International Joint Commission

Lake Ontario – St. Lawrence River Water Level Regulation Study

A REVIEW OF POTENTIAL DATA SOURCES FOR USE IN EVALUATING COASTAL PROCESS AND RIPARIAN IMPACTS ASSOCIATED WITH CHANGING WATER LEVELS ON LAKE ONTARIO AND THE ST. LAWRENCE RIVER

Prepared for the Coastal Processes Working Group

FINAL REPORT

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1.0 INTRODUCTION

1.1 Background to IJC Study

In late 2000, the International Joint Commission (IJC) established the International Lake Ontario – St. Lawrence River Study Board (Study Board), whose mandate is to undertake the studies required to provide the IJC with the information it needs to evaluate options for regulating levels and flows in the Lake Ontario-St. Lawrence River system in order to benefit affected interests and the system as a whole in a manner that conforms to the requirements of the 1909 Boundary Waters Treaty. To do this, the IJC will conduct a number of investigations according to a comprehensive Plan of Study including:

- Reviewing the operation of the structures controlling the levels and flows of the Lake Ontario-St. Lawrence River system in light of the impacts of those operations on affected interests, including the environment;
- Assessing whether changes to the Order or regulation plan are warranted to meet contemporary and emerging needs, interests and preferences for managing the system in a sustainable manner; and
- Evaluating any options identified to improve the operating rules and criteria governing the system.

To help accomplish these investigations, the IJC and the Study Board established a series of Technical Working Groups that would be responsible for investigating various components of the issue. These included working groups to examine coastal processes, recreational boating and tourism, environment and wetlands, commercial navigation, hydrological and hydraulic modeling, domestic, industrial, and municipal water uses, hydropower and common data needs.

This report focuses on tasks associated with the Coastal Processes Working Group (CWG) as outlined below.

1.2 The Coastal Processes Technical Working Group

The Coastal Processes Technical Working Group (CWG) was formed as one of several technical work groups in support of the Lake Ontario Plan of Study. The primary

purpose of the work group is to develop and implement methods to measure the physical impact of water level regulation on coastal and riverine shorelines within the study area. The overall study goals for the CWG can be summarized as follows:

a) Determine the possible response of both Lake Ontario and St. Lawrence River shoreline types to changes in water levels and flows that may occur as a result of changes to the operation of the existing control structures on Lake Ontario at Cornwall;

b) Based on the above responses, determine the various impacts (both positive and negative) that may result to the riparian interest group along these shorelines;

c) Determine as well, the impacts (both positive and negative) of possible flooding or low water level scenarios that may occur as a result of changes to the operation of the existing control structures on Lake Ontario at Cornwall; and

d) Using the above evaluations, provide recommendations of new regulation criteria that best considers the needs of the riparian interest group.

To accomplish these goals a number of specific task objectives are involved:

a) Determine and assess existing physical processes and physical settings. This would include for example developing a knowledge of both lake coastal processes and riverine processes, understanding the range of shore types and nearshore environments that exist, collecting and assessing historic recession rate and other shoreline change information, etc.;

b) Determine and assess existing "landside" or human settings and issues. This would include for example understanding and mapping current and projected land use, the type and quality of shore protection that has been constructed along the shoreline, the numbers and types of structures located along the shoreline, land and structure property values, etc.;

c) Develop a common (U.S. side, Canadian side) and consistent coastal zone database of the above information so that this data can be used in a common format in any modeling and impact assessment activities that are undertaken. Ideally this data would reside in a common GIS database;

d) Assess, determine and apply appropriate state-of-the-art coastal or riverine modeling applications that may be available to evaluate lake and river shoreline response to changes in water levels or flows brought about by alternative water level scenarios. Models must be able to incorporate as data inputs the full range of coastal and riverine processes and physical conditions that have an influence on

erosion/accretion and flooding/low water conditions. Limited model development/enhancement may be undertaken if necessary;

e) In applying the model(s), determine the spatial extent of model application (i.e., full extent of shoreline, or site specific, representative sites) and conduct modeling analysis as appropriate;

f) Use modeling results to determine and assess potential flooding, erosion and low water impacts to the riparian interest group. Provide modeling results as appropriate to other TWG's (e.g., environmental, recreational boating), who may find the results useful in conducting their specific impact assessments;

g) Use impact assessments to assess and evaluate the "existing" or "pre" regulation condition vs. the "post" regulation condition; and

h) In doing this, develop a set of potential regulation criteria (water level ranges) that will minimize negative (or maximize positive) impacts for the riparian interest group.

1.3 The Need for Data

The CWG wishes to utilize and build upon a range of long-term and ongoing data collection efforts that have taken place in the Lake Ontario – St. Lawrence River basin and utilize this data where possible in the modeling and impact assessment tasks described above.

To do this first requires an understanding of just what data is available, the format that it is in, who has it, how it can be obtained, and an assessment of it's applicability to the goals and objectives of the CWG. In this regard, the CWG has conducted a data inventory of various government agencies (federal, provincial, state, regional and local), consultants, academics, non-government organizations and public interest groups to determine what physical and "landside" data is available. This also includes an inventory of any mapping, GIS and aerial photography that may exist for the Lake Ontario shoreline, as well as the U.S. and Ontario sections of the St. Lawrence River.

1.4 Purpose of This Report

This report utilizes the information obtained in the above inventory to provide a comprehensive review of the range of data, reports, GIS data and other background information that is available for use by the CWG and other working groups within the Study.

This report builds on two recent previous data inventories that have been conducted for this shoreline. In 1999, as part of work on the Lower Great Lakes Erosion Study, Stewart (1999a) provided a review of potential GIS, mapping and air photo sources that could be used in evaluating historical recession rates for the Lake Ontario Shoreline. In 2001, as an initial activity for the Common Data Needs Technical Working Group within this IJC Study, Baird & Associates (2001) provided a comprehensive review of existing topographic, bathymetric and imagery data that are available for use. This report, while incorporating information from these two previous activities, also incorporates a wealth of additional data that is available on physical shoreline characteristics, coastal processes, and land use among others.

It should be noted that this report focuses only on data that is available for the U.S. and Canadian shores of Lake Ontario and the New York and Ontario shores of the St. Lawrence River. Data that is available for the Quebec portion of the St. Lawrence River is being summarized in a separate activity.

1.5 Format of This Report

This report is divided into sections based on the primary data type that is being described. Section 2 will highlight data pertaining to the physical classification and composition of the shoreline, including information on shore type, shore protection and nearshore geology. Section 3 will describe various coastal process data including historical recession rates. Section 4 will focus on "land side" data, including data related to land use, land use trends, building and structure inventories and mapping and property ownership. Section 5 will highlight various GIS, mapping, photography and imagery data sources that are available. Finally, Section 6 highlights other background and miscellaneous data sets and reports that are available.

2.0 SHORELINE CLASSIFICATION DATA

A critical task of the CWG will be to determine how different shoreline types along Lake Ontario and the St. Lawrence River respond to changes in water level elevation. To be able to determine this, there is a need to first have a good understanding of the physical characteristics of the shoreline, including three key shoreline components that can influence shoreline response – shore type, shore protection and nearshore geology.

2.1 Shore Type and Geology

The shoreline type refers to the geologic composition of the shoreline above the waterline. Is it a beach? Is it a cohesive bluff? Is it bedrock? Each shore type will respond differently to water level changes. As such the basic information needed is:

- Basic shore type (e.g., bedrock, bluff, beach, etc.)
- Stratigraphy (i.e., is it a composite bluff or is it homogenous?)
- Sand content of bluff shorelines (i.e., how much sand is available to be put into transport and possibly build beaches?)
- Bluff heights, slopes, degree of gullying

2.1.1 Data Sources

Lower Great Lakes Erosion Study (LGLES)
A number of data sets and background information are available as a result of activities that have been undertaken as part of the LGLES which is being carried out by the Buffalo District of the U.S. Army Corps of Engineers. These are summarized below.

Shore Type Classification
Stewart (1999b) has conducted a kilometer-by-kilometer classification of shoreline type for the entire U.S. shoreline of Lake Ontario and the St. Lawrence River. Shore type is based on a classification (including sub-classifications according to percent sand content) of 10 different shore types – sand or cohesive homogenous bluffs, sand or cohesive bluffs with beach, low banks, baymouth barriers, sandy beach/dune, coarse beaches, resistant bedrock, erosive bedrock, open shoreline wetlands and artificial. Data was extracted from aerial photography, which was supplemented by 1999 videotape of the shoreline, background geologic reports, mapping, and field verification. Data exists in MS-Excel format on a reach-by-reach basis. Summary statistics of the lengths and percent of each shoreline type have also been developed. The data is georeferenced (latitude and longitude) to the center point of each reach and has been incorporated into GIS in this manner.

Site Specific Area Descriptions
Detailed field descriptions, including descriptions and photos of shore type, have been undertaken for 13 site-specific areas along the Lake Ontario shoreline (Stewart, 1998). Subsequently, Baird & Associates

(1999) have examined 4 of these sites in greater detail, including a description of possible data needs and field survey programs that would be required should these sites be examined in more detail.

Environmental Sensitivity Atlas for the St. Lawrence River Shorelines, Environment Canada and U.S. Coast Guard (1994)
Designed for use in combating marine spills, this atlas contains detailed shoreline classification data (shoreline habitats, bedrock or impermeable shores, unconsolidated sediment shores, vegetated shores, etc.) for the U.S. and Canadian shorelines of the St. Lawrence River from Kingston, Ontario – Clayton, New York, to just west of Montreal, Quebec. The Atlas also contains photographs and detailed descriptions of the different shoreline types contained in the classification. All data presented on the maps resides in a MapInfo based GIS desktop mapping system and is readily available from Environment Canada (Rob Read, Environment Canada, personal communication). A similar atlas is also available for the Lake Ontario shoreline (Rob Read, Environment Canada, personal communication)

Ontario Ministry of Natural Resources, Shore and Dynamic Beach Classification (1994)
As part of a series of flood, erosion and dynamic beach hazard policies that were being developed by the Ontario Ministry of Natural Resources in the mid 1990s (OMNR, 1994), the Province set about developing a set of criteria and procedure for classifying the Canadian Great Lakes shoreline that would in turn support the definition and implementation of these hazard policies. The classification scheme was developed for OMNR by Atria Engineering and Dr. Robin Davidson-Arnott of the University of Guelph, Ontario. The scheme itself is similar to the LGLES three-tiered classification scheme in that it considers the type of shoreline occurring on the land side, as well as the composition of the nearshore area. It differs slightly in that it also considers surficial nearshore sediments, and shoreline exposure and planform. The OMNR scheme focuses on 4 key criteria in its classification. These include: 1) general shoreline type; 2) controlling nearshore substrate; 3) surficial nearshore substrate, and 4) shoreline exposure and planform.

Waterfront Trust Classification Scheme
We did not obtain any specific reports on a classification scheme that was produced by Baird and Associates for a classification of the Canadian Lake Ontario shoreline for the Waterfront Regeneration Trust. However personal communication with Rob Nairn of Baird & Associates indicates that it very similar to both the LGLES and OMNR schemes described above in that it focuses on a subaqueous assessment - this is clearly the single most important factor for assessing water level sensitivity on cohesive shores (and particularly whether a shore is cobble/boulder shelf or concave). The sand cover thickness (in this and the revised LGLES scheme) would be great data to have but is costly to obtain and thus is presently based on limited knowledge and field investigations. This criteria in the classification should be kept as part of the system as eventually we will/must build this data base. The above water classification provides an indication (not always confirms) several things: 1) whether the shore is sandy or cohesive (but does not confirm this as till can exist at and below water level as we have seen); 2) provides some indication of sediment coming into the system for sediment budget; 3) provides some idea on the type of slope failures that can be experienced; and 4) differentiates between barriers, wetlands, etc. Baird has applied this classification scheme on a “broad brush” level to the Lake Ontario shoreline between the Niagara River and the Bay of Quinte (essentially the whole Canadian shoreline).

Great Lakes Shoreline Classification and Mapping Study (Geomatics International, 1992)
Provides data indicating the number of reaches and the length of shoreline for the geomorphic classification, as well as the geomporphic classification as a % of shoreline length; provides geomorphic data for each reach (boundaries and lengths described) of the shoreline as well as the sources of data. Data produced as ArcInfo / ArcView coverages. GIS data available from Environment Canada. This data represents most recent and comprehensive classification of Canadian shoreline of Lake Ontario and the St. Lawrence River.

Erosion Processes Task Group Report, Stewart & Pope (1993)
Conducted as part of the 1991-1993 Great Lakes Water Level Reference Study, this report summarizes shoreline classification data for the U.S. and Canadian Lake Ontario and St. Lawrence River shorelines. While the specific data contained in this report has been superceded on the U.S. shoreline by work carried out in the Lower Great Lakes Erosion Study, it may still be a useful background reference document for information on shoreline type. It is the most recent data set for this type of information on the Canadian shoreline.

Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes (F.J. Reinders & Associates, 1988)
This report provides brief descriptions of the shoreline geology within each of a series of littoral cells that were defined for the Lake Ontario shoreline.

Canada - Ontario Great Lakes Shore Damage Survey and Coastal Zone Atlas (Boulden, 1975)
The Great Lakes Shore Damage Survey and corresponding Coastal Zone Atlas were prepared for Environment Canada and the Ontario Ministry of Natural Resources. They contain mapped information on shoreline physical characteristics and shore types along the Lake Ontario shoreline. It is not known if this data exists in any type of digital format.

Canada Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981)
This report provides descriptions of the physiography and shoreline geology of the Lake Ontario shoreline.

U.S. Army Corps of Engineers Lake Ontario Shore Protection Study, 1979
As part of a lakewide examination of potential shore protection alternatives for the Lake Ontario shoreline, the Buffalo District of the Corps carried out the mapping and definition of 9 geomorphic units along the Lake Ontario shoreline (US Army Corps of Engineers, 1979; Ray et al., 1980). Each unit is defined based on the shoreline configuration, the geologic nature of the bluffs and the response characteristics of the bluffs to littoral processes. The shore was also divided into 126 reaches and for each, maps are also presented for other shore features including bedrock geology, surficial geology, and soil associations for shoreline. Beach shore characteristics (length, width, stability, slope, bluff height, material, mineralogy, ownership, etc.) are also defined. Some of this data was used to assist in defining shore types within the LGLES data sets defined above. Digital data for this information is not available.

Eastern Lake Ontario Sand Dunes Data Sets
The Eastern Lake Ontario Sand Dune area of New York State has been an area of intense study over the years. In 1989 New York State Department of State undertook a comprehensive study of this area including descriptions and photographs of the unique features found here (L.R. Johnston Associates, 1989). More recently, The Nature Conservancy and Hobart & William Smith College have been undertaking a detailed geologic investigation of this shoreline (Don Woodrow and Sandy Bonanno, personal communication). For determination of shoreline type and geologic composition, useful data sets include Ground Penetrating Radar survey across the dune and beach face, 15 vibracore records, maps and aerial photos showing shoreline evolution throughout the 20th century, various grain size analyses of beach and dune sediments, and a series of recent beach profiles.

New York State Local Waterfront Revitalization Plans
A number of communities along the Lake Ontario and St. Lawrence River shoreline have prepared Local Waterfront Revitalization Plans under the Waterfront Revitalization Program of the Department of State Coastal Management Section. These reports contain brief descriptions of physical shoreline characteristics

and settings in the study areas. Reports have been obtained for each community that had completed a report prior to 1998.

Ontario Conservation Authority Shoreline Management Plans
During the late 1980s and early 1990s a number of Ontario Conservation Authorities prepared Shoreline Management Plans for sections of Lake Ontario shoreline under their jurisdiction. These include:

- Niagara Peninsula Lake Ontario Shoreline Management Plan (M.M. Dillon Limited, 1994): Provides a summary of shoreline characteristics and features from Fifty Mile Point (Grimsby) to Niagara-on-the-Lake. Contains maps of shoreline features and photos of some of the reaches (Appendix 1); Appendix 6 contains an index to a video of the shoreline; maps in back pocket of report contain coastal features (bays, inlets, points, etc).

- Lake Ontario Shoreline Management Plan (Sandwell, 1989): Shore management plan prepared for the Central Lake Ontario, Ganaraska and Lower Trent Region Conservation Authorities. Provides descriptions and photos of the geology (bedrock, surficial geology, physiography, shoreline and bluffs, soils) of the study area; contains tables on bluff compositions and dimensions.

- Raisin Region Conservation Authority Shoreline Management Plan (Gorrell Resource Investigations, 1992).

- Prince Edward Region Conservation Authority Lake Ontario Floodplain Mapping Study (MacLaren Plansearch, 1987).

Environment Canada Soil Sample Data
Environment Canada has data from a number of soil sampling activities that may be useful in determining shoreline type and stratigraphy as well as other sedimentological characteristics of the shoreline. These include:

- Soil samples/analysis from over two hundred sites between NOTL and Pt. Traverse (Prince Edward County) sampled circa 1966. Samples were collected at top of bluff, shoreline, and various depths offshore. These were analyzed for % gravel/sand/silt/clay.

- Soil samples/analysis at each of 70 erosion monitoring stations. One or more surface samples were taken from each site. If bluff, several samples were taken up the face. These were analyzed for % gravel/sand/silt/clay as well as for particle size distribution.

- Soil samples/analysis for a series of samples in the St. Lawrence River from Cornwall to Montreal

Geological Investigations
A number of academic and scientific geological reports or journal articles have been obtained that provide details on shoreline composition and stratigraphy. These include:

- Geology of Clyde and Sodus Bay Quadrangles, New York (Gillette and Dollen, 1940): Contains descriptions and photos of shoreline features and maps of geological features along the shoreline; also provides geologic history of the area and classifies the bedrock.

- Pleistocene Stratigraphy of the Erie and Ontario Lake Bluffs in New York (Calkin and Muller 1992): Provides history, classification and composition of the stratigraphy and geology of the Lake Ontario shoreline.

- Great Lakes Coastal Geology: Analysis of Bluff Erosion along Southern Coastline of Lake Ontario, New York (Brennan and Calkin, 1984): Describes geological composition of bluffs; describes sources of data from previous studies; compares regional variations in bluff stratigraphy, contains photos of bluffs and examples of their erosion; contains cross section of geotechnical data and stratigraphy of bluffs at study stations.

- Quaternary Stratigraphy and Bluff Erosion Western Lake Ontario, New York (Calkin, Muller and Drexhage, 1982): Describes geological features along shoreline study area, contains detailed description of the route used during the study.

- Descriptions of Shoreline Types Concerning Senstivity to Oil Spills: Lake Ontario, Canada, Podor (unpublished): Report prepared for the Environmental Emergencies Section of Environment Canada. Contains general descriptions of the shoreline geology found in Lake Ontario.

- The Canadian Great Lakes: Coastal Environments and the Clean-Up of Oil Spills (Owens, 1979): Provides descriptions and photographs of the coastal environments found along Lake Ontario.

- Fifty-Mile Point Case History (Coakley and Boyd, 1979): Geologic report prepared for Environment Canada providing brief geologic description of 7km length of shoreline.

- Rates of Erosion of Till in the Nearshore Zone, Grimsby, Ontario (Davidson-Arnott, 1984): Describes the characteristics of the field site, located about 15 km east of the city of Hamilton on the southwest shore of Lake Ontario.

- Ontario Ministries of Natural Resources and Northern Development and Mines, Surficial Geology Maps: Maps of the surifcial geology of parts of the provinces at a scale of 1:50,000 provide information on the nature of the shoreline material in areas where available.

Miscellaneous Reports

A number of miscellaneous reports have been obtained that provide data and information pertaining to shoreline type. These include:

- Oswego County Comprehensive Plan (Oswego County Planning Board, 1997): This report contains descriptions and maps of the geological features/areas of Oswego County.

- Conceptualization of Boat Acess Development Zones (White, 1992): Maps in this report contain representations of shoreline features for Barddock Bay, Sodus Bay, and Port Ontario.

- Preservation of Environmentally Sensitive Areas in Monroe County (Monroe County Environment Management Council, 1996): This report provides descriptions of environmentally sensitive shoreline areas including habitat for fish, water birds and mammals.

- Geographic Response Plan for Oil Spills and Hazardous Substance Releases in Lake Ontario (U.S. Coast Guard, 1999): This document provides brief descriptions of shoreline type and habitat for

the counties of Niagara, Orleans, Monroe, Wayne, Cayuga and Oswego Counties in New York State.

- Niagara County Land Use and Natural Resource Inventory (Niagara County Environmental Management Council, 1978): This report contains brief descriptions of shoreline natural resource features along Niagara County.

2.2 Shore Protection

As shoreline protection can have a considerable influence on how shoreline erodes, or responds to water level change, it is important to know what data is available. In addition, shore protection itself can be impacted by water level changes and may become a potential cost or a potential damage. As such it is necessary to know such things as:

- Type, extent and quality of shore protection in place
- Trends in shore protection construction
- Type, numbers and quality of recreational boating structures in place (e.g., docks, marinas, launch ramps, etc.)

2.2.1 Shoreline Protection Data Sources

Lower Great Lakes Erosion Study 1999
Stewart (1999b) has conducted a kilometer-by-kilometer classification of shoreline protection for the entire U.S. shoreline of Lake Ontario and the St. Lawrence River. The classification captures the types and quality of shore protection occurring in each kilometer reach. Data was extracted from aerial photography which was supplemented by 1999 videotape of the shoreline, background reports, mapping, and field verification. Data exists in MS-Excel format on a reach-by-reach basis. Summary statistics of the lengths and percent of each shore protection type have also been developed. The data is georeferenced (latitude and longitude) to the center point of each reach and has been incorporated into GIS in this manner.

Environmental Sensitivity Atlas for the St. Lawrence River Shorelines, Environment Canada and U.S. Coast Guard (1994)
Designed for use in combating marine spills, this atlas contains detailed shoreline classification data (shoreline habitats, bedrock or impermeable shores, unconsolidated sediment shores, vegetated shores, etc.) for the U.S. and Canadian shorelines of the St. Lawrence River from Kingston, Ontario – Clayton, New York, to just west of Montreal, Quebec. Within the impermeable shores category, the Atlas identifies retaining walls, harbour structures, and breakwaters. Information is also included describing marinas and launch ramps including an estimate of their quality for use. Data presented on the maps resides in a MapInfo based GIS desktop mapping system and is readily available from Environment Canada (Rob Read, Environment Canada, personal communication). A similar atlas is also available for the Lake Ontario shoreline (Rob Read, Environment Canada, personal communication).

Great Lakes Shoreline Classification and Mapping Study (Geomatics International, 1992)
Provides data indicating the number of reaches containing shore protection, the percent of each reach protected and the level of protection (e.g., high, moderate, low) for the Lake Ontario and St. Lawrence River shoreline. Data produced as ArcInfo / ArcView coverages. GIS data available from Environment Canada. This data represents most recent and comprehensive shoreline protection classification of Canadian shoreline of Lake Ontario and the St. Lawrence River.

Erosion Processes Task Group Report, Stewart & Pope (1993)
Conducted as part of the 1991-1993 Great Lakes Water Level Reference Study, this report summarizes shoreline protection classification data for the U.S. and Canadian Lake Ontario and St. Lawrence River shorelines. While the specific data contained in this report has been superceded on the U.S. shoreline by work carried out in the Lower Great Lakes Erosion Study, it may still be a useful background reference document for information on shoreline type. It is the most recent data set for this type of information on the Canadian shoreline.

Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes (F.J. Reinders & Associates, 1988)
This report provides brief descriptions of the shoreline protection structures found within each of a series of littoral cells that were defined for the Lake Ontario shoreline.

Canada - Ontario Great Lakes Shore Damage Survey and Coastal Zone Atlas (Boulden, 1975)
The Great Lakes Shore Damage Survey and corresponding Coastal Zone Atlas were prepared for Environment Canada and the Ontario Ministry of Natural Resources. They contain mapped information on shoreline protection structures that are present along the Lake Ontario shoreline. It is not know if this data exists in any type of digital format.

Canada Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981)
This report provides basic descriptions of the percent of Lake Ontario shoreline protected circa 1976 (by structure type). Data was developed through analysis of videotape and oblique photography.

U.S. Army Corps of Engineers Lake Ontario Shore Protection Study, 1979
As part of a lakewide examination of potential shore protection alternatives for the Lake Ontario shoreline, the Buffalo District of the Corps carried out the mapping and definition of protective structures present (material, length, height, condition, type) along the Lake Ontario shoreline. Digital data for this information is not available.

Ontario Conservation Authority Shoreline Management Plans
During the late 1980s and early 1990s a number of Ontario Conservation Authorities prepared Shoreline Management Plans for sections of Lake Ontario shoreline under their jurisdiction. These include:

- Niagara Peninsula Lake Ontario Shoreline Management Plan (M.M. Dillon Limited, 1994): Provides a summary of shoreline characteristics and features from Fifty Mile Point (Grimsby) to Niagara-on-the-Lake. Provides descriptions of existing shoreline protection and recommendations for potential shore protection designs. Contains maps and photos of some of the reaches (Appendix 1).

- Lake Ontario Shoreline Management Plan (Sandwell, 1989): Shore management plan prepared for the Central Lake Ontario, Ganaraska and Lower Trent Region Conservation Authorities. Provides descriptions and photos of shore protection structures in place along the shoreline.

- Raisin Region Conservation Authority Shoreline Management Plan (Gorrell Resource Investigations, 1992).

- Prince Edward Region Conservation Authority Lake Ontario Floodplain Mapping Study (MacLaren Plansearch, 1987).

Miscellaneous Reports

- The Nautical Seaway Trial Chartbook and Waterfront Guide (Seaway Trail Inc., 1991): Illustrates the location of shore protection features such as breakwaters and jetties along the New York State Lake Ontario and St. Lawrence River shoreline.

- Cobourg Harbour, Investigation of Wave Agitation and Related Remedial Structures (Skafel et al.,1979): Provides map of existing shore protection sturctures in the harbour at Coburg, Ontario.

- Shore Protection in the Town of Stoney Creek, Southwest Lake Ontario, 1934-1979: Historical changes and Durability of Structures (Davidson-Arnott and Keizer, 1982): Contains information on the length of shoreline protected, the number of protective structures, the types of protective structures, the durablity of structures, and the historical change in the number and types of structures for a portion of the Canadian shoreline of Lake Ontario.

- LaSalle Park Dock Preliminary Engineering Study (F.J. Reinders and Associates, 1991): Engineering report describing status of shore protection structures at site specific area along the Hamilton, Harbour shorleine of Lake Ontario.

- Spencer Smith Park Waterfront: Preliminary Engineering Study (F.J. Reinders and Associates, 1987): Describes and identifies the existing coastal protection features along the study area and provides recommendations for future shore protection design.

- Metro Toronto Valley and Shoreline Regeneration Project 1992-1996 (Metro Toronto and Region Conservation Authority, 1991a): Describes future shoreline protection designs and recommendations for areas under the jurisdiction of the MTRCA.

- Lake Ontario Waterfront Regeneration Project 1992-1994 (Metro Toronto and Region Conservation Authority, 1991b): Describes future shoreline protection designs and recommendations for areas of the Lake Ontario shoreline under the jurisdiction of the MTRCA.

- Ecosystem Approcah to Shoreline Treatment (Waterfront Regeneration Trust, 1993): Workshop report describing existing shore protection and possible future shore protection designs for site specific areas along the Lake Ontario shoreline between Burlington and Trenton, Ontario.

- Niagara County NY Shore Protection Information: As part of a summary of shore damages that occurred in the Townships of Newfane, Porter, Somerset, and Wilson, information is provided on the types of protection structures in place for each town as well as a summary of all the townships.

2.3 Nearshore Geology

The rate and method by which the underwater portion of a shore profile erodes or responds to water level change, can have a significant impact on the overall response of the entire shore profile to water level change. As such it is critical to understand the composition and geology of the nearshore zone of Lake Ontario and the St. Lawrence River.

2.3.1 Nearshore Geology Data Sources

Lower Great Lakes Erosion Study 1999
Stewart (1999b) has conducted a kilometer-by-kilometer classification of nearshore geology for the entire U.S. shoreline of Lake Ontario and the St. Lawrence River. The classification captures the geologic nature of the nearshore (e.g., bedrock, sand) and where applicable an estimate of the thickness of sand cover. Data was extracted from various background reports, mapping, and field investigations. Data exists in MS-Excel format on a reach-by-reach basis. Summary statistics of the lengths and percent of each nearshore type have also been developed. The data is georeferenced (latitude and longitude) to the center point of each reach and has been incorporated into GIS in this manner.

Great Lakes Shoreline Classification and Mapping Study (Geomatics International, 1992)
Provides data indicating the nearshore composition of a series of reaches for the Canadian shoreline of Lake Ontario and St. Lawrence River. Data does not include any estimate of sand cover thickness. Data produced as ArcInfo / ArcView coverages. GIS data available from Environment Canada. This data represents most recent and comprehensive shoreline protection classification of Canadian shoreline of Lake Ontario and the St. Lawrence River.

Erosion Processes Task Group Report, Stewart & Pope (1993)
Conducted as part of the 1991-1993 Great Lakes Water Level Reference Study, this report summarizes nearshore classification data for the U.S. and Canadian Lake Ontario and St. Lawrence River shorelines. While the specific data contained in this report has been superceded on the U.S. shoreline by work carried out in the Lower Great Lakes Erosion Study, it may still be a useful background reference document for information on shoreline type. It is the most recent data set for this type of information on the Canadian shoreline.

U.S. Army Corps of Engineers Lake Ontario Shore Protection Study, 1979
As part of a lakewide examination of potential shore protection alternatives for the Lake Ontario shoreline, the Buffalo District of the Corps provided brief descriptions of the nearshore/offshore sediment characteristics. Digital data for this information is not available.

Eastern Lake Ontario Sand Dunes Data Sets
The Eastern Lake Ontario Sand Dune area of New York State has been an area of intense study over the years. Recently, The Nature Conservancy and Hobart & William Smith College have been undertaking a detailed geologic investigation of this shoreline (Don Woodrow and Sandy Bonanno, personal communication). For determination of nearshore type and geologic composition, useful data sets include grain-size data from the lake floor (more than 100 locations), high resolution, X-Star, seismic information

along approximately 200km of lines, side-scan records along approximately 75km of lines, eight vibracore records from the lake bottom, several C14 dates on material from lake vibracores, RoxAnn nearshore sediment records on approximately 100km of lines, grain size data at approximately150 locations in Lake Ontario between the Niagara River and Stony Point, and heavy mineral data both for onshore and offshore sands.

Nearshore Sediment Data, Canada Centre For Inland Waters
Detailed mapping of nearshore sediments for the Canadian shoreline of Lake Ontario has been a focus of research at the Canada Centre for Inland Waters for many years. In the late 1960's (Rukavina, 1969 and 1970) nearshore sediment surveys were conducted in two regions of the shore. These maps are derived primarily from echo sounding along lines spaced roughly 1 km apart and from grab samples and vibracores. The data begins in water depths of 2-3 m and the information is provided at quite a coarse scale. More recently (Rukavina, 1996a, 1996b, 1996c and 1997) nearshore sediment classifications have been taking place for a number of areas on Lake Ontario and the St. Lawrence River using a "RoxAnn" echo sounding system. Data from the RoxAnn classification can be exported to a GIS system and has resulted in the differentiation of 8 separate bottom types. RoxAnn data has also been obtained for a portion of the Lake Ontario Sand Dunes area (see above item).

Ontario Conservation Authority Data
The Lake Ontario Shoreline Management Plan prepared for the Niagara Peninsula Conservation Authority (M.M. Dillon Limited, 1994) provides descriptions and maps of nearshore sediments for the portion of the shoreline under NPCA jurisdiction. Quinte Conservation, which encompasses lands under the jurisdiction of the Moira River, Napanee Region and Prince Edward County Conservation Authorities, also have data on nearshore bottom types available (Terry Murphy, Quinte Conservation, personal communication).

Miscellaneous Data

- Environment Canada: has data on subaqueous shore type at about 100 sites circa 1966. Offshore profile plotted out to several thousand feet. Bottom material over profile also plotted.
- Monitoring a Dredged Channel: Braddock Bay New York (Adams and Hubbard, 1979): This report concerns the results of the dredging of a channel between Braddock Bay and Lake Ontario in August and September of 1977. It documents changes in sediment distribution which took place with respect to the channel and adjacent bay and lake floors. Project monitoring took place from October 1, 1977 through July 31, 1978.
- Possible Biological Impacts of Dredging the Existing Channel from Irondequoit Bay to Lake Ontario in Rochester, New York (Gehris and Robb, 1974): This reports evaluates the proposed opening of Irondequoit Bay and involved identifying the biological parameters to be considered and describing the geology and chemistry of the bay and its drainage system.

2.4 Other Shore Classification Data Sets

SPANS TYDAC GIS Files
Digital files used during the Great Lakes Shoreline classification and mapping project were produced from National Topographic Series (NTS) 1:50,000 and 1:250,000 scale map sheets. The 1:50,000 maps were used from Trois Rivieres on the St. Lawrence River, west through Lake Ontario (This data is provided in

the Great Lakes Shoreline Classification and Mapping Study: Canadian Side carried out by Geomatics International (1992)).

Miscellaneous Reports

- Port Ontario, Oswego County Final Environmental Statement (U.S. Army Corps of Engineers, 1979): This report and associated engineering documents provides the design and assessment of the Salmon River Harbor of refuge project and contains a wealth of information on local conditions.

- Reconnaissance Report and Environmental Assessment for Proposed Navigation Improvement at North Sandy Pond, Oswego County New York (U.S. Army Corps of Engineers, 1989): Provides background information on a Section 107 study conducted in this area.

3.0 COASTAL PROCESS DATA

3.1 Wave Data

WIS Hindcast Data, USACE
Wave data has been developed for the Great Lakes by the U.S. Army Corps of Engineers as part of their Wave Information Studies (WIS), which provides wave hindcast data. This can be downloaded for Lake Ontario from the U.S. Army Corps web site at http://bigfoot.wes.army.mil/ma28.html. Figure 1 shows the 44 WIS hindcast stations that are available for Lake Ontario. Data for these stations has been calculated for the period 1956-1987.

Ontario Ministry of Natural Resources Hindcast Data
In 1988, the Ontario Ministry of Natural Resources carried out a wave hindcast for Lake Ontario (Ontario Ministry of Natural Resources, 1988). This wave climate data is based on a 20 year, 2 dimensional wave hindcast model. Hourly records of wave direction, height and period, as well as frequency of occurrence of wave energy by sector are available.

Wave Run-Up Data and Information
Wave run-up data has been calculated for a small portion of the Lake Ontario shoreline under the jurisdiction of the Niagara Peninsula Conservation Authority in Ontario (M.M. Dillon, 1994). In addition, detailed information on wave run-up methods and Great Lakes applications have been reviewed by Atria (1991a and 1991b) for the Ontario Ministry of Natural Resources.

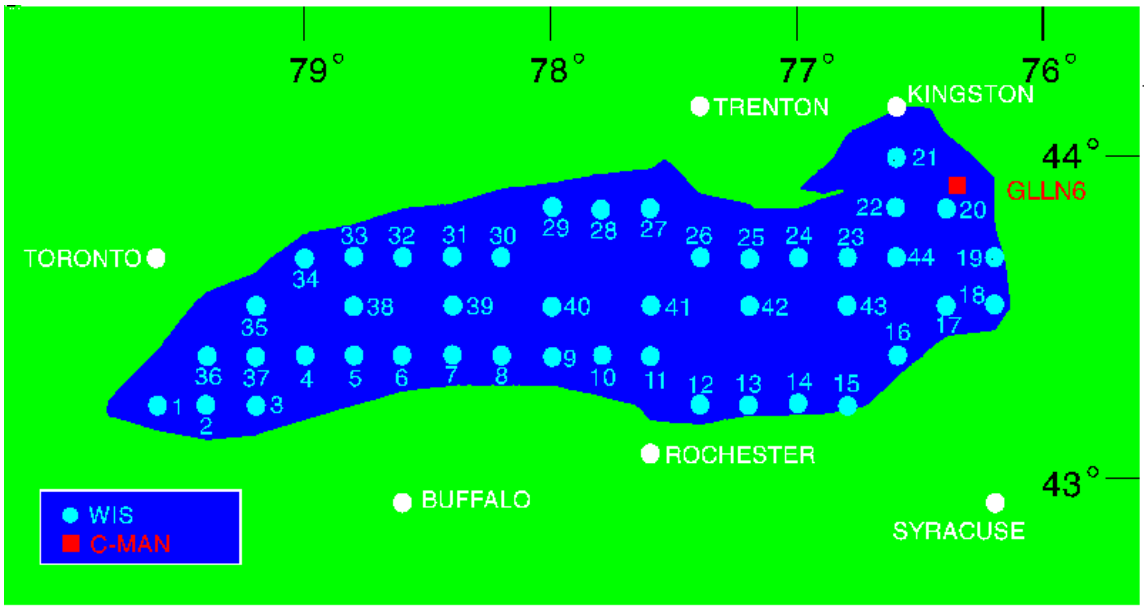


Figure 1 - WIS Hindcast Stations, Lake Ontario

Ship Wake Waves

Data sources not known. It is assumed that there is some data and studies that have taken place in the St. Lawrence River. Possibly studies from other river areas that may be drawn upon.

Miscellaneous Reports
A number of other reports reviewed contain wave related information. These include:

- Environmental Sensitivity Atlas for the St. Lawrence River Shorelines (Environment Canada, 1994): Briefly describes the prevailing winds and wave patterns on the St. Lawrence in the introduction.

- Lake Ontario Shore Protection Study (U.S. Army Corps of Engineers, 1979): Displays the monthly duration of waves of different heights and wave frequency and energy diagrams for four study locations along Lake Ontario; identifies the wind patterns for Lake Ontario.

- Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes (F.J. Reinders and Associates, 1988): Provides wind and wave information for portions of Lake Ontario.

- Potential Damage Estimates for Site Specific Areas (Paragon Engineering Limited, 1993): This report provides wave data (height, direction, etc) and information for the Toronto and Montreal study sites which were examined in detail during the IJC Great Lakes Water Level Reference.

- Cobourg Harbour, Investigation of Wave Agitation and Related Remedial Structures (Skafel et al., 1979): Describes the offshore wave climate that Cobourg is exposed to, provides hindcast wave heights and peak periods for the waves and wind data; describes the effects of a storm on the harbour; provides the results of refraction and shoaling analysis, and estimates significant wave heights and structures to limit them.

- Spencer Smith Park Waterfront: Preliminary Engineering Study (F.J. Reinders and Associates, 1987): Contains data on the deepwater wave climate and wind occurance in the area, describes the wave refraction patterns for the area.

- Quinte Conservation Area Waterfront Study (MIE Consulting Engineers, and M.M. Dillon Limited, 1990): Provides wave height data for winter and summer, contains wind roses for the area.

3.2 Water Level Data

USACE and Environment Canada Water Level Data
Detailed water level and river flow data (hourly, monthly, annual, etc.) is readily available from both Environment Canada and the U.S. Army Corps of Engineers. Specific water level scenarios that may be tested for Lake Ontario and the St. Lawrence River are anticipated to be developed by another working group within the study and available for input to any models developed.

Ontario Ministry of Natural Resources Flood Levels
In 1989, the Ontario Ministry of Natural Resources (1989) completed a comprehensive analysis of water levels for the Great Lakes system. Computations were based on an analysis of monthly mean levels and storm surges. Frequency distributions of highest annual monthly mean lake levels were first derived for each lake. Surge or wind set-up levels were then obtained from gauging station records. A combined frequency analysis was then carried out to obtain 100-year peak instantaneous water levels, or flood levels.

3.3 Recession Rates

3.3.1 United States Recession Rate Data

1994 U.S. Army Corps of Engineers Kilometer-by-Kilometer Historic Recession Rate Database
In 1994, Stewart (1994a) developed a comprehensive kilometer-by-kilometer recession rate database for the entire U.S. shoreline of the Great Lakes including Lake Ontario. For each of a series of one kilometer reach segments, all available recession rate data was recorded and includes, for each kilometer, mean, median, maximum and minimum recession rate values. The number of data points, the period of record, the type of data and the quality of data are also recorded. Where present, multiple data sets occurring in a reach are documented. The data is supplemented by an annotated bibliography that describes the nature of each data set recorded.

Lower Great Lakes Erosion Study, USACE Buffalo District
As part of work on the Lower Great Lakes Erosion Study, the 1994 USACE recession rate database was re-visited and updated with any new information that was available (Stewart, 1998). In addition to an updating of the overall data for Lake Ontario and Lake Erie, a single, most-representative recession rate value was selected for each kilometer reach for mapping and erosion modeling analysis. Also, short-term trends in the data were examined to determine any relationships between extreme high and low water levels and increases or decreases in recorded erosion rates. Single value and short-term recession data developed during this activity has been input into a database management and GIS viewing program (Recession Rate Analysis System) (Stewart, 1998) and has been used for data analysis.

New York Department of Environmental Conservation
In order to determine erosion hazard areas along the Lake Ontario shoreline in New York State, the Department of Environmental Conservation (DEC) has calculated long-term recession rates for the period 1875-1979. Comparisons were made between shoreline positions on 1875 Hydrographic Survey maps with the shoreline position on 1979 aerial photographs. Baselines were established on the 1875 maps using road intersections and other landmarks that also exist on the 1979 air photos. Transects were established approximately every 244 meters along the baseline and baseline to bluff-crest measurements were made for each. Similar measurements were made along the same transects on the 1979 photos, and the net shoreline change was calculated by subtracting the two values. Appropriate scale adjustments were made in order to allow accurate comparisons between the maps and the air photos, and average annual recession rates were calculated simply by dividing the total shoreline change by the 104-year period of record. In some areas of Lake Ontario, 1875 hydrographic charts were not available and 1938 air photos were utilized and compared with the 1979 maps, producing a 40 year period of record. Transect and associated recession rate information were plotted on a series of 1:2400 scale Coastal Erosion Area maps, which use enlarged prints of the 1979 photography as a base and include other reference information. These maps are next scheduled for update in 2003.

Erosion Processes Task Group (Stewart and Pope, 1993)
Produced as part of the work on the 1991-1993 Great Lakes Water Levels Reference Study, this document summarizes erosion rates along the U.S. and Canadian Great Lakes shorelines, as well as providing an erosion sensitivity analysis of different shoreline types to changes in the range of Great Lakes water levels.

New York Power Authority St. Lawrence River Data (Baird & Associates, 1999 and in press)
As part of the re-licensing of the St. Lawrence-FDR Power Project (FERC No. 2000) on the St. Lawrence River near Massena, New York, the New York Power Authority contracted Baird & Associates (1999 and in press) to examine erosion and sedimentation rates for the areas of the St. Lawrence River from Red Mills to the Moses Saunders Power Dam and for the shoreline downstream of the dam to the eastern end of Yellow Island. Data was collected at over 60 erosion sites in these two areas. Data collected included mapping the location and extent of erosion using GPS equipment; establishing the general current direction and speed; measuring typical shoreline profiles of the underwater slope and bluff; identifying the characteristic soil types for both the nearshore underwater profile and the bluff based on the field observations and mapping of surficial geology; and taking one or more photographs for each erosion site and point of interest. Statistics on the total lengths of shoreline that are eroding were generated.

Lake Ontario Recession Rate Data (Drexhage and Calkin, 1981)
This study measured rates of bluff line recession at 250 sites in six counties along the Lake Ontario coastline in order to determine historic rates of recession and to provide information on their spatial and temporal distribution as well as on those factors that influence local differences in recession rates. Long-term recession rates were determined for the 99-year period from 1875-1974 and for the 13-year period from 1938-1951.

Short-term (13 year) recession rates were calculated using 1938 and 1951-1955 U.S. Department of Agriculture aerial photographs. A Bausch and Lomb optical micro-rule was used to directly measure distances between fixed points on land and the bluff line. Measurement locations were indicated on USGS topographic quadrangles. Distances along the east side of a convenient road (or other recognizable line) leading to the shore from a road intersection (or other suitable landmark visible in both sets of photos) to the bluff line were then computed. According to the scale of the photos, the distances determined were then converted to true distances in meters. The difference between distances was then determined and divided by the number of years between photos to give a mean recession rate at that point.

Long-term recession changes were determined using 1:10,000 scale 1874-1875 U.S. Army Corps of Engineers Lake Survey Sheets and 1:9,000 scale 1974 U.S. Army Corps of Engineers aerial photographs. Bluff line positions on the 1875 maps were traced onto a transparent overlay. The bluff line position from the 1974 air photos was projected and traced to scale on the same overlay with the aid of an overhead projector. Sufficient development of the Lake Ontario coastal area by 1875 made correlation with present landmarks for scale matching relatively easy. Sites utilized in the short-term rate determinations were then transferred onto the overlay and recession rates were then determined for the 1875-1974 period for these sites.

NY State Waterfront Revitalization Reports
The Department of State oversees the Local Waterfront Revitalization Program, which over the years has produced a series of Waterfront Revitalization Reports for a number of communities along the Lake Ontario shoreline. These reports provide detailed descriptions of the areas of concern, however the focus is on historical development and opportunity for future waterfront development, recreation and other uses. Some of the reports contain information on the geology of the shoreline and on recession rates (usually referring to recession rates calculated by the NY DEC on the Coastal Erosion Area maps). There are some

reports however that briefly describe site specific erosion problems, which may be of benefit is making qualitative assessments of recession rates in some of these areas.

FEMA Erosion Hazard Study - Monroe County, New York
As part of an overall, countrywide assessment of coastal erosion hazard areas, the Federal Emergency Management Agency, in cooperation with the NY Department of State conducted an erosion hazard assessment "pilot study" along the Monroe County shoreline of New York. This study is referred to in a paper by Leatherman and Anders (1999), but did not provide any detail on the data used or available for the Monroe County area. It is assumed that data for Monroe County would be available from the Department of State.

Other New York State Studies
Other than the comprehensive studies listed above, only a few researchers have examined the New York coast of Lake Ontario. The U.S. Army Corps of Engineers have undertaken most of the work in this area (e.g. U.S. Army Corps of Engineers, 1954, 1955, 1970, 1979), having conducted a number of site-specific erosion related investigations and also descriptions of recession rates as part of the 1979 Lake Ontario Shore Protection Study. Other studies have been conducted by: Palm (1975), who assessed 1938-1974 recession rates and high water damage along the Oswego County shoreline; Brownlie and Calkin (1981), who examined the relationship between the jetties constructed at Sodus Bay and shoreline recession; and Brennan and Calkin (1984), who investigated the sedimentology and one-year recession rates of bluffs along the southern coastline of Lake Ontario.

Miscellaneous Reports
A number of other reports reviewed contain recession related information. These include:

- Analysis and Report on Stage-Damage Relationships for Selected U.S. Shoreline Reaches (C.A., Inc., 1992): Contains maps delinating areas susceptible to erosion and flooding along the Lake Ontario study shoreline areas.

- Quaternary Stratigraphy and Bluff Erosion Western Lake Ontario, New York; (Calkin, Muller and Drexhage, 1982): Contains recession rate data for the study site.

- The Nature Conservancy Eastern Lake Ontario Sand Dunes: The Nature Conservancy has developed a draft GIS-based analysis of change in the barrier beach over the past 60 years.

3.3.2 Canadian Recession Rate Data

Environment Canada Recession Rate Data
As part of the IJC Water Level Reference Study (1986-1993), Environment Canada retained the services of Geomatics International (1992) to complete a shoreline classification of the Canadian shoreline of the Great Lakes. A component of this study was the collection of all available recession rate data and its incorporation into a reach-by-reach database. For each reach, mean, median, maximum and minimum values of recession were provided, along with a number of other related statistics.

The majority of data used in compiling the base data set was obtained from the Canada-Ontario Great Lakes Shore Damage Survey (Boulden, 1975) and Coastal Zone Atlas (Haras and Tsui, 1976), which

examined erosion hazard problems on the lower Great Lakes (southern Georgian Bay to Lake Ontario). The combination of these two data sets provides one of the earliest comprehensive sources of recession rate data for the Canadian Great Lakes shoreline. For the most part, this data is still the best available, although, as will be described shortly, new data is slowly becoming available.

The recession rates calculated in these reports were compiled using three different methods. First, historical recession and accretion rates were determined from the assessment of linear changes in shoreline property dimensions upon comparison of late 1960's - early 1970's land surveys with similar surveys from the past (primarily 1920's-1930's). This provided coverage of all erodible shoreline of the Great Lakes at spacing of not more than 10 km.

Second, recession rates were determined photogrammetrically using aerial photography flown during 1952-1955 and 1973. For this comparison, edge-of-bluff measurements were utilized where available. In areas of non-bluff shoreline, the water's edge was used as a reference point. Measurement spacing along the shoreline was approximately 1 kilometer, thereby providing relatively continuous values for recession along the shoreline.

The final method utilized was to conduct a series of ground surveys along a network of over 160 "erosion monitoring stations" (EMS) that were established between 1971-1972 along the shores of Lakes Huron, Erie and Ontario. Each of these stations was selected to represent a typical reach of shoreline having similar physical characteristics of bluff height and composition, beach material, width of beach, and angle of wave approach. For the Shore Damage Survey, these sites provided short-term recession rate information (1971/1972-1973) which was related to the high water level period occurring at that time. However, the Canada/Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981) which was established in 1973, provided additional funding for the continued re-surveying of these profiles on an annual basis between 1973-1980, thereby providing a longer period of record for these sites.

Ontario Conservation Authority Data

In 1986 and 1987, Conservation Authorities around Lake Ontario began implementing shoreline management plans and conducting a number of mapping initiatives to update and record recession rate data for their shorelines. In many cases this included reestablishing and continuing to monitor the EMS profiles established by Boyd (1981). The information presented below is taken from a review of Canadian recession rate data conducted by Stewart (1994b) in late 1994.

Recession rates for the section of Lake Ontario shoreline from the Niagara River west to Fifty Point were updated by the Niagara Peninsula Conservation Authority (M.M. Dillon Limited, 1994). In this update, Dillon (1994) utilized previous data sets (Hegler, 1974; Matyas, 1976; Haras and Tsui, 1976; Boyd, 1981; and NPCA EMS updates from 1988 to 1990) to calculate "representative average annual recession rates" for defined reaches along the shoreline. As these representative rates were used to define the "regulatory erosion standard" in the NPCA Shoreline Management Plan, they are deemed to be the best available data for this section of Lake Ontario (circa 1994).

For the shoreline between Fifty Point and Hamilton, shoreline recession data was provided by the Hamilton Region Conservation Authority and is outlined in the Stoney Creek Waterfront Study (F.J. Reinders and Associates, 1980). This data was derived through a comparison of air photos from 1931, 1934, 1969 and 1973. Using these photos, recession rates were established for approximately 27 points along the shoreline. These data points were analyzed and average annual rates were calculated for the appropriate reaches.

Recession rates for the shoreline between Burlington and Oakville (under the jurisdiction of the Halton Region Conservation Authority) were calculated using the original EMS profiles and were included in the

original 1992 Environment Canada data set. No updates to this data were available. Data for the Mississauga shoreline were updated in 1994 from the original EMS data as part of the Credit Valley Conservation Authority's Shoreline Management Planning process.

For the City of Toronto, the base data set prepared by Geomatics (1992), includes recession data provided by the Metro Toronto Region Conservation Authority. For the most part, this data consists of the original EMS data, but selected stations were updated to included 1990 information. It should also be noted that a large portion of the Toronto shoreline is artificial in nature, or extremely well protected, and thus has no recession data associated with it.

Recession rate data for the section of shoreline from Pickering to Trenton is outlined in a Lake Ontario Shoreline Management Plan prepared for the Central Lake Ontario, Ganaraska Region and Lower Trent Region Conservation Authorities (Sandwell, 1989). Once again, this data is taken primarily from the original EMS data, but some stations were updated to include data up to 1988. In addition to this, Sandwell (1989), provided recession rate estimates for a number of reaches not initially covered by the base data set. Where these were available they were used to fill appropriate gaps. Sandwell (1989) also calculated "100 year erosion set-backs" for each "reach" in this study area. This also allowed a determination of an average annual recession rate for the reach. This data, while useful for determining areas of erosion hazard, is less accurate than direct measurement of shoreline positions, because it includes an allowance for the formation of a stable slope (i.e. the 100 year set-back is 100 year recession, plus the stable slope allowance). Thus the actual average annual recession rate is likely less than what is reported in the database. This data was only used where no other data was available. It is our understanding that both the Lower Trent and Ganaraska Region Conservation Authorities have continued to monitor the EMS stations and thus recent (up to 2000?) data may be available for these shorelines.

Recession data for the remainder of the Canadian shoreline of Lake Ontario is scarce. A number of EMS stations are scattered along the shore from Trenton to Kingston and their original data is included in the original Environment Canada data set. No new information was available for these stations from either the Prince Edward or Cataraqui Region Conservation Authorities.

Erosion Processes Task Group (Stewart and Pope, 1993)
Produced as part of the work on the 1991-1993 Great Lakes Water Levels Reference Study, this document summarizes erosion rates along the U.S. and Canadian Great lakes shorelines, as well as providing an erosion sensitivity analysis of different shoreline types to changes in the range of Great Lakes water levels.

Miscellaneous Reports

- Rates of Erosion of Till in the Nearshore Zone (Davidson-Arnott, 1984): Describes the vertical erosion of till using a micro-erosion meter at the field site located about 15km east of the city of Hamilton on the southwest shore of Lake Ontario.

- The Shore Damage Survey Final Report (Boulden, 1975) references a report by Langford (1952)(not obtained for this review) that presented recession rates obtained from surveyors records up to 1946 and included the area from Niagara-on-the Lake to Scarborough. Comparison of this pre-1946 data with recession rate data for the same area after 1958 may be useful.

3.4 Beach / Shore Profiles

Canada Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981)
Beach / shore profiles are available for each of the 162 erosion monitoring stations developed during this program. Limited updated profile data for 1981 and onward is available to varying degrees from Ontario Conservation Authorities who continued monitoring these stations.

Eastern Lake Ontario Sand Dunes
A limited number of beach profiles were collected during the summer of 2000 in the Eastern Lake Ontario Sand Dune Area.

Monroe County, New York
In 1998, the Corps performed an instrument survey of the south shoreline. Several counties were surveyed; data for Monroe County is available on CD and hardcopy form the OEP. [Meisenzahl, personal communication]

3.5 Bathymetry

Great Lakes Environmental Research Lab (NOAA) Computerized Bathymetry
Bathymetric data for Lakes Ontario, Erie, Huron, and Superior on a 2-km grid as described in Robertson and Jordan (unpublished) was obtained from the Canada Center for Inland Waters. They superimposed 2-km grids on standard bathymetric charts and averaged a mean depth in each grid square by eye. Depths are relative to the Great Lakes Datum of 1955. All grids are aligned with the central meridian of the bathymetric chart. The chart scale is 1:60,000. These data were used to calculate the average depth in each 2-km grid square by averaging the depth at the center of the square and the four depths at coordinates (.5,.5), (.5,-.5), (-.5,-.5), and (-.5,.5) km relative to the center of the square. Depths at some grid squares near the shoreline were adjusted by hand so that they better fit the actual lake shoreline. Lake Ontario bathymetry data can be downloaded from the GLERL web site at: http://www.glerl.noaa.gov/data/char/

New Bathymetry of Lake Ontario
The new bathymetry of Lake Ontario bathymetry was a collaborative effort between scientists at the NOAA National Geophysical Data Center (NGDC), the NOAA Great Lakes Environmental Research Laboratory (GLERL), the Canadian Hydrographic Service, and the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES).

The entire historic hydrographic sounding database from the U.S. and Canada, originally collected for nautical charting purposes, was used to create a complete and accurate representation of Lake Ontario bathymetry. The U.S. data primarily came from the NOS Hydrographic Survey Data, U.S. Coastal Waters CD-ROM Set (Version 4.0, Data Announcement 98-MGG-03). This and other bathymetric sounding data collected by the U.S. National Ocean Service's (NOS) Coast Survey and the U. S. Army Corps of Engineers was employed to construct bathymetric contours at 1 meter intervals from 1-10 meters depth and 2 meter intervals at depths greater than 10 meters. Compilation scales ranged from 1:10,000 to 1:50,000. Bathymetric sounding data collected by the Canadian Hydrographic Service (CHS) were employed to construct bathymetric contours at 1-meter intervals and compilation scales ranging from 1:1,000 to 1:30,000. Digitization of the bathymetric contours, merging of the bathymetric contour data sets, poster construction, and preparation of a CD-ROM, were accomplished at the NGDC. Multibeam bathymetric data collected by the University of New Brunswick's Ocean Mapping Group (UNB-OMG), with support of

the Geological Survey of Canada (GSC) and the CHS, were kindly made available in gridded form. In two areas where multibeam bathymetric data were made available, no other bathymetric data were used in the compilations. In some areas all available Canadian and U. S. bathymetric sounding data, collected at different times on different survey expeditions, were used to derive the contours.

At this point in time, the products available are full color posters (two sizes)(Figure 2 below), digital images, and an ARC/INFO digital file. The digital file contains the contours of the lake at 1 and 2-meter intervals, and is available at a cost of US $75 plus shipping and handling. To obtain the digital file, contact Robin Warnken at Robin.R.Warnken@noaa.gov.

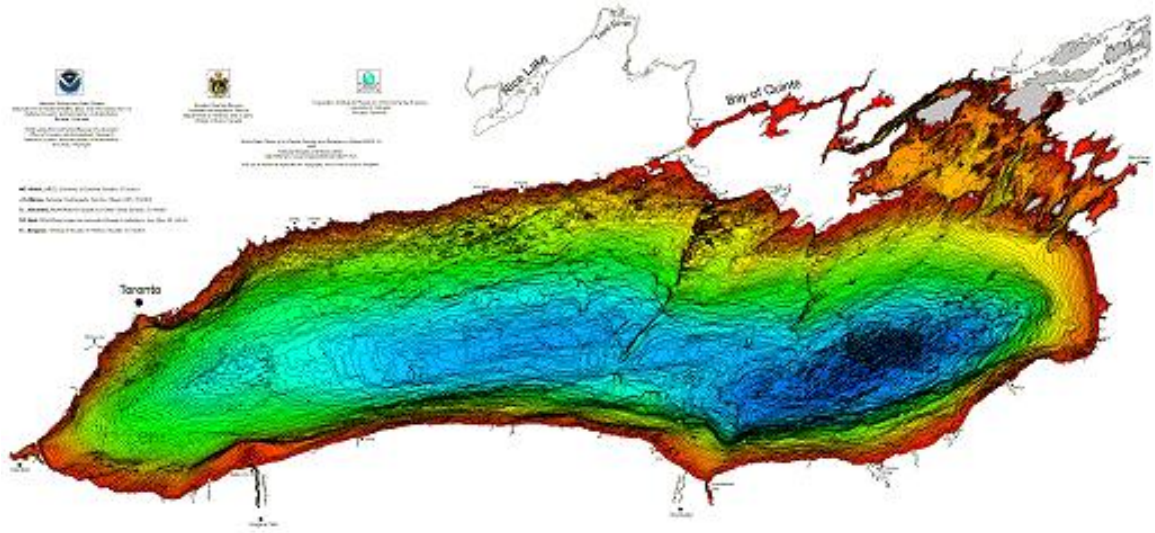


Figure 2 - New Lake Ontario Bathymetric Map

General Hydrographic Survey Data
A range of hydrographic survey data is available for both the U.S. and Canadian shorelines of Lake Ontario and the St. Lawrence River. The information below is extracted from a reach-by-reach description of bathymetric data availability contained in Baird & Associates (2001). This report also provides a table describing all available hydrographic surveys available for Lake Ontario and the St. Lawrence River (table will be provided in final report).

Canada:
- CHS: four surveys from 1990 to 1994, two surveys dated from 1988 to 1990.
- NOAA: two surveys dated 1948
- CHS: eight surveys data 1973 to 1996
- CHS: fourteen surveys dated 1967 to 1995
- CHS: four surveys dated 1961 to 1993, plus historic
- Numerous acoustic surveys by the Toronto Region Conservation Authority
- CHS: eleven surveys dated 1984 to 1993
- CHS: seven surveys dated 1984 to 1997
- CHS: nine surveys dated 1967 to 1991
- CHS: four surveys dated 1984 to 1991

- CHS: twenty-three surveys dated 1962 to 1989
- CHS: two surveys dated 1981 and 1986
- NOAA: five surveys dated 1948 to 1987

U.S.:

- NOAA: eight surveys dated 1948 to 1983
- CHS: one survey dated 1972
- NOAA: two surveys dated 1984 and 1987
- Historic NOAA
- NOAA: three surveys dated 1948
- NOAA: two surveys dated 1948
- NOAA: three surveys dated 1948
- NOAA: two surveys dated 1941

St. Lawrence:

- CHS: three surveys dated 1972 to 1982
- NOAA: one survey dated 1941
- CHS: four surveys dated 1983 to 1992
- NOAA: two surveys dated 1948
- CHS: one survey dated 1986
- Data from hydrographic surveys conducted by the Canadian Hydrographic Service, integrated with EC's digital terrain model
- EC bathymetric data (old and has not yet been updated)
- Few Profiles for the Mille-Iles and des Prairies River, some bathymetric data for the des Prairies River.
- Some marine charts and data from Environment Quebec
- Data from hydrographic surveys conducted by the Canadian Hydrographic Service, Coast Guard and from various other studies, integrated with EC's databases

SHOALS Data

New detailed bathymetric data is being collected within the new IJC study for a number of site-specific areas using the US Army Corps SHOALS (Scanning Hydrographic Operational Airborne LIDAR System). This data will be used to generate computer models of nearshore landforms and will be available for use by the various working groups later in 2001.

Eastern Lake Ontario Sand Dunes Data

As part of their work in this area, the Nature Conservancy and Hobart & William Smith College have high resolution, X-Star, seismic information along approximately ~200km of lines. They also have side-scan records along ~75km of lines (Woodrow, personal communication).

Miscellaneous Bathymetric Information and Reports

- The Nautical Seaway Trail, (Seaway Trail Inc., 1991): Provides basic bathymetric data (charts) for Lake Ontario and the St. Lawrence River.

- Lake Ontario Shore Protection Study (USACE, 1979): Provides bathymetry for US side of Lake Ontario in the maps that display the location of the 126 reaches within the study.

3.6 Ice Cover

All NOAA products described below can be downloaded from the web at http://www.glerl.noaa.gov/data/arc/

NOAA Great Lakes Aerial Photos of Ice Conditions
The collection consists of approximately 50,000 high-quality negatives and transparencies showing ice cover impact on navigation or hydroelectric operation from 1963 to 1973. Coverage is not systematic or complete. Indexing has not been undertaken, but latitude and longitude of flight line begin and end points are logged. Photos from many flights have been made into photo mosaics that can be used on-site as a gross index to the 9-inch roll negatives. Photographic flights were carried out by a U.S. Air Force photo mapping wing, using flight lines selected by NOAA Lake Survey Center (now Great Lakes Environmental Research Laboratory).

NOAA/Great Lakes Environmental Research Laboratory (GLERL) Great Lakes Ice Concentration
Ice concentration grids for 1960 to 1979 are archived for half-month periods, generally December through April. Data values are coded to nearest 10 percent for each 5 x 5 km grid square. A file of geographic coordinates of the centroid of each grid cell is included for each lake. A file of ice climatology data for each lake includes average, median and mode for each grid cell for each half-month period. This data set contains more detail than the NOAA Great Lakes Ice Atlas, including both mode and average ice concentrations that are not in the Atlas. Over 2800 charts were digitized to produce this database. Charts were prepared by NOAA/National Weather Service Forecast Office in Ann Arbor, U.S. Coast Guard Ninth District Ice Navigation Center in Cleveland, and by Canadian Atmospheric Environment Service. Chart data sources include NOAA satellite, U.S. Coast Guard side-looking airborne radar (SLAR) and aerial visual reconnaissance, Canadian Coast Guard SLAR and aerial visual reconnaissance, and Atmospheric Environment Service analyses.

NOAA/Great Lakes Environmental Research Laboratory (GLERL) Weekly Nearshore Ice Thickness and Stratigraphy
During the winters of 1965/66 through 1976/77, NOAA/Great Lakes Environmental Research Laboratory collected weekly ice thickness and stratigraphy data at up to 90 stations on the Great Lakes. Digital data include station name, latitude, longitude and period of record as well as thickness of up to six ice layers, total ice thickness, snow depth (on top of ice), snow condition, ice condition, and ice type code. Data are useful for site-specific shoreline engineering studies, winter navigation projects and remote sensing ground truth. Constraints on the data include the relatively short period of record (11 seasons maximum for any station). Additionally, the time series may not reflect full winter severity range. Nearshore data may not be valid for nearby locations or representative of offshore conditions, and ice type codes (visual observation code) changed in 1974/75. Both old and new code lists are available. Station locations are fairly evenly spread along the U.S. shores of Lake Superior with 11 stations concentrated in the Whitefish Bay area, are mostly north of the Kewaunee-Manistee line around Lake Michigan, are mostly near the Straits of Mackinaw on Lake Huron, include only seven stations on Lake Erie/Lake St. Clair, and are along the southeastern and eastern shores of Lake Ontario.

Great Lakes Daily Ice Observations at NOAA Water Level Gauge Sites
This data set consists of ice type codes, recorded daily from 1 November to 30 April by cooperative observers at up to 39 NOAA/National Ocean Service water level gauge sites on the Great Lakes, 1955/56 through 1996/97. Not all gauge sites have been reported each season; a list of sites with coordinates and reporting years is included with the data set. The longest records tend to be at river stations (St. Clair, St. Mary's, Detroit, and St. Lawrence). Daily observations are coded (open water, solid ice, honeycombed ice,

slush ice, windrowed ice, drifting ice, ice gorge), and first and last reported ice for each season are listed. This time series is a unique data set.

Great Lakes Surface Ice Reports from US Coast Guard
Data consist of ice observations from U.S. Coast Guard vessels operating on the Great Lakes and from Coast Guard shore stations reported via Teletype messages and ice logging forms. Observations include ice thickness and concentration, weather conditions and ice breaking activity. Data from 1961/1962 through 1966/1967 have been processed to a standard format and sorted by year and stations, and are available via ftp as ASCII files, one for each of the five lakes. Data beyond 1966/67 are available in the following manner:

- Data from 1970/71 through 1977/78 are available on 14 reels of 16mm microfilm
- Data from 1979/80 through 1982/83 are available on 1 reel of 16mm microfilm
- Data for 1980/81 exclusively are available on 1 reel of 16mm microfilm
- Data for 1983/84 exclusively are available on 1 reel of 16mm microfilm
- Data for 1991/92 through 1993/94 are available on 1 reel of 16mm microfilm
- Data from 1994/1995 through the last ice season are available via ftp as ASCII files in a single .tar file for each ice season.

Note that no editing or quality control has been performed on this data set. Microfilmed records are difficult to use, as they are merely sorted by date and time, and contain extraneous information. The electronic data from 1994/1995 forward are raw Teletype reports. These are not in a consistent format, and also contain extraneous information.

National Ice Center Weekly Great Lakes Ice Charts
The National Ice Center (NIC) began producing ice charts for the Great Lakes in 1983. Prior to 1983, charts were produced by the National Weather Service. The NIC maintains a record of NWS charts for the Great Lakes back to the early 1970's. Initial NIC charts analyzed yearly surface water temperatures and winter ice cover. By 1985 NIC was responsible for analyzing the seasonal ice in the Great Lakes. NIC charts cover all five lakes and two sub-sectors which highlight the Detroit / St. Claire rivers and the St. Mary's river. The highlighted areas are key junctions between different Lakes that are vital to commercial traffic. These areas were added to provide a more detailed look of ice conditions for safe navigation. This format of coverage was maintained on paper charts until the 1995-1996 ice season, at this time the paper charts were replaced by digital charts produced on a Geographical Information System (GIS) known as GRASS. During the following season (1996-1997) the highlighted regions were increased in number to cover other significant navigational problem spots. The addition of highlighted regions was made possible by the RADARSAT satellite, which offers higher resolution imaging capabilities. Great Lakes and Chesapeake Bay Digital products include sea ice analysis charts in Graphics Interface Format (*.gif), which can be viewed with almost any web browser and/or graphics viewer, and Geographical Information System (GIS) ARC/INFO coverages. GIF charts are labeled using the World Meteorological Organization (WMO) international sea/freshwater ice symbology known colloquially as the "egg code". ARC/INFO coverages are produced in Universal Transverse Mercator (UTM). All ARC/INFO sea ice attribute information is coded in a modified text strings derived from the WMO digital sea ice standard known as SIGRID. All NIC digital ice products use this attribute standard to describe analyzed sea ice parameters.

Miscellaneous Reports

- Environmental Sensitivity Atlas for the St. Lawrence River Shorelines (Environment Canada, 1994): Provides illustration of the extent of ice cover for the St. Lawrence River. A similar atlas is also available for Lake Ontario.

- Quinte Conservation Area Waterfront Study, (MIE Consulting Engineers and M.M. Dillon Limited, 1990): Briefly describes ice cover in winter.

3.7 Sediment Transport Rates and Sediment Budget

Miscellaneous Reports

- Lake Ontario Shore Protection Study (USACE 1979): Describes the longshore drift characteristics for the 126 reaches along the shoreline.

- Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes (F.J. Reinders & Associates, 1988): Provides sediment budgets and sediment transport patterns for specific littoral cells in Lake Ontario as well as the net longshore drift directions for the entire lake and sediment input for 1973-74.

- Great Lakes Erosion Monitoring Programme (Boyd, 1981): Contains information on available littoral drift (m^3) from bluff erosion.

- NPCA Lake Ontario Shoreline Management Plan (M.M. Dillon, 1994): Identifies littoral cells on the southwest shore of Lake Ontario and describes littoral sub cells, and groups each reach into one of the littoral cells; contains estimates of "limited supply" longshore transport rates at nearshore points of the study shoreline; contains littoral transport calculations for each sector.

- Central Lake Ontario Shoreline Management Plan (Sandwell, 1989): Contains table describing the sediment contribution from rivers; describes the littoral cells and sub-cells for the study shoreline.

- Spencer Smith Park Waterfront: Preliminary Engineering Study (F.J. Reinders and Associates, 1987): Outlines the littoral transport patterns and potential sediment transport rate in the area.

3.8 Currents

Minimal information located to date. It is assumed that detailed current data would be available from agencies such as Environment Canada or NOAA.

Some site-specific data has been collected as part of the Eastern Lake Ontario Sand Dunes Study (Woodrow and Bonanno, personal communication). This includes current data for the spring-fall of 1998, 1999 and 2000, as well as short-term data. Data is also

being collected on bottom currents from a single site in 7m depth of water off the Sandy Pond Inlet.

Miscellaneous Reports

- Environmental Sensitivity Atlas for the St. Lawrence River Shorelines (Environment Canada, 1994): Briefly describes the prevailing winds, wave and surface current patterns on the St. Lawrence River. A similar atlas is also available for Lake Ontario.

- Littoral Cell Definition and Sediment Budget for Ontario's Great Lakes (F.J. Reinders and Associates, 1988): Provides (1979-81) current information (direction and speed) for sections of the lake.

- Etobicoke Motel Strip Waterfront Public Amenity Scheme (Johnson and Weinstein, 1989): Contains information on the spread of suspended solid concentrations throughout the bay including a computer model of current patterns.

4.0 LAND SIDE DATA

4.1 Land Use, Land Use Trends, Property Ownership

Lower Great Lakes Erosion Study, USACE 1998
As part of work conducted during the Lower Great Lakes Erosion Study for USACE Buffalo District, Stewart (1998) has catalogued land uses occurring in each of 514-kilometer reaches for the Lake Ontario shoreline and for similar reaches in the St. Lawrence River. Land use data was extracted from circa 1978 land use plots of the shoreline developed by the US Army Corps Detroit District. All land use categories occurring within 500m of the shoreline were recorded. Data is available in both spreadsheet and GIS format.

Stewart (1998) has also summarized land use trends for each kilometer. This was done through an examination of county and township master plans and through discussion with county officials. The data consists of a value from 1-5 each representing a differing percentage of projected land use change. Property ownership information was also collected and is represented on a kilometer-by-kilometer basis. Data essentially consists of the identification of state or federal properties (e.g., parks) or large-scale industrial or utility land uses.

IJC Land Use and Shoreline Management Task Group, 1993
During the IJC Great Lakes Water Level Reference Study (1991-1993) the Land Use and Shoreline Management Task Group derived and prepared summary data on land use and land use trends for all of the Great Lakes (Taylor and Gauthier, 1993).

Environmental Sensitivity Atlas for the St. Lawrence River Shorelines, 1994
This atlas (Environment Canada, 1994) identifies varying land uses such as marinas, and residential, recreational, commercial, and conservation areas. They also identify recreational land uses including recreational beaches, cottages, dive sites and anchorage sites. It also identifies First Nation ownership as well as the locations of federal, provincial and state parks. A similar atlas is also available for the Lake Ontario shoreline (Rob Read, Environment Canada, personal communication).

Lake Ontario Shore Protection Study (USACE, 1979)
Provides statistics of land uses and ownership for the Lake Ontario Shoreline (possibly useful in the identification of past trends).

New York State Waterfront Revitalization Reports
The Department of State oversees the Local Waterfront Revitalization Program, which over the years has produced a series of Waterfront Revitalization Reports for a number of communities along the Lake Ontario shoreline. These reports provide detailed descriptions of the areas of concern, however the focus is on historical development and opportunity for future waterfront development, recreation and other uses. Information in these reports focuses on existing land uses and potential future land uses and property ownership in the waterfront areas. Reports completed up to 1998 are currently available.

Seaway Trail Inc. Projects
The Seaway Trail Inc. has produced a number of documents useful for determining land uses, trends and ownership along the New York state shorelines of Lake Ontario and the St. Lawrence. These include:

- The Seaway Trail Guidebook (Seaway Trail Inc., 1991): Displays the locations of marinas and recreational and park land uses, as well as some retail and commercial areas in coastal towns.

- Visual Resource Inventory Report, Seaway Trail Corridor Inventory and Assessment Study – Volume I (Seaway Trail Inc.,1997a): Contains maps that identify the various land uses along the trail (also data on acerage and % of landuse).

- Intrinsic Resource Inventory Report, Seaway Trail Corridor Inventory and Assessment Study – Volume II (Seaway Trail Inc., 1997b): Contains maps that identify the "intrinsic" features along the trail.

Canada - Ontario Great Lakes Shore Damage Survey and Coastal Zone Atlas (Boulden, 1975)
The Great Lakes Shore Damage Survey and corresponding Coastal Zone Atlas were prepared for Environment Canada and the Ontario Ministry of Natural Resources. They contain mapped information on shoreline land uses and ownership for all of the Great Lakes including Ontario.

Niagara County, New York Land Use Information
Land use photography and "sketches" of land use are available from the Niagara County Planning Department for:

- The Town of Somerset for 1968, 1978, and 1990
- The Town of Newfane for 1968, 1978
- The Town of Wilson for 1968, 1978
- The Town of Porter for 1968

Waterfront Studies
A number of older waterfront revitalization and recreation studies are available, some of which describe general land use, land use trends and ownership. These include:

- Toronto Waterfront Regeneration Reports: Various reports developed by the Royal Commission on the Future of the Toronto Waterfront describe existing and potential future land use along the Lake Ontario shoreline from Burlington to Oshawa (Symmes et al., 1991; Royal Commission on the Future of the Toronto Waterfront, 1992; Waterfront Regeneration Trust, 1993a and 1993b).

- Waterfront Recreation Opportunities Study, Monroe County, New York (Crandall et al., 1990): Identifies the park and public open spaces. Contains information of the development of new and redevelopment of existing shoreline areas for recreation purposes, contains an inventory of recreation facilities and sites, considers environmental factors (flooding and erosion rates, etc.); calculates costs and potential revenue.

- Cornwall Ontario Waterfront Plan (Cornwall Waterfront Committee, 1989): Identifies the land uses along the shoreline of the development area. Provides information on the proposed development and redevelopment of the shoreline, also has maps and sketches of the proposed regeneration.

- Bellville Ontario Waterfront Resource Study (Lahaut et al., 1987): Provides maps of the shoreline to illustrate zoning (open space, public facility, industrial, commercial, residential, etc.).

- Quinte Conservation Area Waterfront Study (MIE Consulting Engineers and M.M. Dillon Limited, 1990): Provides a proposed development/regeneration plan (three different concepts) for the shoreline, provides maps and sketches of proposed facilities and infrastructure, includes comparisons of the three concepts and estimates costs. Contains an inventory of existing parks.

- Socio-economic Profile for the Hamilton Harbor Ecosystem (Robinson and Schaefer, 1991): Outlines the past and current land uses, contains a proposed redevelopment plan, also describes the land in industrial use by industry type (1986); contains a map that illustrates the recreation and heritage sites surrounding the harbor.

- City of Belleville Ontario Bayfront Planning Study (M. M. Dillon, 1990): Maps identify some of the "main" buildings (sewage treatment center, city hall, schools, hotels, parks, retail plazas, etc.); Contains information on the different markets (resident, land based tourist, boater) in the area; includes a land use strategy for future development of the bay front, includes maps of the strategy for each area of the bay front and river front up for development; contains detailed plans, drawings, and descriptions of the development strategy.

- Spencer Smith Park Waterfront: Preliminary Engineering Study (F.J. Reinders and Associates, 1987): Contains plans outlining the development of a new marina and the shoreline development to support the new facility (includes maps, drawings, calculations, costs, options, etc. for the new development).

- Etobicoke Motel Strip Waterfront Public Amenity Scheme (Johnson and Weinstein, 1989): Describes and contains drawings and maps for the proposed development in Etobicoke, Ontario.

- Burlington Beach Waterfront Park: Stage II Master Plan (Halton Region Conservation Authority, 1987): Describes the proposed regeneration of the waterfront site, includes maps with proposed infrastructure (roads, boardwalks, seawalls, marinas, yacht club, etc.).

Zoning By-Laws and Regulations

Most of the townships on the U.S. shoreline of Lake Ontario are likely to have zoning by-laws and policies in place regarding coastal development. Contacts for many of these townships are available (Sandy Bonanno, Nature Conservancy, personal communication) and a number of U.S. zoning by-laws and regulations have been obtained that provide some insight into land use and land use management along certain portions of the shoreline. These include:

- Village of Sackets Harbour, Zoning Laws: Contains a map delineating the land uses (single family residential, general residential, business, etc.) of the area.

- Town of Hounsfield Jefferson County Zoning Law, 1989: Contains a map delineating the various land uses (agricultural and residential, hamlet, industrial and marine) of the area, shows the road network also.

- Town of Brownville Zoning Laws, 1997: Contains a map delineating the various land uses; list lot size restrictions and regulations.

- Town of Cape Vincent, Zoning Law, 1 989: Contains zoning laws for that town (no map).

- Village of Chaumont, Land Development Code, 1990: Contains zoning laws for that village (lot dimension regulations, and site plan review uses); map of area included but not divided into land uses.

- Town of Ellisburg, Jefferson County, Zoning Laws, 1971: Describes the types of structure permitted in differently zoned land, contains a coastal erosion hazard area which describes regulations, restrictions and jurisdictions.

- Town of Henderson, Zoning Laws, 1991: No map, contains dimension regulations and description of special permit uses.

Miscellaneous Reports

- Oswego County Data Book (Oswego County Department of Planning and Community Development, 1994): Contains data the location of buisnesses and facilities in the villages, towns, and cities, information on agricultural land, information transportation networks; contains figures on population growth trends from 1950-90's, population forecasts from 1990-2010, and statistics on population change (and composition) for the towns, villages and cities of Oswego County; contains data on the ownership of various facilities.

- Oswego County Comprehensive Plan (Oswego County Planning Board, 1997): Contains data and maps of public faclities in Oswego County, as well as vacency rates for housing, and has data on land use by percent; contains data on population trends, historic, cultural neighbourhood properties preservation trends, transportation trends, public infrastructure trends, housing trends, conservation/reserve/park trends, and land use in general (industrial, commercial, residential, community, etc); provides data and maps that illustrate the ownership of various facilites, parks and housing.

- Conceptualization of Boat Access Development Zones (White, 1992): Maps delineate public ownership information for Braddock's Bay, Sodus Bay, and Port Ontario.

- Public Access to the New York Shoreline (New York State Department of State, 1988): Describes the boundary limits of typical patterns of beach ownership.

- Trends in Shoreline Land Use and Land Values in selected Growth in the Great Lakes-St. Lawrence River Basin (LURA Group, 1989): Contains information on past land use, current land use and future land use for Oshawa, Ontario on Lake Ontario and Cornwall, Ontario on the St. Lawrence River.

- NPCA Shoreline Management Plan (M.M. Dillon, 1994): Contains brief descriptions of land use and ownership for shoreline areas under the jurisdiction of the NPCA in Ontario.

- New York's Eastern Lake Ontario Sand Dunes (L.R. Johnston & Associates, 1989): Contains a map of the eastern Lake Ontario region which displays the location of management areas and state parks, also contains some info about the percentage of ownership along the shoreline study area.

- Eastern Lake Ontario Megasite (The Nature Conservancy, 1995): Map depicts areas owned by New York State and The Nature Conservancy.

- Deer Creek/Sandy Pond Marcosite (The Nature Conservancy, 1995): Map depicts areas owned by The Nature Conservancy.

- Great Lakes Basin Commission, Summary of Existing and Projected Land Use Information for the Great Lakes Coastal Counties, U.S. Army Corps of Engineers Support Agreement W74RDV 78290-005, November 1978.

4.2 Property/Structure information

4.2.1 Property Type and Value

Lake Ontario Shore Protection Study (USACE, 1979)
Describes the upland development as a percentage of land use type and the total value of structures and land for 126 reaches along Lake Ontario shoreline.

Canada - Ontario Great Lakes Shore Damage Survey (Boulden, 1975)
Describes the value of shoreline per meter of land for some municipalities along the Canadian shoreline of Lake Ontario.

Oswego County Data Book (Oswego County Department of Planning and Community Development, 1994)
Contains data on dwellings, number of units per, estimated value of owner occupied housingunits, estimated value of specified (house & lot) owner occupied units, tenure and vacancy, cost of rent for renter units, property taxes, revenue and expenditures.

Oswego County Comprehensive Plan (Oswego County Planning Board, 1997)
Contains data on the number of housing structures by decated built, the housig values, rental market, as well as information on specialized housing, and mortgage by income and interest rates.

Socio-Economic Profile for the Hamilton Harbor Ecosystem (Robinson and Schaefer, 1991)
Describes the property tax/ft^2 for different land uses, contains a map illustrating the average estimated market value of dwellings (1986).

4.2.2 Damage and Potential Damage Investigations

Potential Damages Task Group, IJC Levels Reference Study (Stewart and Kangas, 1993)
The Potential Damages Task Group of the Levels Reference Study conducted a number of detailed damage investigations including an assessment of damages associated with various water level scenarios, the evaluation of damages at a series of site specific study areas including Toronto and Montreal (Paragon Engineering, 1993), Oswego County and Alexandria Bay, NY, an evaluation of expenditures on shoreline protection (Ecologistics Limited, 1992) and the avoided costs of shoreline protection (Baird & Associates, 1993). Flood and erosion stage-damage curves were also updated (Marshall, Macklin, Monaghan, 1992), critiqued (Yoe, 1992) and applied to the shoreline using an uncertainty analysis methodology (Environment Canada, 1992; U.S. Army Corps of Engineers, 1992).

Analysis and Report on Stage-Damage Relationships for Selected U.S. Shoreline Reaches (C.A., Inc., 1992)
Contains descriptions of damages along a number of Lake Ontario shoreline reaches. Contains data on the dollar values of damage and estimates of future damage based on inundation and erosion stage damage curves.

United States Inundation and Erosion Stage-Damage Relationships (DeCooke, 1991)
Lists damage data surveys and their results for inundation and erosion damage; estimates dollar value of potential damage at the time of the study; contains inundation and erosion damage curves for reaches along the Lake Ontario shoreline.

Great Lakes 1985-87 High Water Levels U.S. Shoreline Damages, Modeling and Mapping, Situation Report (DeCooke, 1988)
Report presents historic damage information as well as a rough assessment of 1985-1987 damage to the U.S. Great Lakes shorelines. Contains information on the value of Lake Ontario shoreline based on land use, as well as data on shoreline damages due to various storm events, the estimated damage in dollars prevented due to protection structures, and newpaper and real estate listing of property values.

Canada – Ontario Great Lakes Shore Damage Survey (Boulden, 1975)
This report provides mapped shoreline damage information associated with high water levels in the early 1970's. The associated Coastal Zone Atlas provides mapping of both flood and erosion damages for various locations along the Lake Ontario shoreline.

Niagara County New York Damage Information
Damage data has been compiled for the Towns of Newfane, Porter, Somerset, and the Town of Wilson by the Niagara County Niagara County Planning Department. This provides information on the cost of damages suffered by land parcels along the shoreline during high water periods and includes information on the types of protection structures for each town as well as a summary of all the townships.

Development of Flood Depth-Damage Curves for Residential Homes in Ontario (Paragon Engineering, 1985).
Contains summary statistics of damage data by category of building (type); contains damage curves and histograms for various types of structures (generally residential one storey with basement); contains depth-damage curves for all categories (types) of structures (broken up into total damage, structure damage and content damage) and pictures to illustrate the categories of structures; also contains questionnaires asked of household in damage estimation and considers varoius factors (warining of flood, duration of flood,etc) affecting damage values.

A Review of Flood Damage Estimation Methodologies (Paragon Engineering, 1984)
Provides a review and guidelines for estimating flood damages.

Monroe County Damage Information
Descriptiive memos regarding 1998-2001 damage to water and wastewater facilities, impacts to public infrastructure, and impacts of high lake level on town facilities and infrastructure for the Town of Greece.

4.2.3 Building, Shore Protection, and Boating Structure Inventories and Mapping

Lower Great Lakes Erosion Study 1999
Stewart (1999b) has conducted a kilometer-by-kilometer classification of shoreline protection for the entire U.S. shoreline of Lake Ontario and the St. Lawrence River. The classification captures the types and quality of shore protection occurring in each kilometer reach. Data was extracted from aerial photography which was supplemented by 1999 videotape of the shoreline, background reports, mapping, and field verification. Data exists in MS-Excel format on a reach-by-reach basis. Summary statistics of the lengths and percent of each shore protection type have also been developed. The data is georeferenced (latitude and longitude) to the center point of each reach and has been incorporated into GIS in this manner.

Potential Damage Estimates for Site Specific Areas, Levels Reference Study
As part of work on the 1991-1993 Levels Reference Study Paragon Engineering (1993) conducted surveys of structures in the Toronto and Montreal site-specific study areas to determine lowest opening and first floor elevations. Data was collected for 268 structures in the Montreal study area and for 55 structures in the Toronto study area.

Environmental Sensitivity Atlas for the St. Lawrence River Shorelines (Environment Canada, 1994)
Identifies the locations of boat launches, light stations, and staging areas as well as anchorage sites, marinas and diving sites.

The Nautical Seaway Trail Guidebook (Seaway Trail Inc., 1991)
Identifies the locations of marinas, piers, ramps, etc.

Lake Ontario Shore Protection Study (USACE, 1979)
Identifies the structures built along the shoreline (i.e., boat ramps, docks, marinas) for Lake Ontario shoreline.

NPCA Lake Ontario Shoreline Management Plan Main Report (M.M. Dillon, 1994)
Contains maps in back pocket of report that contain dock and marina structural information.

Conceptualization of Boat Acess Development Zones (White, 1992)
Provides maps that deliniate boat docks, marinas, launch ramps, etc. for Braddock Bay, Sodus Bay, and Port Ontario.

Cobourg Harbour, Investigation of Wave Agitation and Related Remedial Structures (Skafel, et al., 1979)
Provides a map of the existing strucures in Carbourg Harbour, break waters, piers, fuel docks, etc.

Oswego County Data Book (Oswego County Department of Planning and Community Development, 1994)
Contains data on dwellings, number of units per, estimated value of owner occupied housing units, estimated value of specified (house & lot) owner occupied units, tenure and vacancy, cost of rent for renter units, building permit issues.

Bayfront Planning Study (M. M. Dillon, 1990)
Contains detailed mapping of marinas, docks, etc., along the shoreline of Belleville, Ontario.

Waterfront Recreation Opportunities Study (Monroe County, 1990)
Provides a map of the recreation facilities (marina, boat launch, etc.) for all shorelines in the County and presents a recreation matrix detailing which facilities are available for each portion of the lake, river and creek shorelines.

Quinte Conservation Area Waterfront Study (MIE Consulting Engineers and M.M. Dillon Limited, 1990)
Contains an inventory of existing marina facilities.

4.2.4 Road and Other Infrastructure Mapping

Many of the reports contained in this review provide basic mapping of road and street networks for the area of concern being examined. Detailed mapping of road networks should be available from the New York Department of Transport and through the Ontario Base Mapping Program (see Section 5.0 below). A few reports reviewed provide more specific information on road and utility infrastructure. These include:

Lake Ontario Shore Protection Study (USACE, 1979)
Provides location of present and future expressways for Lake Ontario Shoreline. Also describes the structures that were present (water intakes, sewer outfalls, etc.) as well as their ownership.

Oswego County Data Book (Oswego County Department of Planning and Community Development, 1994) Information on transportation networks, map of U.S. and state highways and county roads, data on public utilities (power, telephone, etc.), maps of water and sewerage services within the county.

Niagara County GIS Data via USDA Natural Resources Conservation Services
List of Arc View Shape Files of traffic analysis zone, US Census Bureau, TIGER files; traffic analysis district, US Census Bureau, TIGER.

Monroe County Infrastructure Mapping
Detailed map showing Shoremont Water Treatment Plant (SWTP) provides good detail of streets and supporting infrastructure. Hard copy map of Long Pond watershed with GIS data, good detail of land parcels in the area and supporting road and utility infrastructure.

5.0 GIS/MAPPING DATA, PHOTOGRAPHY AND IMAGERY

5.1 Aerial Photography

USGS NAPP Aerial Photography
The National High Altitude Photography (NHAP) program was initiated in 1980 and coordinated by the U.S. Geological Survey (USGS) to acquire aerial photography of the 48 conterminous states every five years. This interagency program was designed to eliminate duplicate efforts in various government programs and to maximize the use of government funds to build a uniform archive for multiple uses. In 1987 the program name was changed to the National Aerial Photography Program (NAPP) in recognition of modifications in the user requirements and flight specifications.

NHAP photography was acquired at 40,000 feet above mean terrain and flight lines were centered on the 1:24,000-scale USGS map series. Two different camera systems were used; a 6 inch focal length lens was used to acquire black-and-white film at an approximate scale of 1:80,000 and an 8.25 inch lens was used to acquire color-infrared film at an approximate scale of 1:58,000. A duel port camera system was used to acquire simultaneous coverage.

NAPP photography is acquired at 20,000 feet above mean terrain with a 6-inch focal length lens. The flight lines are quarter quad-centered on the 1:24,000-scale USGS maps. NAPP photographs have an approximate scale of 1:40,000, and are flown in black-and-white or color infrared, depending on state or federal requirements.

The NAPP/NHAP archive contains over 10,000 rolls of cartographic quality aerial photography acquired since 1980. On the average, 700 new rolls are acquired each year based upon a pre-determined flight schedule and season. All photographs are cloud free, and only contract-acceptable photographs are indexed to the map line plots. The photographic frames are maintained as original and working master archives by two support facilities, the EROS Data Center and the U.S. Department of Agriculture's Aerial Photographic Field Office (APFO).

All photographs are manually assessed to ensure that they meet the photographic, cartographic, coverage accuracy, and quality standards of each contract. Commercial flight contractors must meet a stringent list of acceptance criteria and provide proof of camera certification in order to fulfill contract requirements.

The NAPP/NHAP film can be used to resolve objects as small as one to two meters in size. The photography can be manipulated to a variety of non-standard enlargements to generate products of desired scales.

While it was the intent of both the NHAP and NAPP programs to acquire complete coverage of the conterminous United States every five years, that has varied somewhat due to budgetary constraints. Nevertheless, these programs do provide nearly complete coverage of the entire United States on a fairly regular basis. The next cycle of NAPP coverage is planned for 1997-2003.

For the Lake Ontario shoreline in New York State, NAPP photography is currently available for 1994 and 1995 depending on the county and can be ordered through USGS. The next scheduled update is 2001.

USGS Aerial Photography
The U.S. Geological Survey (USGS) Aerial Photography data set includes over 2.5 million film transparencies. Beginning in 1944, photographs were acquired for mapping purposes at different altitudes using various focal lengths and film types. The resultant black-and-white photographs contain less than 5 percent cloud cover, and were flown under rigid quality control and project specifications (i.e., stereo coverage, continuous area coverage of map or administrative units).

Prior to the initiation of the National High Altitude Photography (NHAP) program in 1980, the USGS photography collection was one of the major sources of aerial photographs used for mapping the United States. Since 1980 the USGS has acquired photographs over project areas that require larger scale photographs than those available through the NHAP and NAPP programs.

The spatial resolution varies depending on the scale of the USGS photograph. The USGS aerial photography collection ranges in scale from 1:8,000 to 1:80,000.

The USGS aerial photographs are geographically referenced on photographic indices. An individual photographic index is compiled by tiling together a series of consecutive and adjacent overlapping photographs over a specified geographic area. These indices of tiled photographs provide information (i.e., project, roll, and frame numbers) required for the ordering process.

The coverage area includes the conterminous U.S., Alaska, Hawaii, and Puerto Rico. Specific coverages available for the Lake Ontario and St. Lawrence River shorelines of New York State will need to be determined by querying USGS.

U.S. Army Corps Buffalo District Aerial Photography
A number of aerial photography sets are available from USACE Buffalo District including:

1986 - These are 1:4,800 scale, black and white prints of good quality. They were used as baseline information to supplement the 1999 shoreline video used in re-classifying the Lake Ontario shoreline. Bluff edge and shoreline determination should be easy to accomplish.

1974 - These are 1:6,000 scale color prints of fair to good quality. Generally they are at the limit of scale useful for recession rate determination.

1964 - These are 1:40,000 scale (?) black and white prints taken in October of 1964. The photos are generally clear and sharp, however their scale could lead to accuracy problems in determining bluff edge and shoreline position, even with the aid of zoom transfer scopes and other photogrammetric techniques. The preference would be to use other photo sets, but these could likely be used in some areas to establish, for example, 1964-1974 recession rates.

1938 - These are 1:12,000 scale (approx.) black and white prints taken in June. They are fair quality and are likely the earliest set of air photos that might be found for this area.

Other U.S. Government Aerial Photography
The United States (U.S.) Government Aerial Photography data set includes film received from the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Bureau of Reclamation (BOR), the Environmental Protection Agency (EPA), the National Park Service (NPS), the U.S. Air Force, the U.S. Army, and the U.S. Navy that is archived at the EROS Data Center. Originally, the photographs were acquired for a variety of agency projects, thus, providing irregular coverage over the conterminous U.S.,

Alaska, Hawaii, and Micronesia. The film types, scales, acquisition schedules, and available end products differ according to individual agency project requirements. Low-, middle-, and high-altitude photographs using a variety of film types were collected.

Except for EPA and NPS photography, data are compiled into black-and-white photographic indexes that are available for viewing on microfilm or microfiche and are available as paper print products.

EPA, NPS, and some U.S. Air Force photographs are plotted onto large-scale topographic maps. The frame corner points are digitized for retrieval using geographic (latitude/longitude) coordinates.

Spatial resolution varies according to the scale of the photographs. The U.S. Government Aerial Photography data set base-scale ranges follow:

Agency	Scale Range
BIA	1:15,000
BLM	1:12,000 - 1:31,600
BOR	1:3,000 - 1:48,000
EPA	1:5,000 - 1:80,000
NPS	1:10,000 - 1:30,000
U.S. Air Force	1:25,000 - 1:80,000
*U.S. Army	1:5,000 - 1:80,000
U.S. Navy	1:17,000 - 1:60,000

**Army Map Service and Corps of Engineers photography*

Geographic and temporal coverage is irregular and varies by agency and program. Coverage areas for agency photography include the conterminous United States, Alaska, Hawaii, and Micronesia.

Agency	Temporal Coverage
BIA	03/16/58 - 09/13/89
BLM	07/17/61 - 08/24/82
BOR	04/21/39 - 11/14/76
EPA	02/12/72 - 10/12/88
NPS	02/09/79 - 03/03/90
U.S. Air Force	12/21/40 - 10/15/80

*U.S. Army	12/23/42 - 06/30/78
U.S. Navy	01/01/48 - 03/31/72

**Army Map Service and Corps of Engineers photography*

Specific coverages available for the Lake Ontario shoreline of New York State will need to be determined by querying USGS.

Environment Canada Aerial Photography
Environment Canada in Burlington, Ontario has a number of sets of aerial photography available that could be of use (Ralph Moulton, personal communication). This includes the following:

1955 - Entire Lake Ontario shoreline; 1:16,000 scale
1973 - Entire shoreline; 1:20,000 scale
1986 - Entire shoreline; 1:8,000 scale (approx.)
1988 - Niagara Peninsula area; 1:8,000 scale
1989 - Entire shoreline except Niagara Peninsula; 1:8,000 scale

The photos from 1988 and 1989 were used to make Flood Damage Reduction maps for the shoreline at a scale of 1:2,000. The maps were done in a digital format, which was suitable to load into SPANS GIS at that time.

Ontario Ministry of Natural Resources (OMNR) Air Photography
OMNR in the past has maintained a catalog of aerial photography and has flown a range of photography for use in its various divisions. For the purposes of this report, we were unable to determine the status of the air photography catalogue, or whether OMNR still retains this function. Aerial photography is likely available for portions of the shoreline, but a more in depth search will have to be conducted.

Natural Resources Canada National Air Photo Library
The Canadian National Air Photo Library (NAPL) has over six million aerial photographs covering all of Canada, some dating back 70 years. The library, located in Ottawa, indexes and stores all federal aerial photography for Canada, and maintains a comprehensive historical archive and public reference centre.

An inquiry with the Library indicated that a number of sets of air photos are available for the shoreline of Lake Ontario for Toronto (table below). It was not specified if this was for the city only, or for shorelines surrounding the city.

DATE	SCALE
1988	1:40,000
1984	1:25,000
1976	1:50,000
1970	1:26,000
1959	1:30,000
1950	1:12,000(?)
1946	1:20,000
1939	1:20,000

Other Aerial Photography
Various sets of aerial photography are available for site-specific areas as highlighted below:

- **Eastern Lake Ontario Sand Dunes Area**: Various maps and aerial photos showing shoreline evolution throughout the 20th century are available (Woodrow, personal communication).

- **Ontario Conservation Authorities**: 1993, 1:10,000 scale air photos are available for areas covered by the Quinte and Lower Trent Region Conservation Authorities. In addition, historic (1953+) photos are available for the Lower Trent Region. Historical air photos may also be available at the University of Waterloo Ontario map library (?), and Trent University.

- **Niagara County, New York Photography**: Various photo sets are available including: 1990 hardcopy and 2000 (slides)(Niagara County Soil & Water conservation District, USDA Farm Service Agency); Aerial photos produced by the US Depart. of Agriculture (1'': 660' scale) for years 1938, 1951, 1966, 1977, 1991 archived at Niagara county DPW-Highway office & Niagara County Soil and Water Conservation District office; and aerial photos produced by various companies at a scale of 1'':2000' for years 1958, 1962, 1966, 1981, 1990.

5.2 Digital Orthophotography

Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. They serve a variety of purposes, from interim maps to field references for Earth science investigations and analyses. The digital orthophoto is useful as a layer of a geographic information system (GIS) and as a tool for revision of digital line graphs and topographic maps.

Unlike a standard aerial photograph, relief displacement in Orthophotos has been removed so that ground features are displayed in their true ground position. This allows for the direct measurement of distance, areas, angles, and positions. Also, an orthophoto displays features that may be omitted or generalized on maps.

USGS Digital Orthophoto Program
The National Aerial Photography Program (NAPP) imagery and NAPP-like photography are the primary sources of aerial photography used in the production of 1-meter digital orthophotos for the National Digital Orthophoto Program (NDOP). NAPP photography is quarter-quadrangle centered (3.75-minutes of latitude by 3.75-minutes of longitude in geographic extent) and taken at an aircraft altitude of approximately 20,000 feet above mean terrain using a 152-millimeter focal-length camera. The scale of the NAPP photography is approximately 1:40,000. Orthophoto quadrangles may also be produced through the tiling together of digital orthophoto quarter-quadrangles. Color infrared (CIR) photography may be used as a source. However, the resulting DOQ may either be a single black-and-white composite of all bands or a color DOQ with all three bands. Although NAPP is the primary image source, this does not prevent the use of additional aerial photographs or digital images in the future.

The DOQ coverage area includes the conterminous United States, Alaska, Hawaii, and Puerto Rico. DOQs are available for the entire Lake Ontario shoreline. Dates of coverage will need to be determined by querying USGS.

New York State GIS Clearinghouse
The New York State GIS Clearinghouse (http://www.nysgis.state.ny.us/gis/gateway/index.html) contains reprocessed digital orthophotography based on Digital Ortho Quarter Quads (DOQQ) derived from the National Aerial Photography Program (NAPP). The original DOQQs were completed under the federal DOQQ program with state representation by the NY Department of Environmental Conservation. A digital orthophoto is a raster image of remotely sensed data in which displacement in the image due to sensor orientation and terrain relief have been removed. Digital orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The digital orthophotos in this series have a 1-meter pixel ground resolution. The data set presents information that represents current conditions for New York State from 1994 - 1998. The coverage includes New York State and extends to parts of New Jersey, Pennsylvania, Vermont, and Canada. New York State is taking a bold step forward this year with the first cycle of a new Statewide Digital Orthoimagery Program. The new program will create high-resolution orthoimagery for a portion of the State every year, and is perhaps the most ambitious state orthoimagery program in the country.

Ontario Conservation Authorities
A number of Ontario Conservation Authorities may have digital orthophotos that they have had flown and developed for their shorelines. To date, confirmation of this has come from:

- Metro Toronto Region Conservation Authority: Digital B/W orthophotos (1999) for 46 km of waterfront;
- Ganaraska Region Conservation Authority: Digital B/W photography – Durham, J.D. Barnes, 1:8,000 – 1:2,000 scale.

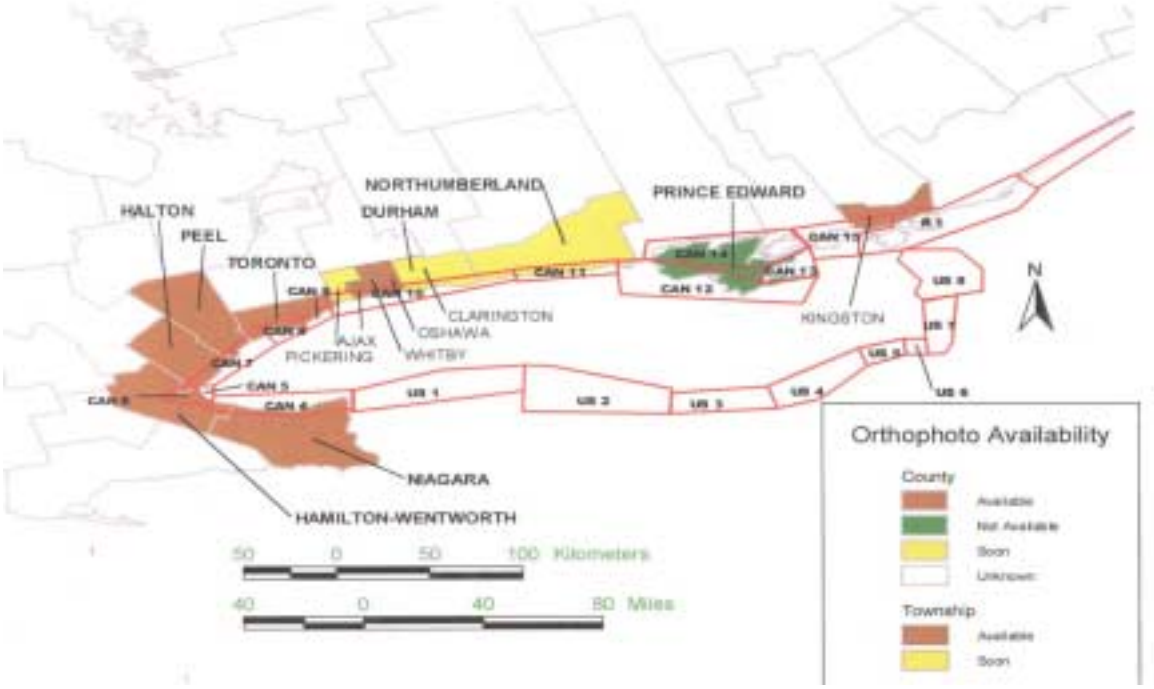
Niagara County New York
Digital ortho quads from 1995 are available on CD ROM. Produced by the Niagara County Soil & Water Conservation District and the USDA National Conservation Service.

Available Canadian Lake Ontario Digital Orthophotography
The Common Data Needs Working Group has been conducting their own inventory of available digital orthophotography (Wendy Leger and Aaron Thompson, Environment Canada, personal communication). Results are summarized in the table and Figure 3 below.

Summary of Current Aerial Photography for the Canadian portion of Lake Ontario

Location	Date of Collection	Resolution	Scale	Ortho	Comments
Niagara Region	April, 2000	0.5m horizontal, 0.8m vertical	1:20000	yes	black and white, leaf off, snow and ice free
Hamilton Region	Spring, 1999	12.5 cm	1:8000	yes	colour, leaf on, Ham. Region also possess a vector datafile outlining buildings and roads.
Halton	Spring, 1999	0.5m	n/a	yes	colour, Triathlon, MNR owns data
Peel	Spring, 1999	0.5m	n/a	yes	colour, Triathlon, MNR owns data
Toronto	Spring, 1999	0.5m	n/a	yes	colour, Triathlon, MNR owns data
Durham: Ajax, Whitby, Oshawa	Spring, 2000	20 cm	n/a	yes	black and white, J.D. Barnes Ltd.
Durham: Pickering, Clarington	Spring, 2000	20 cm	n/a	soon	orthorectified by October 2001, black and white, available from J.D. Barnes Ltd.
North Humberland (Hope to Brighton)	no aerial photography currently available				County plans to collect aerial photography in the fall of 2001.
Prince Edward - Quinte	1993				no plans to collect aerial photography in the near future
City of Kingston	Spring, 1998	n/a	1:2000	yes	imagery collected immediately following the ice storm

Orthophoto Availability for Lake Ontario



Triathalon Greater Toronto Area Orthophotos
1999 half-meter color digital orthophotos have been produced for the complete regions of Halton, Peel, City of Toronto, Pickering and Ajax (Baird & Associates, 2001) by Triathlon Mapping. Photos are at 1:20,000 scale. Photos are available at a cost of $75 CDN per tile.

NOAA Website / NOAA Mapfinder (www.noaa.gov)
The NOAA Web site above provides a link to the National Ocean Service Mapfinder site which provides on-line access to a range of NOS Products and data including digital photography, coastal survey maps (T-sheets), Environmental Sensitivity Index Maps, estuarine bathymetry, geodetic control points, historical maps and charts, hydrographic survey outlines, nautical charts, and water level gauging stations.

5.3 Digital Elevation Model Data

USGS Digital Elevation Model Data
The USGS Digital Elevation Model (DEM) data files are digital representations of cartographic information in a raster form. DEMs consist of a sampled array of elevations for a number of ground positions at regularly spaced intervals. These digital cartographic/geographic data files are produced by the U.S. Geological Survey (USGS) as part of the National Mapping Program and are sold in 7.5-minute, 15-minute, 2-arc-second (also known as 30-minute), and 1-degree units. The 7.5- and 15-minute DEMs are included in the large-scale category while 2-arc-second DEMs fall within the intermediate scale category and 1-degree DEMs fall within the small-scale category.

The DEM data for 7.5-minute units correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series for all of the United States and its territories. Each 7.5-minute DEM is based on 30- by 30-meter data spacing with the Universal Transverse Mercator (UTM) projection. Each 7.5- by 7.5-minute block provides the same coverage as the standard USGS 7.5-minute map series.

The 7.5-minute Alaska DEM data correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 7.5-minute Alaska DEM data consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of the North American 1927 Datum (NAD 27) or the North American 1983 Datum (NAD 83). The spacing between elevations along profiles is 1 arc second in latitude by 2 arc seconds of longitude.

The 15-minute DEM data correspond to the USGS 1:63,360 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 15-minute DEM data consist of a regular array of elevation referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27. The spacing between elevations along profiles is 2 arc seconds of latitude by 3 arc seconds of longitude.

The 2-arc-second DEM data cover 30-minute by 30-minute areas which correspond to the east half or west half of the USGS 30- by 60-minute topographic quadrangle map series for the conterminous United States and Hawaii. Each 2-arc-second unit is produced and distributed as four 15- by 15-minute cells. The spacing of elevations along and between each profile is 2 arc seconds.

The 1-degree DEM (3- by 3-arc-second data spacing) provides coverage in 1- by 1-degree blocks for all of the contiguous United States, Hawaii, and most of Alaska. The basic elevation model is produced by or for

the Defense Mapping Agency (DMA), but is distributed by the USGS, in DEM data record format. In reformatting the product, the USGS does not change the basic elevation information. The 1-degree DEMs are also referred to as 3-arc-second or 1:250,000 scale DEM data.

The EROS Data Center (EDC) also linked the 1- by 1-degree blocks for the contiguous United States in the Land Analysis System (LAS) environment using the elevation data from the photographic sources. This is referred to as the 1-degree DEM mosaic data set. Nine strips of linked imagery comprise the data set.

The UTM-based 7.5-minute DEM data are available for much of the contiguous United States, Hawaii, and Puerto Rico. Data is available for the entire Lake Ontario shoreline.

The 2-arc-second DEM data are available for portions of the contiguous United States and Hawaii. For New York State, this data is presently available for portions of the Lake Ontario shoreline near Oswego and the Eastern Lake Ontario sand dunes, as well as for a small portion of shoreline in Orleans and Monroe County.

The 1-degree DEM data are available for all of the contiguous United States, Hawaii, and most of Alaska. The linked images (1-degree mosaic data) cover only the contiguous United States. Coverage for New York State was unable to be determined.

5.4 Digital Raster Graphics

USGS Digital Raster Graphics
A digital raster graphic (DRG) is a scanned image of a U.S. Geological Survey (USGS) standard series topographic map, including all map collar information. The image inside the map neatline is georeferenced to the surface of the earth and fit to the Universal Transverse Mercator projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. The map is scanned at a minimum resolution of 250 dots per inch.

A DRG can be used on-screen to collect, review, and revise other digital data, especially digital line graphs (DLG). When the DRG is combined with other digital products, such as digital orthophoto quadrangles (DOQ) or digital elevation models (DEM), the resulting image provides additional visual information for the extraction and revision of base cartographic information.

The DRGs are georeferenced to the Universal Transverse Mercator (UTM) grid. A DRG may be used as a source or background layer in a geographic information system, as a means to perform quality assurance on other digital products, and as a source for the collection and revision of digital line graph (DLG) data. The DRGs also can be merged with other digital data (e.g., digital elevation model (DEM) or digital orthophotoquad (DOQ) data) to produce a hybrid digital file. These DRG data are produced by the USGS through cooperative agreements with private industry and other Federal, State, and local agencies.

A DRG is a scanned image of a USGS topographic map. The scanned image includes all map collar information. The image inside the map neatline is georeferenced to the surface of the Earth. The DRG can be used to collect, review, and revise other digital data, such as DLG data. The USGS is producing DRGs from 1:24,000-, 1:24,000/1:25,000-, 1:63,360- (Alaska), 1:100,000-, and 1:250,000-scale topographic map series.

The DRG uses a standard palette to ensure uniform color throughout a particular map series. The values for a particular color, therefore, will remain consistent throughout that DRG series. Although the color values of the DRG may sometimes match those of the paper source map, a user will usually notice small differences between the colors on the digital image and on the paper map. Also, the quality of the user's monitor affects the DRG color displayed. Although the DRG generally contains the complete content of the source map, features may occasionally be blurred because of substandard source materials. The DRG also may contain misclassified pixels (color noise).

The horizontal positional accuracy of the DRG matches the accuracy of the published source map. To be consistent with other USGS digital data, the image is cast on the UTM projection, and therefore, will not always be consistent with the credit note on the image collar. Only the area inside the map neatline is georeferenced, so minor distortion of the text may occur in the map collar.

For New York, DRGs are available in 1:24,000, 1:100,000, and 1:250,000 scale for the entire Lake Ontario Shoreline. These may be obtained via free download on the New York State GIS Clearinghouse web site (http://www.nysl.nysed.gov/gis/).

5.5 Digital Line Graphs

USGS Digital Line Graphs (DLGs)
The U.S. Geological Survey's (USGS) digital line graph (DLG) files are digital vector representations of cartographic information. Data files of topographic and planimetric map features are derived from either aerial photographs or from cartographic source materials using manual and automated digitizing methods.

The large-scale DLG data primarily are derived from USGS 7.5-minute topographic quadrangle maps at 1:24,000 and 1:25,000 scales (1:25,000 and 1:63,360 scales for Alaska).

Intermediate or 100,000-scale DLG data are derived from USGS 1:100,000-scale, 30- by 60-minute quadrangle maps. If these maps are not available, Bureau of Land Management (BLM) planimetric maps at a scale of 1:100,000 are used.

Small or 1:2,000,000-scale DLG data are organized two ways (by section or by State) and contain information on planimetric base categories, including transportation, hydrography, and boundaries for all 50 States. The Section DLG data files are historical files dating between 1973 and 1980 that are organized by sections of the United States (e.g., northeastern States). The State data files are recent files dating between 1990 and 1994 that are organized by State.

These DLGs are produced from the largest scale topographic quadrangle maps available, which are usually the USGS 7.5-minute, 1:24,000-scale topographic maps for the contiguous United States, Hawaii, and the Virgin Islands. Large-scale DLGs also are produced from 1:25,000- and 1:63,360-scale maps for Alaska and 1:30,000-scale maps for Puerto Rico.

The DLG data are being collected for all 50 States, and the 1:24,000-scale series eventually will provide complete national coverage. For New York State coverage at this level is only available for hydrography, although portions of Niagara and Orleans county have not been completed (as of 1998). Boundary and hypsography (contour) information are not yet available.

The 1:100,000-scale DLG data are being collected for the contiguous United States and Hawaii. The hydrography and transportation categories are complete, and the series will eventually provide complete national coverage for all categories. Boundary and hydrography information for New York State have been completed. Hypsography (contour) information has not.

The 1:2,000,000-scale DLG data files do not appear to be available for New York State.

5.6 Other Base Mapping and GIS products

Note: Further detail on NY State Department of Transport Mapping Data described below can be found in Appendix I.

New York State Department of Transport Planimetric Maps
NY State DOT provides black and white planimetric maps that include a wide range of information. Statewide coverage includes 968 7.5-minute quadrangles. They are also available as raster digital files for quads produced since 1990. Each map covers approximately 6x8 miles. Transportation data includes all roads and most major trails, railroads, airfields and ferry lines. Roads are symbolized to tell if they are divided or undivided and all ramps and other interchange details are shown. Boundary lines are shown for all cities, villages, towns, and counties as well as for miscellaneous state lands, Indian reservations and federal lands. Individual buildings are shown. Larger building outlines are shown and many landmark buildings (schools, churches, etc.) are separately symbolized. A gray tint is used to identify heavily built-up areas. Within the tint areas only landmark buildings are shown. Virtually all water features in the state, from small streams to the Great Lakes are also shown. (Content differs slightly on pre-1972 maps.) An index map is available which shows the name and limits of each 1:24,000 scale map.

New York State Department of Transport Topographic Maps
NY State DOT topographic maps combine the Planimetric Map image with elevation contours from the corresponding U. S. Geological Survey map. The contours generally appear in light brown, the Planimetric Map image is black. Although the Planimetric Map has been extensively revised, in most cases the contours are reproduced exactly as they appear on the U. S. Geological Survey map. This means that in areas of major new construction the contours may be incorrect.

Within the Adirondack area Topographic Maps are black and white, brown is not used to show contours. An index map is available on request from the Map Information Unit which shows the name and limits of each 1:24,000 scale map.

New York State Department of Transport County Base Map Files
NY State DOT's County Base Map files cover whole counties and are separated into five themes:

- **Roads** - all public roads digitized as centerlines; classified by jurisdiction, access control, divided/undivided status, and number of lanes; road names and route numbers.
- **Boundaries** - municipalities, Indian reservations, state recreational lands, state facilities, federal lands, county and municipal parks.
- **Hydrography** - rivers and streams > 1 mile in length, water bodies > 500 feet in the shortest dimension, swamps > 2000 feet in the shortest dimension, and other hydrographic features (waterfalls, dams, etc.).
- **Miscellaneous Transportation** - active and abandoned railroads, public airports, major electric, gas, and telephone lines, state and federal trails, ferry routes, and state and county boat launches.

- **Names** - all populated place names (with populations > 50) route numbers, major road names, and feature names shown on the body of the printed County Base Map; compiled for use at publication scale.

These files are used to publish the County Base Map Series. It will be several years before all maps are published. For those counties which lack County Base Map coverage, unrevised CLASS files are available. These files are offered in either ARC/INFO coverage format or MicroStation design file format.

All NY State DOT digital base map files use the New York Transverse Mercator (NYTM) projection/grid system based on the North American Datum of 1927 (NAD-27). NYTM is an east and west mathematical extension of Zone 18 of the Universal Transverse Mercator (UTM) projection/grid system to accommodate all of New York State in a single zone with a single origin point.

Two data sources form the foundation of the County Base Map digital files. 1:100,000 scale Digital Line Graph (DLG) files from the U.S. Geological Survey are the basis for the Hydrography and Miscellaneous Transportation themes. The DLG data is converted to NYTM coordinates, edge matched, substantially updated using revised NYSDOT 1:24,000 scale quadrangles, reclassified, and integrated with other files. For the Roads and Boundaries themes, NYSDOT Centralized Local Accident Surveillance System (CLASS) files are used. For use in the County Base Map Series, these files are updated using recently revised NYSDOT quadrangles and aerial photographs, merged to form county files, reclassified to depict road jurisdiction and physical characteristics, and selectively generalized as appropriate for publication at county map scale. Boundaries are also updated using official boundary descriptions from administering agencies. All other features in the County Base Map Series are table digitized from stable base (Mylar) copies of NYSDOT 1:24,000 scale quadrangles.

The positional accuracy of features in the file is no better than the sources used for digitizing. Data sources for information in the files range from 1:24,000 to 1:100,000. For this reason, the files are not recommended for use in applications requiring greater positional accuracy than can be obtained from 1:24,000 or 1:100,000 mapping, depending on the theme file used. In addition, some features have been selectively repositioned for symbolization at final map scale. In these cases, the original position of the feature is retained on a separate level.

New York State Department of Transportation 1" = 200' Topographic Maps Highway Corridor Maps

These maps may be of use where state highways are found near the shoreline. They are black and white maps that show a wide range of detailed information. Among the features shown on most of the maps are: all roads, with identifying route numbers and names, railroads, airports, transmission lines, individual buildings, hydrography, civil boundaries, fence lines, and in some cases, property lines. The State Plane Coordinate System usually is shown. The 1"=200' Topographic Maps are produced by photogrammetric methods usually on 30x54 inch sheets. Individual sheets generally cover a 1x2 mile area. Most Highway Corridor Maps were produced prior to 1970. These maps are generally only available in narrow corridors along state highways, highways which often were built after the production of the map. The limits of coverage, date, and sheet identification numbers are shown on a four sheet Index Map. The Index Map, which should be consulted before ordering any 1"=200' maps, can be purchased or inspected in the Map Information Unit or in any of the Department of Transportation's region offices.

Ontario Base Maps

Ontario Base Maps (OBMs) are monochrome topographic maps that cover the entire province of Ontario and are available for the entire Lake Ontario study area. OBMs have been produced for most of northern

Ontario at a scale of 1:20,000 (with 10 meter contours) and for part of southern Ontario at a scale of 1:10,000 (with 5 meter contours). They are a digital topographic vector database containing many types of information. Contour intervals on the maps are 5 meters. Cost for acquisition is $100 per OBM tile (5km x 5km).

Canada Ontario Floodplain Mapping and Flood Damage Reduction Program
In cooperation with Environment Canada, the OMNR produced a series of digital shoreline floodplain maps at scale of 1:2000 in early 1990s for use by various Conservation Authorities. The maps detail both flood and erosion hazards along the shoreline and were created from 1988 and 1989 aerial photography (Ralph Moulton, Environment Canada, personal communication). Specific mapping available from Environment Canada or other sources includes:

- parts of Niagara Peninsula CA – 50 km
- all of Hamilton RCA
- all of Halton CA except Beach Strip
- all of Credit Valley CA
- all of Metro Toronto CA
- all of Central Lake Ontario CA
- all of Lower Trent CA (Lake and Bay of Quinte)
- all of Moira River CA
- portions of Napanee CA (no digital)
- portions of Prince Edward RCA (some digital, some not)
- portions of Cataraqui RCA

OMNR, through the Common Data Needs Group, has provided Environment Canada with all the digital tapes of this mapping for conversion into GIS. For the digital mapping, the specifications required full topographic detail to the 100 year flood elevation, (1 meter contours, with 1/2 m meter auxiliary contours). Basic planimetric detail beyond the full mapping to some limit specified on the supplied photographs, beyond the 100 year was also required. In bluff areas, the mapping contains full topographic compilation from the water's edge to the toe of the bluff and from the top of the bluff to some limit specified on the photographs. If the height from the toe of the bluff to the top is less than ten metres, then solid contours with no auxiliary contours are captured up the bluff face. If the bluff height is ten metres or greater, index contours are captured on the bluff face and sufficient hypsographic detail should be collected on the bluff face as well as at the toe and top of the bluff to facilitate their identification by the user (i.e.: two solid contours on the bluff face at toe and top). All planimetric features are captured on the bluff face.

NOAA Website / NOAA Mapfinder (www.noaa.gov)
The NOAA Web site above provides a link to the National Ocean Service Mapfinder site which provides on-line access to a range of NOS Products and data including digital photography, coastal survey maps (T-sheets), Environmental Sensitivity Index Maps, estuarine bathymetry, geodetic control points, historical maps and charts, hydrographic survey outlines, nautical charts, and water level gauging stations.

5.7 Digital and Other Parcel Mapping Data

Niagara County New York
1998-1999 digital parcel mapping has been obtained for all of Niagara County. Files are in ArcView and Arc/Info format. Problems were encountered when opening some of these files in ArcView and thus they may be corrupt.

Monroe County New York
2000 (?) digital parcel mapping has been obtained for all of Monroe County. Files are in ArcView and Arc/Info format.

Province of Ontario Digital Parcel Mapping
The Province of Ontario in cooperation with a private sector company, Teranet, is building an electronic land registration database which contains land parcel information (Ala Boyd, OMNR, personal communication). The dataset contains survey quality information, right down to individual land parcels and lots. This is also automatically updated with every approved land use decision, ie, approved plan of subdivision, lot severance etc...so it is always current. Data is apparently available by lot or individual address at $50 per property however, the Surveyor General for Ontario is in negotiations for the data set, given that OMNR apparently paid for much of this work.

Land Information Ontario
The Province of Ontario is also building an on-line geospatial data clearinghouse for the distribution of a wide range of land information. The web site (www.lio.mnr.gov.on.ca/lioweb/default.asp) contains a search engine that allows the user to search for a wide variety of geospatial information both by topic and geographic extent.

Miscellaneous Reports
A number of the reports reviewed for this activity contain map products depicting land parcel information. In addition, paper based parcel mapping has been obtained for portions of Jefferson County, NY and ?? County (need to confirm county name). While this information is not digital in format, it may prove useful. Some of the report products with parcel information include:

- Lake Ontario Shore Protection Study (USACE 1979): Lists the number of parcels within each of the 126 reaches along the shoreline.
- NPCA Lake Ontario Shoreline Management Plan (M.M.Dillon, 1994): Conatins maps in back pocket of report that contain land parcel information for Niagara Peninsula CA shoreline area of Lake Ontario.
- Conceptualization of Boat Acess Development Zones (White, 1992): Maps contain parcel land information for Barddock Bay, Sodus Bay, and Port Ontario.
- Deer Creek/Sandy Pond Macrosite (The Nature Conservancy, 1995): Map depicting land parcels in Eastern Lake Ontario Sand Dune area.
- Village of Sackets Harbor, Zoning Laws: Contains a map delineating the land uses (single family residential, general residential, business, etc.) of the area; land parcels are also included on the map.

- City of Belleville, Ontario Bayfront Planning Study (M. M. Dillon, 1990): Contains detailed mapping of the land parcels for the shoreline area for the entire town.

5.8 Satellite Imagery

Further data sets still being sought.

IKONOS
The Common Data Needs and other working groups within the study are contemplating IKONOS imagery for acquisition and use.

5.9 Oblique and Ground Photography

USACE Buffalo District Photography
Buffalo District has a number of ground level photographs on hand that have been taken over the course of various coastal investigations along the Lake Ontario shoreline. These could be used in providing qualitative descriptions of shore change in areas of coverage. Sets of available photos include 1935 photos at Webster, New York, 1939 photos in the Olcott and Wilson areas, 1953, 1954 and 1960 black and white Polaroids with associated index maps for various spots along the shoreline.

Lower Great Lakes Erosion Study Photography
A large number of modern day photos exist for a number of sections along the Lake Ontario shoreline including those taken in 1998 and 1999 as part of site study investigations associated with the Lower Great Lakes Erosion Study.

Environment Canada
Environment Canada has various sets of oblique aerial photography from 1967 to 1981 and for portions of the St. Lawrence to Trois Rivieres dated 1974.

New York County Farm Service Agencies Photography
The County Farm Service Agencies fly their entire county every year to monitor the implementation of their crop programs and compliance with their requirements. Photographs are usually on 35 mm slides and are vertical format. Contact information is available for Oswego and Jefferson County (Sandy Bonanno, Nature Conservancy, personal communication).

5.10 Videos

USACE Buffalo District Shoreline Video
In April of 1999, the Buffalo District flew the entire shoreline of Lake Ontario and the St. Lawrence River by helicopter and obtained good quality videotape. This tape can be used effectively with air photos, ground photos or other mapping information to make qualitative assessments of shoreline erosion and recession. It could also be compared to previous video of the shoreline that is available, including 1995 video of the eastern Lake Ontario shoreline flown by New York Sea Grant, or other video that may reside in Buffalo District.

New York Sea Grant Video
New York Sea Grant has videotaped a portion of the Lake Ontario shoreline in Oswego and Jefferson Counties in 1995.

Environment Canada
Environment Canada has a series of oblique aerial videotapes (Betamax) for the Lake Ontario shoreline to Gananoque, dated 1978. In addition, Environment Canada, Environment Protection Branch has color videotapes of the shoreline taken in July 1991. These are available for almost all of Lake Ontario. These were all shot from a helicopter flying at an altitude of approximately 50-100 m and a distance of several hundred meters offshore.

Ontario Ministry of Natural Resources
The Ontario Ministry of Natural Resources has limited video available as described below for 1991 and 1994.

Lake Ontario

Start- Niagra on the Lake **End-** Hamilton Harbour	LO 1	July 08 1991
Start- Humber Bay Marina **End-** Cobourg Marina	LO 2	July 08 1991
Start- Filtration Plant past Cobourg **End-** Young Cove	LO 3	July 08/09 1991
Start- Ostrander Point (part of Long Point)Prince Edward County **End-** Port Perry Coast Guard Station	LO 4	July 09 1991
Start- Bay of Quinte - Sauguin Island **End-** Main Duck Island	LO 5	July 09 1991
Start- Baker Island **End-** Lennox Generating Station	LO 6	July 10 1991
Start- Bluff Point at Amherst Island **End-** 1000 Islands	LO 7	July 10 1991
Start- Oak Point on Wolf Island **End-** end of Wolf Island	LO 8	July 10 1991
Start- Niagra on the Lake **End-** Hamilton Harbour	LE 1	May 1994
Start- Humber Bay Marina **End-** Cobourg Marina	LE 2	May 1994
Start- Filtration Plant past Cobourg **End-** Young Cove	LE 3	May 1994
Start- Ostrander Point (part of Long Point)Prince Edward County **End-**	LE 4	May 1994
Start- Bay of Quinte - Sauguin Island **End-** Main Duck Island	LE 5	May 1994

5.11 Miscellaneous GIS and Other Data Sets

SPANS TYDAC GIS Files
Digital files used during the Great Lakes Shoreline classification and mapping project were produced from National Topographic Series (NTS) 1:50,000 and 1:250,000 scale map sheets. The 1:50,000 maps were used from Trois Rivieres on the St. Lawrence River, west through L.O. (This data is provided in the Great Lakes Shoreline Classification and Mapping Study: Canadian Side carried out by Geomatics International (1992)).

Niagara County New York GIS Data
Various Sources via USDA Natural Resources Conservation Service and Erie County Soil and Water Conservation District. Contains Arc View Shape Files (UTM, Zone 17, NAD 1927, Clark 1866) for:

- Preliminary release, detailed soils, USDA NRCS for 14 quadrants of NY State
- Bedrock geology, NYS Museum, Albany
- Traffic analysis zone, US Census Bureau, TIGER
- Traffic analysis district, US Census Bureau, TIGER

- US Fish & Wildlife Service, National Wetlands Inventory
- US Federal Emergency Management Agency Floodplains
- Niagara County municipal boundaries, USDA AmeriCorps
- NYS freshwater wetlands (article 24)
- US Census Bureau, TIGER hydrology
- US Census Bureau, TIGER streets
- Point location of NY municipalities, USDA NRCS
- Generalized soil map, USDA NRCS
- Surficial geology, NYS Museum
- 7.5 min. topographic boundaries, USDA AmeriCorps
- Western NY 11 digit hydrologic unit watersheds, USDA NRCS &USGS
- Niagara Co Digital Orthoquads (?)

Monroe County New York GIS Data
The Monroe County Department of Environmental Services has provided a CD ROM with the following GIS data layers:

- Parcel boundary layers (for all towns that border Lake Ontario)
- Topographic
- USGS DRG
- Floodways
- Geology (surface)
- Geology (bedrock)
- Primes soils
- Protected streams
- Soils
- Streams (arcs)
- Streams (polygons)
- Watersheds
- Wetlands (Federal)
- Wetlands (State)
- Woodlots (1984)
- Woodlots (1999)

FEMA Digital Q3 Flood Zone Dataset
Federal Emergency Management Agency Q3 Flood Data is developed by scanning existing flood insurance rate maps and capturing a thematic overlay of flood risks. Digital Q3 flood data files contain only certain features from the FIRM hardcopy in effect at the time of scanning and do not replace the existing firm hardcopy maps. These maps should only be considered an advisory tool for general hazard awareness, education and flood plain management (Baird & Associates, 2001). These maps can be downloaded from the NY State GIS Clearinghouse.

Federal and State Sources of Water-Resource Information for Participating Western New York Counties, August 1998
The following are a series of GIS data that were summarized in a matrix that was obtained (source unknown). This will be sorted in more detail for the final report. The data are for a wide variety of items.

- Agriculture: Agricultural district boundaries; New York Department of Agriculture and Markets, Cornell Institute for Resource Information Systems (ARC/INFO 1:2500,000)
- Biodiversity inventory: Rare & endangered species & habitats; New York State Natural Heritage Program (ARC/INFO, ArcView 1:24,000)
- Compilation of BIS databases in nine Finger Lakes counties; Genesee/Finger Lakes Regional Planning Council (ACR/INFO, ArcView, Atlas GIS)
- Economic: Business, employment & labor; New York Data Center (ArcView, Atlas GIS), New York Department of Labor (ArcView, Atlas GIS)
- Emergency: Dose-assessment models, fires, floods, historical seismicity, hurricanes, nuclear-plant evacuation routes, rain gages, tornadoes toxic-waste inventories, weather stations; New York state Emergency Management Office (ARC/INFO 1:24,000; 1:100,000; 1:250,000)
- Flood: Q3 flood data; Federal Emergency Management Agency (ARC/INFO, MapInfo 7.5', DLG, DRG)
- Forests: Fire-effects information system, forest inventory and research, pest condition, etc.; USDA Forest Service (ARC/INFO, ER MAPPER), US Environmental Protection Agency (ARC/INFO, GIF)
- Geographical reference data: Locations & records for meteorological stations, reservoirs &stream gages; US Geological Survey GCIP Reference Data Set (DLG, ARC/INFO)
- Geology: Bedrock, faults, glacial & minerals; New York State Geological Survey (ARC/INFO), New York State Museum (ARC/INFO)
- Great Lakes: Commercial fishing database, research vessel data, lake surveys; Great Lakes Center, USGS, Biological Research Division (ARC/INFO); Areas of Concern for beneficial water use; US Environmental Protection Agency (ArcExport 1:24,000)
- Health data: County environmental health data, health profiles, hospital locations, vital statistics; New York State Department of Health (MapInfo)
- Historic landmarks: Archeological and historical sites; New York State Parks, Recreation & Historic Preservation (MapInfo 1:24,000), National Register Information System (dBase, Atlas GIS 1:24,000)
- Hydrology: Lakes, rivers, streams, and wetlands > 12 hectares; watershed boundaries; New York State Department of Environmental Conservation (ARC/INFO 1:24,000); Hydrological Unit maps, stream gages; USGS (ARC/INFO 1:250,000, 1:2,000,000)
- Landfills and Resource Conservation and Recovery Act sites: Locations and characteristics of waste-disposal sites; USGS (ARC/INFO 1:2,000,000)
- Miscellaneous: Locations of: active and closed municipal-waste sites; air-permit data; locations of ground-water wells, public water supplies; & wastewater discharge; radon measurements; toxic-chemical release inventory; water and gas lines; New York State Department of Health (ARC/INFO, other); Aerial photos, base maps, biological resource data, geological data, GIS data for water resources, satellite images, etc.: USGS (ARC/INFO, other)
- National water information system: locations of precipitation- & stream-gauging stations; wells; and associated data (discharge rates, water levels, water quality, etc.); UGS (ARC/INFO)
- Natural resources: location of mines, oil & gas wells; NYS Department of Environmental Conservation – Mineral Resource Division (ARC/INFO, MapInfo)
- Center for Technology in the Environment
- Statewide GIS Data Sharing Cooperative Participants & Inventories
- New York Counties on the Web
- New York State Department of Environmental Conservation: Coverages under development include: air-monitoring stations; bedrock data; hydrographic features; inventories of dams,

inactive hazardous waste sites, & regulated facilities; larges pollution generators; mine locations; roads; wildlife-management & natural-resource data (ARC/INFO, ArcView)

- Parks: Archeological and national register sites, amps, natural resource inventories, park boundaries, snowmobile trails; New York State Office of Parks, Recreation & Historic Preservation (ARC/INFO 1:24,000); National Park Service (ARC/INFO, ArcView, Adobe Acrobat)
- Police: Landmarks, roads, water features, etc.; New York State Police (ARC/INFO)
- Political boundaries: Counties, manipulates, towns, etc. (New York State Office of Real property Services (ARC/INFO 1:24,000)
- Population: Census blocks (1990); Census Bureau (ARC/INFO 1:100,000), New York State Department of Health (ARC/INFO, MapInfo, Atlas GIS 1:24,000)
- School districts: Boundaries of school districts for tax attendance purposes; NYS Office of Real Property Services (ARC/INFO, ArcView 1:600, 1:4,800, other)
- Soils: STATSCO; Natural Resource Conservation Service (ARC/INFO 1:250,000); Soil maps completed, in progress, for the following counties: Chautauqua, Clinton, Dutchess, Erie, Genesee, Madison, Monroe, Oneida, Otsego, Putnam, Rennssellaer, Rockland, Saratoga, Seneca, St. Lawrence, & Suffolk. Also Catskill & Onondaga & Skaneateles Lakes watersheds; Cornell University under contract with NRCS (ARC/INFO, GRASS 1:24,000)
- Tax maps for various cities: Boundaries of tax district; Southern
- Thematic mapping: topical maps on a variety of subjects; US Environmental Protection Agency Region 2 (ARC/INFO 1:100,000), NYS Department of State (25-meters pixels)
- Transportation: Airports, bridges, names, railroads, remote imagery, roads, survey monuments, maps etc.; NYS Transportation Department (ARC/INFO 1:1,200, 1:24,000, 1:250,000, other)
- US Environmental Protection Agency: Air quality; biological, cultural & water resources; control layers; image & CAD data; regulatory & terrain features; transportation; utilities (ARC/INFO, ArcView 1:24,000 other)
- Utilities: gas pipelines, gas & electric franchise data, utility infrastructure, cable TV, water companies, telecommunications; NYS Public Service Commission (ARC/INFO 1:24,000 other)
- Watershed boundaries: Major watersheds in Lake Ontario basin; subwatersheds delineated for ~50% of the basin; USGS (ARC/INFO 1:24,000)
- Water quality: ambient & effluent water quality, intensive surveys, water way planimetric data; US Environmental Protection Agency Region 2 (ARC/INFO, ArcView)
- Wetlands: locations and types of wetlands; NYS Department of Environmental Conservation (ARC/INFO 1:24,000), US Fish & Wildlife Service National Wetlands Inventory (ARC/INFO, DLG, GRASS 1:24,000)
- WWW links: general GIS information; National Center for Geographic Information & Analysis, National States Geographic Information Council, Environmental System Research Institute, Remote sensing and GIS resources, GIS links Yahoo HIS links, Geodata Information Services

5.12 Environmental GIS Datasets

US Fish and Wildlife Service National Wetlands Inventory
Niagara County has ArcView shape files of the US Fish and Wildlife Service National Wetlands Inventory.

Niagara County Natural Resources Inventory
The Niagara County Environmental Management Council has compiled a 'natural Resources Inventory." This mapped information has been compiled on a municipal basis at a scale of 1''=2000' in the towns/villages and a scale of 1''=400' in the cities and contains the following information compiled as overlays: land use/natural resources (LUNR) mapping derived from aerial photo interpretation of 1978 photos by Cornell University; surficial geology; soils; wetlands; drainage patterns; waste disposal sites; zoning; water/sewer locations; and 1968 land use maps. The Town of Somerset Land Use information has been interpreted from 1990 aerial photos and mapped at 1''= 2000'. None of the above has been digitized.

NY DEC Freshwater Wetland Maps
Available as resource information is the New York State Department of Environmental conservation Freshwater Wetland maps (1984) on Mylar. The National Wetland inventory maps are also available on Mylar.

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APPENDIX I

NY STATE DEPARTMENT OF TRANSPORTATION NAD 83 DATA

All NYS Department of Transportation vector data sets and 1:250,000 NYS Map Raster Images are now available in NAD 83.
http://www.nysgis.state.ny.us/inventories/dot.htm lists all available data sets.

Note: All NYSDOT raster images are in GeoTIFF format.

Dataset Name	Dataset Description	Scale	Comments	More Info.
New York State 1:24,000 Scale Quadrangles	• Quadrangle data sets consisting of 5 RASTER image files (Map Body, Map Margin, Contours, Hydrography Tint, Built-up Area Tint) • File resolution 400 dpi • New files added continuously as part of the NYSDOT map revision program	1:24,000	• 395 of 968 quadrangle data sets available with all five raster image files; the remaining quadrangle data sets currently have only the Map Body raster image file available • Available to the public • Files are in GeoTIFF format, which places the raster file at correct scale and Coordinate System (UTM Zone 18, extended)	Not Yet Available
New York State 1:250,000 Scale County Images	• NAD 83 • RASTER map image files of New York State generated from the VECTOR 1:250,000 New York State Map Files dataset • Coverage by county • Metadata by county	1:250,000	• Data is copyright protected	Metadata

Vector Data

Note: **All NYSDOT vector data sets are in ARC/INFO format, NAD 83, and UTM (Zone 18, extended) Coordinate System unless otherwise stated. Click on any data set name to get to the downloadable data, which is grouped in county, regional and statewide collections.**

Dataset Name	Dataset Description	Scale	Comments	More Info.
New York State DOT Quadrangle Index	• NAD 83 • VECTOR file indicating the areas that 1:24,000 scale NYSDOT 7.5 minute quadrangle maps comprise • Attributes include NYSDOT quadrangle name and NYSDOT reference code • Statewide coverage	N/A	• Available to the public	Metadata
New York State Public Roads: County Base Map	• NAD 83 • VECTOR files of the NYS public road network, originally created from existing NYSDOT CLASS Road files and updated with NYSDOT 1:24,000 scale quadrangle revisions • Most line work has the original CLASS Road file road names and route numbers attached, but these attributes have not been updated • In congested areas, files have an optional generalized road line work network - this generalized road network does not have GIS attributes • Age of data is dependent on county	1:24,000	• Data is copyright protected • 23 of 62 counties available	Metadata

	• Coverage by county			
New York State Public Roads: CLASS	• NAD 83 • VECTOR files of the NYS public road network, originally created for the Centralized Local Accident Surveillance System project • Line work has the original road names and route numbers attached, but these attributes have not been updated • Data not updated since digitized in the late 1970's to early 1980's from 1:24,000 scale NYSDOT quadrangles • Coverage by county	1:24,000	• CLASS road data not available for counties where County Base Map Roads Files exist	Metadata
New York State Primary Route System	• NAD 83 • Vector data • Statewide coverage	Primarily 1:24,000	• Data is copyright protected	Metadata
New York State Route Shields and Numbers	• NAD 83 • Contains attributed points representing route shields and annotation (route number as text string) features for selected sets of highways in New York State. • Statewide coverage	1:250,000	• Data is copyright protected	Metadata
New York State Multi-use Trails	• NAD 83 • Linear and point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State Bridges	• NAD 83 • VECTOR point	1:24,000	N/A	Metadata

	coverage of over 19,000 bridges • Bridge ID Number (BIN) attribute used to identify each bridge • Statewide coverage and coverage by DOT Region			
New York State Railroad Lines and Stations	• NAD 83 • VECTOR files of Active and Abandoned Railroads in NYS • Attribution in progress • Statewide coverage and coverage by DOT region	1:100,000	• Data is copyright protected	Metadata
New York State Statewide Names	• NAD 83 • VECTOR files of populated places, route numbers, recreation areas, and other named features on the printed Four-Sheet New York State Map • Point and annotation attributes present • Data current as of May 1994 • Statewide coverage and coverage by DOT Region	1:250,000	• Data is copyright protected	Metadata
New York State 1:100,000 Scale Hydrography	• NAD 83 • VECTOR files of linear and areal Hydrography features • Polygon and linear attributes present • Coverage by DOT Region	1:100,000	• Data is copyright protected	Metadata
New York State 1:250,000 Scale	• NAD 83 • VECTOR files of linear and areal Hydrography features	1:250,000	• Data is copyright protected	Metadata

Hydrography	• Polygon and linear attributes present • Data current as of May 1994 • Statewide coverage and coverage by DOT Region			
New York State 1:3,000,000 Scale Hydrography	• NAD 83 • VECTOR file of the major hydrographic features • Suitable for simple A-size map • NOT detailed • Polygon attribute exists • Data current as of September 1997 • Statewide coverage	1:3,000,000	• Data is copyright protected	Metadata
New York State Civil and Public Land Boundaries	• NAD 83 • Vector file of civil boundaries, state and federal lands, and, where available, county and municipal parks • Statewide coverage and coverage by DOT region	1:24,000	• Data is copyright protected	Metadata
New York State County Boundaries (Shoreline Version)	• NAD 83 • Vector file of county boundaries up to, and using the shorelines of, major hydrographic features • Statewide coverage and coverage by DOT region	1:250,000	• Data is copyright protected	Metadata
New York State Federal-Aid Urban Area Boundaries	• NAD 83 • Vector file of Census-defined urban area boundaries • Statewide coverage	1:24,000	• Data is copyright protected	Metadata

	and coverage by DOT region			
New York State Unincorporated Place Points	• NAD 83 • Point file of unincorporated places • Statewide coverage and coverage by DOT region	1:250,000	• Data is copyright protected	Metadata
New York State DOT Residency Boundaries	• NAD 83 • NYSDOT Maintenance Residency boundaries • Statewide coverage and coverage by DOT region	1:24,000	• Data is copyright protected	Metadata
New York State Small Public Land Sites	• NAD 83 • Point file of selected national and state public lands that are too small to be represented in the 'Civil and Public Boundaries' file and/or have an indefinite boundary • Statewide coverage and coverage by DOT region	1:24,000	• Data is copyright protected	Metadata
New York State Ferry Lines	• NAD 83 • Linear and point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State Public Boat Launch Sites	• NAD 83 • Linear and point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State Public Airports	• NAD 83 • Linear and point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata

New York State DOT Towers	• NAD 83 • Point attributes • Statewide coverage	N/A	• Data is copyright protected	Metadata
New York State County Seats	• NAD 83 • Linear and point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State DOT Facilities	• NAD 83 • VECTOR point coverage of DOT facilities including Region offices, Residencies, etc. • Point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State Rest Areas	• NAD 83 • Point attributes present • Statewide coverage	1:24,000	• Data is copyright protected	Metadata
New York State Survey Monument Data Base	• NAD 83 • VECTOR point coverage of entire survey monument database of New York State as extracted from the National Geodetic Survey (NGS) CD-ROM • Accuracy of each actual point is provided as an attribute that states the National Geodetic Survey horizontal and/or vertical order • Statewide coverage	N/A	• Approximately 20,000 points are in the database, including the 218 NYS Geodetic HARN Network points • Coordinates for each point are in geodetic latitude/longitude • NAD 83/92 • ArcView shape file • NYSDOT expects to act as Cooperative Custodian of this dataset	Metadata