NWRI CONTRIBUTION 86-112

Coakley (43)

CONTAMINATION HAZARD FROM WASTE DISPOSAL SITES NEAR RECEDING GREAT LAKES SHORELINES

by

J.P. Coakley

Shore Processes Section
Hydraulics Division
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada L7R 4A6

March 1986

ABSTRACT

Of the approximately 4000 waste disposal sites in Ontario, more than 230 are located within 5 km of the shoreline of the Lower Great Lakes. Sixty sites are within 1 km of the shore. Unlike the more resistant bedrock shores of the Upper Great Lakes, the shoreline south of Midland (Georgian Bay) is composed primarily of unlithified glacial deposits, and thus is prone to significant erosion. This report presents an examination of the potential for contamination of nearshore lake waters either directly through shoreline recession at the waste site, or indirectly through the transport to the lake of leachates from the nearby sites via groundwater discharges. A compilation of the relevant physical data on the sites, and on the shorelines involved, is also presented, using Ontario Ministry of the Environment files and the available literature as data sources. Recession-related hazards were identified at three sites (two on Lake Ontario and one on Lake Erie). Groundwater contamination hazards were harder to identify due to insufficient subsurface and hydrogeological information. However, 31 sites, less than 0.2 km from the shore, were identified as potentially hazardous, 19 of these were located in the northern Lake Ontario shore zone.

RÉSUMÉ

Des quelque 4000 sites d'enfouissement de déchets en Ontario, plus de 230 sont situés à moins de 5 km du rivage des Grands Lacs inférieurs. Soixante sites sont à moins de 1 km de la rive. Contrairement au rivage de roche en place plus résistante des Grands Lacs supérieurs, au sud de Midland (baie Georgienne) le rivage se compose principalement de dépôts glaciaires non lithifiés, et est donc vulnérable de façon significative à l'érosion. Le présent rapport examine le potentiel de contamination des eaux côtières soit directement à cause du recul de la rive près du site d'enfouissement, soit indirectement par le transport souterrain vers le lac des lixiviats provenant de sites avoisinants. Des dossiers du ministère ontarien de l'environnement et la littérature disponible ont servi à compiler des données physiques concernant les sites et les rives touchées. Des risques liés au recul de la rive ont été repérés à trois sites (deux près du lac Ontario et un près du lac Érié). Vu l'insuffisance de données hydrogéologiques et souterraines, il a été plus difficile de déceler les risques de contamination souterraine. Cependant, nous avons identifié comme présentant un risque potentiel 31 sites situés à moins de 0,2 km de la rive, dont 19 étaient situés dans la zone de la rive du nord du lac Ontario.

MANAGEMENT PERSPECTIVE

This report documents dump sites in close proximity to the lower Great Lakes shoreline. These sites could become sources of contaminants for the lake waters, as a result of shore recession or ground water movement. A short list of potentially hazardous sites is given. More specific information on these sites in terms of dump contents, local recession rates and/or hydrology is required to establish if any of these sites are indeed hazardous.

PERSPECTIVE-GESTION

Le présent rapport traite de sites d'enfouissement situés très près du rivage des Grands Lacs inférieurs. Ces sites pourraient être des sources de contaminants des eaux du lac, par suite du recul de la rive ou de la migration des eaux souterraines. Nous présentons une courte liste de sites présentant un potentiel de risque. Nous avons cependant besoin de plus de renseignements sur ces sites, notamment sur le contenu du site, les taux locaux de recul et/ou les caractéristiques hydrologiques, afin de déterminer si ces sites présentent réellement un risque.

1.0 INTRODUCTION

According to unofficial estimates by the Ontario Ministry of the Environment Waste Management Branch (B. Hogarth, pers. comm., 1986), the total number of waste disposal sites in Ontario, active or closed, is approximately 4000 (Table 1a). More than 230 of these sites, or approximately 6%, are now located within 5 km of the shoreline of the lower Great Lakes and their adjacent inflowing streams and estuaries. In view of the persistent phenomenon of shoreline recession along these lakes, it is conceivable that such waste sites could present a potential contamination hazard to nearshore lake water quality. The hazard could be direct, namely through the eventual destruction of the sites by shore erosion processes. It might also be indirect, caused by the reduction of attenuation lengths for contaminants in groundwater discharges to the nearby shoreline. This study is aimed at compiling and analyzing existing data on waste disposal sites, shore recession rates, and shoreline geology in the coastal zone defined above, and to pinpoint areas where contamination problems might be anticipated.

1.1 Background

The negative economic impacts of shoreline recession on land-based assets in the Great Lakes are already well documented (Boulden, 1975). The impact of shoreline recession on water-related assets, however, has received far less attention. This might be because shore erosion is generally regarded to be a relatively minor factor in lake water quality considerations. In fact, some see the eroded sediment as having a positive effect in removing contaminants from the water column and trapping them in sediment deposits (M.N. Charlton, NWRI, 1985, pers. comm.). This reasoning is weakened considerably if the eroded sediment itself is contaminated, as was demonstrated in the International Joint Commission PLUARG (Pollution from Land Use Activities Reference Group) studies (IJC, 1979). One of the more potentially serious forms of such impacts, and one which has up to now been largely overlooked, is the contamination of nearshore waters by nearby waste disposal sites as these are gradually brought into contact with shoreline-related erosion and hydrogeological processes. An excellent discussion of how waste disposal sites can contaminate groundwater is presented in Hughes et al. (1971).

Recent initiatives to document this problem include some of the PLUARG studies, especially Ostry (1979), and Thomas and Haras (undated). Also, attention is now being given to the impacts on Lake Ontario water quality resulting from the refinery waste disposal site owned by Eldorado Nuclear Ltd. at Port Granby (Quigley, 1982; Golder Associates, 1983). Another example of increased interest in waste sites is the general concern over the discharges of highly toxic wastes into the Niagara River via contaminated groundwater from nearby closed and degraded disposal sites in New York state.

In 1979, the Waste Management Branch (WMB) of the Ontario Ministry of the Environment (OME) initiated a computer inventory of waste disposal sites in the province. Provincial certification of waste disposal sites was only begun in 1972, so valuable information on specific contents and amounts dumped is lacking for sites closed prior to this date. In 1980, Environment Canada began the cataloging of waste disposal sites on lands administered by agencies of the federal government. The results to date are contained in two contract reports to Environment Canada (1983 and 1984 by M.M. Dillon, Ltd. and Morrison Beatty, Ltd., respectively).

2.0 DATA SOURCES

2.1 Waste Disposal Sites

In May, 1984, a request was made to the WMB for a computer listing of all waste disposal sites within the coastal zone (defined here as a 5 km strip along the present shoreline) of the Lower Great

Lakes shoreline between Midland and Kingston, including the Bay of Quinte. Because the investigation was aimed primarily at lakeshore erosion processes, sites near rivers and minor lakes in the region were deliberately excluded, except in cases where they otherwise filled the above criteria. Later, in view of recent occurrences of contaminants in nearshore sediments of the upper St. Clair River, an exception to this rule was made for waste disposal sites along the St. Clair River - Lake St. Clair - Detroit River system.

The information requested was kindly supplied by WMB at intervals over the subsequent months in the form of computer printouts from the original WMB data base. In July 1986, shortly before this report went to press, a preliminary report on the waste disposal site inventory was released (Ontario Ministry of the Environment, 1986). A listing of the sites meeting the request criteria was compiled from these data sources and is presented here as Appendix A. Unlike the original computer printouts, the OME report contained information on waste site type and waste composition; this information is also included in Appendix A. The classification is explained in detail in the OME report. Briefly, the sites are divided into two groups (A: potentially hazardous to humans; and B: potentially hazardous to the environment). Increasing degrees of concern are expressed as numerals from 1 to 3; e.g., A3. Waste types stored at the sites, where such information is available, are noted; e.g., L100: site contains 100% liquid wastes. Other important classes are H (hazardous), ϕ (other) and CL (commercial). Only sites whose contents were listed as H, L or ϕ were noted in the Appendix.

In addition to the above, very useful data on waste disposal sites on lands under federal government control were obtained from the two reports contracted by Environment Canada (1983, 1984). These reports also graded the sites according to their perceived hazard with respect to leachate emissions to local water resources, but did not directly address the issue of contamination through shore recession. Waste disposal sites on federal lands are usually minor in importance, and were included in the listing only if they occurred within 1 km of the shoreline. However, those that fell into M.M. Dillon's site category II or higher (based mainly on toxicity of contents and size)were included if they met the criterion of being within 5 km of the shoreline. Information regarding waste sites managed by the Atomic Energy Control Board, another Crown agency, was not available in any of the above sources. However, unpublished information from Environment Protection Service of Environment Canada (R. Krauel, pers. comm, 1986), enabled the inclusion of such sites meeting the study criterion in this report.

2.2 Shoreline Geology

Published sources for the surficial geology of the coastal zone are listed in Table 2. Information on shoreline recession rates was supplied by the Coastal Zone Atlas (Haras and Tsui, 1976) and the Canada-Ontario Great Lakes Shore Damage Report (Boulden, 1975). Generalized estimates of the permeability of the coastal zone materials based on their hydraulic conductivity, K, were obtained from Freeze and Cherry (1979), Desaulniers et al. (1981), and Ontario Waste Management Corporation (OWMC, 1982).

3.0 PRELIMINARY RESULTS

3.1 Waste Disposal Sites in the Coastal Zone

Although Lake Ontario has the highest combined number of waste disposal sites located in the coastal zone (147), only 11 active sites exist at present (Table 1b). Despite their larger coastal zones, Lake Huron (including Georgian Bay) and Lake Erie have much fewer such sites overall, perhaps reflecting their lower level of urbanization. However, active sites around these lakes form a larger proportion of the total than for Lake Ontario.

Figures 1 to 4 show the plotted locations of all the waste disposal sites listed in Appendix A. grouped according status (i.e.,active or closed). In Lake Ontario, significant concentrations of closed disposal sites are found in the northeast Toronto area, in north Burlington, and in the Hamilton area (Figure 1). Lesser concentrations are associated with the Trenton-Belleville, Oshawa, Grimsby, and St. Catherines areas.

For the Lake Erie region, including Lake St. Clair (Figure 2), active sites in the coastal zone are relatively few, with a noticeable bias toward the eastern end of the lake. Closed sites, however, show clusters in the Lake St. Clair area immediately east of Windsor, and near Amherstburg.

Waste disposal sites in the Lake Huron area are concentrated in the northern shoreline reach (Kincardine - Douglas Point - Southampton area), and in the extreme south (Sarnia - St. Clair River). This is especially true for the active sites (Figure 3). For the Georgian Bay area, active sites occur around Meaford - Collingwood (Figure 4).

3.2 Minimum Distance to Shoreline

The computer program used to plot the sites located within the 5 km zone was also capable of computing the minimum distance from each site to the digitized shoreline for each lake. The resulting distance is subject to some uncertainty due to the coarse scale of the original digitization of the shoreline. For this reason, waste disposal sites located along the major connecting channels and along the Bay of Quinte and Hamilton Harbour (except the Niagara River) were plotted manually onto 1:25000 topographic maps and the minimum distance to the shoreline scaled off. Also, all sites whose computed distances were less than 1 km were plotted manually onto 1:10000 topographic sheets (Coastal Zone Atlas (Haras and Tsui, 1976)), and the distance checked by scaling prior to being recorded in Table 3.

The error associated with the measurement procedure is therefore deemed minor; however, no assessment can be made here of errors in the original raw data from OME.

Table 3 shows a total of 60 sites less than 1 km from the shoreline. By far the largest number (46) are found around Lake Ontario. This is in contrast with the 7 sites around Lake Erie (including Lake St. Clair), and the 7 sites in the Lake Huron - Georgian Bay area (including the St. Clair River). Relatively high concentrations of sites less than 1 km from the present shoreline are found between Oshawa and Port Hope, Mississauga, and Hamilton areas of the Lake Ontario shoreline (Figure 1), and the Essex County shoreline of Lakes Erie and St. Clair (Figure 2).

3.3 Overview of Surficial Geology

Figures 5 to 7 present a generalized picture of the surficial geology of the coastal zone of the Lower Great Lakes. The shoreline usually consists of a combination of shoreline types, the three most prevalent of which are described below.

3.3.1 Bedrock

The eastern shoreline of Lakes Ontario and Erie, and the Bruce Penninsula (between Lake Huron and Georgian Bay) are all composed primarily of bedrock, generally with a thin cover of glacial sediments and soils. The rocks outcropping along these shores are predominantly carbonates, and are very resistent to shore erosion. Permeability values for carbonate materials tend to be generally low (i.e. hydraulic conductivity (K) averaging around 10^{-7} m/s) but might be several orders of magnitude higher if open fractures and joints are present. Permeability of shale materials, such as those outcropping in the western end of Lake Ontario, are even lower ($K < 10^{-10}$ m/s). Variable thicknesses of coarse granular materials are almost always found overlying bedrock at depth, and these have a much higher permeability (K ≈ 10^{-6} m/s).

3.3.2 Till

Till is a dense, partially consolidated earth material, deposited in direct contact with glacial ice. It is typically poorly-sorted, being composed primarily of clay with varying admixtures of materials ranging (in grain-size) from silt to boulders. Tills usually occur as sheet-like deposits of irregular areal extent and often form part of an alternating vertical sequence with sand-rich, stratified glaciolacustrine or glaciofluvial deposits. The sequence reflects the oscillating advance and retreat of the glacier. Thus, tills commonly are associated with irregular lenses or layers of granular material. Also, when weathered, till is characterized by a columnar fracture pattern. Therefore, although the hydraulic conductivities of tills are generally low (in the range of 10^{-12} to 10^{-9} m/s), zones of enhanced permeability are common, especially in the case of such weathered and fractured tills. Till shore-zones comprise a large portion of the study area. The Halton Till, making up the shoreline and subsurface along the western end of Lake Ontario and eastern Lake Erie, extending roughly from Toronto to Welland, is a fine-textured, silt till of relatively low permeability, while the Wentworth Till, which underlies it and outcrops further to the west, is a sandy, stoney till. Along Lake Erie, the tills occurring in the coastal zone vary from the very fine clay-rich Port Stanley Till (between Long Point and Pointe-aux-Pins), and the sandy Catfish Creek Till at the western end of the lake. The till that occurs at the southern end of the Lake Huron shoreline is known as the St. Joseph Till, characterized by a very fine, clayey texture (K ≈ 10^{-10} m/s; Desaulniers et al., 1981).

3.3.3 Glaciolacustrine and Glaciofluvial Materials

These materials generally occur adjacent to till sheets. They comprise stratified deposits laid down in an ice-margin lake, river, or delta, although they may be altered considerably by subsequent aeolian processes. As such they include a variety of textures, from thick, varved clay deposits to well-sorted sand and gravel, depending primarily on the original environment of deposition. Deposits of this type within the study area date back to the sequence of high-level late glacial and postglacial lakes that once covered most of southern Ontario. Massive glaciolacustrine clay deposits, occurring in the eastern end of Lake Erie and in the Lake St. Clair area, are characterized by a remarkable uniformity of texture and, as a result, have very low permeability values (K ≈ m/s; Desaulniers *et al*. (1981)). Glaciolacustrine and glaciofluvial sand and gravel deposits occur in the Leamington area of Lake Erie and at the Scarborough Bluffs on Lake Ontario and can have high permeabilities (K ≈ 10^{-7} m/s, or greater). Till/glaciolacustrine complexes (i.e., vertically alternating sequences of till and stratified sediments) dominate the surficial sediment column exposed along most of the north shore of Lake Ontario, central Lake Erie, and most of southern Lake Huron and Georgian Bay.

3.4 Recession Rates

A generalized summary of historical recession rates (ca. 1900 - present) for each county fronting on the lakes (Boulden, 1975) is presented in Table 4. The highest rates occur in Kent County along the eastern shore of Lake St. Clair, followed by Elgin County in east-central Lake Erie. These averges suffice for a general overview of shore recession trends, but for analysis of contamination hazard, it was decided to use the site-specific rates nearest to the waste disposal site, even though they might be shorter-term. These were taken from Haras and Tsui, (1976) and from Boulden (1975), and are presented in Table 3.

4.0 CONTAMINATION HAZARD FROM SHORELINE RECESSION

The contamination hazard posed by shore recession in the vicinity of coastal zone waste disposal sites can be assessed in large measure as a function of the shore recession rate and the local hydrogeology. This ignores, for simplicity sake, the quality of management of the site, e.g. whether leachate control was used, presence of an impervious cap, etc. Another equally important factor required in a more thorough assessment, namely the toxicity of the contents of the site, is very difficult to quantify for these sites, especially in the case of the closed uncertified sites. Preliminary site classification and assessment of waste types were included in Ontario Ministry of the Environment (1986). These are reproduced in Appendix A and Table 2. Classification of many of the closed sites, however, require verification in the field. Under legislation existing prior to 1972, waste disposal sites were not required to disclose their contents. Furthermore, the older sites are the ones expected to be most threatened at present by on-going recession and leachate break-through.

In determining the potential recession hazard to coastal zone waste disposal sites, the nearest measured shoreline recession rate was combined with the calculated or scaled distance of the site from the shore. This provided an estimate of the time required for the receding shoreline to reach the waste disposal site, assuming no future change in recession rate. This time period is referred to here as the contact time. Waste disposal sites are arbitrarily deemed to pose a recession hazard in the context of this report if the contact time is 50 years or less.

In contrast to the availability of data on surficial geological conditions, detailed hydrological information in the vicinity of the sites is not available except in scattered, isolated cases.

For this reason, groundwater contamination hazards cannot be evaluated to the extent that erosion hazards can. The key consideration is the likely presence in the subsurface sediments of high-permeability zones, such as coarse sediment layers, or fractured bedrock or till. Any of these situations would provide a means for contaminated leachate-bearing groundwater to reach the shoreface and the lake. In this analysis, assessment of potential contamination hazard through groundwater is therefore based on whether leachate break-throughs could reach the lakeshore within 50 years, assuming reasonable hydraulic conductivities for the geological materials concerned, and conservative estimates of the shore-zone hydraulic gradient.

4.1 Recession Hazards

The right-most column in Table 3 shows the published recession rate (Boulden, 1975) at the shoreline station nearest the waste disposal site concerned. With few exceptions, the recession rates are quite low; most are less than 0.25 m/y, and only 8 exceed 0.5 m/y. Insofar as contact times are concerned, only two sites along the Lake Ontario shoreline (site 0-125 near Cobourg, and the Eldorado Nuclear (ENL) site at Port Granby) are expected to contact the shoreline within the next 50 years. These sites are shown in boldface in Table 3. In the case of site 0-125, the calculated contact time for this to occur is around 25 years, when the maximum (short-term) recession rate was used. This site is classified by OME as (A), i.e, hazardous to humans. For the Port Granby site, the selection of the appropriate recession rate to use might be a factor in assessing whether a recession hazard exists. Using the mean of two recession measurement points equidistant from the site gives a contact time of 40 years, assuming the waste disposal area is located 25 m inland from the present shore. The Port Granby site contains mildly radioactive industrial wastes from the refining of uranium ore, and this may be considered hazardous to humans.

The only site along the other lake shorelines that might meet the 50-year criterion is the DOE site in Point Pelee National Park (P-105). Although the long-term recession rate for that part of the eastern shore of Point Pelee is given as 0.6 m/y (Boulden, 1975), i.e., a contact time of 166 years, short-term rates during the recent high lake level period are given as around 6 m/y (contact time: <20 years). Shaw (1985) gives an average recession rate of 4 m/y, for a contact time of approximately 25 years. Therefore, this site was included in the list of recession-related hazardous waste disposal sites.

4.2 Groundwater Contamination Hazards

As stated previously, groundwater contamination hazard depends greatly on the nature of the waste contained at the site, information on which is either unavailable or questionable. The surficial geology described here, while indicative of overall groundwater flow conditions, represents only one factor in the equation. Nevertheless, using average hydraulic conductivity values (Freeze and Cherry, 1979, Table 2.2) as a guide, it is clear that areas composed of sands and silts, primarily of glaciolacustrine or glaciofluvial origin, are most vulnerable. For instance, by substitution into Darcy's equation (flow velocity, $v = Ki$), contaminants from a site in contact with relatively permeable materials (hydraulic conductivity (K) of 10^{-5} m/s) could be transported down a hydraulic gradient (i) of 0.01 at a velocity of 3 m/year. In other words, the contaminant would travel approximately 0.2 km in 50 years. The hydraulic gradient is defined as the ratio of the change in hydraulic head to distance measured at right angles to the shoreline. The above value for the hydraulic gradient is based on averages for the Lake Ontario shore zone (Haefeli, 1972; p.33), so it might vary somewhat for other lakes. If the gradient were steeper, such as in high-relief bluff shorelines, then the rate would increase in a linear fashion. Also, since the above transport does not include hydrodynamic dispersion, chemical reactions, or adsorption, it represents only a crude estimation.

High-relief shorelines composed of glaciolacustrine materials occur along much of the north shoreline of Lake Ontario between Toronto and Presqu'ile (Fig. 5), where a number of waste disposal sites are located within 1 km of the shoreline (Figure 1, Table 3). Thus waste disposal sites in such materials that are located 0.2 km or less from the shore are considered potential hazards for groundwater contamination. These sites are shown in boldface in Table 3. Also noted in the list are sites in Point Pelee National Park (P-105, E-17). These sites are located in clean sand deposits having a relatively high permeability although the hydraulic gradient is very low. Their proximity both to the lake and the partially-open back shore marsh makes them potential contaminant sources via groundwater diffusion.

In contrast, Darcy flow displacements in clay-rich tills and glaciolacustrine clay deposits ($K \approx 10^{-10}$ m/s, hydraulic gradient $\approx$ 0.01) would be only on the order of a few tenths of a metre over 50 years. This analysis makes no attempt to take more rapid fracture flow conditions, or vertical migration to more permeable layers at depth, into account. Therefore, all disposal sites located in thick sections of such materials are deemed to pose no hazard of groundwater-related contamination.

5.0 SUMMARY

The waste disposal sites that meet the 50-year criterion, grouped into either recession or groundwater hazards, are indicated in bold face in Table 3. The data indicate that shore recession presents a contamination hazard for the lakes in only three cases, two of which are located in the the central northern shoreline of Lake Ontario, and one in the Point Pelee area of Lake Erie. The former area, located on the sand-rich shoreline from Scarborough to Port Hope, also represents a considerable potential hazard insofar as groundwater-related contamination is concerned. The sandy surficial materials in the Hamilton area, where a number of waste disposal sites are located, also contribute to creating a potential area of concern for groundwater contaminant inputs. This factor is aggravated in the the case of those disposal sites located in the Hamilton Harbour area on reclaimed land which could be relatively permeable. Furthermore, the steep hydraulic gradients created by the proximity of the Niagara Escarpment to the south suggest the presence of substantial groundwater flux which might lead to entrainment of contaminants from the sites. The sites located on the south shore of Lake St. Clair, while less vulnerable to recession, are low-lying and thus is susceptible to flooding. This can pose a hazard for direct contamination of surface waters by the sites' contents, with eventual effects on Lake St. Clair waters.

One reason for the low number of sites threatened by shoreline recession is that many front onto bays or inner harbour areas, where recession rates are low due either to low-energy wave regimes, or to widespread shore protection. Nevertheless, data shortcomings such as the relative scarcity of site-specific long-term recession rates, might also be a factor in the low number of recession-threatened sites. The analysis could therefore be improved by on-site verification or more detailed inspection of the rates used.

REFERENCES

Barnett, P.J. 1983. Quaternary Geology of the Port Burwell area, Southern Ontario. Ont. Geol. Surv. Map P. 2624, Geol. Series.

Barnett, P.J. and A. Zilans. 1983. Quaternary Geology of the Long Point Area, Southern Ontario. Ont. Geol. Surv. Map P. 2616, Geol. Series.

Boulden, R. 1975. Canada-Ontario Great Lakes Shore Damage Survey. Tech. Report. Environment Canada and Ontario Ministry of Natural Resources, 97 p.

Chapman, L.J. and D.F. Putman. 1966. The Physiography of Southern Ontario. Univ. of Toronto Press, 387 p.

Cooper, A.J. and C. Baker. 1978. Quaternary Geology of the Bothwell-Ridgetown Area, Southern Ontario. Ont. Geol. Survey Prelim. Map P. 1973, Geol. Series.

Desaulniers, D.E., J.A. Cherry and P. Fritz. 1981. Origin, Age, and Movement of Pore Water in Argillaceous Quaternary Deposits at Four Sites in Southwestern Ontario. Jour. Hydrology, 50, pp. 231-257.

Dreimanis, A. and P.J. Barnett. 1985. Quaternary Geology of the Port Stanley Area, Southern Ontario. Ont. Geol. Surv. Map P. 2827, Geol. Series.

Environment Canada, 1983. Study of Abandoned Waste Disposal Sites (Land) for Selected Federal Agencies in Ontario. Final Report (Phase I) of contract to M.M. Dillon, Ltd., from EPS-Ontario Region, 32 p. plus appendices.

Environment Canada. 1984. Study of Abandoned Waste Disposal Sites (Land) for Selected Federal Agencies in Ontario. Final Report. Phase (II) of contract to Morrison Beatty, Ltd., from EPS-Ontario Region, 31 p. plus appendices.

Feenstra, B.H. 1972a. Quaternary Geology of the Niagara Area, Southern Ontario. Ont. Div. Mines Prelim. Map P. 764, Geol. Series.

Feenstra, B.H. 1972b. Quaternary Geology of the Welland Area, Southern Ontario. Ont. Div. Mines, Prelim. Map. P. 796, Geol. Series.

Feenstra, B.H. 1974. Quaternary Geology of the Dunnville Area, Southern Ontario. Ont. Div. Mines, Prelim. Map P. 981, Geol. Series.

Feenstra, B.H. 1975. Quaternary Geology of the Grimsby Area, Southern Ontario. Ont. Div. Mines Prelim. Map P. 993, Geol. Series.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc., 604 p.

Golder Associates. 1983. Review of Stability and Monitoring and Response Plan, Port Granby Waste Management Area, Port Granby, Ontario. Contract report to Eldorado Resources Ltd., December 1983, 73 p.

Haefeli, C.J. 1972. Groundwater Inflow into Lake Ontario From the Canadian Side. Can. Dept. Environment, IWD, Sci. Series No. 9, 101 p.

Haras, W.S. and K.K. Tsui. 1976. Canada-Ontario Great Lakes Shore Damage Survey - Coastal Zone Atlas. Environment Canada, Ontario Ministry of Natural Resources publ., 95 p.

Hegler, D.P. 1972. Lake Ontario Shoreline Erosion in the Regional Municipality of Niagara. Unpubl. M.A.Sc. Thesis, Dept. Civil Engineering, Univ. of Waterloo, 346 p.

Hughes, G., J.J. Tremblay, H. Anger, and J. D'Cruz. 1971. Pollution of Groundwater due to Municipal Dumps. Inland Waters Branch, Dept. Energy, Mines and Resources, Tech. Bull. 42, 98 p.

IJC, 1979. Annotated Bibliography of PLUARG Reports. IJC Great Lakes Regional Office, 121 p.

Karrow, P.F. 1967. Pleistocene Geology of the Scarborough Area. Ont. Dept. Mines, Geol. Report 46, 108 p.

Martini, I.P., M.E. Brookfield and Q.H.J. Gwyn. 1981. Quaternary Stratigraphy of the Coastal Bluffs of Lake Ontario East of Oshawa. Field Guide Symposium on Quaternary Dating Methods, York Univ., pp. 89-111.

Ontario Ministry of the Environment. 1986. Waste Site Inventories. Preliminary report, Waste Management Branch, July 1986. unpag.

Ostry, R.C. 1979. The Hydrogeology of the Forty Mile and Oakville Creek Study Areas. Ont. Min. Env. Water Res. Br., Report 5b, 44 p.

Ostry, R.C. 1979. The Evaluation of the Effect of Some Waste Disposal Practices on Great Lakes Water Quality. IJC PLUARG report (Task Group C), 40 p.

Ostry, R.C. and S.N. Singer. 1981. The Hydrogeology of the Moira River, Wilton Creek, and Thousand Islands Study Areas. Ont. Min. Env. Water Res. Br., Report 5e, 40 p.

Quigley, R.M. 1982. Review of Port Granby Shoreline Bluffs. Contract report to Eldorado Nuclear Ltd., July 1982, 9 p.

Rutka, R.N. 1975. Bluff Recession on Western Lake Ontario. Unpubl. M.A.Sc. Thesis, Dept. Civil Engineering, Univ. of Waterloo, 210 p.

Sharpe, D.R. 1980. Quaternary Geology of Toronto and Surrounding Area. Ont. Geol. Surv. Prelim. Map P. 2204, Geol. Series.

Shaw, J.R. 1985. Beach and Offshore Changes at Point Pelee National Park, Lake Erie 1974-1982. Unpubl. MA Thesis, Dept. of Geography, Univ. of Waterloo, 161 p.

Singer, S. 1973. Surficial Geology Along the North Shore of Lake Ontario in the Bowmanville-Newcastle Area. Proc. 16th Conf. Gt. Lakes Res., pp. 441-453.

Thomas, R.L. and Haras, W.S. (undated). Contribution of Sediment and Associated Elements to the Great Lakes from Erosion of the Canadian Shoreline. IJC PLUARG Tech. Rep. Task, D, Activity 1, 57 p.

Vagners, U.J. 1972. Quaternary Geology of the Windsor-Essex Area (Eastern Part), Southern Ontario. Ont. Dept. Mines and Northern Affairs, Prelim. Map P. 749, P. 750, Geol. Series.

Zeman, A.J. 1980. Stratigraphy and Textural Composition of Bluff Soil Strata, North Shore of Lake Erie Between Rondeau and Long Point. Unpubl. Hydr. Div. Report, H79 049, 82 p.

Zeman, A.J. 1979. Results of Geotechnical Investigation for the Colchester South/Gosfield South Shoreline, Western Lake Erie. Unpubl. Hydr. Div. Report, 39 p.

TABLE 1a

Ontario Waste Disposal Sites

Site Designation	Number In Coastal Zone	Total
Active (certified) < 1979	50	1500
Abandoned (certified)	*	(est.)1000**
(uncertified) < 1971	180	1450
Total	> 230	3950

TABLE 1b

Ontario Waste Disposal Sites in the Coastal Zone

Lake	Active	Abandoned Cert.	Abandoned Uncert.	Total
Ontario	11	*	136	147
Erie (incl. Lake St. Clair)	13	*	21	34
Huron (incl. Georgian Bay)	26	*	23	49
Total	50	*	180	230

* Data on this group were not available as of May 1986.
** B. Hogarth, OME, pers. comm., 1986.

TABLE 2

Sources of Shoreline Geological Information

Information Type	Coverage	Reference
Lake Ontario Surficial	Great Lakes region	Chapman and Putman (1966)
Stratigraphy, hydrogeology, profile	Lake Ontario (Moira River, Wilton Creek, Thousand Is. areas)	Ostry and Singer (1981)
Stratigraphy profile	Lake Ontrio (Oshawa - Port Hope)	Martini et al. (1981)
Stratigraphy hydrogeology profile	Lake Ontario (Bowmanville - Newcastle)	Singer (1973)
Surficial, stratifgraphy, profile	Lake Ontario (Clarkson - Whitby)	Sharpe (1980)
Stratigraphy, hydrogeology	Lake Ontario (Duffins Creek area)	Ostry (1977)
Surficial, stratigraphy, profile	Lake Ontario (Scarborough area, Toronto)	Karrow (1967)
Stratigraphy, hydrogeology	Lake Ontario (Forty-Mile Creek, Oakville Ck.)	Ostry (1979)
Surficial stratigraphy profile	Lake Ontario (Niagara-Etobicoke)	Feenstra (1972a, 1975); Hegler (1972); Rutka (1975)
Surficial	Lake Erie (Fort Erie - Peacock Pt.)	Feenstra (1972b, 1974)
Surficial	Lake Erie (Port Dover - Long Point)	Barnett and Zilans (1983)
Surficial	Lake Erie (Long Point - Port Bruce)	Barnett (1983)

TABLE 2. Sources of Shoreline Geological Information (continued)

Information Type	Coverage	Reference
Surficial, stratigraphy, profiles	Lake Erie (Port Bruce Patrick Pt.)	Dreimanis and Barnett (1985)
Surficial	Lake Erie (Patrick Pt. - Erieau)	Cooper and Baker (1978)
Surficial strat. boreholes, profile	Lake Erie (Long Point - Pointe-aux-Pins)	Zeman (1980)
Surficial	Lake Erie (Wheatley - Stoney Point, Essex Co.)	Vagners (1972)
Surficial strat. boreholes, profile	Lake Erie (Colchester - Kingsville)	Zeman (1979)

TABLE 3

Waste Disposal Sites Less Than 1 km From Shore

(* distances scaled from 1:10000 map)
H - denotes distance to shoreline of harbour (H), coastal river or stream (R), marsh or bay (B)
DND - Dept. National Defence; DOE - Environment Canada;
DINA - Dept. Indian & Northern Affairs)
Contents code: (L100) - liquid waste 100%
(ϕ100) - unidentified waste 100%

W.D. site Ident. This study	MOE, other	COUNTY / (Area)	DISTANCE to shore* (km)	STATUS 1972	Recess. rate m/y	OME CLASS.
LAKE ONTARIO						
		FRONTENAC				
D-81	(DND)	(CFB Kingston)	0.7	CLOSED	?	?
		LENNOX & ADDINGTON				
0-7	A370801	(Millhaven, Quinte)	0.8	CLOSED	<0.25	A
0-8	A370809	(Millhaven)	0.3	ACTIVE	"	A4(ϕ100)
0-128	X9101	(Bath)	0.1	CLOSED	"	A
0-129	X9102	(Bath)	0.8	CLOSED	"	A
0-130	X9104	(Picton)	0.1	CLOSED	"	A
		HASTINGS				
0-131	A360101	(Belleville)	0.1	ACTIVE	"	A3(ϕ100)
0-133	X1065	(Belleville)	0.1	CLOSED	"	A
0-136	X1067	(Trenton)	0.2 H	CLOSED	"	A
0-139	A360204	(Trenton)	0.1 R	ACTIVE	"	A1(L100)
		NORTHUMBERLAND				
0-123	X4015	(Cobourg)	0.2 R	CLOSED	<0.25	A
0-125	X4017	(Cobourg)	0.1	CLOSED	0.5-4.3	A
0-120	X4012	(Port Hope)	0.1 H	CLOSED	<0.25	A
0-121	X4013	(Port Hope)	0.1 R	CLOSED	"	A
0-122	X4014	(Port Hope)	0.2 R	CLOSED	"	A
Eldorado Nuclear?		(Port Hope)	0.1 R	CLOSED	?	?
		REG. MUNIC. DURHAM				
0-110	X7089	(Bowmanville)	0.1 R	CLOSED	<0.25	A
Eldorado Nuclear		(Port Granby)	<0.1	CLOSED	0.6	?
0-112	X7096	(Oshawa)	0.1	CLOSED	0.35	A
0-113	X7097	(Oshawa)	0.5	CLOSED	<0.25	A
T-99	Trns.Can.	(Oshawa)	0.2 H	CLOSED	<0.25	?
0-108	X7085	(Whitby)	0.2 H	CLOSED	0.35	A
0-100	X7077	(Ajax)	0.8	CLOSED	"	A
0-11	A390203	(Pickering)	0.2	ACTIVE	<0.25	A3

TABLE 3. W.D. Sites Less Than 1 km From Shore (Continued)

W.D. site Ident. This study	MOE, other	COUNTY / (Area)	DISTANCE to shore* (km)	STATUS 1972	Recess. rate m/y	OME CLASS.
		YORK				
0-80	**X4001**	**(Scarborough)**	**0.2**	**CLOSED**	**1.4**	**A**
0-83	X4004	(Scarborough)	0.3	CLOSED	<0.25	A
0-84	X4005	(Scarborough)	0.8	CLOSED	0.6	A
		PEEL				
0-88	**X3051**	**(Mississauga)**	**0.2**	**CLOSED**	**<0.25**	**A**
0-96	X7068	(Mississauga)	0.3	CLOSED	"	A
0-97	**X7069**	**(Mississauga)**	**0.1 R**	**CLOSED**	**"**	**A**
0-98	X7070	(Mississauga)	0.4	CLOSED	"	A
		HALTON				
0-33	**X7052**	**(Bronte)**	**0.1 R,H**	**CLOSED**	**<0.25**	**A**
		HAMILTON-WENTWORTH				
0-26	X8023	Dundas	0.9 B	CLOSED	<0.25	A
0-27	X8028	Dundas	0.9 B	CLOSED	"	A
0-28	X8033	Dundas	0.3 B	CLOSED	"	A
0-40	X0030	(Hamilton West)	0.9 H	CLOSED	"	A
0-41	X0031	(Hamilton West)	0.8 H	CLOSED	"	A
0-42	X0032	(Hamilton Hbr.)	0.4 H	CLOSED	"	A
0-43	**X0033**	**(Hamilton Hbr.)**	**0.2 H**	**CLOSED**	**"**	**A**
0-44	X0034	(Hamilton Hbr.)	0.3 H	CLOSED	"	A
0-47	X0037	(Hamilton Hbr.)	0.9 H	CLOSED	"	A
0-48	**X0039**	**(Hamilton East)**	**0.1 R**	**CLOSED**	**"**	**A**
		REG. MUNIC. NIAGARA				
0-13	**X0046**	**(St. Catherines)**	**0.1 H**	**CLOSED**	**<0.25**	**A**
0-16	X0049	(St. Catherines)	0.2	CLOSED	1.5	A
A-17	X0056	(Niagara-on-the-Lake)	0.5	CLOSED	1.7	A
0-18	X0057	(Niagara-on-the-Lake)	0.3	CLOSED	1.7	A
LAKE ERIE						
		REG. MUNIC. NIAGARA				
E-11	A120310	(Port Colborne)	0.8	ACTIVE	0.4	A1(ϕ95)
		ESSEX				
E-3	A011801	(Pelee Island)	0.2	ACTIVE	<0.25	A4
E-17	**X5099**	**(Pt. Pelee Nat. Park)**	**0.9**	**CLOSED**	**0.2-0.6**	**A**
P-105	**(DOE)**	**(Pt. Pelee Nat. Park)**	**0.1**	**CLOSED**	**0.6**	**?**
E-22	X5097	(Amherstburg, Det.R.)	0.2 R	CLOSED	<0.2	A
E-25	X6060	(Lake St.Clair)	0.9	CLOSED	"	A
E-26	**X6062**	**(Windsor, L. St.Clair)**	**0.1**	**CLOSED**	**"**	**A**

TABLE 3. W.D. Sites Less Than 1 km From Shore (Continued)

W.D. site Ident. This study	MOE, other	COUNTY / (Area)	DISTANCE to shore* (km)	STATUS 1972	Recess. rate m/y	OME CLASS.
LAKE HURON AND GEORGIAN BAY						
		LAMBTON				
I-9	**(DINA)**	**(Walpole Is. Reserve)**	**0.2 R**	**CLOSED**	**<0.25**	**?**
H-24	A031802	(St. Clair River)	0.3 R	ACTIVE	"	A4
H-22	A032014	(Sarnia East)	0.5	ACTIVE	0.4	A3
		BRUCE				
H-39	X6094	(Southampton)	0.3	ABAND.	<0.25	A
H-45	X6091	(Lions Head)	0.5	ABAND.	"	A
		SIMCOE				
H-44	X4122	(Wasaga Bch.Prov.Pk.)	0.9	ABAND.	<0.25	A
H-43	X4148	(Nottawasaga)	0.8	ABAND.	"	A

TABLE 4
Historical Recession Rates for Lower Great Lakes
(from Boulden, 1975)

Lake Ontario Historical Recession Rates

County or Regional Municip-ality	Shoreline Length (km)	Coverage (km)	Coverage (%)	No. of Stations	Range of Values (m/yr)*	Weighted Average (m/yr)*
Niagara	49.09	28.73	58.5	19	+0.06 to +3.56	+1.01
Hamilton-Wentworth	18.31	9.74	53.2	5	+0.03 to +0.93	+0.50
Halton	26.90	17.71	65.8	8	- 0.64 to +0.47	+0.11
Peel	14.72	5.44	37.0	3	- 0.61 to +0.04	- 0.19
Metro Toronto	46.82	.00	0.0	0	-	-
Durham	64.92	24.49	37.7	15	0.00 to +1.16	+0.34
Northum-berland	114.03	19.80	17.4	10	0.00 to +1.16	+0.42
Prince Edward	289.54	11.83	4.1	5	0.00 to +0.20	+0.08
Hastings	68.12	0.00	0.0	0	-	-
Lennox & Addington	156.59	5.96	3.8	6	0.00 to +0.24	+0.08
Frontenac	212.92	1.61	0.8	1	+0.76	+0.76
Total:	1,061.96	125.31	11.8	72	- 0.64 to +3.56	+0.43

*Positive values indicate recession
Negative values indicate accession

Lake Erie Historical Recession Rates

County or Reg-ional Municip-ality	Shoreline Length (km)	Coverage (km)	Coverage (%)	No. of Stations	Range of Values (m/yr)*	Weighted Average (m/yr)*
Essex	146.36	38.50	26.3	60	-1.63 to +1.74	+0.28
Kent	116.56	44.78	38.4	26	-0.21 to +1.20	+0.29
Elgin	90.22	28.63	31.7	16	-1.83 to +5.61	+1.53
Haldimand -Norfolk	223.40	19.60	8.8	13	-0.44 to +2.82	+0.67
Niagara	58.12	5.66	9.7	2	-0.13 to -0.05	-0.06
Total:	634.66	137.17	21.6	117	-1.83 to +5.61	+0.59

* Positive values indicate recession
Negative values indicate accession

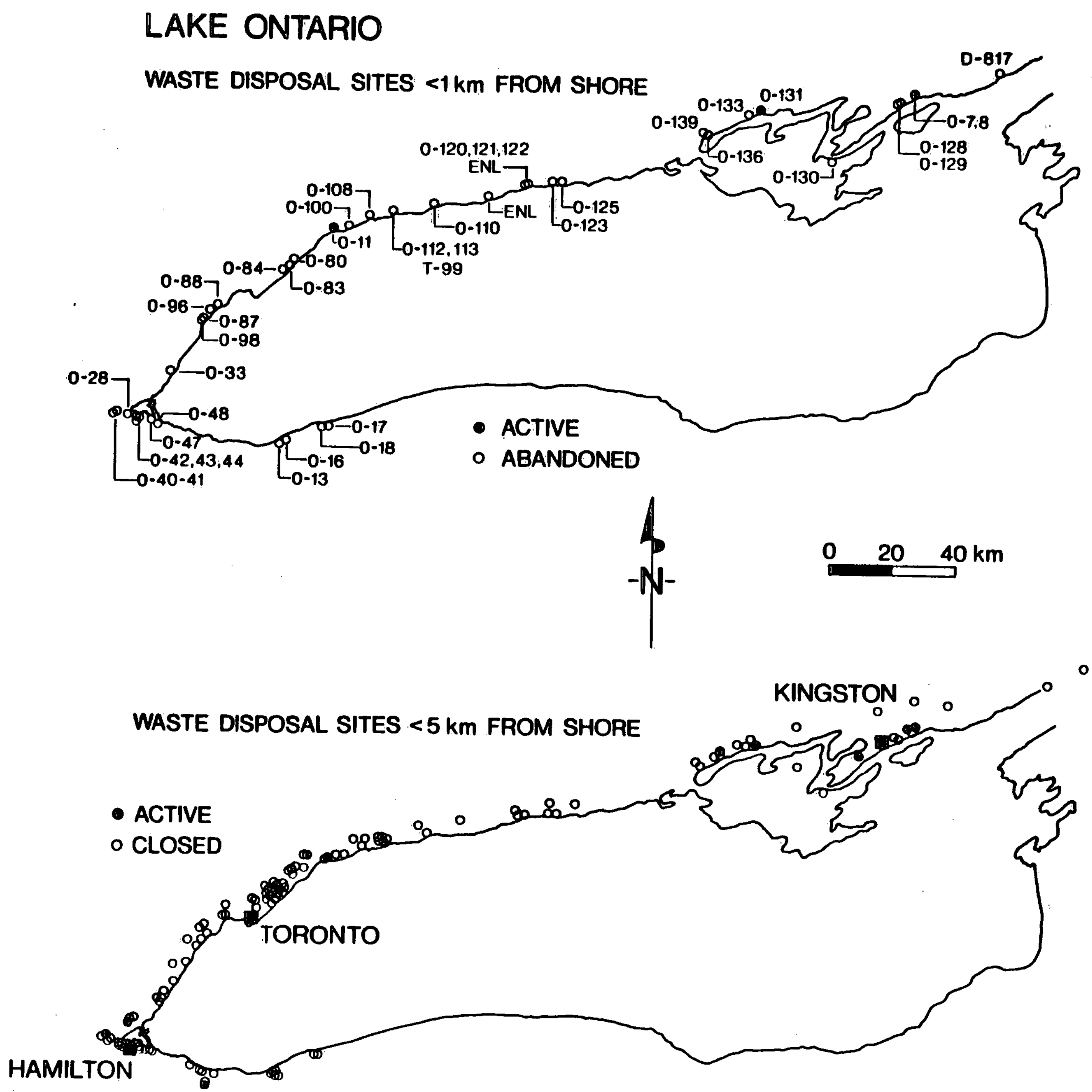
LAKE ONTARIO
WASTE DISPOSAL SITES <1 km FROM SHORE
D-817
0-7,8
0-128
0-129
0-131
0-133
0-139
0-136
0-130
0-120,121,122
ENL
ENL
0-125
0-123
0-108
0-100
0-11
0-110
0-112, 113
T-99
0-84
0-80
0-83
0-88
0-96
0-87
0-98
0-33
0-28
0-48
0-47
0-42,43,44
0-40-41
0-16
0-13
0-17
0-18
ACTIVE
ABANDONED
N
0 20 40 km
WASTE DISPOSAL SITES <5 km FROM SHORE
KINGSTON
ACTIVE
CLOSED
TORONTO
HAMILTON

FIGURE 1.

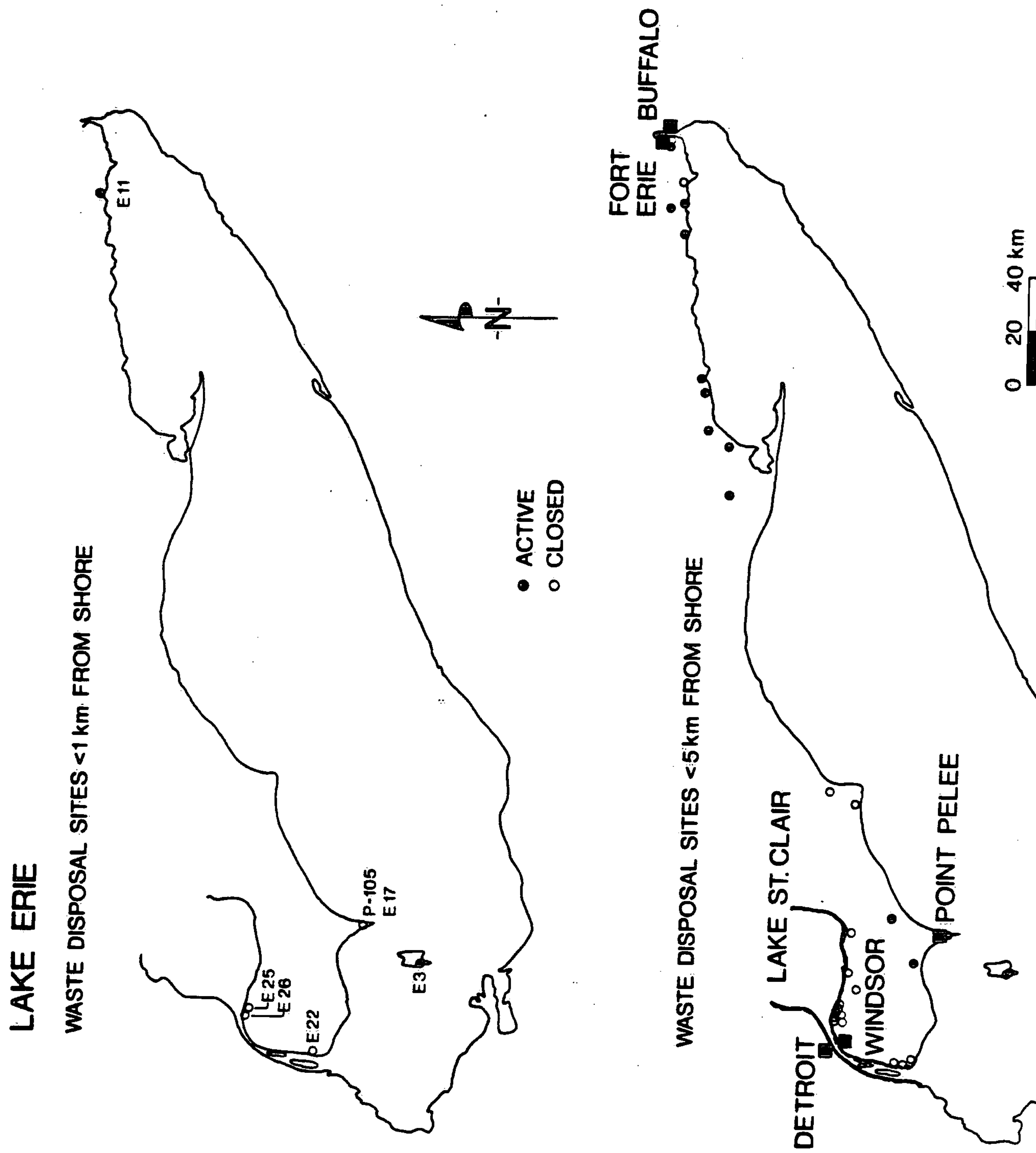
LAKE ERIE
WASTE DISPOSAL SITES <1 km FROM SHORE
E11
P-105
E17
E3
E25
E26
E22
ACTIVE
CLOSED
N
WASTE DISPOSAL SITES <5 km FROM SHORE
FORT ERIE
BUFFALO
LAKE ST. CLAIR
WINDSOR
POINT PELEE
DETROIT
0 20 40 km

FIGURE 2.

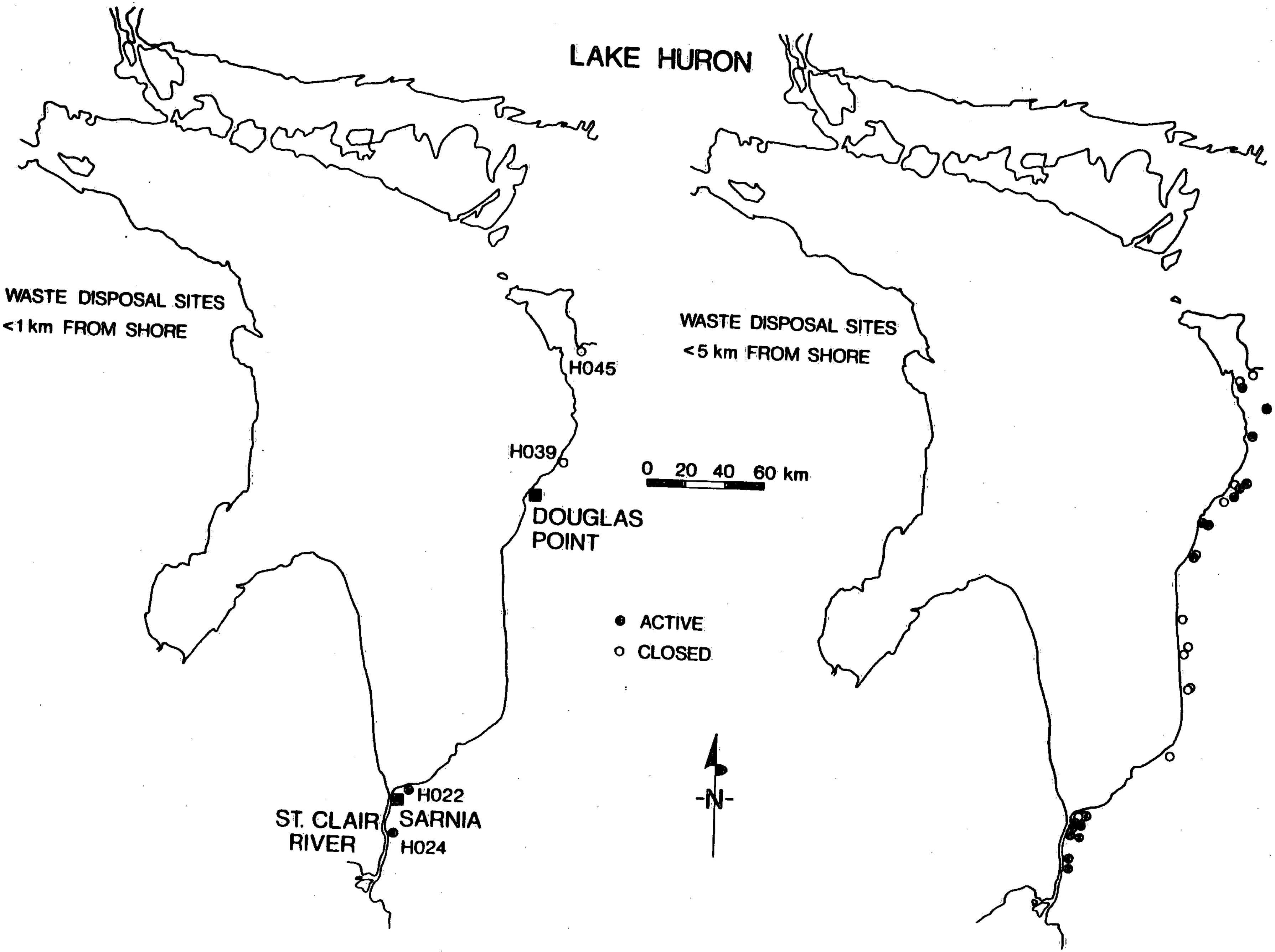
LAKE HURON
WASTE DISPOSAL SITES
<1 km FROM SHORE
H045
H039
DOUGLAS
POINT
H022
SARNIA
ST. CLAIR
RIVER
H024
WASTE DISPOSAL SITES
<5 km FROM SHORE
0 20 40 60 km
ACTIVE
CLOSED
-N-

FIGURE 3.

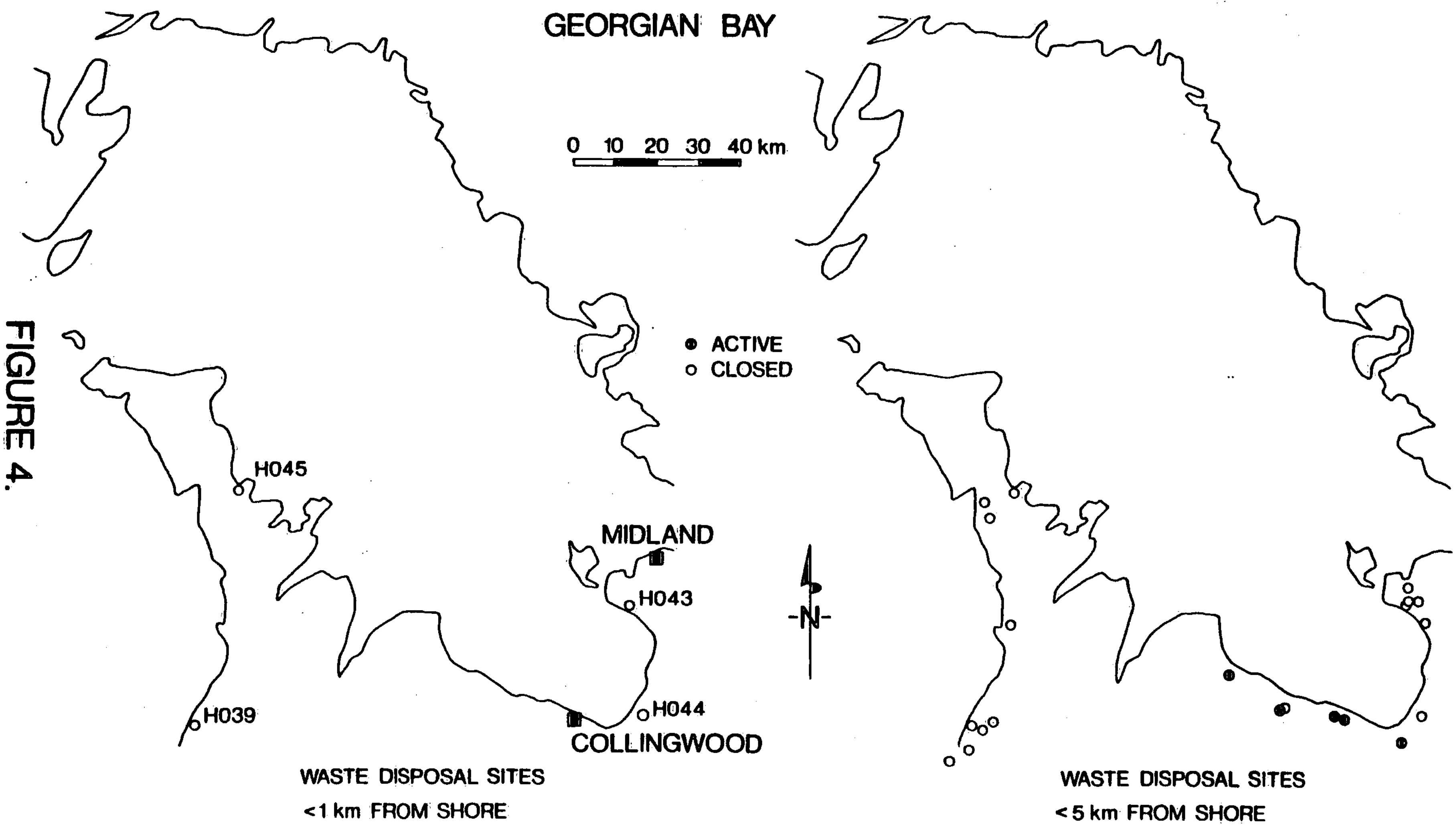
GEORGIAN BAY
0 10 20 30 40 km
ACTIVE
CLOSED
MIDLAND
H043
H044
COLLINGWOOD
H045
H039
N
WASTE DISPOSAL SITES
<1 km FROM SHORE
WASTE DISPOSAL SITES
<5 km FROM SHORE

FIGURE 4.

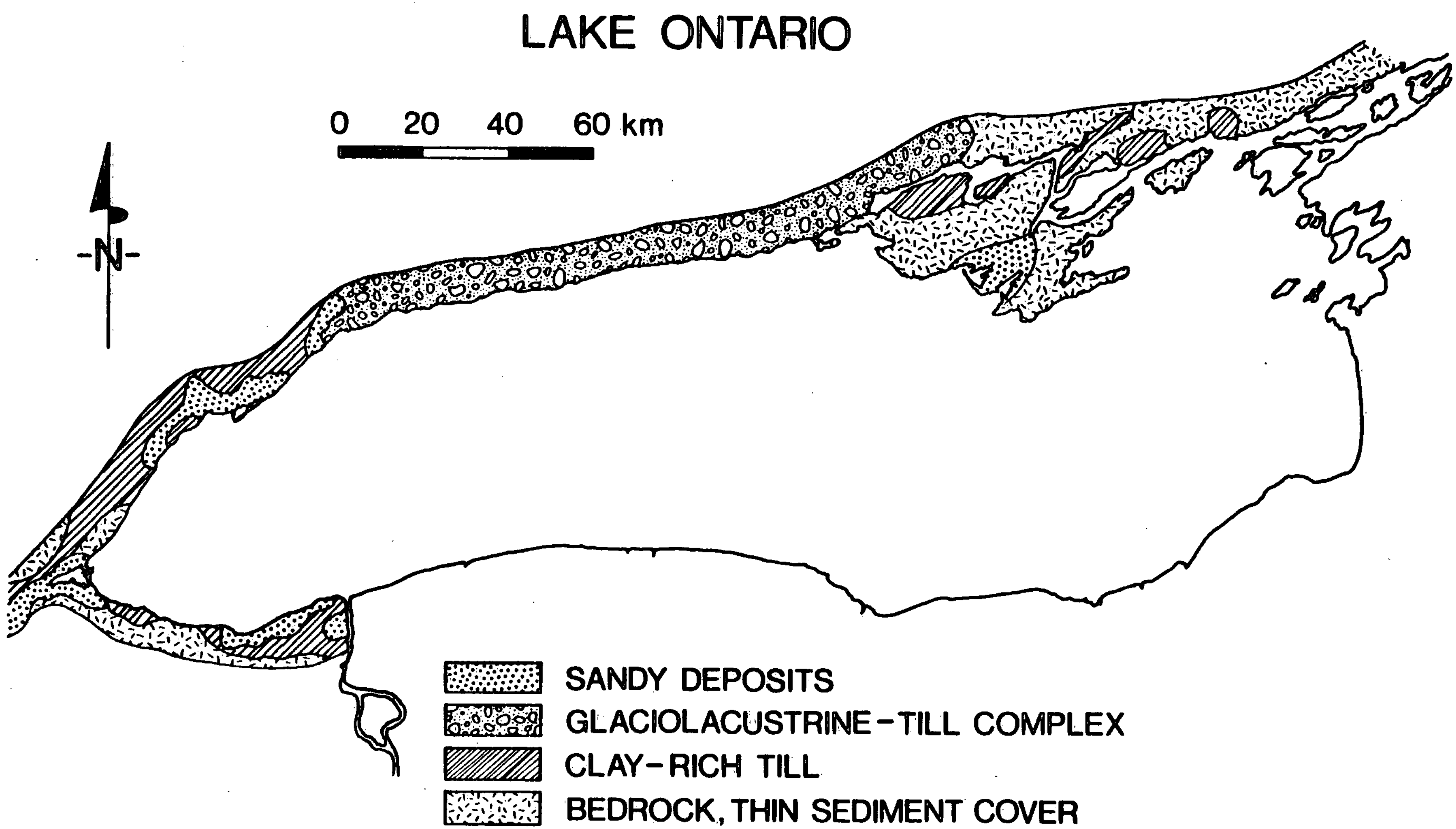

FIGURE 5. GENERAL MAP OF SURFICIAL MATERIALS WITHIN THE COASTAL ZONE

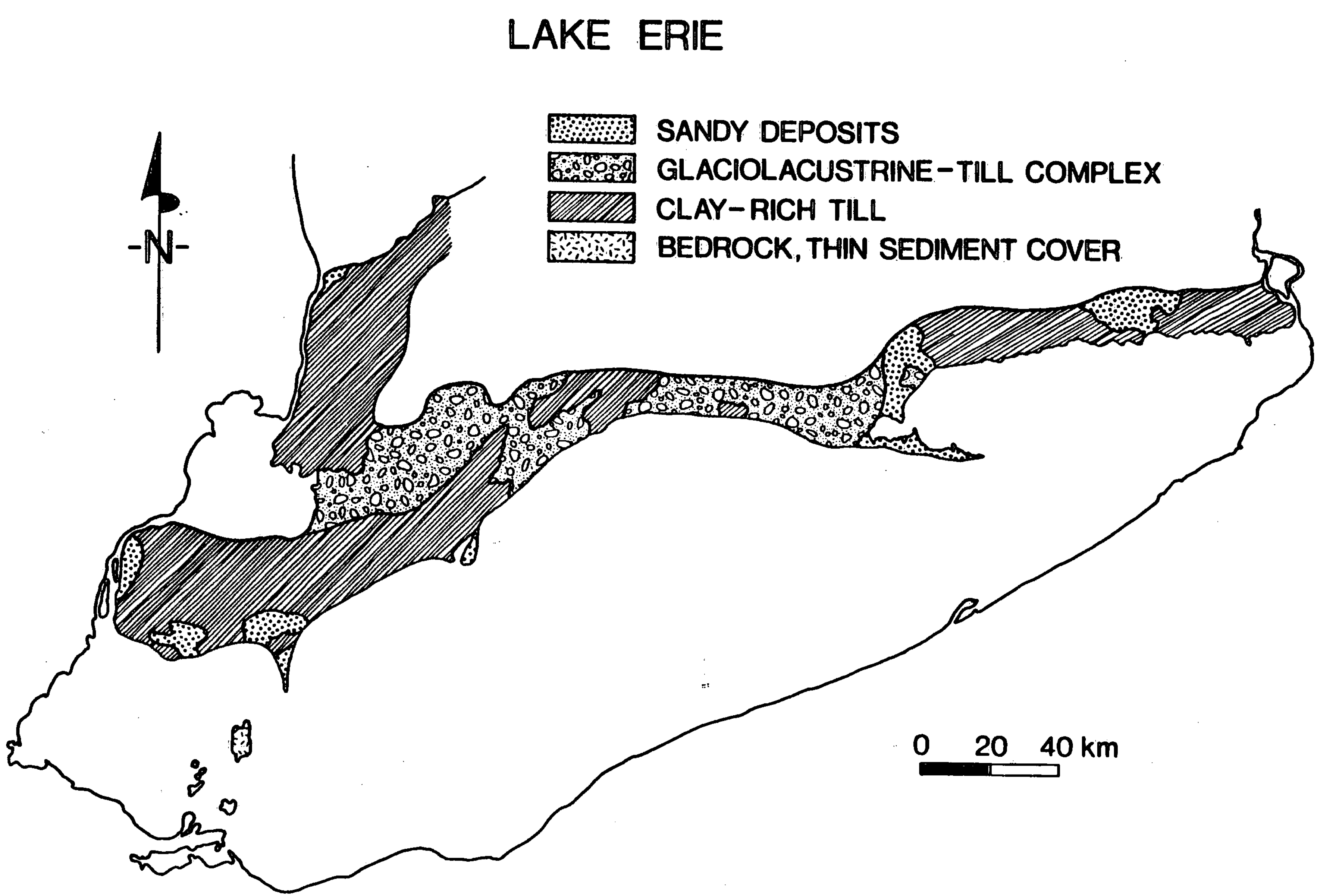

FIGURE 6. GENERAL MAP OF SURFICIAL MATERIALS WITHIN THE COASTAL ZONE

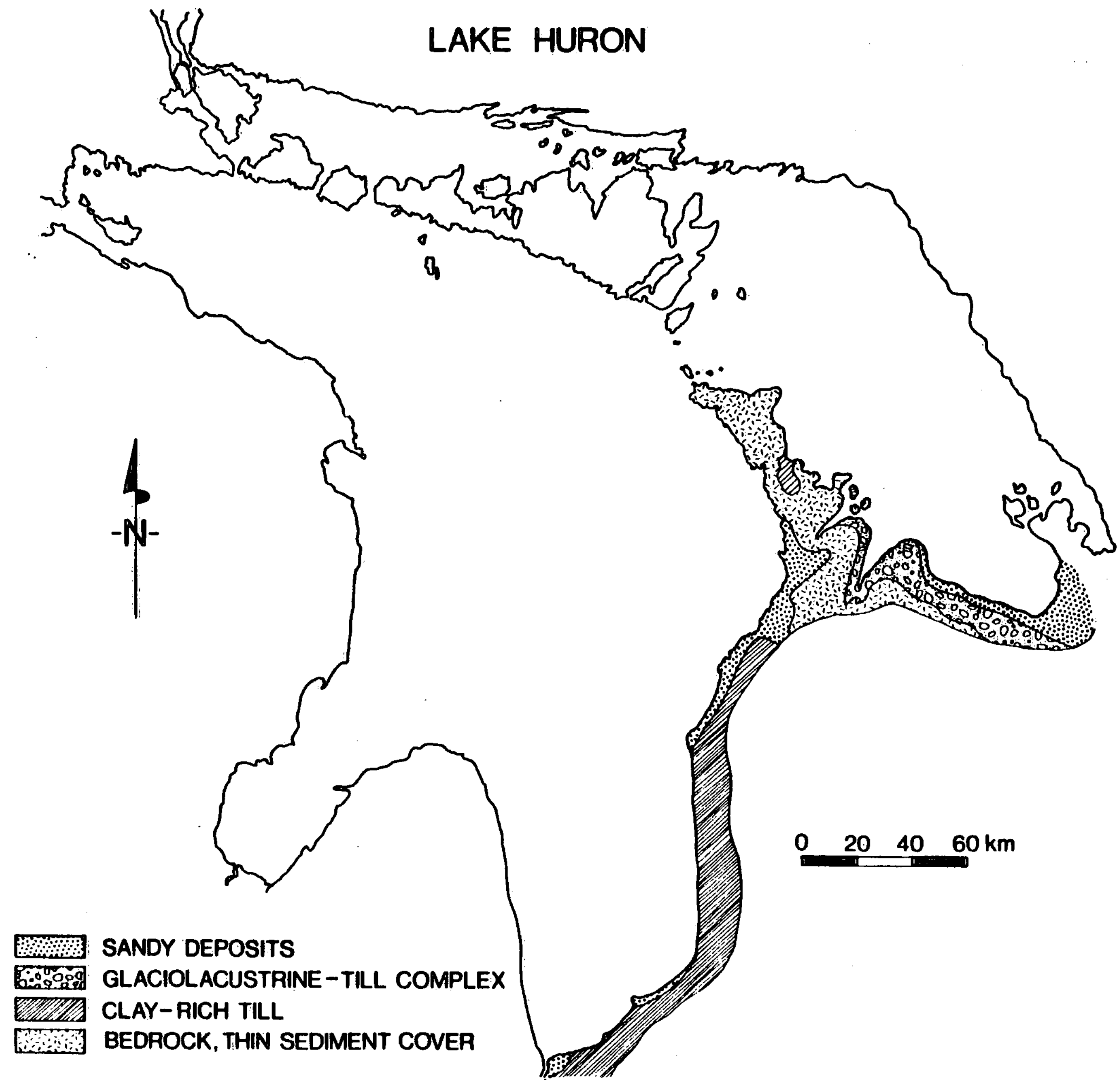

FIGURE 7. GENERAL MAP OF SURFICIAL MATERIALS WITHIN THE COASTAL ZONE

APPENDIX A

Information on Waste Disposal Sites Within The Coastal Zone
(obtained from OME (1986) and other sources)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
				LAKE ONTARIO			
A120601	0001	17	618440	4777860	5.5	15800.0	A3
A210102	0003	17	592450	4797650	3.3	183200.0	A3
A280401	0004	17	647750	4854000	4.3	316000.0	A1
A370801	0007	18	362330	4896560	0.8	0.0	A
A370809	0008	18	362460	4896000	0.3	2300.0	A4
A371001	0009	18	344600	4888560	1.0	430.0	B4
A390203	0011	17	655000	4852650	0.2	175.0	A3
X0045	0012	17	640250	4783300	1.5	CLOSED	A
X0046	0013	17	640800	4784325	0.1 H*	"	A
X0047	0014	17	640925	4783325	1.6	"	A
X0048	0015	17	641625	4782925	2.2	"	A
X0049	0016	17	641350	4784780	0.2	"	A
X0056	0017	17	655225	4791025	0.5	"	A
X0057	0018	17	654350	4790975	0.3	"	A
X0060	0019	17	621225	4782350	1.4	"	A
X0062	0020	17	617050	4783825	1.3	"	A
X0063	0021	17	616350	4783500	1.7	"	A
X0064	0022	17	614050	4784900	1.2	"	A
X8053	0023	17	617525	4784175	1.2	"	A
X8054	0024	17	618850	4779125	4.2	"	A
X8055	0025	17	617350	4783125	1.8	"	A
X8023	0026	17	585875	4790950	0.9 H	"	A
X8028	0027	17	585700	4790825	0.9 H	"	A
X8033	0028	17	586500	4791500	0.3 H	"	A
X7048	0029	17	607275	4810875	2.4	"	A
X7049	0030	17	607275	4810875	2.4	"	A
X7050	0031	17	607275	4810875	2.4	"	A
X7051	0032	17	607275	4810875	2.4	"	A
X7052	0033	17	604125	4805075	0.3	"	A
X7053	0034	17	603800	4807900	2.3	"	A
X7054	0035	17	592775	4798275	3.7	"	A
X0027	0036	17	589950	4790300	1.7	"	A
X7055	0037	17	594350	4798800	3.0	"	A
X0028	0038	17	590160	4789775	2.1	"	A
X0029	0039	17	589725	4789625	2.4	"	A
X0030	0040	17	589975	4790560	0.9 H	"	A
X0031	0041	17	589950	4790825	0.8 H	"	A
X0032	0042	17	592875	4791580	0.4 H	"	A
X0033	0043	17	593520	4791150	0.2 H	"	A

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
X0034	0044	17	594450	4790850	0.3 H*	CLOSED	A
X0035	0045	17	595950	4790300	1.2	"	A
X0036	0046	17	597050	4790050	1.5	"	A
X0037	0047	17	597975	4789860	0.9 H	"	A
X0039	0048	17	600075	4789100	0.1 R*	"	A
A210403	0049	17	602100	4805500	2.4	ACTIVE	A1(H100)
A210405	0050	17	602700	4805200	1.8	"	A1(L100)
A210406	0051	17	602900	4803900	1.1	"	A1(L100)
A210407	0052	17	602250	4804380	1.9	"	?
A210408	0053	17	601850	4805300	2.6	"	A1(L100)
X3006	0053	17	638400	4844925	5.8	CLOSED	A
X3007	0053	17	640900	4844600	3.5	"	A
X3009	0054	17	638500	4842525	3.7	"	A
X3010	0055	17	637025	4841650	4.2	"	A
X3014	0056	17	638700	4840500	2.2	"	A
X3015	0057	17	638100	4839850	2.6	"	A
X3016	0058	17	638800	4839850	2.0	"	A
X3017	0059	17	638350	4838850	2.2	"	A
X3018	0060	17	638150	4838500	1.9	"	A
X3019	0061	17	638250	4838100	1.5	"	A
X3020	0062	17	638550	4837850	1.2	"	A
X3030	0063	17	631500	4839050	5.9	"	A
X3031	0064	17	631950	4838950	5.6	"	A
X3032	0065	17	632350	4837875	4.5	"	A
X3038	0066	17	635975	4839200	3.7	"	A
X3039	0067	17	636050	4839600	3.9	"	A
X3040	0068	17	636750	4839300	3.3	"	A
X3041	0069	17	637025	4839200	3.0	"	A
X3042	0070	17	637250	4839400	3.1	"	A
X3043	0071	17	637100	4839500	3.3	"	A
X3046	0072	17	636125	4840450	4.6	"	A
X3049	0073	17	635700	4841400	5.3	"	A
X3050	0074	17	637300	4839550	3.2	"	A
X3053	0075	17	621525	4833050	2.2	"	A
X3054	0076	17	621550	4833600	2.3	"	A
X3069	0077	17	635450	4843400	6.5	"	A
X3070	0078	17	622600	4837225	4.7	"	A
X3071	0079	17	632500	4836425	3.6	"	A
X4001	0080	17	643300	4842500	0.2	"	A
X4002	0081	17	642650	4841725	1.5	"	A
X4003	0082	17	641625	4841925	1.7	"	A
X4004	0083	17	642100	4840700	0.3	"	A
X4005	0084	17	640400	4840075	0.8	"	A
X4006	0085	17	639875	4841700	2.2	"	A

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
X4007	0086	17	639150	4841975	2.8	CLOSED	A
X4009	0087	17	641700	4844700	2.9	"	A
X3051	0088	17	617600	4826550	0.2	"	A
X3052	0089	17	615800	4830650	4.3	"	A
A220101	0090	17	611100	4817300	1.6	ACTIVE	?
A220102	0091	17	612150	4811750	3.0	"	A1(H100)
A220113	0092	17	610750	4825170	4.3	"	A3
X7047	0093	17	606000	4817050	5.1	CLOSED	A
X7066	0094	17	614250	4829450	4.4	"	A
X7067	0095	17	614575	4829200	4.0	"	A
X7068	0096	17	616050	4824875	0.3	"	A
X7069	0097	17	614025	4822875	0.1 R*	"	A
X7070	0098	17	614250	4822275	0.4	"	A
X7076	0099	17	657950	4854900	1.8	"	A
X7077	0100	17	660125	4854500	0.8	"	A
X3026	0101	17	647625	4850150	3.5	"	A
X3005	0102	17	644450	4847500	2.6	"	A
X4010	0103	17	645400	4850500	4.8	"	A
X4011	0104	17	644900	4850400	4.8	"	A
X4008	0105	17	643850	4849150	4.2	"	A
X7083	0106	17	663625	4860350	3.1	"	A
X7084	0107	17	667100	4859400	1.8	"	A
X7085	0108	17	666375	4857575	0.2	"	A
X7088	0109	17	684400	4865750	3.6	"	A
X7089	0110	17	687100	4862550	0.1	"	A
X7091	0111	17	697650	4868350	5.0	"	A
X7096	0112	17	674300	4858600	0.1	"	A
X7097	0113	17	674050	4859350	0.5	"	A
X7098	0114	17	673050	4859350	1.4	"	A
X7099	0115	17	673750	4860475	1.9	"	A
X7100	0116	17	673350	4861200	2.6	"	A
X7102	0117	17	671400	4861500	3.9	"	A
X7103	0118	17	671900	4860750	3.2	"	A
X4012	0120	17	717175	4869200	0.1 H*	"	A
X4013	0121	17	717200	4869950	0.1 R	"	A
X4014	0122	17	717100	4870075	0.2 R	"	A
X4015	0123	17	726500	4870600	0.1 R	"	A
X4016	0124	17	726375	4874975	4.3	"	A
X4017	0125	17	728075	4870900	0.1	ACTIVE	A
A310403	0126	17	716200	4870600	1.8	"	A3
A311702	0127	17	734400	4875260	3.2	CLOSED	A4
X9101	0128	18	358100	4893450	0.1	"	A
X9102	0129	18	357600	4894050	0.8	"	A
X9104	0130	18	335650	4879125	0.1	"	A

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
A360101	0131	18	312250	4892750	0.1	ACTIVE	A3(φ100)
X1063	0132	18	325650	4885650	3.0	CLOSED	A
X1065	0133	18	309200	4891400	0.1	"	A
X1066	0134	18	310800	4894775	2.5	"	A
X1070	0135	18	301000	4890000	2.1	"	A
X1067	0136	18	294600	4886200	0.2 H	"	A
X1068	0137	18	299100	4889100	1.5	"	A
X1069	0138	18	299000	4889350	2.0	"	A
A360204	0139	18	292800	4887700	0.1 R*	"	A1(L100)
A311903	0145	17	715050	4871810	3.5	"	A3(φ100)

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
X0034	0044	17	594450	4790850	0.3 H*	CLOSED	A
X0035	0045	17	595950	4790300	1.2	"	A
			LAKE ERIE INCL. DETROIT R. AND LAKE ST.CLAIR				
A010201	E001	17	328500	4665000	3.6Det.R*	200000.0	A2(L100)
A011401	E002	17	363350	4657210	2.7	44500.0	A3
A011801	E003	17	359980	4622590	0.2	200.0	A4
A022002	E004	17	379750	4665750	4.9	700.0	A4(ϕ100)
A110107	E005	17	560000	4739000	4.5	20000.0	A4
A110115	E006	17	573000	4738620	1.4	237000.0	B4
A110117	E007	17	578440	4741830	1.6	1400.0	B4(L100)
A110503	E008	17	553790	4730370	3.7	4000.0	A4
A120302	E010	17	642150	4753800	4.9	20805.0	A3
A120310	E011	17	644050	4749150	0.8	23800.0	A1
A120501	E012	17	666400	4754700	4.1	18000.0	?
A121101	E013	17	632440	4748590	1.6	2100.0	B4
X8048	E014	17	652700	4749275	1.8	CLOSED	A
X8050	E015	17	668225	4754525	2.3	"	A
X5106	E016	17	359680	4622800	1.2	"	A
X5099	E017	17	374350	4644775	0.9	"	A
X5112	E018	17	427500	4690550	4.3	"	A
X5127	E019	17	422840	4680900	2.8	"	A
X5104	E020	17	326650	4665150	1.2 Det.R	"	A
X5098	E021	17	327490	4658575	2.7 Det.R	"	A
X5097	E022	17	325450	4662500	0.2 Det.R	"	A
X6052	E023	17	341390	4687575	1.8 Det.R	"	A
X6055	E024	17	343650	4686690	2.0 Det.R	"	A
X6060	E025	17	341400	4687900	0.9 Det.R	"	A
X6062	E026	17	340160	4689300	0.1 L.St.Clair	"	A
X6066	E027	17	341050	4684150	5.0 "	"	A
X2046	E028	17	359625	4682600	1.3 "	"	A
X2048	E029	17	345145	4686700	1.3 "	"	A
X2049	E030	17	346050	4686410	1.1 "	"	A
X2050	E031	17	353600	4679500	5.8 "	"	A
X2051	E032	17	347750	4685360	1.5 "	"	A
X2054	E033	17	344000	4685000	3.5 "	"	A
X2057	E33A	17	375100	4681650	3.4 "	"	A

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site Ident.		UTM Zone	N.	E	Dist. from shore (km)		Rate tonnes/y	OME Class.
LAKE HURON, GEORGIAN BAY, AND ST. CLAIR RIVER								
A250401	H001	17	557050	4928740	3.8	G.Bay	4400.0	A4
A250402	H002	17	558840	4927890	3.9	G.Bay	18100.0	B3
A252501	H003	17	572770	4922320	4.2	G.Bay	2000.0	A4
A260401	H004	17	531770	4938110	2.9	G.Bay	4000.0	A3
A261401	H005	17	543750	4929830	4.6	G.Bay	2500.0	A4
A270203	H006	17	449400	4890300	2.3		4500.0	A2
A271701	H008	17	480150	4949800	2.0		3400.0	A4
A271801	H009	17	476220	4926850	6.3		CLOSED	A4
A272003	H010	17	453900	4907200	2.7		CLOSED	B4
A272004	H011	17	453575	4906250	2.2		0.0	?
A272006	H012	17	453550	4906450	2.4		2600.0	B4
A272301	H013	17	475350	4975050	5.2		900.0	B4
A273101	H014	17	473600	4925100	4.9		2400.0	A4
A273102	H015	17	470400	4920350	4.4		5100.0	A3
A030104	H016	17	386200	4755600	3.7		1000.0	A1(L+H=52)
A030105	H017	17	386250	4754900	4.0		56200.0	A3
A030107	H018	17	386620	4755550	4.2		29500.0	A1(L+H=65)
A032005	H019	17	389470	4761380	4.4		200.0	A3(φ100)
A032006	H020	17	389700	4762450	4.4		15000.0	?
A032013	H021	17	387300	4755950	4.6		17900.0	?
A032014	H022	17	391000	4763270	5.7		45900.0	A3
A032105	H023	17	381770	4735460	1.5	St.Cl.R.	0.0	?
A031802	H024	17	380930	4739460	1.5	St.Cl.R.	279100.0	A4
A031810	H025	17	385850	4750950	6.1	St.Cl.R.	19100.0	A4
A031817	H026	17	382290	4751400	4.6	St.Cl.R.	"	A1(L100)
X5116	H027	17	388575	4762100	3.3	St.Cl.R.	CLOSED	
X5117	H028	17	388550	4762300	3.3		"	A
X5118	H029	17	388150	4762375	2.8		"	A
X5121	H030	17	389950	4763050	4.6		"	A
A031301	H031	17	434680	4790240	3.5		ACTIVE	A3
X2070	H032	17	441850	4841750	2.3		"	A
X5130	H033	17	445360	4823450	5.4		"	A
X5131	H034	17	444650	4823100	4.6		"	A
X2071	H035	17	442850	4858450	3.6		"	?
X2073	H036	17	445150	4844650	6.7		"	A
X6102	H037	17	449900	4891450	1.9		"	A
X6107	H038	17	465800	4917800	2.9		"	A
X6094	H039	17	469900	4926350	0.3		"	A
X2092	H041	17	545050	4930450	3.4	G.Bay	"	?
X4147	H042	17	577625	4951650	1.9	G.Bay	"	A

APPENDIX A. Information on W.D. Sites Within The Coastal Zone (continued)

(* See Table 3 for key)

Site	Ident.	UTM Zone	N.	E	Dist. from shore (km)	Rate tonnes/y	OME Class.
X4148	H043	17	573850	4954000	0.8 G.Bay	CLOSED	A
X4122	H044	17	578000	4929000	0.9 G.Bay	"	A
X6091	H045	17	481050	4981370	0.5 G.Bay	"	A
X6092	H046	17	473880	4978770	2.0	"	A
X4137	H047	17	577150	4956000	3.4 G.Bay	"	A
X4139	H048	17	574700	4956000	3.5 G.Bay	"	A
X4144	H049	17	574650	4959200	1.7 G.Bay	"	A