Brennand, T.A., 1998. Urban Geology Note: Oshawa Ontario. In P.F. Karrow, and O. L. White (Eds.), Geological Association of Canada, Special Paper 42: Urban Geology of Canadian Cities, p. 353-364.

Urban Geology Note: Oshawa, Ontario

Tracy A. Brennand[1]
Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8

Abstract

Oshawa, located centrally along the north shore of Lake Ontario east of Toronto, is mainly situated on the glacial Lake Iroquois sand plain. Ordovician shale and limestone are only exposed along creeks which cut through 10 to 40 m of drift. Multiple-till sequences known from the lake bluffs at Newcastle to the east, together with intercalated sand and clay, span most of Wisconsinan time, but are poorly known at Oshawa. Water-bearing sands and the search for waste disposal sites are leading problems in the area. A major inter-agency project, centred on the Oak Ridges Moraine north of the city, is yielding new surface mapping and subsurface geologic analysis using a comprehensive computerized data base. Computer-generated bedrock topography and drift thickness maps have been produced, as well as subsurface geologic cross-sections.

Résumé

Oshawa qui est située centre de la rive nord du lac Ontario et à l'est de Toronto ; cette agglomération a été bâtie surtout sur la plaine sableuse de Lake Iroquois. Les couches de schistes argileux et de calcaires ordoviciens n'affleurent que dans le lit des cours d'eau où 10 à 40 m de dépôts glaciaires ont été érodés. Les nombreuses séquences de moraines avec leurs unités de sables et d'argiles intercalaires que l'on peut apercevoir dans les falaises du lac vers l'est, à Newcastle, et qui couvrent presque tout le Wisconsinien ne sont très connues à Oshawa. Les problèmes reliés aux sables saturés d'eau et la recherche de sites de construction de décharges publiques sont les deux principales préoccupations de la géologie urbaines dans la région. Un important projet regroupant plusieurs organismes concernant la Moraine de Oak Ridge au nord de la ville a permis d'accumuler de nouvelles données de cartographie de surface et résultats d'analyse de la géologie souterraine au moyen d'une base de données informatique très détaillée. Des cartes numériques de la topographie du socle, de l'épaisseur des dépôts glaciaires ainsi que des coupes stratigraphiques de la géologie de subsurface ont été réalisées.

INTRODUCTION

Oshawa lies within the Region of Durham (Fig. 1). With a projected population growth rate of about 3% per year (1991-2015), Durham Region may boast a population of some 550,000 by the year 2000 (Region of Durham, 1990), over one quarter of whom will live in the City of Oshawa (personal communication, City of Oshawa, Department of Development and Planning Services, 1994). Such growth places increasing pressure on the urban infrastructure. Geologically informed planning for water supply, sewage and waste

---

[1] Present Address: Department of Geography, Simon Fraser University, Burnaby, British Columbia V5A 1S6

disposal, transportation corridors, industrial plants and structures is increasingly demanded. This note presents an update on our present understanding of the geology in and around Oshawa, urban geological issues, the status of the Oshawa Urban Geology Automated Information System (UGAIS) data base and a new Geological Survey of Canada (GSC) geological and hydrogeological initiative, the Oak Ridges Moraine National Mapping Program (ORM NATMAP) and hydrogeology project and data base.

GEOLOGIC SETTING

The City of Oshawa is located on the Iroquois Plain along the north shore of Lake Ontario (Figs. 1, 2; Coleman, 1936a). The relatively flat Iroquois Plain is bordered to the north by the South Slope and the Oak Ridges Moraine (Fig. 1) (Chapman and Putnam, 1984). The South Slope is drumlinized and gullied. The Oak Ridges Moraine (Fig. 1) is a hummocky, east-west trending, mainly sandy ridge which forms a surface and groundwater divide, as well as a recharge zone north of Oshawa. The wave-washed Iroquois Plain and raised shorelines (Fig. 2) (~150 m a.s.l., north of Oshawa) record the presence of glacial Lake Iroquois, which existed at the end of the Late Wisconsinan (~12.5 ka).

BEDROCK GEOLOGY

Oshawa is built on Quaternary drift which overlies Ordovician Lindsay Formation limestones and Whitby

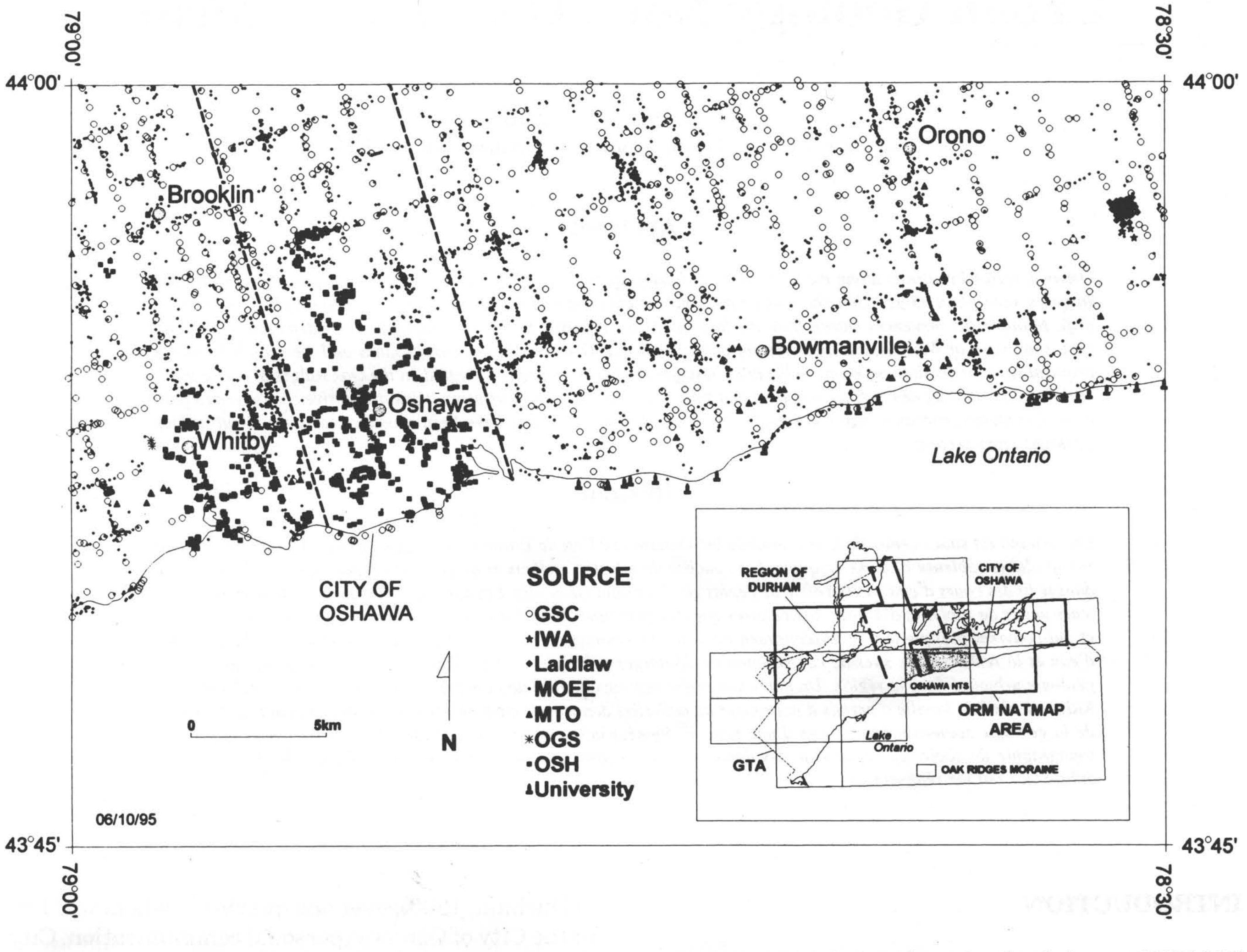

Figure 1. *Distribution of data by source agency from the ORM NATMAP data base in the Oshawa (30M/15) 1:50,000 scale NTS sheet. Extent of the ORM NATMAP and hydrogeology project area, the Region of Durham, and the City of Oshawa inset.* ***GSC****, Geological Survey of Canada surficial geology investigation (Brennand, 1994);* ***IWA****, Interim Waste Authority hydrogeologic investigations; Laidlaw, Laidlaw hydrogeological investigations;* ***MOEE****, Ontario Ministry of Environment and Energy water wells;* ***MTO****, Ministry of Transportation Ontario geotechnical reports;* ***OGS****, location of bedrock exposures from Holden* et al. *(1993);* ***OSH****, Oshawa UGAIS geotechnical boreholes within 30M/15;* ***University****, geological logs from Brookfield* et al. *(1982).*

Formation shales (Fig. 3). Bedrock topography has been reconstructed from an interpretation of water well logs, geotechnical and hydrogeological boreholes and bedrock exposures (Fig. 1; see also Holden *et al.*, 1993). Figure 3 differs from the previously published bedrock topography map (Holden *et al.*, 1993) in that: (i) there are some different interpretations of water well data resulting in differences in the location and/or elevation of bedrock in some wells; (ii) there are differences in the additional geotechnical boreholes used in the reconstructions, (*e.g.*, more boreholes were used to reconstruct the Oshawa bedrock interfluve in Figure 3 (A, Fig. 3), whereas Holden *et al.* (1993) used more boreholes to generate bedrock topography around the Darlington nuclear power plant (B, Fig. 3) and St. Mary's cement works (C, Fig. 3); (iii) Figure 3 is an interpretation of bedrock topography from boreholes extending to bedrock alone, whereas Holden *et al.* (1993) used additional wells that did not reach bedrock to supplement the bedrock well data. Despite the details of bedrock topography differing in the two interpretations, the general pattern of bedrock valleys and interfluves (Fig. 3) is similar.

The mainly buried Paleozoic bedrock surface slopes gently southeastward towards Lake Ontario, but exhibits local topographic relief on the order of 30 m over 2 km around Oshawa (Fig. 3). Southerly sloping bedrock valleys (Fig. 3) may be tributaries of the ancient Laurentian Channel which joined Georgian Bay to Lake Ontario, and which trended along the Lake Ontario axis and down the St. Lawrence River (Wilson, 1904). Bedrock geology does not appear to have a significant effect on bedrock topography, although this observation could be a result of sparse data on the surfacing routine (Fig. 3); alternatively, the bedrock geology map may require modification given our updated knowledge of bedrock topography (*cf.* Karrow, 1973).

A new high-density, shallow gravity survey is presently being undertaken by the ORM NATMAP and hydrogeology project. It is hoped that by removing the regional gravity anomaly from these data, calibrating by known bedrock depths, and forward modelling drift thickness, more detailed mapping of bedrock topography will be facilitated (Jack Sweenie, GSC

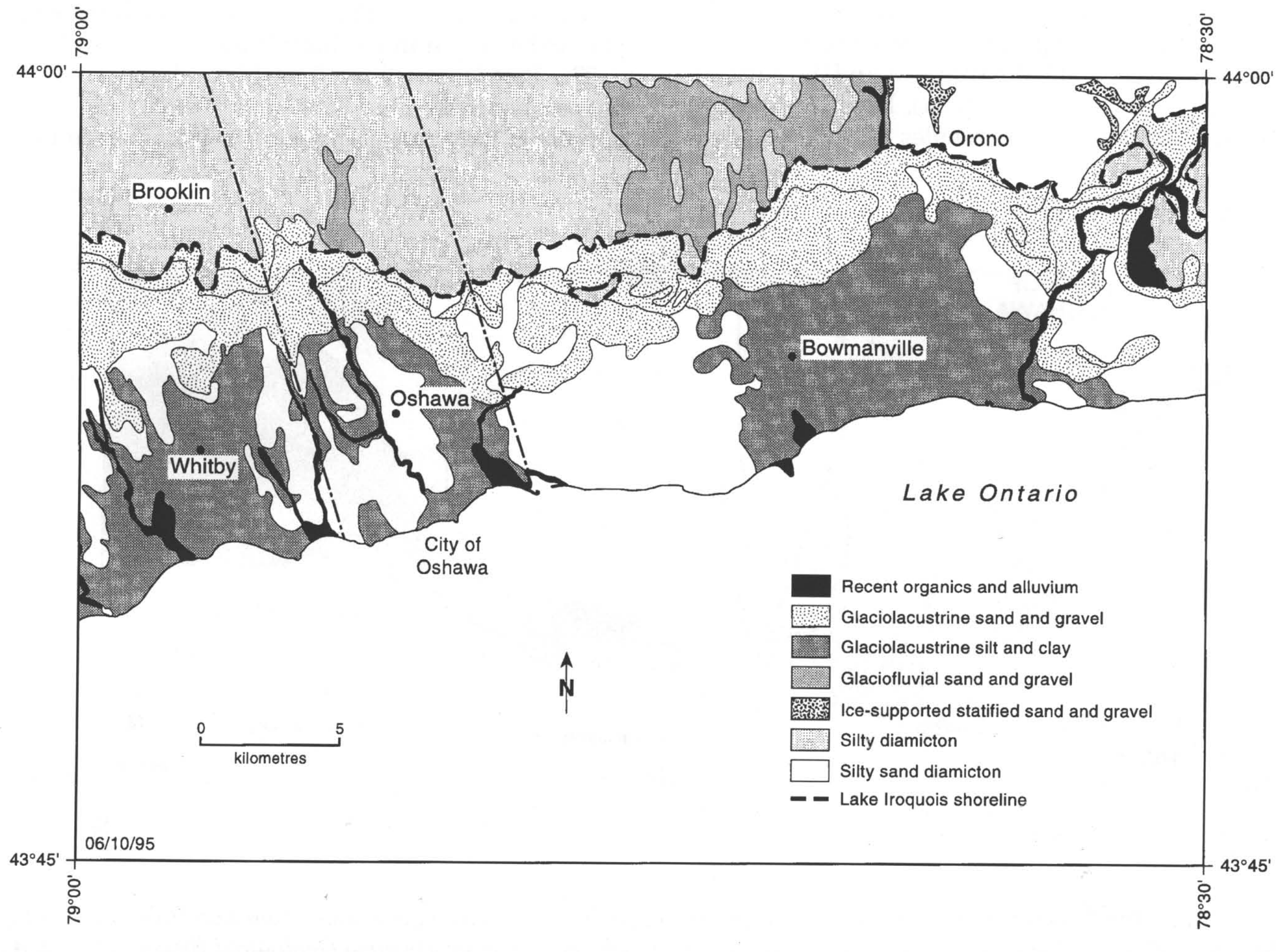

Figure 2. *Surficial geology in the Oshawa (30M/15) 1:50,000 NTS sheet modified from Gravenor (1957) and Barnett* et al. *(1991).*

retired, personal communication, 1994; *cf.* Greenhouse and Monier-Williams, 1986).

It has been noted that the orientation of contemporary rivers and bedrock channels are similar, leading to the hypothesis that structures in the Precambrian basement may control the location of contemporary rivers, faults having been reactivated through Paleozoic and Quaternary cover by neotectonic activity (Eyles *et al.*, 1993). This assertion raises questions regarding seismic hazard, particularly around sensitive structures such as the Darlington nuclear power plant (B, Fig. 3), east of Oshawa (Wallach, 1995a,b). However, Oshawa Creek is located on a bedrock interfluve (A, Fig,. 3); it is not located over a bedrock valley. Neotectonic activity in the Oshawa area remains a hypothesis; faults extending continuously from the Precambrian basement, through the Paleozoic and Quaternary cover have yet to be demonstrated (Stepp *et al.*, 1995).

QUATERNARY GEOLOGY

The thickness of Quaternary sediments over bedrock is highly variable (0-114 m; Fig. 4), the main controls being: (i) bedrock topography, (ii) original deposition; (iii) erosion by glacial Lake Iroquois, and (iv) surficial dissection (recent or late-glacial). Drift thickness is reconstructed here from boreholes extending to bedrock and bedrock exposures only; even so, the abrupt change in drift thickness at the Iroquois shoreline is apparent north of Oshawa (Fig. 4). In general, the Quaternary drift over the Paleozoic terrain thins towards the Lake Ontario bluffs and thickens towards the ORM (Brennand *et al.*, 1995) and in bedrock channels (Figs. 3, 4). Bedrock is exposed along Oshawa and Lynde creeks (Liberty, 1953).

A comprehensive, subsurface geologic model of the Oshawa area is presently lacking. Much of our current stratigraphic understanding comes from detailed analysis of the Lake Ontario bluffs east of Oshawa, between Bowmanville and Newcastle (Wilson, 1905; Coleman, 1936b; Singer 1973, 1974; Brookfield *et al.*, 1982; Martini *et al.*, 1984, Martini and Brookfield, 1995), supplemented by high quality borehole records (Brennand *et al.*, 1995) and geophysical surveys (Greenhouse and Schneider, 1994), generally collected during hydrogeologic investigations for waste site assessments and geotechnical investigations for construction projects. East of Oshawa, four tills, three glaciolacustrine sequences and one subaerial fluvial unit are reported to overlie bedrock (*e.g.,* Brookfield *et al.*, 1982) (Table 1). Pre-Wisconsinan sediments appear to be absent in Durham Region.

The Port Hope till (5-15 m thick) discontinuously drapes bedrock. This clast-poor (<1%), silty clay diamicton may record a period of ice advance over

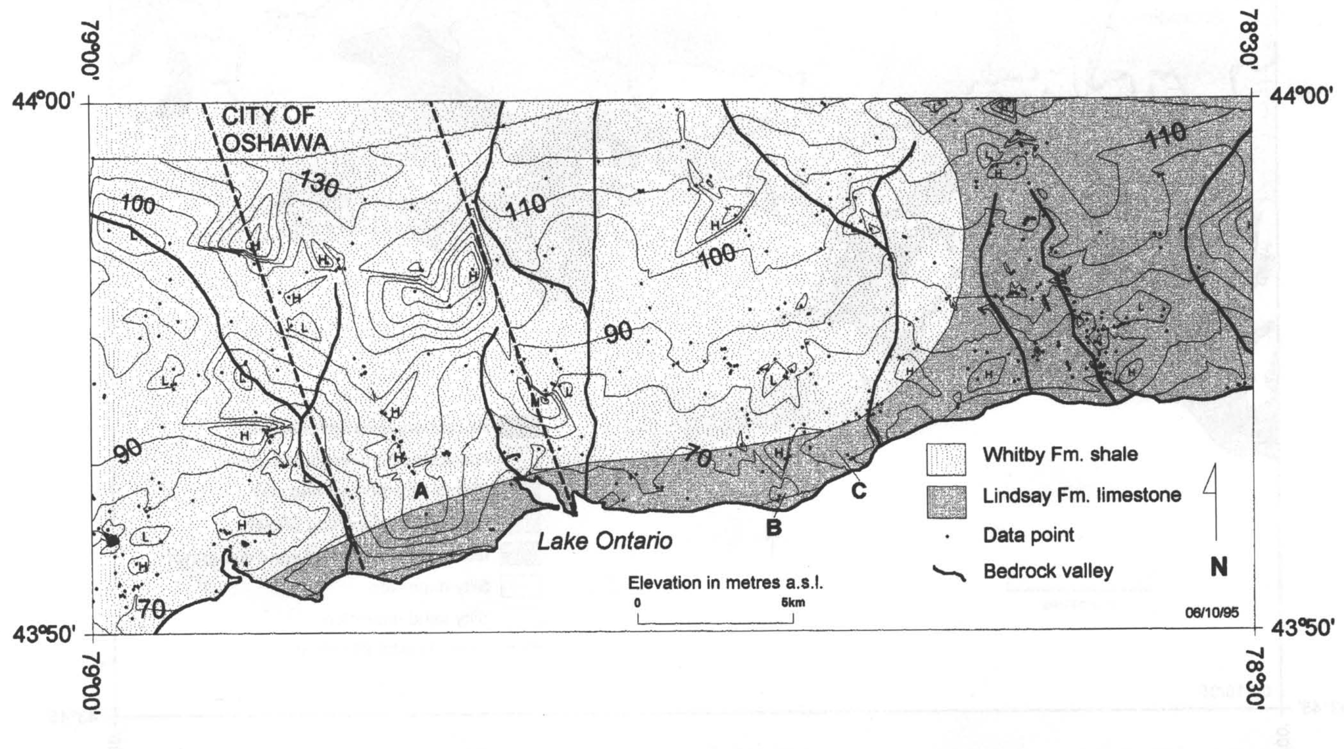

Figure 3. *Bedrock topography (triangular irregular network, TIN, model) generated from boreholes extending to bedrock. Major valleys in the bedrock illustrated. Bedrock geology from Ontario Geological Survey (1991).* ***A,*** *Oshawa bedrock interfluve;* ***B,*** *Darlington nuclear power plant;* ***C,*** *St. Mary's cement works;* ***H,*** *bedrock high;* ***L,*** *bedrock low.*

pre-existing fine-grained lacustrine sediments (Martini *et al.*, 1984), or ice-marginal deposition into a glacial lake during the initial stages of ice retreat (Brookfield *et al.* 1982) in the Early Wisconsinan (> 64 ka). Subsequent easterly ice retreat in the Middle Wisconsinan (64-23 ka) resulted in a proglacial lake in the Lake Ontario basin recorded in a clay-to-sand sequence. This coarsening-upward sequence may have resulted from (i) removal of the ice dam and a drop in lake level following further ice retreat (Brookfield *et al.* 1982), or (ii) ice readvance and/or the development of a more proximal meltwater source. The Bond Head till (clast-poor (< 2%), clayey silt diamicton) may have been deposited during an ice readvance into the lake (Brookfield *et al.* 1982), or may represent a more local debris flow deposit. Major ice retreat, lake ponding and shallowing, or switches in the location and proximity of meltwater outlets, resulted in a second coarsening-upward glaciolacustrine sequence. This Middle Wisconsinan glaciolacustrine-diamicton complex is often termed the Clarke beds (Wilson, 1905). In places it is absent, but in others it can be upward of 40 m thick (GL, Fig. 5).

Locally the Clarke beds are interrupted by lenticular sand and/or gravelly sand units. As lake level fell below that of the present Lake Ontario, subaerial fluvial dissection may have formed valleys (Plum Point Interstadial, ~28 ka) which were filled as lake level rose during Late Wisconsinan ice readvance (Brookfield *et al.*, 1982). However, despite limited geophysical surveys (Greenhouse and Schneider, 1994), the full three-dimensional geometry and extent of these sand bodies is unknown. Preliminary materials cross-sections generated from the ORM NATMAP borehole data base (Brennand *et al.*, 1995) suggest that the sediments may not be filling extensive valleys, but rather recording discrete subaqueous fans (Sharpe and Barnett, 1985). The sand bodies carry ground water which discharges at the lake bluffs, resulting in springs and headward bluff erosion. A knowledge of sand body geometry would facilitate its characterization as a local or regional aquifer, and allow geologically informed land use zoning along the Lake Ontario bluffs.

The main Late Wisconsinan (23-10 ka) ice readvance from the north deposited a clast-rich (often > 10%) silty sand to sandy silt diamicton (Bowmanville till; Fig. 5). Locally, Bowmanville till is separated into upper and lower units by lenticular sand and silt packages up to 15 m thick. This regional till sheet (variously named: Newmarket, Bowmanville, Lower Lea-side, lower Halton and northern) appears to extend north beneath the ORM and covers much of the Paleozoic terrain (Sharpe *et al.*, 1994a). It is exposed at the surface north of the ORM where it is drumlinized and dissected by tunnel channels (Barnett, 1990). The till sheet is buried by Halton drift along the South Slope and is likely exposed at the surface in the Iroquois Plain (Figs. 2, 5). Around Oshawa the Bowmanville till sheet is generally less than 30 m thick, but may

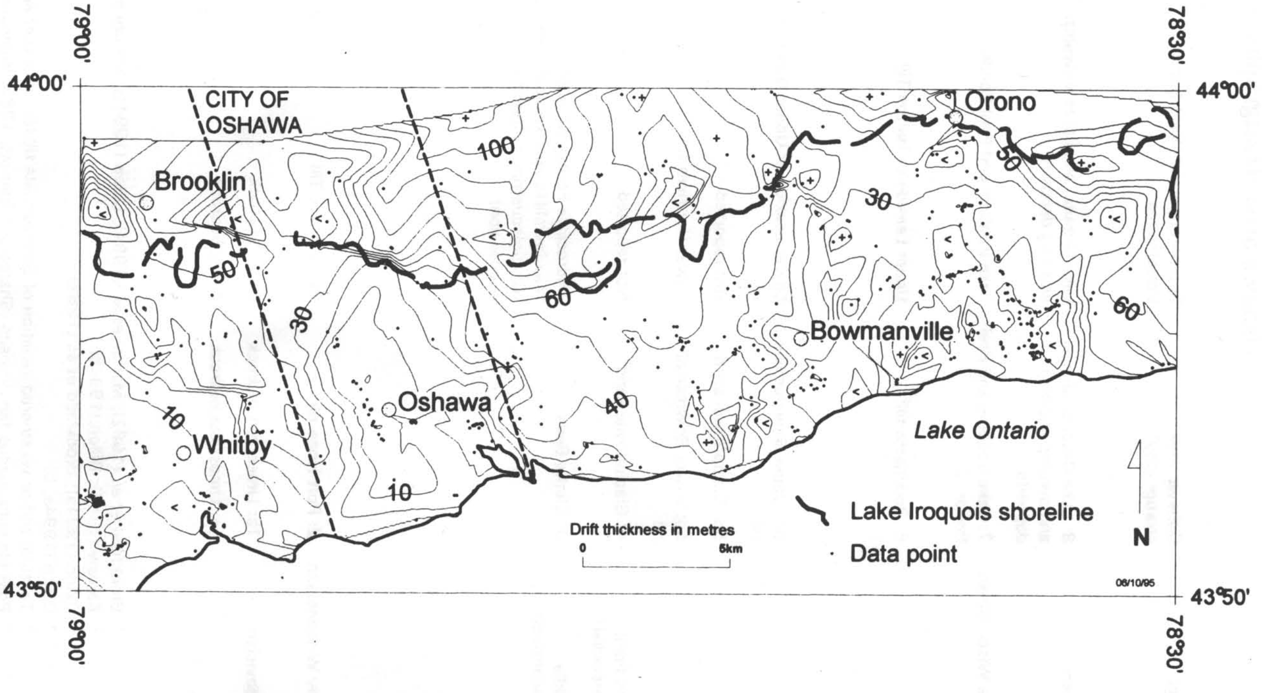

Figure 4. *Drift thickness (TIN model) generated from the boreholes extending to bedrock. Abrupt change in drift thickness north of Oshawa coincides with the Lake Iroquois shoreline. +, thick drift; <, thin drift.*

Table 1

Oshawa area stratigraphy, proposed regional correlations and hydrostratigraphy.

Stage	Oshawa area stratigraphy[1]	Scarborough and West Durham[2] Correlations	Material	Clay range %[3]	Hydrostratigraphic Unit	Average Hydraulic Conductivity cm.s^{-1}. [4]
Recent	8: Lake Ontario, alluvial and swamp and bog deposits	Lake Ontario, alluvial and swamp and bog deposits	Gravel, sand, silt, clay, organics	NA	Local aquifer	NA
Late Wisconsinan	7: Lake Iroquois and Peel Ponds	Lake Iroquois and Peel Ponds	Gravel, sand, silt, clay, shells	NA	Local aquifer	10^{-3}
	6: Bouchette till[5]	Upper Leaside or Halton Till	Silty diamicton, locally varying from sandy silt to silty sand diamicton with <2 % gravel; includes sand lenses	0.1 - 32	Local aquifer or aquitard	10^{-5}
			OAK RIDGES MORAINE			
	5c: Upper Bowmanville till	Lower Leaside or Upper Northern till	Silty sand to sandy silt diamicton, dense, massive, boulder horizons, drumlinized, generally >10% gravel	3 - 14.1	Regional aquitard	10^{-8}
	5b: Glaciofluvial sand	Not reported	Sand and silt locally present	NA	Local aquifer	10^{-4}
	5a: Lower Bowmanville till	Lower Northern till	Silty sand to sandy silt diamicton with interbedded sand, generally >10% gravel	4.5 - 21	Regional aquifer	
Plum Point Interstadial?	4: Glaciofluvial sand[6]	Not reported	Discontinuous sand and gravel	NA	Aquifer, local?	
Middle Wisconsinan	3: Clarke Beds	Thorncliffe Formation with Meadowcliffe and Seminary tills (Glaciolacustrine deltaic to fluvial succession)	Complex glaciolacustrine sequence 3c; Silty varves, coarsening and thickening up	NA	Regional aquifer	
			3b: Bond Head till: very compact silty diamicton; <2% gravel; discontinuous	2.3 - 55.5	Aquitard	NA
			3a: Coarsening upward sequence of sand-silt-clay varves with interbedded diamictons and sandy gravel	NA	Regional aquifer	NA
Early Wisconsinan	2: Port Hope till	Sunnybrook Till	Silty or clayey diamicton with disturbed silt-clay rhythmites, <1% gravel, discontinuous	3.6 - 40.1	Aquitard	NA
Ordovician	1b: Limestone bedrock	Shale bedrock	Weathered limestone or shale	NA	Regional aquifer	10^{-4}
	1a: Limestone bedrock	Shale bedrock	Sound limestone and shale	NA	Regional aquitard	10^{-7}

[1] Brookfield *et al.* (1982); Martini *et al.* (1984); Dillon (1994a); Martini and Brookfield (1995)
[2] Karrow (1967); Dillon (1994b)
[3] Dillon (1994a); Brookfield *et al.* (1982)
[4] Dillon (1994a, b)
[5] Textural and/or weathered variation of Bowmanville till (Brookfield *et al.*, 1982) or remnant patches of Halton Till (Martini and Brookfield, 1995)
[6] Possible subaqueous fan deposits (Sharpe and Barnett, 1985; Brennand *et al.*,1995)

locally exceed 50 m thick (BT, Fig. 5). It functions as a regional aquitard (Sharpe *et al.*, 1994a).

Toward the end of the Late Wisconsinan, ice may have readvanced out of, or melted back into, Lake Ontario and deposited Halton drift (interstratified sorted glaciolacustrine and glaciofluvial sediments and silty diamicton). The Bouchette till (Table 1) may be correlated with Halton drift (Brookfield *et al.*, 1982), or be a finer-textured, weathered variant of the Bowmanville till. Around Oshawa, Halton drift (HD) is the main surficial sediment north of the Iroquois shoreline (Figs. 2, 5). It seems likely that any Halton drift south of the Iroquois shoreline was eroded by wave action in glacial Lake Iroquois (Barnett *et al.*, 1991). Local ponding of water is recorded in Peel Pond deposits over Halton drift.

During final Late Wisconsinan ice retreat, glacial Lake Iroquois eroded a lacustrine plain north of the present Lake Ontario shoreline, and deposited discontinuous sand, silt and clay (Figs. 2, 5; Gravenor, 1957). Generally, Iroquois sediments form only a thin cover (1-2 m), but they may attain 10 m in local basins (IR, Fig. 5). At the shoreline, wave attack resulted in the formation of gravel beaches, bars and spits (Gravenor, 1957) which have provided Oshawa with a ready supply of aggregates. Recent sediments include Lake Ontario beaches, alluvial floodplains, swamps and bogs.

URBAN GEOLOGICAL ISSUES

With population growth projections on the order of 40% (1990-2000) for the Region of Durham (Region of Durham, 1990), there is a need to maintain and expand the urban infrastructure. Planning decisions for road and rail maintenance and construction, building foundation design, water supply, storm drains and sewage treatment demand geologic knowledge in an area of variable ground conditions such as around Oshawa. High water tables, saturated sands, buried aquifers and dewatering associated with local wells all have geological explanations and need to be considered during urban planning and engineering design.

Most overburden water wells around Oshawa pro-

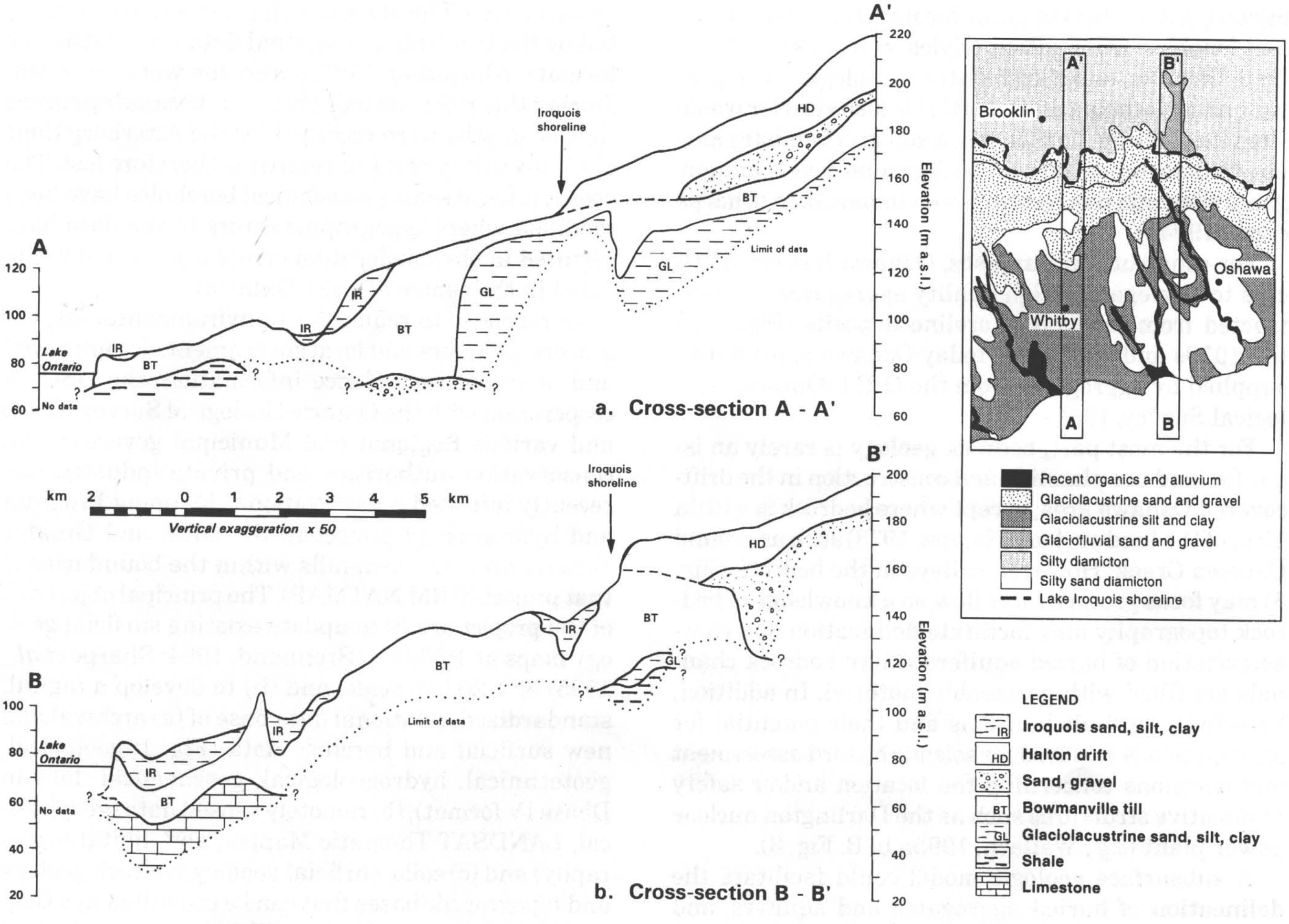

Figure 5. *Interpreted, north-south, materials cross-sections around Oshawa, generated from standardized MOEE water well and Oshawa UGAIS boreholes.*

duce less than 0.7 $m^3 \cdot s^{-1}$ of water (Ministry of the Environment, 1973). Consequently, residents of Oshawa obtain their water supply mainly from Lake Ontario. As the lake bluffs south of Oshawa are relatively low and primarily cut into sandy diamicton (BT, Fig. 5), lake bluff erosion is rarely a problem. The exception is just west of Oshawa harbour where a sand unit is exposed at the bluff. Here various forms of riprap have been employed in bluff stabilization. Similarly, river bank stability is seldom an issue. Silting up of Oshawa harbour and coastal marshes can be a concern for ship traffic and wildlife. Oshawa harbour is dredged regularly.

As current waste sites near capacity, waste disposal is becoming a critical issue (Interim Waste Authority, 1991). As the Oshawa area is mainly drift covered, a knowledge of the geologic and hydrogeologic characteristics (Table 1) of the Quaternary sediments into which waste may be placed forms the foundation for a rigorous waste site selection process. For example, the most geologically favourable landfill sites should exhibit low to moderate hydraulic conductivity (*e.g.,* a massive, relatively fine-grained diamicton, silt or clay) to allow for natural containment and leachate attenuation (Eyles *et al.*, 1992). Aquifer delineation and a knowledge of geologic, hydrogeologic and geochemical properties is also vital for waste site remediation. To this end, a soil geochemistry survey to determine natural background levels of inorganic elements has recently been undertaken (Sharpe *et al.*, 1994b).

For construction purposes, Oshawa has ready access to aggregates. High quality aggregates were extracted from Iroquois shoreline deposits (Fig. 2) in the 1950s and 1960s, but today Oshawa is primarily supplied by aggregates from the ORM (Ontario Geological Survey, 1981).

For the most part, bedrock geology is rarely an issue for land use planning and construction in the drift-covered Oshawa area, except where bedrock is within 10 m of the land surface (Karrow, 1973) such as around Oshawa Creek. However, valleys in the bedrock (Fig. 3) may focus groundwater flow, so a knowledge of bedrock topography may facilitate delineation and characterization of buried aquifers where bedrock channels are filled with permeable material. In addition, knowledge of fault locations and their potential for reactivation is required for seismic hazard assessment and decisions concerning the location and/or safety of sensitive structures such as the Darlington nuclear power plant (*e.g.,* Wallach, 1995a,b; B, Fig. 3).

A subsurface geologic model could facilitate the delineation of buried aggregates and aquifers, and could form the foundation for geologically informed zoning and planning decisions. An integrated understanding of the subsurface geologic framework around Oshawa is currently being formulated by the ORM NATMAP and hydrogeology project.

STATUS OF THE OSHAWA UGAIS AND ORM NATMAP DATA BASES

In the 1970s the GSC implemented a program to collect and collate available geotechnical information for 28 of the larger Canadian urban centres; Oshawa was one such centre (UGAIS, Harrison and Bélanger, 1975). The geotechnical data were coded and stored on magnetic tapes in fixed format ASCII. Included were location and drilling information as well as geologic (materials and depths), geotechnical (penetration resistance and Atterberg limits) and hydrogeologic (depth of water found) data for each borehole. The Oshawa UGAIS data base includes data from engineering test holes drilled during the period February 1950 to March 1972, from Oshawa to Scarborough, along the north shore of Lake Ontario. The Ontario Geological Survey is the current repository of this data base. To date, this data base has been little used by the geotechnical community in the Oshawa area. This data base has now been reformatted by the GSC into a relational data base (Dbase IV format). Altogether 3777 boreholes were recorded. During this reformatting process it became apparent that no depths were recorded for the Atterberg limit data; the utility of these records is therefore lost. The coordinates of some geotechnical boreholes have been modified where typographic errors in the data base resulted in obvious location errors (*e.g.,* boreholes located in the centre of Lake Ontario).

In response to requests by environmentalists, engineers, planners and local governments for improved and accessible geoscience information, the GSC, in cooperation with the Ontario Geological Survey (OGS) and various Regional and Municipal governments, conservation authorities and private industry, has recently initiated a new National Mapping Program and hydrogeology project in the ORM and Greater Toronto area; Oshawa falls within the boundaries of that project (ORM NATMAP). The principal objectives of the project are (i) to update existing surficial geology maps at 1:50,000 (Brennand, 1994; Sharpe *et al.*, 1995) or 1:20,000 scale, and (ii) to develop a digital, standardized, relational data base of (a) archival and new surficial and borehole data (Fig. 1; geological, geotechnical, hydrogeological, geochemical data in Dbase IV format), (b) remotely sensed data (geophysical, LANDSAT Thematic Mapper, and digital topography) and (c) soils, surficial geology, bedrock geology and topographic bases that can be consulted in a Geographic Information System (GIS) to generate derived maps and documents (Russell *et al.*, 1995). The search for new data sources and the updating and verification of this data base is ongoing (Table 2). Much of the archival data is available only as non-digital (hard copy) reports. Digital conversion of these reports is time consuming and expensive. The challenge has been to integrate records from different sources, produced for different purposes and exhibiting different levels of information and reliability (Table 3). A rigorous standardization process is being implemented to rationalize a vast array of reported sediment descriptions into geologically relevant materials. It is only after this process that geologic interpretations can be made. In addition, a series of analysis and visualization tools within an affordable, yet robust, low-end GIS, which can be accessed without the assistance of computer specialists, is being developed by private industry partners to assist in improving the accessibility of this data base to potential users.

The ORM NATMAP data base (Fig. 1; Russell *et al.*, 1995) is currently being used to generate bedrock topography (Fig. 3) and drift thickness (Fig. 4) maps, and to suggest answers to three-dimensional stratigraphic questions such as the geometry and extent of subsurface stratigraphic units (Fig. 5) and buried aquifers. Some preliminary observations on materials cross-sections created from standardized data bases (Ontario Ministry of Environment and Energy (MOEE) water well and UGAIS) around Oshawa (Fig. 5) and Port Hope (Brennand *et al.*, 1995) suggest: (i) a regional southerly bedrock slope dissected by valleys; (ii) the likely presence of a regional sandy till beneath the ORM and extending to Lake Ontario; (iii) the possibility that some of the sand bodies and glaciolacustrine sequences at the Bowmanville bluffs represent local basin sedimentation, and cannot be followed inland more than 1-2 km. In concert with cross-sectional analysis, a three-dimensional GIS (LYNX) is being employed to develop the regional, three-dimensional geologic and hydrostratigraphic framework (solids model), the key to future ground water, waste disposal, land use and resource planning.

Table 2

Status of data acquisition, format and verification in the ORM NATMAP data base.

DATA SOURCE	DATA FORMAT ACQUIRED	CURRENT DATA FORMAT	DATABASE VERIFICATION
GSC surficial and borehole	Hard copy	Digital & hard copy	Partial
OGS surficial and borehole	Hard copy	Digital & hard copy	Partial
OGS aggregate resources inventory test holes	Hard copy	Digital & hard copy	East complete
GSC paleoenvironmental investigation sites	Hard copy, locations only	Digital	Required
GSC geophysical surveys	Hard copy, locations only	Digital	Partial
GSC hydrogeological surveys	Hard copy, locations only	Digital	Required
University of Guelph (Brookfield *et al.* 1982)	Hard copy	Digital	Complete
Interim Waste Authority	Hard copy	Digital & hard copy	Required
Laidlaw (Newcastle)	Hard copy	Digital & hard copy	Required
Siting Task Force Secretariat	Hard copy & digital	Digital & hard copy	Required
Low Level Radioactive Waste Management Office (Port Hope)	Hard copy	Digital & hard copy	Required
Ministry of Transportation Ontario geotechnical reports	Hard copy	Digital & hard copy	Required
Oshawa urban geology database	Digital	Digital	Partial
Ministry of the Environment and Energy municipal water wells and boreholes	Hard copy	Digital & hard copy	Required
Ministry of the Environment and Energy water wells	Digital	Digital	Partial
Canadian National Railway geotechnical reports	Hard copy	Hard copy	Not yet entered
Consumers' Gas pipelines	Hard copy	Hard copy	Not yet entered

Table 3. Subsurface geology data type by source in the ORM NATMAP database

		GSC Surficial & Paleoenvironmental Sites	GSC/OGS Boreholes	OGS Surficial	University[1]	IWA[2]	Laidlaw	STFS[3]	LLRWMO[4]	MTO[5]	Oshawa UGAIS	MOEE[6]
Geographic Location		▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Site Description		▓	▓	▓	▓	▓	▓	▓	▓	▓		
Soil Description		▓		▨		▨	▨	▨	▨	▨		▨
Sediment Description:	**Depth Intervals**	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
	Texture	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
	Colour	▓	▓	▓	▓	▓	▓	▓	▓	▓		▨
	Structure	▓	▓	▓	▓	▨				▨		
	Paleoflow	▓		▓	▓							
	Clasts	▓	▓	▨	▓	▨	▨	▨	▨	▨		▨
	Contacts	▓	▓	▓	▓							
Sample Type:	**Geotechnical**	▧	▓	▓	▓	▓	▓	▓	▓	▓	▓	
	Geochemical	▓	▓	▓	▓			▓	▓			
	Heavy Mineral			▨	▓							
	Organic	▓	▧	▨								
Bedrock Description & Depth		▓	▓			▓	▓		▨	▓	▓	▓
Geophysical:	**Shallow Seismic**	▓	▓			▓						
	Downhole		▓			▓						
	EM-34, 37	▓										
	GPR	▓										
	Gravity	▓										
Hydrogeology:	**Static Level**	▓	▓			▓	▓	▓	▓	▓	▓	▓
	Piezometric level		▓			▓	▓	▓	▓			▓
	Water quality					▓						▓

LEGEND: ▓ Data Recorded ▨ Minimal Data Recorded ▧ Planned Analyses

[1] Brookfield *et al.* (1982); [2] Interim Waste Authority; [3] Siting Task Force Secretariat; [4] Low Level Radioactive Waste Management Office, Port Hope; [5] Ministry of Transportation Ontario; [6] Ontario Ministry of the Environment and Energy

ACKNOWLEDGEMENTS

The ORM NATMAP data base was designed by the author and project collaborators at the GSC: David Sharpe, Hazen Russell and Charles Logan. The data base was implemented by Charles Logan. The maps were generated by Jamie Ross and the author. Cross-sections were drafted by Wendy Lewis. A beta version of Vertical Mapper (Northwood Geosciences Ltd.) was used to generate the bedrock topography and drift thickness contours. Discussions with Garry Farrington (Region of Durham) and Peter Cox (City of Oshawa) and reviews by Peter Barnett, Peter Martini, Paul Karrow and Owen White are gratefully acknowledged. This note is Geological Survey of Canada contribution 29995.

REFERENCES

Barnett, P.J., 1990, Tunnel valleys: evidence of catastrophic release of subglacial meltwater, central-southern Ontario, Canada: Geological Society of America, Northeastern Section, Abstracts with Program, v. 22, p. 3.

Barnett, P.J., Cowan, W.R. and Henry, A.P., 1991, Quaternary geology of Ontario, southern sheet: Ontario Geological Survey, Map 2556, scale 1:1 000 000.

Brennand, T.A., 1994, Preliminary surficial geology site attributes, Oshawa area, Ontario (NTS 30M/15): Geological Survey of Canada, Open File 2877, 1 sheet, scale 1:50 000.

Brennand, T.A., Hinton, M. and Sharpe, D.R., 1995, Terrestrial geologic and hydrogeologic framework, Port Hope Region (Oshawa-Cobourg), *in* Sharpe, D.R., compiler, Regional Geology and Tectonic Setting of Lake Ontario Region: Geological Survey of Canada, Open File 3114.

Brookfield, M.E., Gwyn, Q.H.J. and Martini, I.P., 1982, Quaternary sequences along the north shore of Lake Ontario: Oshawa-Port Hope, Canadian Journal of Earth Sciences, v. 19, p. 1836-1850.

Chapman, L.J. and Putnam, D.F., 1984, The physiography of southern Ontario: 3rd Edition, Ontario Geological Survey, Special Volume 2, 270 p.

Coleman, A.P., 1936a, Lake Iroquois: Ontario Department of Mines, Annual Report, v. 45, pt.7, p. 1-36.

Coleman, A.P., 1936b, Geology of the north shore of Lake Ontario: Ontario Department of Mines, Annual Report, v. 45, pt. 7, p. 37-74.

Dillon, M.M., 1994a, Geology/hydrogeology technical appendix 5: Site KK2, for Durham Region Landfill Site Search, EA Document IV, prepared for Interim Waste Authority Limited.

Dillon, M.M., 1994b, Detailed assessment of the proposed site EE11 for Durham Region landfill site search: prepared for Interim Waste Authority Limited.

Eyles, N., Boyce, J.I. and Hibbert, J.W., 1992, The geology of garbage in southern Ontario: Geoscience Canada, v. 19, p. 50-62.

Eyles, N., Boyce, J. and Mohajer, A.A., 1993, The bedrock surface of the western Lake Ontario region: evidence of reactivated basement structures? Géographie physique et Quaternaire, v. 47, p. 269-284.

Gravenor, C.P., 1957, Surficial geology of the Lindsay-Peterborough area, Ontario, Victoria, Peterborough, Durham, and Northumberland counties, Ontario: Geological Survey of Canada, Memoir 288, 60 p.

Greenhouse, J.P. and Monier-Williams, M., 1986, A gravity survey of the Dundas buried valley west of Copetown, Ontario: Canadian Journal of Earth Sciences, v. 23, p. 110-114.

Greenhouse, J. and Schneider, G., 1994, Report on a geophysical survey in the Vicinity of Bond Head, Ontario: Geophysical Technical Note, GTN-95-01, University of Waterloo, Waterloo, ON, 24 p.

Harrison, J.E. and Bélanger, J.R., 1975, Status of the urban geology automated information system (UGAIS) project, *in* Field Trip Guidebook 10, Environmental Geology Kitchener-Guelph Area: Geological Association of Canada, Annual Meeting, Waterloo, ON, p. 286-290.

Holden, K.M., Mitchell, D. and Karrow, P.F., 1993, Bedrock topography, Oshawa area: Ontario Geological Survey, Preliminary Map P.3192, scale 1:50,000.

Interim Waste Authority, 1991, Draft approach and criteria for Durham Region landfill site search: Environmental Assessment, Document I.

Karrow, P.F., 1967, Pleistocene geology of the Scarborough area: Ontario Department of Mines, Geological Report 46, 108 p.

Karrow, P.F., 1973, Bedrock topography in southwestern Ontario: a progress report: Geological Association of Canada, Proceedings, v. 25, p. 67-77.

Liberty, B.A., 1953, Preliminary map Oshawa, Ontario and Durham Counties, Ontario: Geological Survey of Canada, Paper 53-18., scale 1:63 360.

Martini, I.P. and Brookfield, M.E., 1995, Sequence analysis of Upper Pleistocene (Wisconsinan) glaciolacustrine deposits of the north-shore bluffs of Lake Ontario, Canada: Journal of Sedimentary Research, B65 (3), p. 388-400.

Martini, I.P., Brookfield, M.E. and Gwyn, Q.H.J., 1984, Quaternary stratigraphy of the coastal bluffs of Lake Ontario east of Oshawa, *in* Mahaney, M.C., ed., Quaternary Dating Methods: p. 417-427.

Ministry of the Environment, 1973, International field year for the Great Lakes, Lake Ontario drainage basin, Ontario-New York, Map 5926-2, overburden well yields, scale 1:500,000.

Ontario Geological Survey, 1981, Aggregate resources inventory of the City of Oshawa, Regional Municipality of Durham, southern Ontario: Aggregate Resources Inventory Paper 40, 31 p.

Ontario Geological Survey, 1991, Bedrock geology of Ontario, southern sheet: Ontario Geological Survey, Map 2544, scale 1:1,000,000.

Region of Durham, 1990, Region of Durham Commissioner's Report 90-204 to Planning Committee, September 1990.

Russell, H.A.J., Brennand, T.A., Sharpe, D.R. and Logan, C., 1995, Quaternary and environmental geology in the Oak Ridges Moraine NATMAP area: digital compilation: Geological Survey of Canada, Forum 1995, Abstracts.

Sharpe, D.R. and Barnett, P.J., 1985, Significance of sedimentological studies on the Wisconsinan stratigraphy of southern Ontario: Géographie physique et Quaternaire, v. 39, p. 255-273.

Sharpe, D.R., Barnett, P.J., Dyke, L.D., Howard, K.W.F., Hunter, G.T., Gerber, R.E., Paterson, J. and Pullan, S.E., 1994a, Quaternary geology and hydrogeology of the Oak Ridges Moraine area: Geological Association of Canada-Mineralogical Association of Canada, Joint Annual Meeting, Field Trip A7, Guidebook, 32 p.

Sharpe, D.R., Barnett, P.J., Brennand, T.A. and Russell, H.J. 1994b, Background soil geochemistry results for NATMAP/GTA study area south-central Ontario: Geological Survey of Canada, Open File (in review).

Sharpe, D.R., Barnett, P.J., Brennand, T.A., Russell, H.A.J. and Finley, W.D., 1995, Surficial geology of the Greater Toronto Area, southern Ontario: Geological Survey of Canada, Open File 3026, scale 1:200,000.

Singer, S., 1973, Surficial geology along the north shore of Lake Ontario in the Bowmanville-Newcastle area: 16th Conference, Great Lakes Research, Proceedings, p. 441-453.

Singer, S., 1974, A Hydrogeological Study along the North Shore of Lake Ontario in the Bowmanville-Newcastle Area: Ministry of the Environment, Water Resources Report, 5d, Toronto, ON.

Stepp, J.C., Price, R.A., Coppersmith, K.J., Klimkiewicz, G.C. and McGuire, R.K., 1995, AECB workshop on seismic hazard assessment in southern Ontario: Atomic Energy Control Board, Report, Ottawa, ON, 15 p.

Wallach, J.L., 1995a, Characteristics of the Niagara-Pickering and Georgian Bay linear zones and their implications for a large magnitude earthquake in the vicinity of the Darlington and Pickering Nuclear Power Plants, near Toronto: Atomic Energy Control Board, workshop on seismic hazard in southern Ontario.

Wallach, J.L., 1995b, Geophysical signatures beneath Lake Ontario in the vicinity of the Darlington Nuclear Generating Station; seismic hazard implications: Atomic Energy Control Board, workshop on seismic hazard in southern Ontario.

Wilson, A.W.G., 1904, Trent River and Saint Lawrence outlet: Geological Society of America, Bulletin, v. 15, p. 221-242.

Wilson, A.W.G., 1905, A forty-mile section of Pleistocene deposits north of Lake Ontario: Canadian Institute, Transactions, v. 8, p. 11-21.

Since this note was first submitted in 1995 a new surficial geology map has been published for the Oshawa area:

Brennand, T.A., 1997, Surficial geology of the Oshawa area, southern Ontario (30M/15): Geological Survey of Canada, Open File 3331, 1 colour map, scale 1:50,000.