on the Richmond Hill topographic sheet. This slope is also capped by silt till in part but in many places fine sand underlying the till comes to the surface. Indeed, the main mass of this deposit seems to be sand. Perhaps these permeable sediments yielded water in sufficient quantity to aid substantially, by the process of sapping, the removal of the till cap by surface streams.

Primary morainic topography, complete with kettle lakes (e.g. Philips Lake, Bond Lake, Wilcocks Lake, and St. George Lake) occurs along the crest of the spur in the map sheet to the north (Richmond Hill) but compared to the apparent mass of the deposits underneath, it forms but a minor superimposed feature. Areally, the morainic topography consists of a linear belt which curves in an arcuate pattern with the convex side to the north. It can be traced from north of Stouffville southwest nearly to Maple, beyond which it fades out. Chapman and Putnam (1966) suggest this spur links up with the Trafalgar moraine.

Extensive surface and subsurface studies of the deposits in the vast interlobate complex north of the area will be necessary to unravel the history of this major landscape feature.

Lacustrine clay plains

Nearly level areas underlain by glacial lake deposits account for a large proportion of the map-area. They are more extensive than shown on the accompanying map by the occurrence of lake sediments because these sediments are shown only where they exceed three feet in thickness. The boundary between lake plain and till plain is often vague and ill-defined, particularly in the southwestern part of the area where the original relief of the till surface was slight. Well-defined boundaries are more evident along the valley of the East Don River (see photo 1) and generally in the northeastern half of the area.

As was noted in the Scarborough area to the east (Karrow, 1967) glacial lake sediments tend to be concentrated along the flanks of the major stream valleys. The lake plains are particularly well developed in a belt extending along the East Don River from north of Carrville and Richvale, southeast to Steele's Avenue at Bayview Avenue. Other major areas are: east of Leslie Street and north of Highway 7, extending east to Unionville in the Scarborough area; north and south of Highway 7 in the vicinity of Concord.

The elevations of the lake plains give an indication of the minimum level of the lakes which formed them, there being no features identified as shorelines in the area for obtaining the lake levels directly. The highest of these is the small plain extending up to about 750 feet elevation along Carrville Road at the west edge of the area.

Photo 1. Level lake plain (foreground) with projecting till ridge in the distance, Bathurst Street, south of Carrville.

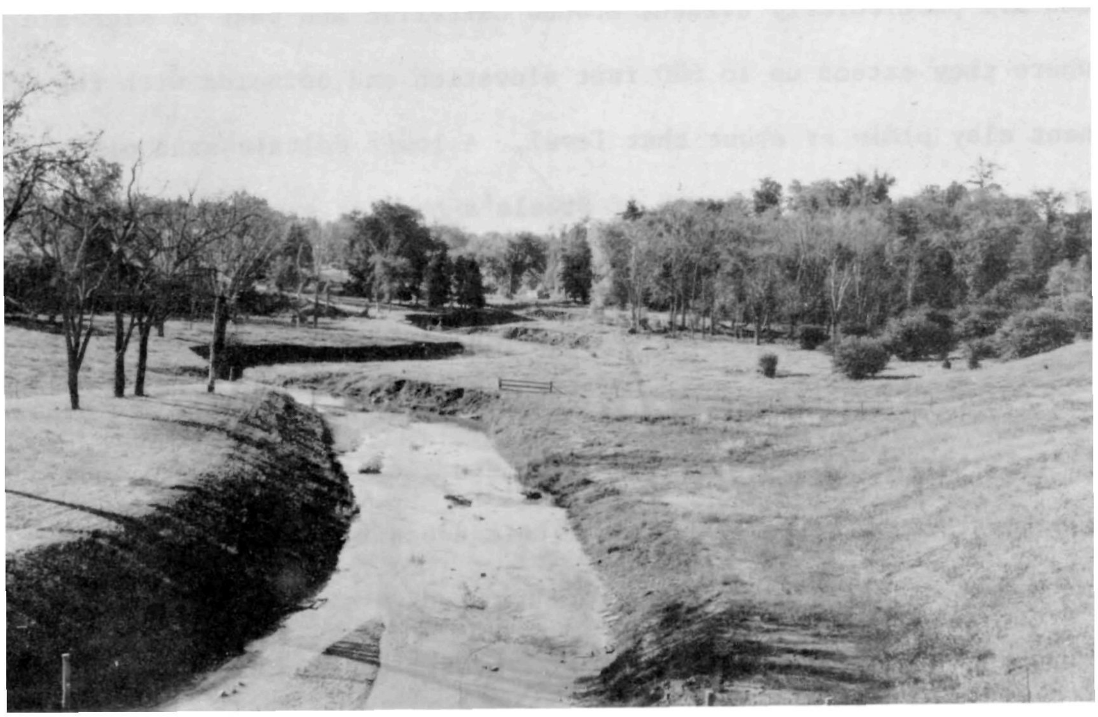


Photo 2. East Don River floodplain, south of Highway 7.

The most widespread clay plain level includes the Concord, Carrville-Richvale, and Unionville clay plains at about 650 to 680 feet elevation. Areas of clay between and below these levels exist but it must be remembered that any area not covered by glacial ice and situated below the level of a particular lake was available for lacustrine sedimentation. Thus the determination of former lake levels from clay plain levels is a highly interpretive procedure and resulting conclusions must be considered as only tentative.

Deltas

Deltas are alluvial accumulations which form where streams enter standing water. Their upper surfaces tend to be nearly level and approximate the level of the standing water. Thus they are often useful in determining the former levels of glacial lakes.

The deltas of the Thornhill area consist of small sand plains and are particularly evident around Carrville and east of Richvale, where they extend up to 680 feet elevation and coincide with the prominent clay plain at about that level. A lower deltaic sand plain occurs along Bayview Avenue, north of Steele's Avenue, extending up to about 550 feet elevation, and indicating a lower lake level.

These deltaic sands have been classified on the county soils map (Hoffman and Richards, 1955) as Fox sandy loam when sands are deep, and as Berrien sandy loam when shallow. Study of the soils map indicates the possible presence of other deltaic deposits outside the map-area: northeast of Elgin Mills (near the north edge of Richmond Hill) at 800 to 825 feet elevation, and apparently corresponding in elevation roughly to the edge of extensive lake clays southwest of Stouffville; sand plain around Unionville at about 600 feet elevation; and at about 525 feet south of Woodbridge along the Humber valley (also in White, 1964).

Lake levels at 525 feet, 465-475 feet, and 420-435 feet (Lake Iroquois) have been recorded by Watt (1957) to the south in North York township. Chapman and Putnam (1966) refer to deltaic sands along the Humber River near Nashville at an elevation of 725 feet.

From all these sources, it is evident there was a succession of temporary glacial lakes formed between the retreating ice front on the south and higher land on the north. The deltas record the action of some of the earliest streams flowing off exposed ground to the north and fed by precipitation rather than glacial meltwaters. The most evident lake levels appear to be 800-825, 750, 680, 600, 550 (probably to be correlated with the 525 level if isostatic uplift is allowed for), 465-475, and finally Lake Iroquois at 420 to 435 feet above sea level. Earlier levels, probably the 725-foot level in particular, have been named Peel Pondings by Chapman and Putnam (1966). As suggested earlier (Karrow, 1963), Lake Peel at a level of about 725 feet probably drained when the ice retreated south of the Trafalgar moraine; therefore the numerous lower levels are younger and shorter-lived water bodies. These lakes were probably long and narrow, paralleling the edge of the ice.

Stream terraces

Abandoned former stream flood plains or portions of channels, now forming elevated stream terraces, are not a prominent feature of the valleys in the Thornhill area. Only in a very few places along the East Don River have small remnants of such terraces been found. These are shown on the accompanying geological map by the occurrence of stream gravel about 15 feet above present stream level. As this terrace level is traced downstream, it appears to correspond to the delta built at 525 to 550 feet, north of Steele's Avenue.

Terraces equivalent to the prominent Lake Iroquois level have not been identified in the area although they are to be expected farther south along the valleys. To the south, terracing is better developed and more evident. A terrace of Lake Iroquois age has been reported along West Duffin Creek in the Scarborough area (Karrow, 1967).

Lower terraces, about 7 feet above the present stream level along the East Don River (see photo 2), and about 5 feet above present stream level along the West Don River, are attributable to deposition in modern times by the present streams. This is indicated by the fact that exposures in the edges of these lower terraces show only alluvial materials, whereas the higher terraces expose glacial deposits under the layer of terrace gravels. These lower terraces are subject to periodic flooding.

The general lack of terraces appears to be attributable to the relative youth of the valleys. The area is situated at or near the headwaters of most of the streams, where terraces are latest developing. Also, the various glacial lake levels apparently were too short-lived to lead to extensive terrace development along the streams flowing into them, although each lake acted as a temporary base level. The only lakes which did have such an effect apparently were the 550-foot level and Lake Iroquois; this suggests that these were the longest-lived of the series.

Swamps and bogs

Undrained or poorly-drained areas are rare in the map-area. A few small areas near the eastern and western extremities of Carrville

Road are swampy and represent residual depressions in the till surface. Numerous others have probably been filled and concealed by glacial lake sediments.

Stratigraphy

General

Stratigraphic information is sparse in the Thornhill area. Only a few stream bank exposures are of significant height and these seldom expose more than one till sheet, which is usually seen to overlie sand. Exposures of multiple till sections are numerous west, south, and east of the area, and a comparable sequence of deposits is believed to underlie the area.

Columnar sections illustrating the available river sections are shown in figure 1. More detailed descriptions of the exposures are provided in Appendix A. Geologic columns for the Toronto and Thornhill areas are given for reference in the accompanying table.

Subsurface sediments

The chief source of information on subsurface sediments is the logs of water and gas wells and a few construction excavations. It is seldom possible to establish the presence of specific stratigraphic units on the basis of the generalized lithologic logs available from wells, but certain inferences are supported by them.

Several records indicate the widespread occurrence of buried plant and animal remains; these appear to be most abundant in bedrock depressions, in which they have apparently been somewhat protected from later erosion, or were perhaps deposited initially in thicker masses in those locations.

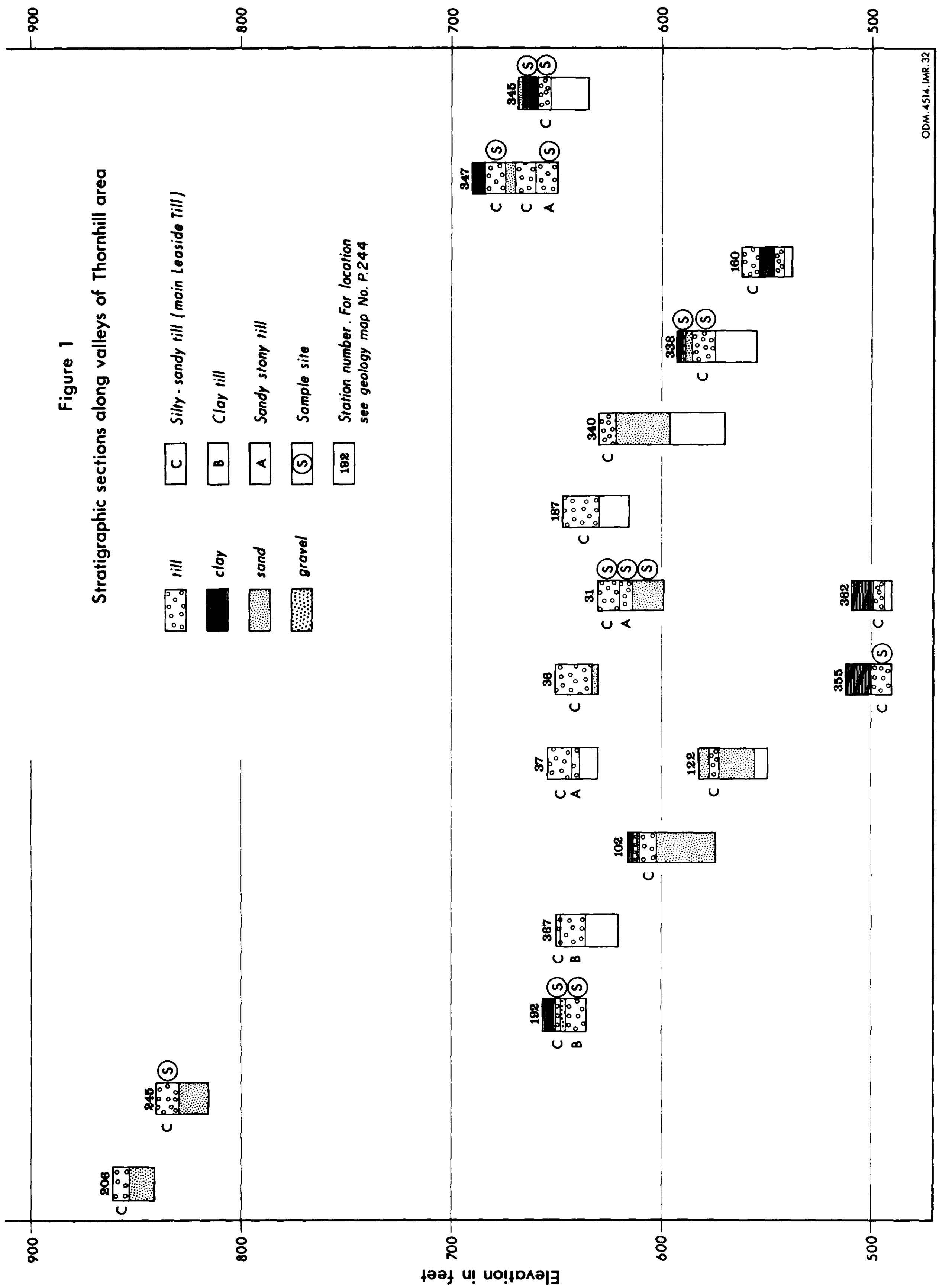


Figure 1

Stratigraphic sections along valleys of Thornhill area

Table of formations for the Toronto and Thornhill areas

	Toronto (Karrow, 1968)		Thornhill
Recent			alluvium
Late Wisconsinan	Port Huron	Leaside Till (upper)	lake deposits Leaside Till clay till? glaciofluvial sands
	Port Huron - Tazewell	Leaside Till (lower) Meadowcliffe Till Seminary Till	sandy till
Middle Wisconsinan	Port Talbot interstade	Thorncliffe Fm.	glaciofluvial sands
Early Wisconsinan		Sunnybrook Till	Sunnybrook Till
	St. Pierre interstade	channel sands	various subsurface fossiliferous units
		Scarborough Fm.	
Sangamonian		Don Fm.	
Illinoian		York Till	

The old Page well went through "sand containing a pine cone, wood and bark, and several species of shells, including both coiled forms and unios" (Coleman, 1933, p. 13) at a depth of 380 feet or an elevation of about 300 feet above sea level. At this elevation, and with this assemblage of fossils, correlation with the interglacial Don Formation, as suggested by Coleman, is quite plausible. Much farther south, elevations on the top of the Don slope down from 340 feet at Davisville and Yonge streets to below 250 feet to the south and east (Karrow, 1968). Strata below the fossiliferous sand in the Page well suggest the presence of older glacial and non-glacial deposits which could be of Illinoian age or older. Illinoian till is probably present, but concealed, under much of the Thornhill area; it is exposed west of the area at Woodbridge, south of the area at the Don Brickyard, and east of the area in Scarborough.

Test holes drilled by International Water Supply Ltd. near Concord, in the southwest part of the area, penetrated sand and silt containing visible plant remains and scattered shell fragments. J. Terasmae identified the following types of pollen (particularly abundant at a depth of 272 feet, or about 385 feet elevation in Vaughan test 1/63):

Tree pollen	% of total tree pollen	Non-tree pollen	% of tree pollen
White spruce	14.4	*Artemisia*	0.5
Black spruce	21.4	Compositae	4.8
Jack pine	42.2	Cyperaceae	3.2
Pine sp.	0.5	Gramineae	0.5
Balsam fir	0.5	Ericaceae	0.5
Birch	13.4	Chenopodiaceae	1.1
Alder	1.6	Unident.	3.7
Oak	2.1	total	14.4
Hickory	0.5	*Sphagnum* spores	15.5
Blue beech and ironwood	2.7	*Lycopodium*	1.1
		Fungus remains	present

Terasmae comments (letter, October 5, 1967): "The assemblage obtained would be in agreement with an interstadial assignment of the beds studied." Shells, identified by A. H. Clarke, Jr., National Museum of Canada, and H. B. Herrington, Westbrook, Ontario, as Zonitoides arboreus Say, Helisoma trivolvis (Say), Pisidium compressum Prime, and Sphaerium striatinum (Lamarck), were recovered from a depth of 273 feet in Vaughan test 3/63. The writer would suggest the correlation of these beds with the Scarborough Formation, which is extensively exposed along valleys which cut below 400 feet elevation to the south and east of the area, and at Scarborough Bluffs; possible correlative beds are also exposed at a higher elevation in the Woodbridge cut (Karrow, 1969).

Two wells were drilled near the Dunlap Observatory, southeast of Richmond Hill, by Jordan Roberts Sales Ltd. in 1933. The western well, situated at the base of the observatory hill and near the Canadian National railway line, encountered wood at a depth of 160 feet (535 feet elevation).

Other well logs indicate alternations of clay and sand several times within the 200- to 300-foot depth of Pleistocene deposits. This is interpreted as consistent with the multiple till sequences known from outside the area. As an example, the following log of surface strata penetrated by the Mann well (Vaughan, Conc. III, Lot 13) was provided by B. V. Sanford:

clay	0-20
sand and gravel	20-40
sand and clay	40-60
clay	60-175
fine quicksand	175-225
clay and gravel	225-270
quicksand	270-275
sand	275-285
clay and sand	285-290
Hudson River shale	290-370
Precambrian at	1175'

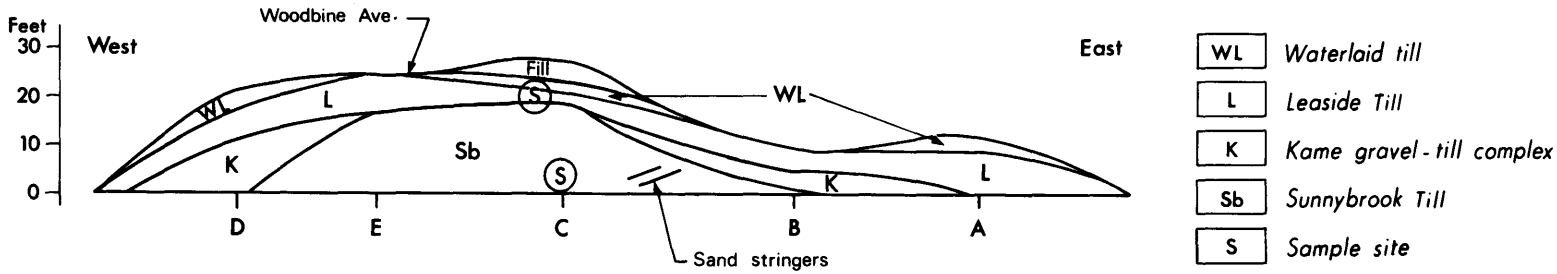
Further test drilling, with adequate sampling, would probably make possible definite correlation of buried till and non-glacial sediments with nearby areas.

Occurrences of an older clay till, probably the Early Wisconsinan Sunnybrook Till, were noted at excavation sites in or near the Thornhill topographic sheet. The first of these is one of the many large cuts made for the recently-completed Canadian National Railways Toronto Bypass. Although about one mile outside of the area to the east, it is included here because of its proximity to the important Markham Sand and Gravel pit section described by Dreimanis and Terasmae (1958), from which peat balls of probable Middle Wisconsinan age were recovered in gravels. The railway cut extends east and west of Woodbine Avenue and provides an extension of the pit exposure located a short distance to the north. A sketch of the railway cut section is shown in figure 2. This section, not yet exposed when the Scarborough area was mapped, reveals Late Wisconsinan sandy Leaside Till overlying Early Wisconsinan clayey silt Sunnybrook Till.

Excavations for the Natural Science Building on the campus of York University, on the southwest corner of Steeles Avenue and Keele Street, open in the summer of 1964, revealed the presence of three superimposed till sheets (O. L. White, personal communication). Only the upper two tills were still exposed when the writer visited the site later--an upper sandy silt till, and a lower sandy gravelly till. The third till, a fine-grained till occurring below the gravelly till, is believed to be the Sunnybrook Till.

A 20-foot deep trench, located three-quarters of a mile northeast of the intersection of Keele Street and Highway 7, revealed a

Figure 2 – Canadian National Railways Bypass cut at Woodbine Avenue



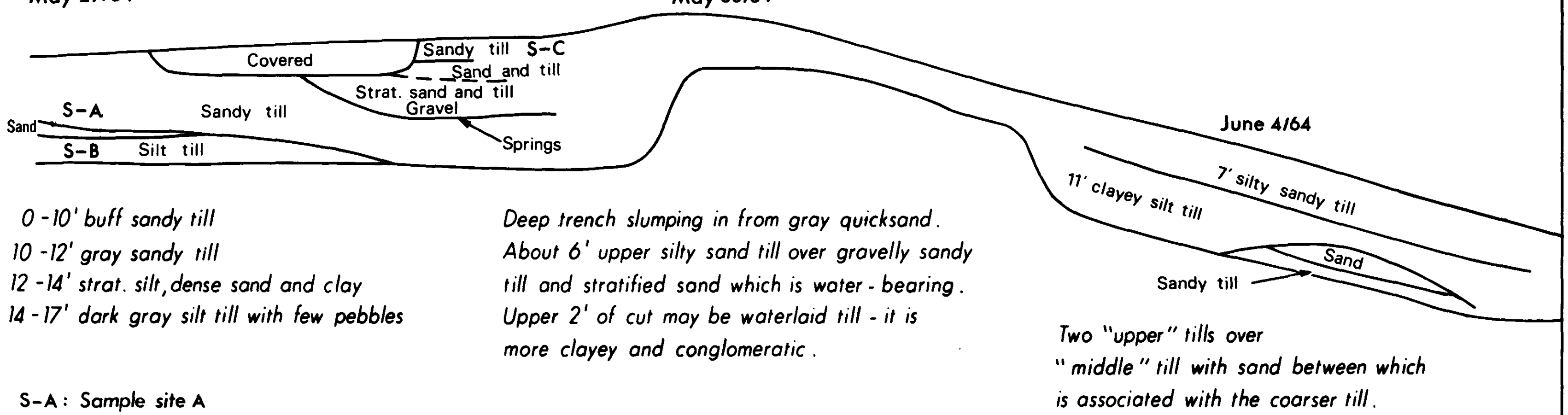


Figure 3 – West Don Sewage Plant trench (T–38)

ODM. 4515, IMR. 32

confusing array of till layers of varying texture, interbedded with sand and silt (figure 3). Fine-grained till underlying sandy surface till is considered to be perhaps Sunnybrook Till; carbonate analysis of the till matrix revealed a low calcite to dolomite ratio, which is typical of Sunnybrook Till. Sunnybrook Till, as studied in areas to the west, south, and east, usually has a carbonate ratio varying from about 0.5 to 1.5.

In summary, rare exposures and test holes reveal the presence of a large assemblage of older deposits which include several till sheets and major occurrences of buried fossiliferous sediments. The occurrence of these beds in the Thornhill-Woodbridge district is probably related to prominent bedrock lows, which allowed a northward projection of the Toronto interglacial sediments.

Interstadial sand

Sand occurs in most parts of the area under the youngest till sheet and is apparently the oldest deposit in the area exposed at the surface. It is believed to represent, in most cases, glaciofluvial or meltwater sediments deposited during an interval of significant ice retreat. It is thought that most of the sands below the youngest till are of roughly the same age, although there is some evidence of possibly several intervals of sand deposition. Because only very careful mineralogical work could sort out the various sand deposits and relate them to specific phases of glacier activity, it is not yet possible to do more than lump the sub-till sands together for mapping purposes.

Nevertheless, it is evident in the field that the sands are not a uniform, homogeneous mass. Thus, sands from the morainic spur west of Richmond Hill are very variable in texture and include gravelly zones.

It is believed this represents an overridden kame moraine. The age and origin of this moraine are unknown, but only the latest till has been recognized on top of it (photo 3). The buried sand ridge has a smaller extension to the southeast down Dufferin Street beyond Carrville Road. The origin of this extension is even more obscure than that of the main ridge.

Individual kame deposits, mostly gravel, occur east of Richmond Hill just north of the map area. These also have been overridden and have a cap of till. The original knoll form has only been smoothed and not destroyed by the overriding.

Along the valleys of the East and West Don, and some of their larger tributaries, sand is often exposed under the youngest till. Most of the sand is variable in texture but is often fine and silty, occasionally with thin brown clay bands.

An excavation for the West Don Sewage Plant, west of Concord, revealed stratified medium sand under two till sheets; some fine gravel was also present with the sand at this site.

In the southeast corner of the area a large, thick deposit of sand underlies one or two tills. Extensive exposures in the Sabiston sand pit suggest a deltaic origin for the deposit. It has been referred to in the report on the Scarborough area (Karrow, 1967) as possibly part of the Mid-Wisconsinan-aged Thorncliffe Formation.

A few analyses of the various sands (figure 4 and Appendix B) indicate they are generally well-sorted fine sands with carbonate ratios in the Middle or Late Wisconsinan range of 2 to 3.5. They are tentatively considered to be of Port Talbot age (25-50,000 years old), at least in part, and to be correlative with the Thorncliffe Formation of the Scarborough area, although no organic remains were found in them which could

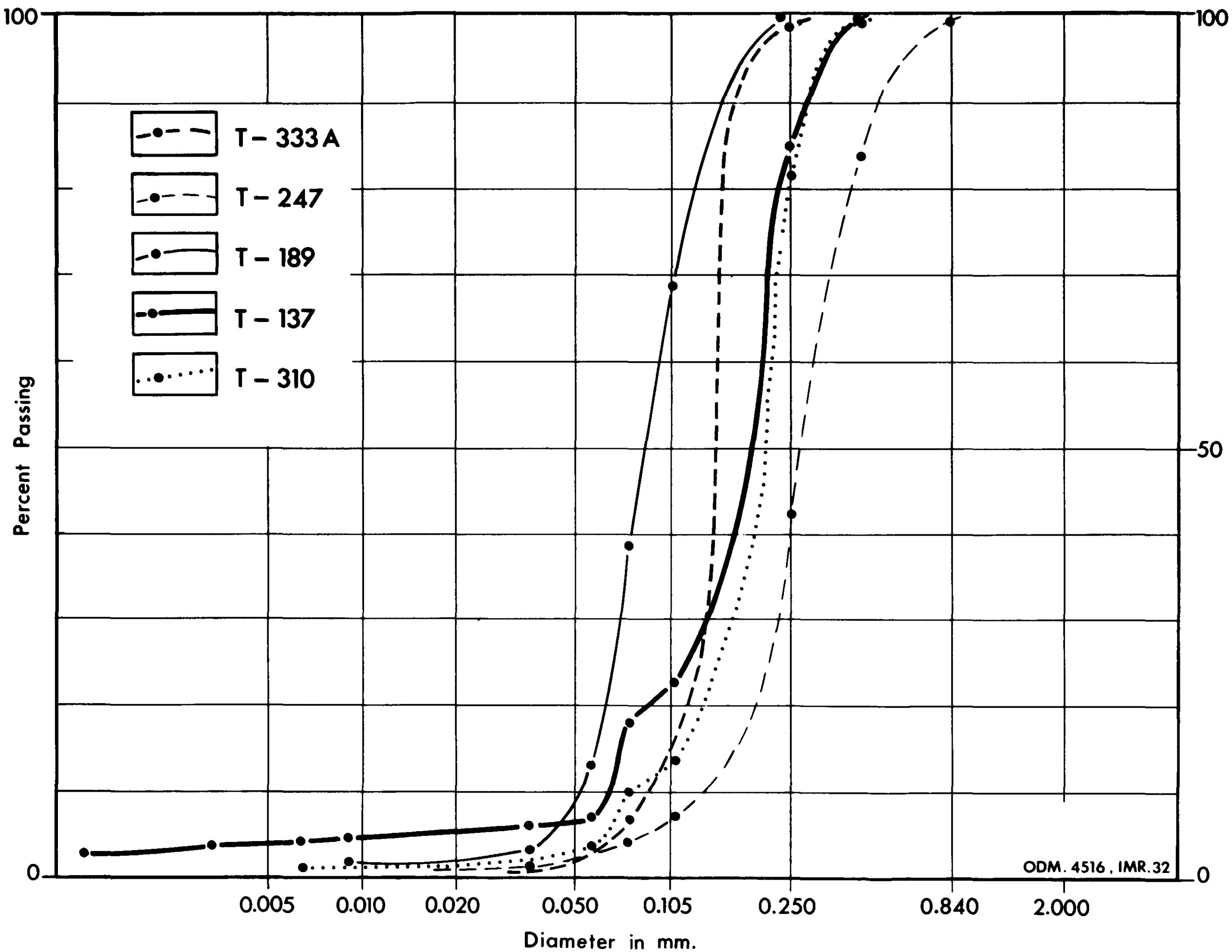


Figure 4 – Mechanical analyses of sand samples, Thornhill area

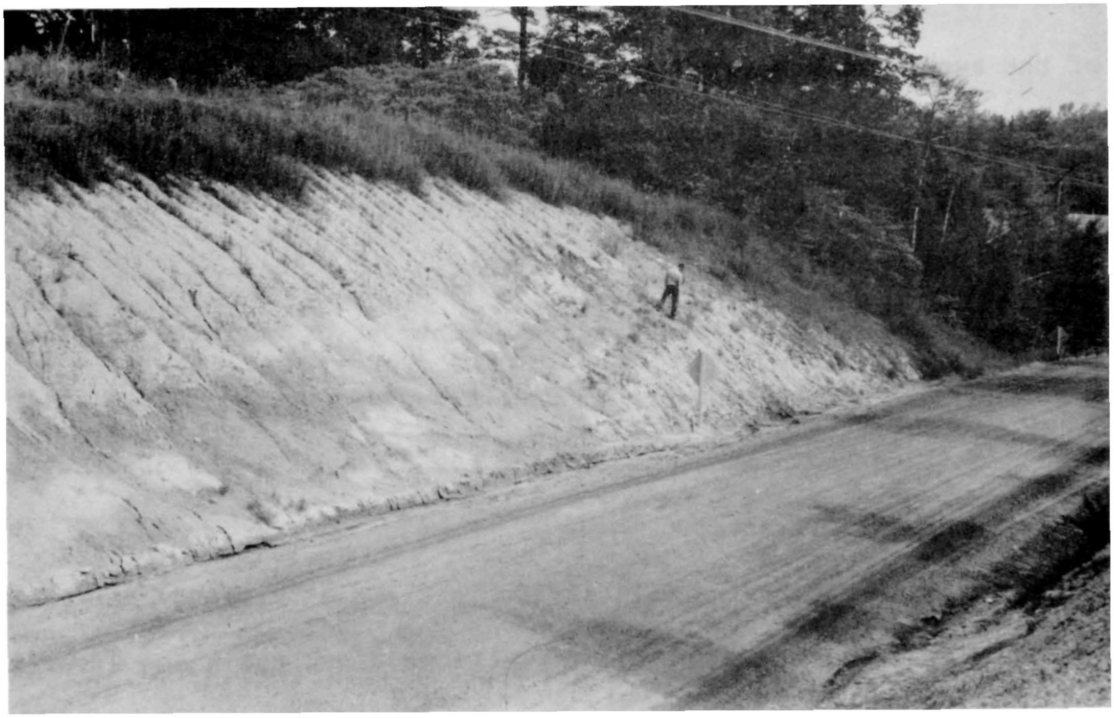


Photo 3. Road cut exposing Leaside Till over sand. Dufferin Street, north of Maple Road and near Department of Lands and Forests Research Station.

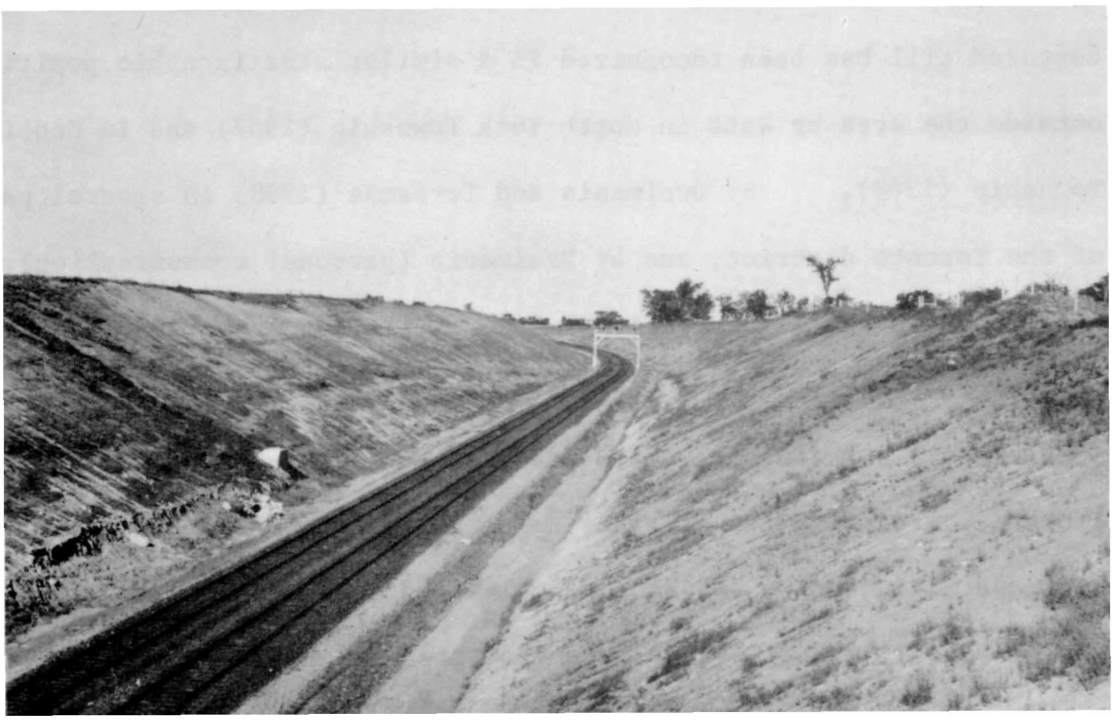


Photo 4. Canadian National Railways Bypass cut in thick Leaside Till west of Yonge Street.

shed more light on this uncertainty. At least some, and perhaps most, of the sands are probably younger, and perhaps date from Port Huron time, about 12,000 to 13,000 years ago.

Late Wisconsinan tills

Tills of Late Wisconsinan age occur at or near the surface over more than half of the map-area. One, and possibly two, older tills have been seen in a few places, underlying the almost ubiquitous sandy to silty youngest till sheet.

The oldest of the till layers is a gravelly, sandy till. It has been observed in the lower part of sections along the Rouge River in the extreme northeast corner of the area, and at several points along or near the West Don River (such as: T-37; T-31, West Don Sewage Plant; and at York University campus excavations). In almost all cases it is directly overlain by the latest Wisconsinan till, which is finer-textured. Coarse-textured till has been recognized in a similar stratigraphic position outside the area by Watt in North York Township (1957) and in Etobicoke Township (1968), by Dreimanis and Terasmae (1958) in several parts of the Toronto district, and by Dreimanis (personal communication) and the writer in the Humber valley. Some similar occurrences of questionable correlation were also noted by the author in the Scarborough area. Similar till was found at the surface at two localities north of the Thornhill area: on the crest of Heise Hill, four miles northeast of Richmond Hill, and on top of a gravel-cored hill two miles northeast of Richmond Hill. These two occurrences appear to be inliers of the older till, projecting upward as hills through the younger, finer-grained till, which is at the surface everywhere else in the district.

Five samples of this till from different localities (see Appendix B) gave analytical ranges and averages of 4 to 11 (7) per cent clay, 17 to 50 (32) per cent silt, 45 to 78 (61) per cent sand; the till matrix contains 16 to 25 (20) per cent calcite, 7 to 12 (9) per cent dolomite, and has a calcite-dolomite ratio of 1.4 to 3.6 (2.2). Pebble counts on two samples indicated the presence of 67 to 82 per cent limestone, 0 to 7 per cent dolomite, 2 to 3 per cent siltstone and sandstone, and 16 to 23 per cent Precambrian crystalline rock types. Among the few samples studied, higher calcite-dolomite ratios in both the till matrix and pebbles occur in the northeast part of the area, and low ratios occur in the southwest. Dreimanis reports (personal communication) that the equivalent till in the Humber valley has a northeast fabric. A northeast fabric (preferred orientation of pebbles in the till) was determined at the Heise Hill locality during this study.

The correlation of this till is rather obscure because of the limited information at hand in the Thornhill area. This till appears to correspond to the till referred to as "middle Wisconsin till" by Watt, and Dreimanis and Terasmae. The writer reaffirms his suggestion (1967) that this till is equivalent to the Wentworth Till (and earlier tills?) of Late Wisconsinan age. As such, it represents the ice advance which brought to an end the long Port Talbot Interstade, of Mid-Wisconsinan age. More work is needed to permit assignment of a specific name to this till unit.

Fine-grained till, older than the youngest till, but believed to be of Late Wisconsinan age, has been seen at a few places in the area. In only one exposure was the possible relationship to the sandy gravelly till, discussed above, revealed; in the West Don Sewage trench (T-38), till of this kind appeared to overlie the gravelly till and underlie the youngest till. Elsewhere this till is only exposed lying below the surface till with no lower units exposed. Samples from such occurrences were taken at T-2 and T-192, which yielded similar analytical results: sand 16 and 17 per cent, silt 35 and 50 per cent, clay 34 and 48 per cent, calcite 22 and 23 per cent, dolomite 5 and 6 per cent, and calcite-dolomite ratios of 3.8 and 4.4. The T-2 locality is a C.N.R. Bypass cut just north of the Sabiston sand pit in which a similar lens of clayey till was noted in 1960 between the sand and the capping of sandy Leaside Till. Another occurrence of possibly correlative till is T-120, but relationships were even less clear in this locality. These four occurrences, none of which is very impressive, constitute the evidence for a fine-grained penultimate till of Late Wisconsinan age. Similar till of this age has not been identified in nearby areas, so for the present these occurrences will be dismissed as representing local units of little regional significance. Future work may be more enlightening on this problem.

The most significant Late Wisconsinan till, because of its general distribution across the area, and obvious continuation into nearby areas, is the youngest till, known in the Toronto area as the Leaside Till. This till can be seen almost anywhere in the area and so more is known about it than any of the earlier deposits. Most till samples from the Thornhill area were taken from this till.

In the field, there are obvious textural variations in the till, from silty sand to clayey silt, which are more clearly defined by size analyses in the laboratory. The till is moderately stony, shale and limestone being the most obvious lithologies present; the dark shale and limestone pebbles contrast sharply with either the unweathered light gray or the weathered light buff color of the till.

Laboratory analyses on 31 samples of the till yielded ranges and averages of 6 to 51 (22) per cent clay, 29 to 62 (45) per cent silt, 4 to 59 (33) per cent sand, 15 to 33 (24) per cent calcite, 2 to 11 (6) per cent dolomite, and calcite to dolomite ratios of 1.8 to 16.5 (4.5). Pebble counts at seven localities yielded 53 to 83 (69) per cent limesone, 0 to 6 (3) per cent dolomite, 0 to 19 (6) per cent shale, 0 to 6 (1) per cent siltstone, 0 to 4 (2) per cent sandstone, and 10 to 28 (18) per cent Precambrian crystalline types. Study of the distribution of these results through the area reveals coarser till extending over most of the area but with a belt of much finer till extending diagonally across the area from the northwest to the southeast corners; this belt approximately coincides with the East Don River valley and it is presumed that this finer facies is associated with a lacustrine environment--the overriding of older lake deposits concentrated along this major valley and/or deposition in standing water during final ice retreat. It has already been pointed out (p. 14) that areas of lacustrine deposition were to some extent concentrated along the future sites of the present valleys. The areal distribution of other parameters is relatively irregular although there is a tendency to higher sandstone percentages among the pebbles along the East Don valley and higher limestone pebble percentages toward the east across the area.

The till is believed to vary greatly in thickness. Most measurements of thickness have been made in river bank sections, where the till is frequently thin. In such locations till has been encountered up to 20 feet in exposed thickness, but often less than 10 feet thick overlying sand. By contrast, between the valleys the till is much thicker in drumlins; as much as 50 feet of till was exposed in deep railway cuts along the C.N.R. Bypass near Yonge Street (see photo 4). The direction of ice movement when this till was deposited is believed to have been northwest out of the Lake Ontario basin. This is indicated by the trend of drumlins in the area (about 135 degrees). Till fabric determinations at a few sites in the Scarborough area (Karrow, 1967) were consistent with this trend. At the West Don Sewage Plant excavation (T-31) a well-striated boulder in the top of the underlying sandy ("middle") till indicated ice overriding (depositing the silty surface till) at 135 degrees.

This till sheet is continuous with the surface till of the Scarborough area and North York township and is thus to be referred to as the Leaside Till. The age of this till is believed to be equivalent to later Mankato or Port Huron (Karrow, 1967). The same till sheet appears to continue westward to the Niagara Escarpment (where it is named Halton Till) and northward up the slopes of the interlobate Oak Ridges moraine.

Glacial lake sediments

Mappable lake deposits, three feet or more in thickness, cover the Leaside Till over approximately half of the Thornhill area. Thinner deposits occur on top of the till over additional large portions of the area. Because the till surface has local relief of several tens of feet where it is drumlinized, areas of relatively deep lake sediments are distinguishable in this area, as they were in the Scarborough area to the east. To the west however, the till surface becomes more nearly level and areas of lake sediments become much more difficult to delineate (O. L. White, personal communication).

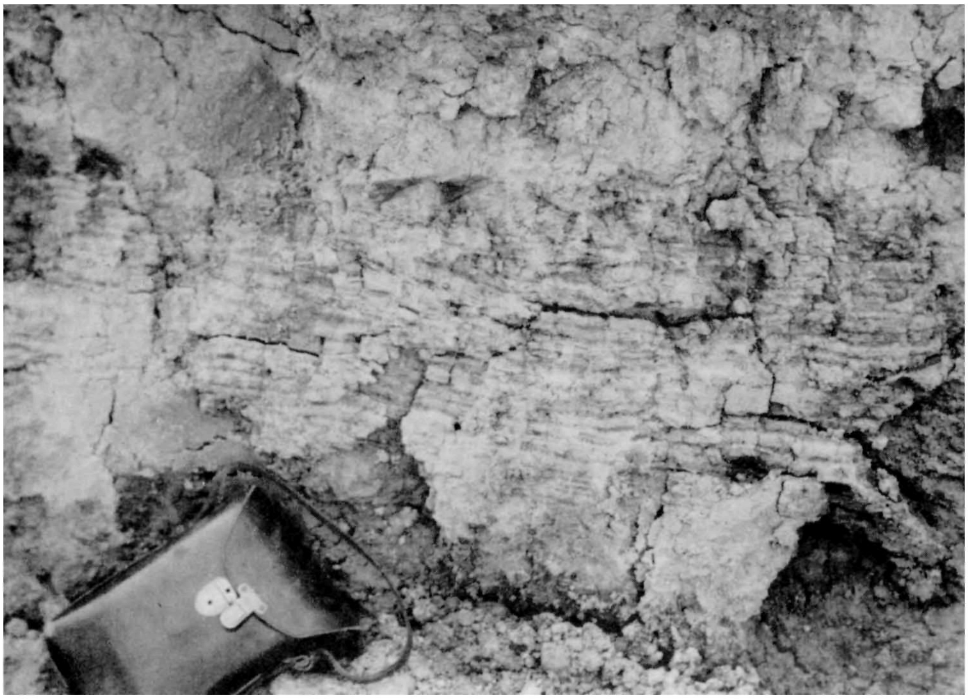


Photo 5. Glaciolacustrine varved clay overlying Leaside Till north of Carrville.

Photo 6. Contorted glaciolacustrine silt, Highway 7 east of Concord.

The lake sediments include a varied complex of materials: varved clay (photo 5), till bands, stratified silt and sand, and many intermediate facies. Often there are layers of the different materials superimposed or interbedded. Varved clays and silts are brown and white in color, and frequently contain pebbles, tilly laminae, and silt and clay balls and chips, the latter a texture often described by the writer as "conglomeratic varves" in the field. Often there is a layer of massive stony clay between well-stratified varves and underlying sandy till, a change of color, as well as texture, from dark clayey material above to buff sandy material below usually marking the contact. At some places there is an indication of a more sandy washed surface on the till. Stratification is variable, and varving in the clays is often not visible until a newly exposed surface has partly dried. Individual varves tend to be thin--1/4 to 1/2 inch being common. The widening of Highway 7 near Concord exposed some of the lake sediments very well (see photo 6); considerable contortion in the stratification was evident which may have been caused by post-lacustrine periglacial frost action of by ice shove while the lake existed.

Shallow-water deposits of deltaic origin occur one or two miles south and west of Richmond Hill and southeast of Thornhill. These deposits, principally fine sand and some silt, were formed where streams entered glacial lakes at various levels. The textural distribution of one sample of deltaic sand is shown in figure 4.

The thickness of the lake deposits is variable, depending primarily on the irregularities of the till surface below. Large areas of lake sediment are only three to five feet thick but greater thicknesses have been observed. A building excavation at the northeast corner of

John and Yonge streets in Thornhill revealed 10 feet of stratified silt and clay over till. Section T-355, near Bayview Avenue along the East Don River, exposed 12 feet of varved clay over till; over 225 varves were present, individually varying from 1/16 to 3 inches thick. Thicknesses of deltaic sand of up to 5 or 6 feet have been noted.

Terrace sediments

Abandoned stream terraces are represented by only a few small remnants about 15 feet above river level along the valley of the East Don River. These deposits consist of a few feet of angular to rounded medium to fine gravel and sand.

Areally more extensive alluvial deposits are to be found on the flood plains of the present streams. These deposits are quite variable, but are most often poorly sorted sand and rounded gravel, frequently with layers of wood and other plant matter and sometimes with mollusc shells. Deposits are less than 10 feet thick.

Peat and muck

Four small areas in the northern part of the area have been mapped as peat and muck. Good peat more than five feet thick occurs northwest of the intersection of Maple Road and Dufferin Street. The depth of this deposit might be as much as ten feet but considerable disturbance has occurred during sand pit operation nearby. East of the corner of Dufferin Street and Carrville Road, one and a half feet of muck overlie one foot of cream-colored marl. A deposit of peat and muck five and a half feet thick occurs one and a half miles east of Richvale. Two miles east of Richvale a muck deposit four feet thick in the east thins to the west to one foot thick over lacustrine silt and clay. These accumulations of partly decayed plant matter have been formed in undrained depressions. Such deposits might have been more abundant had not many of the depressions already been filled by lake sediments during retreat of the ice.

Historical Summary

The stratigraphic record of the Thornhill area is so incomplete and fragmentary that most of the history of the area must be inferred from areas beyond it to the west, south, and east.

Thus, it is probable that the York Till, representing an ice advance during the second last (Illinoian) Glacial Stage will be found at or near the base of the Pleistocene sequence of the Thornhill area. Following this major glaciation, a warm Interglacial Stage (Sangamonian) saw the deposition of fossiliferous sands and clays of the Don Formation in fluvial and lacustrine environments. Rising water levels, probably brought about by an advancing glacier, led to the deposition of a vast delta in the Toronto district (Scarborough Formation), the clays and sands of which enclose cold-climate fossil plants and animals. Temporary ice retreat, tentatively correlated with the St. Pierre Interstade of Quebec (Karrow, 1968) led to the deposition of channel sands at Toronto. The St. Pierre Interstade has a radiocarbon age of 60-to 65,000 years, all the older Pleistocene deposits having ages greater than the range of radiocarbon dating.

A strong ice advance of Early Wisconsinan age covered the area with ice for several thousand years and laid down the Sunnybrook Till. During a long cool interval (Port Talbot Interstade) the area again became free of ice although the ice front probably lay not far north of the Ontario basin. During this interval sand and clay were deposited, in a few places containing cold-climate plant fossils 44,000 to 49,000 years old. Sediments of this age are grouped into the Thorncliffe Formation.

With a return to colder climates, the last great glaciation occurred. Fluctuations during the advance and retreat of this ice laid down several tills of Late Wisconsinan age in the Toronto area, the best represented in the Thornhill area being the Leaside Till. The source of the sandy "middle" till of this area remains unknown. During the final retreat of the ice, a succession of temporary ice-marginal glacial lakes was formed between the ice and higher land to the north. Later, a major glacial lake, Lake Iroquois, occupied the Lake Ontario basin about 12,000 years ago. With the draining of Lake Iroquois as the ice withdrew from the St. Lawrence valley, glacial events came to an end in this region. During the subsequent 10,000 years, stream erosion has dissected the till and lake plains, forming modest flood plains along the valley bottoms.

Economic Geology

The location of the Thornhill area, at the fringe of Metropolitan Toronto urban development, on the one hand focuses attention on any existing or potential mineral resources because of its proximity to large and growing markets, but on the other hand creates a poor outlook for the exploitation of these resources because of the already extensive urban development rapidly covering the area.

Actively exploited mineral resources consist of gravel, sand, and water. Clay resources exist but are not exploited. The *in situ* use of mineral materials will be discussed in the section on Engineering Geology.

Sand and Gravel

Sand and gravel occur as interstadial deposits in the Maple spur of the Oak Ridges interlobate moraine, and as an extensive sheet below the youngest till. Exploitation of the coarser-textured kame complex west of Richmond Hill is carried out by several operators, all but one of which are located outside of the map-area to the north and northwest. Superior Sand, Gravel, and Supplies Limited is the only operator of this group within the area. This deposit is mostly sand with some good gravel at lower levels. A possible extension of the ridge, and perhaps its buried sand and gravel, projects southeastward for a couple of miles to west of Carrville. Heavy overburden will probably limit exploitation in this direction. Surface gravel along this ridge on Dufferin Street is exposed in a small old pit; this gravel could be an inlier of the interstadial sediments, but has been interpreted as younger than the Leaside Till rather than older. The log of the Mann well (p. 21) to the southwest suggests the extension of buried sand and gravel in that direction.

Another interstadial deposit is worked by J. Sabiston Limited east of Thornhill in the southeast corner of the area. This deposit is almost entirely fine sand (see photo 7) and, as with the Superior pit, there is a till capping which must be removed. The location of this pit, within a mile of Metropolitan Toronto in an area rapidly being subdivided for housing will lead to difficulties in extending the operation.

A buried (till-capped) kame just beyond the north edge of the area and one mile east of Bayview Avenue (T-333) probably extends under increasingly heavy overburden southward into the area. It resembles in many ways the Regan pit in Scarborough township, lot 6, concession IV. Another buried kame, 2 miles northeast of Richmond Hill has already been referred to (p.25).

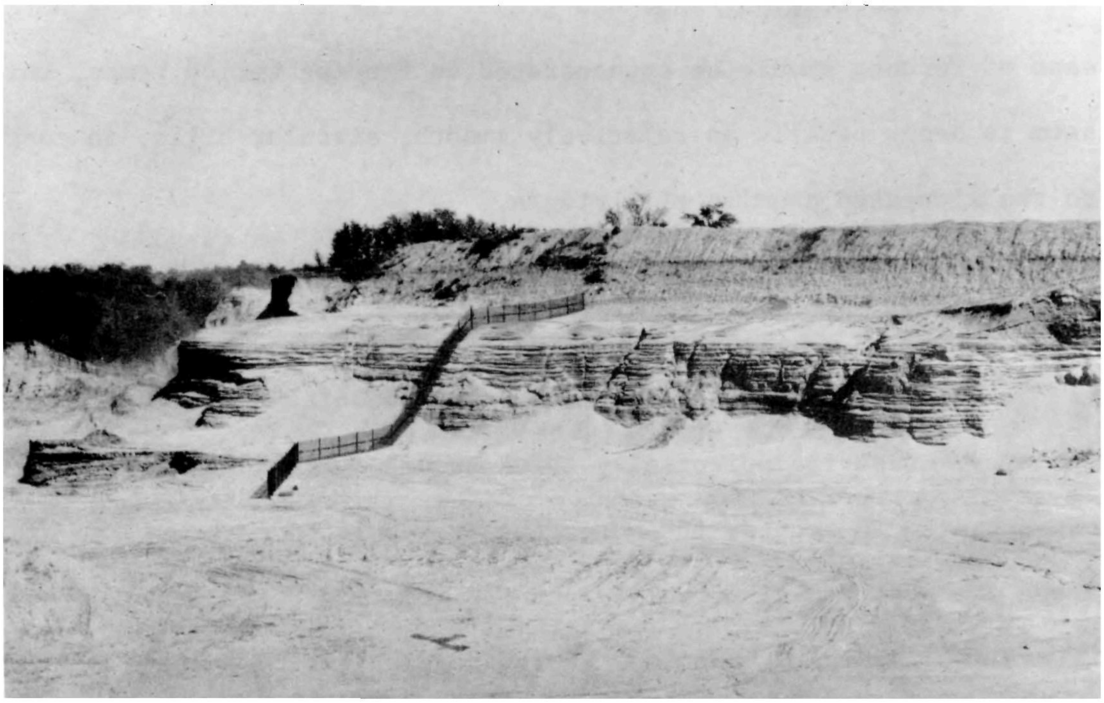


Photo 7. Leaside Till overlying fine sand. Sabiston pit, Thornhill.

Terrace gravels of small extent have been mapped along the East Don River valley. One small abandoned pit was noted in these gravels one mile northwest of Langstaff. These deposits are thin and of limited extent, but are not till-capped.

Further information on some of these deposits has been presented by Hewitt and Karrow (1963).

Prospecting for sand and gravel in the till plain area north and east of Toronto should be concentrated on finding buried kames, which seem to occur usually as relatively smooth, circular hills, in contrast to the elongated drumlin till ridges.

Clay

Clay occurs as sheet-like surface deposits over large parts of the area. Deposits potentially thick enough for working are unfortunately concentrated in or near the more densely populated parts of the area--i.e. along the East Don River valley not far from the Yonge Street transportation axis. Again, appropriate zoning regulations could have made these deposits more readily available for exploitation, as discussed by Hewitt (1962). Useful volumes of clay might be available as a byproduct of construction excavation in the deposits.

Guillet (1967) has described a clay deposit north of Weston, along the Humber River valley, worked by Booth Brick Limited, which probably is comparable in its properties to those of the East Don valley in the Thornhill area. Further study of the clay deposits of the Thornhill area might be warranted.

Water

The Thornhill area, being high and relatively far from Lake Ontario, depends primarily for its water supply on ground sources. Deep wells, many of which penetrate into the shale bedrock, have been drilled in most parts of the area. Indeed, comparison with compilations made 30 years ago, published 20 years ago (Caley, Clark, and Owen, 1947; Hainstock, Owen, and Caley, 1948), reveals a substantial increase in the number of deep drilled wells, no doubt reflecting sharply increased demand in the area. It is not known whether the increased demand has had any great effect on the water table level, but this is assumed to be the case. Progressively deeper water sources have been sought.

The potential aquifers of the area are surface (post-glacial) sands, interstadial sand under the Leaside Till, and sand of the Don Formation and Scarborough Formation.

Surface sands are principally of deltaic origin, consisting of fine sand with some silt. Since the deposits are thin the water potential of this aquifer is limited. Being a surface deposit, and commonly located in the more densely populated districts, it is readily contaminated by surface pollution.

Interstadial fine sand is believed to underlie the Leaside Till over much of the area, and is believed to be one of the principal aquifers. The aquifer is believed to have a sheet-like form and be connected to the exposed kame sand of the Oak Ridges moraine. Probably several major and many minor sand and gravel aquifers of interstadial origin occur in the area but their interrelationships are not known.

Early Wisconsinan and Sangamonian sand of the Scarborough and Don formations are inferred to be present under the area and may be expected to yield abundant water. Their areal extent is unknown.

Large quantities of water are sometimes obtained from the bedrock but it is usually too mineralized (salty) for most purposes. The drift sands remain the best source of good quality water in the area.

Engineering Geology

Areas of glacial till are extensive in the map-area and are generally dependable foundation sites because of the preconsolidation of the till by glacial overriding. Areas mapped as till include thin lake deposits in some areas which will usually be penetrated by any foundation excavation; highway pavement performance may be affected where the clays are not stripped off.

Structures built in areas of lacustrine sands and silts will be subject to settlement because these deposits are normally consolidated. Water problems can be expected in deltaic sand areas at the contact with underlying clay.

Structures at valley crossings may encounter sub-till sands which might be water-bearing. Most older deposits will not be encountered very often; these will all be preconsolidated.

The Leaside Till provides good fill material for embankments. Minor slumping and water problems may be encountered where sand and silt lenses occur in the till.

Waste disposal in the area must take account of groundwater flow systems, about which more must be learned. The placing of waste in permeable materials at high elevations, such as the Maple spur of the Oak Ridges moraine could lead to pollution of a major groundwater aquifer. Till areas, because of their low permeability, and low areas, because of rising water flow, are better sites (Hughes, 1967).

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Appendix A

Descriptions of measured sections

West Don River valley

T-37

footage
0-11 buff silty-sandy till
11-15 sandy, more stony, buff till interbedded with sand bands.
15-24 slump to creek. Elsewhere gray sandy till in upper part.

T-36 borrow pit

footage
0-17 buff sandy silt till
17-20 fine to medium stratified sand and sandy silt. Spoil pile from hole at corner of pit showed gray clay till low in stones.

T-31 West Don Sewage Plant excavation

footage
0-10 buff over gray sandy silt till. Striae on underlying boulder at 135^{o}.
10-16 gravelly coarse sandy orange and gray till.
16-31 gray medium stratified sand. Foreset beds in upper part slope north. Lens of gravel in west face of excavation.

East Don River valley

T-206 Maple Road, west edge of map-area.

footage
0-8 silty till, becoming sandy downward.
8-20 fine stratified sand.

T-245 Dufferin Street, opposite Lands and Forests Station

footage
0-10 buff silt till. Stratified sand and silt bands in lower 4 feet.
10-24 stratified fine to medium sand and silty sand.

T-192

footage
0-6 varved clay and silt. Varves 1/4 to 1/2 inch thick. Silt balls and cobbles distort bedding.
6-8 buff sandy silt till.
8-10 stratified fine gravel, silt, and sand.
10-20 blocky, dark gray, clayey silt till, low in pebbles. Also in creek bed.

T-367

footage
0-2 sandy silt till. Dirty coarse sand at base.
2-14 buff silt till, gray at base.
14-29 slump to creek. Across creek same till to creek level.

T-102 Langstaff Road cut

footage
0-2 varved clay
2-4 stony sandy buff till.
4-5 stratified buff silt and fine sand.
5-13 buff fine sandy silt till becoming sandier to base.
13-41 stratified fine cross-bedded sand.

T-122 West tributary to East Don River

footage
0-5 stratified buff fine sand with brown bands.
5-8 buff fine sandy till.
8-9 fine stratified white sand.
9-10 same till but siltier.
10-27 white and yellow fine stratified and cross-bedded sand. Wet silty bands in lower part.
27-33 slump to creek.

T-355

footage
0-12 varved clay. Counted 225 varves 1/16 to 3 inches thick, thickest at base.
12-22 silt till.

T-362

footage
0-10 thick-varved clay and silt. Thins to north to 5 feet as till rises.
10-16 gray silt till.
16-19 slump to creek.

East tributary to East Don River

T-187

footage
0-18 sandy silt till.
18-32 slump to pond.

T-340

footage
0-6 moderately stony silt till.
6-8 till and sand interbedded.
8-34 stratified dense, fine, massive and cross-bedded sand and silty sand. Few clay bands.
34-60 slump to creek.

T-338

footage
0-3 stratified silt.
3-4 buff sandy silt till.
4-7 medium to coarse sand with till lenses.
7-13 buff, hard, more stony sand till.
13-18 gray sandy to silty till.
18-38 slump to creek.

T-160

footage
0-8 sandy silt till, more clayey and stone-free to base.
8-15 stratified gray clay. Small pebbles in coarse layers.
15-20 interbedded sandy till, silt till, fine sand, and medium sand.
20-23 slump to creek.

Rouge River

T-347 at Headford, 0.3 miles north of map-area

footage
0-6 varved clay.
6-16 brown silty-sandy till.
16-20 fine stratified silty sand.
20-30 brown silty-sandy till.
30-40 stony sandy till.

T-345

footage
0-2 orange medium sand.
2-4 brown disturbed varved clay.
4-5 orange and buff soft sandy till.
5-9 stratified to massive buff silt.
9-11 buff sandy silt till, gray at base.

transfer section south 100 feet.

9-10 stratified fine sand. Old terrace?
10-15 sandy silt till, gray at base.
15-33 slump to creek.

York University

T-352 Northwest corner Natural Science Building.

footage
0-14 sandy silt till. Upper part varved faintly some places.
14-22 variable sandy till with many sandy and gravelly lenses.

APPENDIX B. Till and sand analyses

Locality	Unit	Size analyses Clay %	Silt %	Sand %	Pebble counts Limestone %	Dolomite %	Shale %	Siltstone %	Sandstone %	Crystallines %	Carbonate analyses Calcite %	Dolomite %	Total %	Calcite/Dolomite
T-2U	C	13	37	50							23	9	32	2.6
T-2L	B	48	35	17										
T-2L	B	48	35	17							23	6	29	3.8
T-3	C	18	29	53							26	8	34	3.3
T-5	C	19	39	42							20	11	31	1.8
T-10	C	24	41	35							28	7	35	4.0
T-27	C	15	43	42							22	7	29	3.1
T-31A	C	25	44	31	64	5	1	-	1	28	19	8	27	2.4
T-31B	A	4	28	68	67	7	-	2	1	23	16	10	26	1.6
T-31C	OS	1	4	95							15	8	23	1.9
T-38A	A?	5	50	45							17	12	29	1.4
T-38B	Sb	44	48	8							13	12	25	1.1
T-38C	C	10	45	45							18	5	23	3.6
T-119	C	18	42	40							23	10	33	2.3
T-120	B?	37	54	9							23	2	25	11.5
T-135	C	20	62	18	53	4	19	6	4	14	26	6	32	4.3
T-137	DS	3	5	92							1	0.2	1.2	5.0
T-149	C	9	34	57							33	2	35	16.5
T-169	C	22	42	36	70	1	8	1	4	16	26	6	32	4.3
T-189	KS	1	22	77							13	4	17	3.3
T-191	B?	37	43	20							36	3	39	12.0
T-192A	C	17	43	40							26	8	34	3.3
T-192B	B	34	50	16							22	5	27	4.4
T-245	C	29	46	25							24	5	29	4.8
T-247	KS	0	2	98							12	6	18	2.0
T-255	C	37	55	8							20	6	26	3.3
T-287	C	11	43	46	73	-	3	-	-	24	27	4	31	6.8
T-297	C	17	38	45							26	8	34	3.3
T-328	C	21	54	25	76	5	7	1	1	10	15	8	23	1.9
T-333A	KS	0	3	97	73	-	2	-	1	24	17	5	22	3.4
T-333B	C	17	42	41							31	4	35	7.8
T-338A	C	21	47	32							31	6	37	5.2
T-338B	C	17	44	39							27	9	36	3.0
T-345A	C	6	35	59							22	3	25	7.3
T-345B	C	26	41	33							24	6	30	4.0
T-346	C?	14	49	37	83	-	-	-	-	17	30	3	33	10.0
T-347A	C	17	43	40							26	7	33	3.7
T-347B	A	11	31	58							23	8	31	2.9
T-348	C	12	37	51							23	9	32	2.6
T-352A	C	29	44	27							20	6	26	3.3
T-352B	A	8	35	57							17	10	27	1.7
T-354	C	51	42	7							22	5	27	1.7
T-355	C	29	51	20	64	6	6	-	4	20	24	7	31	3.4
T-360	C	27	56	17							25	6	31	4.2
T-361	C	51	45	4							25	4	29	6.3
T-364	C	27	45	28							25	7	32	3.6
Heise Hill	A	5	17	78	82	-	-	1	1	16	25	7	32	3.6
Woodbine CNR	C	14	34	42							26	9	35	2.9
"	Sb	28	54	18							13	12	25	1.1

Symbols:
- C - Main Leaside Till
- B - clay till
- A - sandy, stony till ("Middle Wisconsin till")
- Sb - Sunnybrook Till
- KS - kame sand
- OS - outwash sand
- DS - delta sand

Notes:
1. clay-silt boundary = 0.002 mm. silt-sand boundary = 0.062 mm.
2. pebble counts on pebbles 1-2 in. diameter.
3. carbonate analyses on till matrix passing 200-mesh sieve, using Chittick apparatus.

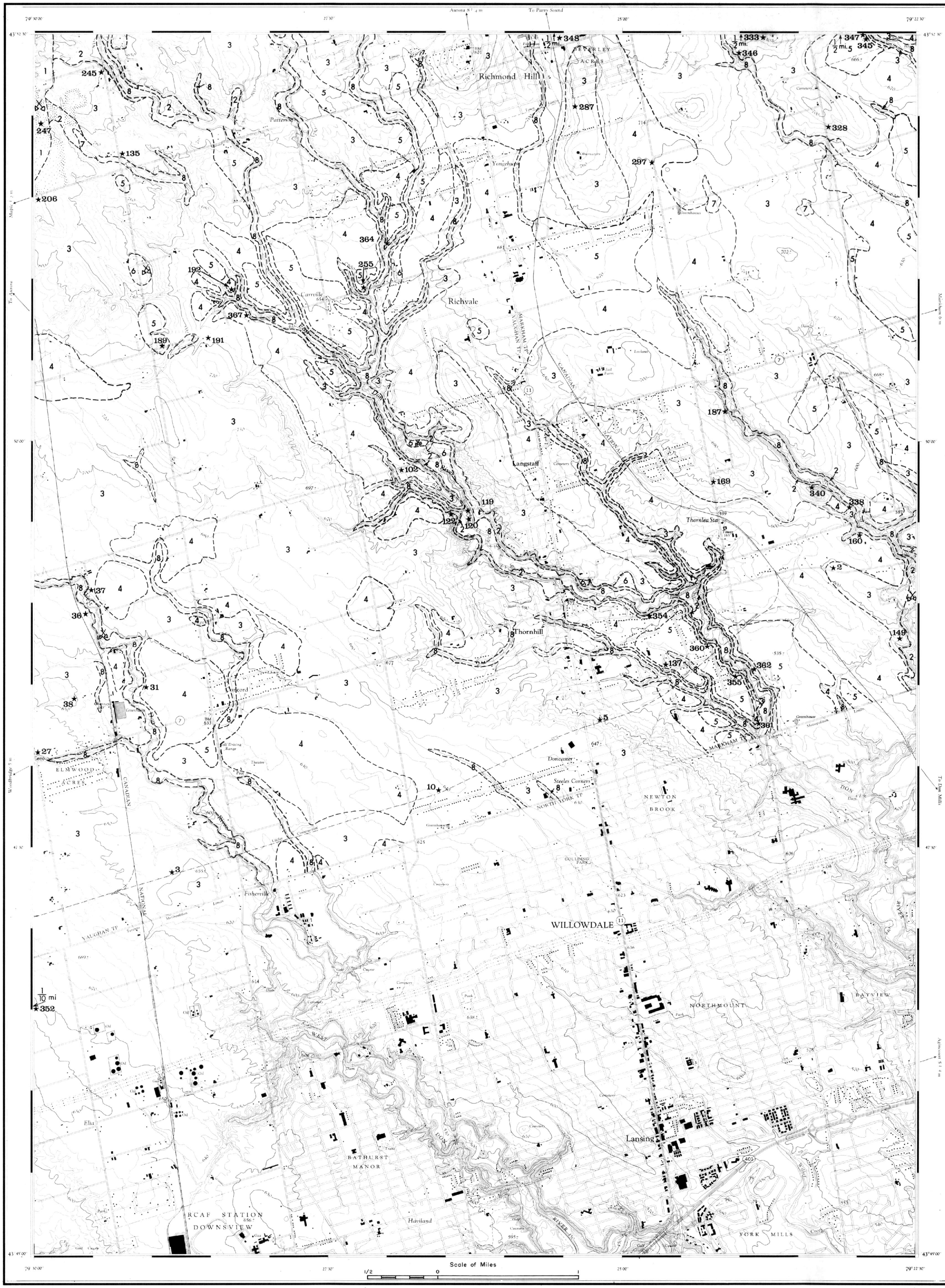
ONTARIO DEPARTMENT OF MINES

PRELIMINARY GEOLOGICAL MAP No. P.244 (Revised)

Pleistocene Geology of the
THORNHILL AREA
YORK COUNTY

Scale 1:25,000

NTS Reference 30M/14d



LEGEND

CENOZOIC

PLEISTOCENE

RECENT

8	Alluvium: modern flood plain deposits of silt, sand, and gravel.
7	Peat and muck.

WISCONSINAN

6	Glacial outwash and old stream terrace deposits: Sand and gravel.
5	Outwash, deltaic, and lacustrine fine sand.
4	Lacustrine silt and clay.
3	LEASIDE TILL: Sandy to silty till.
2	Interstadial outwash, deltaic, and fluvial sand.
1	Kame gravel and sand.

Deposits on this sheet are mapped where they reach three feet or more in thickness. Thinner deposits are not shown.

SYMBOLS

550	Topographic contours.
	Geological boundary, approximate.
	Sand or gravel pit.
★ 135	Sample locality; (see report).

For other conventional signs refer to 1:25,000 National Topographic Map Series.

SOURCES OF INFORMATION

Geology by P.F. Karrow and assistants, 1964, revised 1969.
Topography directly from Thornhill sheet 30 M/14d of the National Topographic Series.

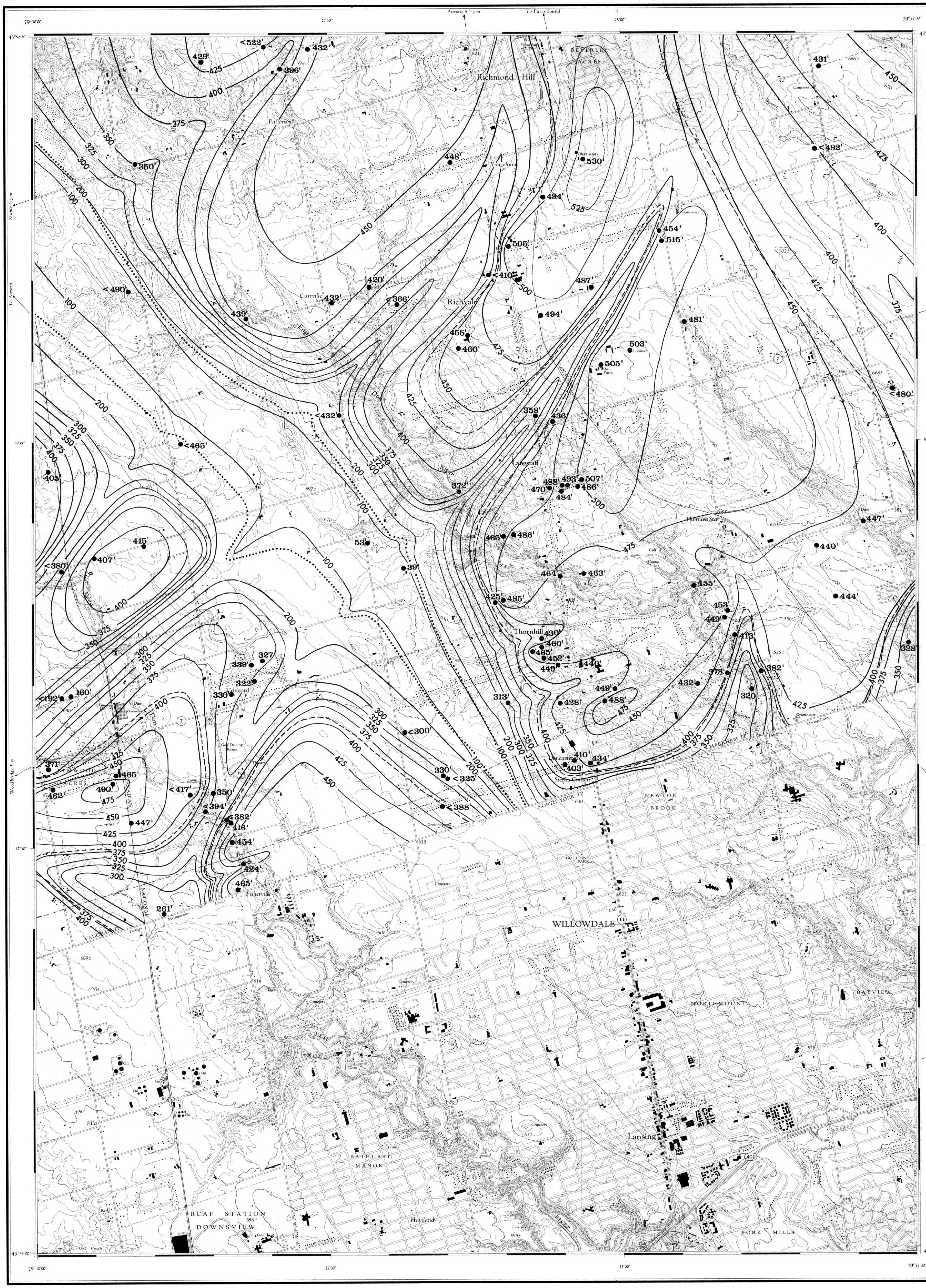
NOTES

For additional information refer to the following sources:

Aerial photography: Forests Resources Inventory, Ontario Department of Lands and Forests; National Air Photo Library, Department of Mines and Technical Surveys, Ottawa.
Bedrock geology: Paleozoic Geology of the Toronto-Hamilton Area, Ontario, J.F. Caley; Geological Survey of Canada, Mem. 224, 1940.
Physiography: The Physiography of Southern Ontario, L.J. Chapman and D.F. Putnam, 1966.
Magnetic declination in the map area was approximately 7°W., 1961.

Issued 1964, re-issued 1970.

ODM 4531, IMR 32



ONTARIO DEPARTMENT OF MINES

PRELIMINARY MAP No. P.574

THORNHILL AREA

YORK COUNTY

Bedrock Topography Series

Scale 1:25,000

NTS Reference: 30 M/14d

LEGEND

● 375' — Well location and elevation of bedrock surface.

● <400' — Well-location, elevation of bottom of hole, bedrock not reached.

500 — Contour with elevation of bedrock surface. Contour interval: above 300 feet elevation--25 feet below 300 feet elevation --100 feet

Contact between Lindsay Formation (limestone) and Whitby Formation (black shale)

Contact between Whitby Formation (black shale) and Georgian Bay Formation (gray shale).

EXPLANATION

This map is based largely on information in the files of the Ontario Water Resources Commission up to January 1968. Other information has been obtained from the Geological Survey of Canada, the Ontario Fuel Board, and the International Water Supply Ltd., Oakville. Not all information obtained from the Ontario Water Resources Commission files has been checked in the field so any errors in the records will be uncorrected.

Bedrock contours are approximate and interpretative. Revisions will be necessary as more information becomes available.

Base map from Thornhill sheet 30 M/14d of the National Topographic Series.

Prepared by P.F. Karrow and assistants, 1968.

Issued 1970.

ODM 4532, IMR 32