THE ONTARIO GREAT LAKES COASTAL WETLAND ATLAS:

A Summary of Information (1983-1997)

Environment Canada

- Canadian Wildlife Service

Ontario Ministry of Natural Resources

- Conservation and Planning Section - Lands and Waters Branch; and
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Executive Summary

Information and needs assessments with respect to wetlands in the Great Lakes basin consistently call for digital information on the location, distribution, relative significance and status of wetlands. The Ontario Great Lakes Coastal Wetland Atlas was prepared in response to various initiatives such as the State of the Lakes Ecosystem Conference (SOLEC) and the Great Lakes Wetlands Conservation Action Plan (GLWCAP) that pointed to the need for a basin-wide, comprehensive and digital database of coastal wetlands in the Great Lakes basin.

The Atlas represents a compilation of information on coastal wetlands of the Great Lakes and connecting channels in Ontario and provides a framework for the development of a comprehensive digital coastal wetland database for Ontario. The best available sources at the time of Atlas preparation (late 1990s) were used to produce the Atlas, including Ontario Ministry of Natural Resources Wetland Evaluation reports, which provide a consistent approach to evaluating and mapping wetlands, the Natural Heritage Information Centre's Natural Areas Database and Environment Canada's Great Lakes Environmental Sensitivity Atlases. These sources and others were consolidated to provide data such as the location, area and type of wetlands, significance and status, significant species within the wetlands, as well as a qualitative assessment of stressors and major threats affecting coastal wetlands.

Summaries of coastal wetlands in each major lake and connecting channel of the basin are accompanied by detailed maps and appendices. Results indicate that numerous significant species use these primarily marsh-type wetlands, but that human-induced wetland stressors remain prevalent and incremental and site-specific losses continue. There is no comprehensive estimate of historical and recent wetland loss, nor have wetland gains been quantified.

While a great deal of coastal wetland information exists, spatial and temporal gaps in data are common. Spatially, gaps in wetland evaluations are more extensive in the upper lakes and connecting channels where Atlas methodologies have identified that numerous wetlands exist in these areas that have yet to be evaluated by the OMNR Wetland Evaluation System. It is suspected that many of these wetlands may be provincially significant, or contain features to support other conservation designations. There are also temporal gaps in the available data, in that the state of existing wetlands may differ from what the Atlas is able to show. Well over half of the OMNR evaluations took place prior to 1988, within the first five years of implementation of the evaluation system. These evaluations may no longer be accurate, especially in light of changing water levels and the incremental losses that continue to occur throughout the basin.

The uncertainty of loss rates, the known significance of evaluated wetlands, and the gaps in wetland evaluations reinforce the need to achieve the ultimate goal of a larger, interactive database for the future protection and management of basin wetlands.

Sommaire

Les évaluations de l'information et des besoins concernant les terres humides du bassin des Grands Lacs font sans cesse appel à de l'information numérique sur l'emplacement, la répartition, l'importance relative et la situation des terres humides. L'Atlas des terres humides riveraines de l'Ontario a été préparé en réaction à diverses initiatives telles que la Conférence sur l'état de l'écosystème des lacs (CEEL) et le Plan d'action en matière de conservation des terres humides des Grands Lacs (GLWCAP), qui ont souligné le besoin d'une base de données numérique exhaustive, à l'échelle du bassin, sur les terres humides côtières du bassin des Grands Lacs.

L'Atlas réunit des renseignements sur les terres humides côtières des Grands Lacs et les canaux interlacustres de l'Ontario, et offre un cadre pour la constitution d'une base de données numérique exhaustive sur les terres humides côtières de l'Ontario. Les meilleures sources disponibles au moment de la préparation de l'Atlas (fin des années 1990) ont servi à sa production, y compris les rapports d'évaluation des terres humides du ministère des Richesses naturelles de l'Ontario, qui utilisent une approche cohérente de l'évaluation et de la cartographie des terres humides; la base de données sur les zones naturelles du Centre d'information sur le patrimoine naturel; et les Atlas de sensibilité environnementale des Grands Lacs d'Environnement Canada. Ces sources ont été réunies, ainsi que d'autres, pour offrir des données telles que le lieu, la superficie et le type des terres humides, leur importance et leur état, les espèces importantes qu'elles accueillent, ainsi qu'une évaluation qualitative des facteurs de stress et les principales menaces qui affectent les terres humides côtières.

Des résumés sur les terres humides côtières de chaque lac et chaque canal interlacustre d'importance dans le bassin sont accompagnés de cartes et d'annexes détaillées. Les résultats indiquent que de nombreuses espèces d'importance utilisent ces terres humides composées surtout de marécages, mais que les facteurs d'agression anthropiques des terres humides demeurent prépondérants et que les pertes graduelles et sitospécifiques se poursuivent. Il n'y a pas d'estimation globale des pertes historiques et récentes des terres humides, pas plus qu'il n'y a de quantification des gains réalisés par les terres humides.

Bien qu'il existe une foule de renseignements sur les terres humides côtières, les données présentent couramment des lacunes sur les plans spatial et temporel. Sur le plan spatial, les lacunes dans les évaluations des terres humides sont plus prononcées dans les lacs ou les canaux interlacustres supérieurs où les méthodologies de l'Atlas ont déterminé qu'il reste encore de nombreuses terres humides à évaluer par le système d'évaluation des terres humides du MRLO. On soupçonne que bon nombre de ces terres humides sont d'importance provinciale, ou présentent des caractéristiques qui les rendent admissibles à d'autres types de désignation en matière de conservation. Il y a aussi des lacunes temporelles dans les données disponibles, dans la mesure où l'état des terres humides actuelles peut différer de ce que l'Atlas est en mesure de révéler. Bien au-delà de la moitié des évaluations du MRLO ont eu lieu avant 1988, dans les cinq premières années suivant la mise en place du système d'évaluation. Il se peut que ces évaluations ne soient plus à jour, compte tenu surtout de l'évolution du niveau des eaux et des pertes graduelles qui continuent de survenir dans l'ensemble du bassin.

L'incertitude quant aux taux de perte, l'importance connue des terres humides évaluées et les lacunes des évaluations des terres humides accentuent le besoin d'en arriver au but ultime, soit une base de données interactive plus vaste pour la protection et la gestion futures des terres humides du bassin.

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1.0 Introduction

Despite initiatives undertaken by partnerships such as the Eastern Habitat Joint Venture and the Great Lakes Wetlands Conservation Action Plan, leading to advances in wetland policy, restoration and conservation, wetland area and quality and the number of significant wetland-dependent species continue to decline. The most recent account of wetland loss in southern Ontario (Snell, 1984) is over 20 years old, and although there have been numerous site-specific descriptions of wetland loss, a comprehensive review does not exist. To keep track of current wetlands and monitor future losses, a comprehensive database of wetlands in the Great Lakes basin is needed. The Ontario Great Lakes Coastal Wetland Atlas represents a significant step toward an interactive database of the status and trends of coastal and inland wetlands of the Great Lakes basin.

The goals of the Ontario Great Lakes Coastal Wetland Atlas and future applications include:

- developing a database with complete geographic coverage of coastal wetlands of the Great Lakes basin, with a consistent evaluation methodology and current information sources;
- developing a database that is digital, with each wetland geo-referenced, which will serve as a registry for new wetland identification or evaluation;
- identifying gaps in wetland data and strategically planning to fill these gaps;
- assessing and monitoring the contribution of wetlands to biodiversity conservation; and,
- mapping wetland polygons with complete geographic coverage of the Great Lakes basin with links to summary data for each wetland to provide a visual distribution of wetlands and their relative significance.

Information on wetlands is required by many national, provincial and local governments, non-government agencies and individuals interested in wetland conservation and restoration. The information from the Atlas will be used to identify inventory and information gaps, assess the status, losses of and changes to coastal wetlands, identify natural heritage areas for land use planning purposes and establish priority areas for conservation. From a management and enhancement perspective, the content will help develop habitat management strategies, target limited resources for conservation and restoration programs, and contribute to setting goals for biodiversity conservation and recovery of species at risk in wetlands.

2.0 Background

Several initiatives have documented the need for a complete inventory of wetlands in the Great Lakes basin in order to better track and monitor wetland status and change, loss and restoration efforts. In part, the Ontario Great Lakes Coastal Wetland Atlas was produced in response to the work of the 1996 State of the Lakes Ecosystem Conference (SOLEC) and the Great Lakes Wetlands Conservation Action Plan (GLWCAP). SOLEC is held biennially in support of the Great Lakes Water Quality Agreement (GLWQA), under which the United States and Canada committed to the restoration and maintenance of the chemical, physical and biological integrity of the Great Lakes basin ecosystem. The 1996 SOLEC examined the health of aquatic and terrestrial communities and the biological habitat of nearshore ecosystems of the Great Lakes. The background paper presented on coastal wetlands concluded that there was no comprehensive current inventory or evaluation of Great Lakes coastal wetlands (Maynard and Wilcox, 1997). A review of all available data sets identified in the Catalogue of Wetland Databases and Inventories for the Canadian Great Lakes basin (Environment Canada, 1995) supported this conclusion. This lack of information on Great Lakes wetlands was also recognized in the Great Lakes Wetlands Conservation Action Plan, which calls for development of an accessible, computerized, database for Great Lakes basin wetlands.

The Atlas responds to the need to develop a coastal wetlands database for the Great Lakes by updating and consolidating information on coastal wetlands from the best available sources including OMNR

District/Area Office Surveys and Wetland Evaluations, Environment Canada's Great Lakes Environmental Sensitivity Atlases, the Natural Heritage Information Centre's (NHIC) Natural Areas Database, the NHIC Coastal Meadow Marsh Summary and other site specific studies. This information in turn provides:

- a framework for the development of a comprehensive and current Ontario wetland database;
- detailed, spatially referenced information that can be analyzed at a variety of levels for Great Lakes and connecting channels;
- information on wetland type (marsh, fen, bog, swamp), site type (palustrine, lacustrine, riverine, isolated) and associated functions and values;
- information on wetland significance and status; and,
- a qualitative assessment of stressors affecting coastal wetlands and data on biodiversity with respect to significant species dependent on coastal wetlands.

Typical of such large-scale projects, the Ontario Great Lakes Coastal Wetland Atlas data and results have limitations that must be recognized. For example, trend through time information is not available because each record represents a single evaluation at one point in time. The wetland evaluations themselves are of varying quality and do not provide comprehensive biophysical inventories. The evaluations are not comprehensive because the evaluation system only requires that certain information is recorded for each wetland, such as the presence of provincially significant plant and wildlife species, while more general information, such as the presence of common species, is omitted. Further, although attempts were made to update wetland status where possible, this information was compiled in the late 1990s and dates back to 1983. For example, lower water levels since the late 1990s have likely resulted in many wetlands that were not previously identified.

Additionally, the limitations of statistical analysis of the data should be recognized and respected. The data gaps previously identified and the variations in effort (e.g., number of people conducting wetland evaluations, time spent at a site, varying experience of evaluators) that might contribute to inaccurate results must be taken into consideration upon analysis. The Atlas lays the foundation to facilitate the tracking of historical wetland evaluations and wetland changes, permit the identification of data gaps, and provide baseline data on coastal wetlands.

3.0 Methods

3.1 Background

An important issue that arose from SOLEC 1996 was that current mapping methods did not effectively capture changes to wetlands. For example, site-scale changes were not always captured by air photos, and Landsat Thematic Mapper data (30 m spatial resolution) did not provide accurate information on the location, size and type of wetlands. Participants in a 1997 workshop on remote sensing and wetlands concluded that information collected through site-level wetland evaluations and studies is critical for providing a large-scale summary of the location, characteristics, and status of Great Lakes wetlands (Riley and Snell, 1997).

For years, wetland scientists had identified that existing information on coastal wetlands in the Great Lakes basin was piecemeal and dated. In May 1996 a survey was sent to Ontario Ministry of Natural Resources District/Area Offices bordering the Great Lakes. The purpose of this survey was to help determine the current status of Great Lakes coastal wetlands. The results provided summaries of the main characteristics of these wetlands, identified data gaps and identified major stressors affecting specific coastal wetlands.

The findings of SOLEC 1996 (Maynard and Wilcox, 1997), the outcomes of the remote sensing workshop, the results of the OMNR survey, the ultimate goals of the Atlas, and the criteria outlined in the following section all contributed to the selection of the data sources.

3.2 Data Sources

The following general criteria were established for data selection:

- data sets chosen must result in full geographic coverage of the Ontario shoreline of the Great Lakes and connecting channels;
- data must show coastal wetlands within 2 kilometres of the shore;
- data must reflect aerial extent of wetlands;
- data must be at a meaningful scale to identify extent, location, and type;
- data must be accessible; and,
- the integrity of the data must be known (source, collection method, consistency).

The aim was to select the best information available that satisfied these criteria and the needs and goals of the Atlas. No one data set met all the criteria. The Atlas is the result of the compilation and integration of the following data sets.

1. OMNR Wetland Evaluation records (1983 to 1997)
2. Environment Canada's Great Lakes Environmental Sensitivity Atlases (1991 to 1994)
3. Natural Heritage Information Centre's Natural Areas Database
4. 1996 OMNR District/Area Offices survey
5. Natural Heritage Information Centre's Significant Species Lists (1999)
6. Coastal Meadow Marsh Summary (NHIC, 1995)

3.3 Methodology

For the purposes of the Atlas, coastal wetlands were considered to be those wetlands within 2 kilometres of the shoreline, greater than 2 hectares in size. Two hectares is the minimum area for a non-complexed wetland to be included in the OMNR Wetland Evaluation Protocol.

3.3.1 Data Sources

3.3.1.1 Ontario Ministry of Natural Resources Wetland Evaluation Records (1983 to 1997), Ontario Ministry of Natural Resources District Offices

The Wetland Evaluation records provided a consistent approach to evaluating and mapping wetlands across the basin, thereby enabling distribution and relative significance comparisons. They also provided information on size, type, site type, ownership data and significant species information. OMNR Wetland Evaluations are the most detailed surveys available for wetlands in Ontario. The Wetland Evaluation reports were collected from OMNR District Offices in June 1997. The evaluations ranged from 1983 to 1997, however the majority dated from the early to mid-1980s. Three editions of the Wetland Evaluation System were in use over this time period (OMNR, 1993a,b, 1984, 1983). Data in the evaluations were interpreted and verified (Appendix B).

For evaluated wetlands, only evaluation information completed pre-1997 is included in the Atlas. Information from other sources is presented for unevaluated wetlands. The data source, most recent year and method of evaluation were recorded for each wetland. The most recent evaluation was used wherever possible. "DU" after the year of evaluation indicates a desktop update edition of the evaluation. In the case of desktop updates, previous edition evaluation information is transferred to a new edition evaluation without new fieldwork or research. Thus a 1996DU evaluation does not have the same currency of information that an evaluation actually carried out in 1996 would.

Using UTM coordinates, each wetland was plotted in ARCVIEW as a point on a map using a pie-shaped symbol (Figures 1 to 6). Large symbols were used for Provincially Significant Wetlands, while smaller symbols represent Non-Provincially Significant Wetlands. Summary tables providing information such as wetland size, type and significance, based on evaluation results, were created in Excel (Appendices E, G, I, K, M, O). Detailed information for each OMNR-evaluated wetland was entered into the Natural Areas Database (Microsoft Access) and each wetland was assigned a Natural Area Number and cross-referenced to the digital maps (Figures 1 to 6). The NHIC's Natural Areas Database therefore includes all the information from the summary tables (Appendices E, G, I, K, M, O) along with lists of dominant vegetation forms and communities, biodiversity lists, and information on landforms/soils, ecological and other values, land use, offsite uses, wetland stressors, rating/scoring evaluation edition, chronology of evaluations and references. Publicly accessible NHIC Natural Areas data can be found at www.mnr.gov.on.ca/MNR/nhic/areas.cfm. Where vegetation community and plant information was provided, an assessment of plant community significance was made (based on W. Bakowsky, pers. com., 1998).

Unevaluated wetlands identified through other data sources (described below) were plotted in a similar manner, using alphanumeric characters based on the sources (Figures 1 to 6). Unevaluated wetlands are under-represented in the Atlas.

3.3.1.2 Environmental Sensitivity Atlases (1991 to 1994), Environmental Protection Branch, Environment Canada

The Great Lakes Environmental Sensitivity Atlases (GLESAs) provided information on wetland features that could be used to identify unevaluated coastal wetlands plus additional information on adjacent land uses. The information contained in the Sensitivity Atlases was compiled by Environment Canada between 1991 and 1994 for use in the preparation and response to spills of oil and other chemicals in the Great Lakes and connecting channels. They were created to provide a visual reference for general environmental protection initiatives and for increasing the awareness of sensitive shoreline areas. The data were compiled primarily from species surveys, OMNR Wetland Evaluations, aerial video photography of the shoreline, and ground surveys. The shoreline classification categories in the Sensitivity Atlases that correspond to wetlands are low vegetated banks, delta mudflats, fringing wetlands and broad wetlands.

Once the OMNR-evaluated wetlands were identified, the Sensitivity Atlases were reviewed for each of the Great Lakes and unevaluated wetlands were identified. Many shoreline areas showed extensive fringing and broad wetlands in the Sensitivity Atlases, but have not been evaluated formally as wetlands by any government agency. Therefore only wetlands that were identified in the Sensitivity Atlases and also recognized by these agencies were included in the Atlas. Where wetland evaluations did not exist for the wetlands identified in the Environmental Sensitivity Atlases, the UTM coordinates were obtained from topographic maps, added to the database, and the wetland was plotted in ARCVIEW and identified on the maps with a star-shaped symbol (Figures 1 to 6).

3.3.1.3 Natural Areas Database, Natural Heritage Information Centre

The Natural Heritage Information Centre has developed a Natural Areas Database (NAD) in which information on natural areas such as wetlands can be entered and stored. Currently, it holds more than 6,000 records and is being updated and revised on an ongoing basis. Many coastal wetlands support significant features and are therefore included in this database. In order to identify natural areas with coastal wetland features, all natural areas within 2 kilometres of the Great Lakes shoreline were identified using ARCVIEW, and the descriptions of each natural area (such as Areas of Natural and Scientific Interest (ANSI), International Biological Program Sites (IBP), Wildlife Areas, Conservation Areas, etc.), were reviewed to determine if they contained representative coastal wetland features (see Appendix C). Using the coordinates, these were plotted on a map using red squares (Figures 1 to 6). Information from the NAD was included in summary tables (Appendices E to O).

3.3.1.4 1996 Ontario Ministry of Natural Resources District/Area Offices survey

In 1996, as part of this project and as background for SOLEC 1996, a survey (Appendix A) was sent to OMNR District and Area Offices bordering the Great Lakes. The results presented in the tables, appendices, and throughout the Atlas augment the Wetland Evaluations and update the current status of Great Lakes coastal wetlands based on staff knowledge, where coastal wetland status had changed since evaluation. It also served to identify unevaluated wetlands (Table 3). The results of this survey also provided summaries of the main characteristics of Ontario coastal wetlands, and identified data gaps and major stressors affecting specific coastal wetlands.

3.3.1.5 Significant Species Lists, Natural Heritage Information Centre

The significant species lists provided extensive information on significant species and wetland features that could be used to augment Wetland Evaluation information. Occurences of rare flora and fauna compiled by the NHIC were used to identify rare species occurring in Ontario. A comprehensive list of rare species that utilize coastal wetlands was then generated, based on an extensive literature review and information provided by biologists within the NHIC and OMNR. These species are ones found in coastal areas or areas with wetlands, but are not necessarily obligate wetland species. The list includes significant plant, bird, amphibian, reptile, fish, and lepidopteran species; there are currently no provincially significant mammal species listed that use coastal wetlands in the Great Lakes basin.

Because of the potential sensitivity of rare species information, locations of specific rare species were noted only by identifying the corresponding lake or connecting channel (Appendices P to U) in this report. Wherever possible, the location of rare species based on NHIC data and OMNR Wetland Evaluations were linked to each wetland and included in the Atlas (Appendices E, G, I, K, M, O).

Species listed in the Significant Species Tables (Appendices P to U), are those rare species with a provincial rank (S Rank) of S1, S2, S3 or S3S4, as designated by the NHIC. Species of these ranks are considered to be "provincially significant". Rare species identified in these tables have been taken from various data sources, and may not qualify for points under the Special Features Component of the Ontario Wetland Evaluation System (OMNR, 1993a). As well, some records of rare species listed in OMNR Wetland Evaluations have not been confirmed by NHIC staff (Appendix U). For bird species, two S-Ranks are assigned: breeding (B) and non-breeding (N) status. For the purposes of the Atlas, the S-Rank with the highest significance or that which is the limiting habitat (usually breeding) is used.

The Significant Species Tables (Appendices P to U) also identify the status assigned to these species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC November 2002) and the Committee on the Status of Species at Risk in Ontario (COSSARO September 2002). A more detailed explanation of the type of data found in the Significant Species Tables is in Appendix D.

3.3.1.6 Coastal Meadow Marsh Summary, Natural Heritage Information Centre

NHIC conducted a literature review to summarize knowledge of coastal meadow marshes (shoreline fens) (NHIC, 1995). Where the UTM coordinates of the Great Lakes coastal meadow marshes overlapped with Environmentally Sensitive Areas (ESA), Natural Areas and evaluated wetlands, a reference was made in the Atlas.

3.3.2 Data Compilation

The Great Lakes Environmental Sensitivity Atlases, OMNR-evaluated wetlands, and the Natural Areas with coastal wetlands were plotted and overlapping areas were identified. Where Natural Areas overlapped with evaluated wetlands or Great Lakes Environmental Sensitivity Atlas wetlands, they were recorded on the maps using red squares around the numbers of the pie and star-shaped symbols (Figures 1 to 6), and the unique Natural Area Number was recorded (Appendices E, G, I, K, M, O). Where a Natural Area with a wetland component occurred within 2 kilometres of the shoreline, and did not correspond with an evaluated or Environmental Sensitivity Atlas wetland it was added to the Unevaluated Wetland list, given a unique identifier and plotted separately using an solid red square symbol. Summaries were created for the Natural Area wetlands, GLESA wetlands and other unevaluated wetlands, providing location information, a brief description of the wetland components, and presence/absence of significant species (Appendices F, H, J, L, N).

4.0 Atlas Summary and Future Plans

4.1 Accomplishments

The Ontario Great Lakes Coastal Wetland Atlas has provided a preliminary snapshot of the state of the Great Lakes wetland ecosystem in the late 1990s, in terms of the quality and quantity of both the available wetland-related information and the wetland resource itself. These results will help direct future wetland evaluation, protection, and management efforts. Several of the goals outlined in the Introduction have been achieved laying the groundwork for the basin-wide, interactive digital database. Coastal wetlands have been geo-referenced, therefore a consistent naming system exists, ultimately reducing duplication and confusion of sites.

4.2 Key Findings

4.2.1 General Information/Significance

The Ontario Great Lakes Coastal Wetland Atlas provides general information on the number, extent and type of wetlands in the basin. There are 236 OMNR-evaluated coastal wetlands and over 170 unevaluated coastal wetlands identified from the Natural Areas Database, Great Lakes Environmental Sensitivity Atlases, and other sources (Table 1). When evaluated and unevaluated wetlands are considered, all four wetland types (marsh, swamp, bog and fen) are found on virtually every lake and connecting channel. Lake Erie has the largest total area of evaluated wetlands at almost 20,000 ha.

Individual evaluated wetlands range in size from 2.0 ha (on Lake Ontario) to 13,465 ha (on Lake Erie) and cover over 53,600 ha (Table 2). Marshes make up over three-quarters of evaluated coastal wetland area in the basin; the majority of the remaining area is swamp. The majority of the over 170 unevaluated coastal wetlands also appear to be marsh. The Lake Huron/St. Marys River region has the most unevaluated wetlands, with 151 recorded (Table 3).

Despite the losses and impacts to Great Lakes coastal wetlands, they have retained remarkable characteristics such as the complex vegetation communities of Lake Huron and the great biodiversity of Lake Erie. Three-quarters of the evaluated wetlands are provincially significant (in part because priority was given to evaluating those wetlands thought to be provincially significant), and many evaluated and unevaluated wetlands also have special designations such as Areas of Natural and Scientific Interest or International Biological Program Sites (Table 1). Many of the unevaluated wetlands are suspected to be provincially significant, and could potentially contain species at risk or their habitat. This has implications for setting goals for biodiversity conservation and species at risk recovery.

4.2.2 Stressors

The Atlas outlines the major stressors encountered in the coastal wetlands of the lakes and connecting channels (Appendices E, G, I, K, M, O). All areas have been affected by agricultural drainage, urban encroachment, shoreline modification and sediment contamination. Wetlands in connecting channels that serve as shipping lanes are further affected by wave action and dredging. The lower Great Lakes are particularly impacted by industry outfalls, sewage treatment, and toxic chemical contamination. The more northerly sites, such as Lakes Superior and Huron and the St. Marys River, are comparatively less affected by human stressors. The relative remoteness of these northern wetlands results in more gaps in evaluation data, but less urgency to identify the provincially significant sites that could be afforded protection from human impacts. Significant gaps in evaluation data in the highly pressured lower lakes and channels were also found (Table 1, Appendix M).

4.2.3 Significant Species

A significant number of provincially significant species are found in Great Lakes coastal wetlands (Table 4), including a number of species at risk (Appendices P to U). Of the 45 species listed in the Atlas as at risk by COSEWIC, one-third are endangered, one-third are threatened, one species is vulnerable, and one-third are species of special concern. Provincially, of the 30 species listed in Atlas that are considered at risk by COSSARO, eight are endangered, 13 are threatened and 12 are vulnerable (Appendices P to U).

Lake Erie and Lake Huron are the most biodiverse and important sites in terms of significant species: approximately half of the provincially significant plants, birds, herptiles, fish and lepidoptera of coastal wetlands are found in these two lakes. These significant species were found in a large number of wetlands, many of which are provincially significant, which affords them some protection. There is great potential that species at risk or their habitats will be found in unevaluated coastal wetlands once they are evaluated, particularly in ANSIs. Since the time of many wetland evaluations (mid-1980s) and preparation of the Atlas (late 1990s), a number of wetland dependent species have suffered dramatic population declines (e.g., King Rail, Fowler's Toad, Bluehearts, and Pugnose Shiner).

4.2.4 Identification of Information Gaps

One goal of the Atlas was to identify information gaps. Gaps in wetland evaluations are more extensive in the upper lakes and connecting channels where Natural Area and Great Lakes Environmental Sensitivity Atlas information has identified that numerous wetlands exist in these areas that have yet to be evaluated by the OMNR Wetland Evaluation System (see Table 1 and Appendix G). It is suspected that there may also be provincially significant and other important wetlands that have not yet been identified, evaluated, or assigned a conservation status designation. In addition, results of the OMNR District/Area Offices survey identified numerous wetlands that had not yet been evaluated (Table 3).

There are also temporal gaps in the available data, in that the state of existing wetlands may differ from what the Atlas is able to show. Well over half of the OMNR evaluations took place prior to 1988, within the first five years of implementation of the evaluation system (OMNR 1984). These evaluations may no longer be accurate, especially in light of changing water levels and the incremental losses that continue to occur throughout the basin. The extent of both the historical widespread and current incremental losses of wetlands reported for all lakes and connecting channels is unknown. Wetland evaluations can now become more strategic due to the awareness of both spatial and temporal gaps in wetland identification and evaluation.

4.3 Future Plans

The information contained in the Atlas is not exhaustive; rather it presents a late 1990s snapshot in time and an overview of the type of information that can be obtained from such a database. Although this is the most comprehensive map of coastal wetlands in Ontario, and serves as a framework for future data collection, analysis and application, it is already dated and further work would be required to complete the database described in the goals. The completion and electronic maintenance of the coastal wetland database and expansion to include inland wetlands may become part of OMNR's Natural Resource Values Information System and Wetland Evaluation Information Management System. Ideally, all the wetlands in the basin would be identified and evaluated using the OMNR evaluation system. Further analysis of existing mapping is also a priority, as is the collection of additional biophysical information (such as water level fluctuations and near-shore bathymetry) and the creation of wetland polygons with links to summary information. Remote sensing will continue to be examined as a possible technique for tracking changes to wetland area. Different methods are currently being evaluated. Ultimately, the Ontario Great Lakes Coastal Wetland Atlas will contribute to the development of a basin-wide, interactive map of Great Lakes basin coastal and inland wetlands.

Table 1: Summary of Ontario Great Lakes Coastal Wetland Atlas Results

Lake/ Connecting Channel	Evaluated Wetlands (1983 to 1997)[6]									Unevaluated Wetlands					
	No. Evaluated Wetlands	No. PSW[1]	No. NPSW[2]	Total area of evaluated wetlands (ha)	Designations[4] (an individual wetland may have more than one designation)					Estimated No. unevaluated wetlands[5]	Designations (an individual wetland may have more than one designation)				
					ANSI	PWA	NWA	IBP	Ramsar		ANSI	PWA	NWA	IBP	Ramsar
Lake Superior	11	3	8	1,080.6[3]						13	2			1	
St. Marys River	7	3	4	3,567.0[3]						54	1				
Lake Huron	48	41	7	7,459.0[3]	22	4	1	11	1	97	29			6	
St. Clair River	5	4	1	87.2											
Lake St. Clair	5	5	0	2,522.9[3]	1		1		1	1	1				
Detroit River	4	4	0	1,136.3	1										
Lake Erie	30	26	4	19,329.8	14	1	2	2	2	3	2		1	1	
Niagara River	4	4	0	84.5	1			2							
Lake Ontario	82	64	18	11,334.5[3]	30		1	5		5	2				
St. Lawrence River	40	21	19	7,017.7[3]	11	1		5		[7]					
Total	236	175	61	53,619.5	79	6	5	23	4	173	37	0	1	8	0

[1] PSW = Provincially Significant Wetlands
[2] NPSW = Non-Provincially Significant Wetland
[3] Evaluations incomplete; see also Table 3
[4] ANSI= Area of Natural and Scientific Interest; PWA= Provincial Wildlife Area; NWA= National Wildlife Area; IBP= International Biological Program Site; Ramsar=Wetland of International Importance
[5] Identified from Natural Areas Database, Environmental Sensitivity Atlas, and Other
[6] Number of evaluated wetlands counts a wetland complex as one wetland
[7] Although there are unevaluated wetlands on the St. Lawrence River (Table 3), they have not been individually identified in the Appendices nor maps, and cannot be included in this summary.

Table 2: Summary of Evaluated Ontario Great Lakes Coastal Wetlands

Lake/ Connecting Channel	Evaluated Wetlands[1]			Wetland Area				Wetland Type			
	Number Evaluated Wetlands	Number Provincially Significant	Number Non-Provincially Significant	Total Area (ha)	Mean Size (ha)	Smallest Wetland > 2 ha (ha)	Largest Wetland (ha)	Swamp (ha)	Marsh (ha)	Bog (ha)	Fen (ha)
Lake Superior[2]	11	3	8	1,080.6[2]	98.2	4.6	429.0	611.8[2]	392.5[2]	41.3[2]	32.4[2]
St. Marys River	7	3	4	3,567.0	509.6	42.0	2,275.0	1,387.6	1,724.4	0	455.0
Lake Huron[2]	48	41	7	7,459.0[2]	155.4	5.0	807.4	3,768.8[2]	3,227.7[2]	16.1[2]	447.8[2]
St. Clair River	5	4	1	87.2	17.4	3.0	44.3	6.9	80.3	0	0
Lake St. Clair	5	5	0	2,522.9	504.6	3.9	2,335.0	270.9	2,252.0	0	0
Detroit River	4	4	0	1,136.3	284.1	32.0	575.0	37.1	1,099.2	0	0
Lake Erie	30	26	4	19,329.8	644.3	3.2	13,465.0	1,446.9	17,878.9	4.0	0
Niagara River	4	4	0	84.5	21.2	4.5	37.2	39.3	45.2	0	0
Lake Ontario	82	64	18	11,334.5	138.2	2.0	2,093.0	2,518.4	8,780.7	6.3	29.1
St. Lawrence River	40	21	19	7,017.7	175.4	3.6	1,398.0	1,270.5	5,719.2	28.0	0
Total[2]	236	175	61	53,619.5[2]	227.2	2.0	13,465.0	11,358.2[2]	41,200.1[2]	95.7[2]	964.3[2]

[1] Number of evaluated wetlands counts a wetland complex as one wetland
[2] For two Lake/Connecting Channels, the total areas (ha) of swamp, marsh, bog and fen, do not add up to the total size (ha) of wetland area, due to percentage of wetland type being recorded as either under or over 100% in several original evaluations, particularly Neebing Marsh and Caldwell Lake (Lake Superior) and Wye Marsh (Lake Huron)

Table 3: Summary of Unevaluated Ontario Great Lakes Coastal Wetlands

Atlas methodologies identified a total of 173 unevaluated coastal wetlands (Estimated No. Unevaluated wetlands). The 1996 OMNR District/Area Survey identified that there are likely significantly more coastal wetlands that remain to be evaluated (Evaluation Status). Therefore, the Atlas likely under-represents the total number of coastal wetlands on the Great Lakes. Many of these wetlands have the potential to be provincially significant or contain habitat of significant species.

Lake/ Connecting Channel	**Estimated No. Unevaluated Wetlands** (from Natural Areas, Environmental Sensitivity Atlas, and Other)	**Evaluation Status** (from 1996 OMNR District/Areas Survey)
Lake Superior	13	• approximately five wetlands not evaluated in Goulais Bay/ Batchewana Bay in northeastern Lake Superior; and seven not yet evaluated in Thunder Bay, Black Bay, Nipigon Bay Area in northwestern Lake Superior; several of these wetlands are likely Provincially Significant Wetlands (A. Dupont, pers. com., 1996) • there are no wetlands larger than 2 ha along the remainder of the north shore
St. Marys River	54	• 130+ wetlands larger than 2 ha along shoreline to be evaluated and many more wetlands within 2 kilometres of the St. Marys River (A. Dupont, pers. com., 1996) • number of potential Provincially Significant Wetlands to be evaluated unknown (A. Dupont, pers. com., 1996)
Lake Huron	97	• Wingham Area: evaluations complete • Bruce Peninsula: unknown number of wetlands that need to be evaluated • Midhurst: 5 to 10 wetlands greater than 2 ha need to be evaluated and at least one is a Provincially Significant Wetland (G. Allen, pers. Com., 1996) • Parry Sound: one large wetland and many smaller wetlands (mostly marshes < 10 to 20 ha) need to be evaluated and the number of Provincially Significant Wetlands is unknown (R. Black, pers. com., 1996) • Sudbury/Manitoulin: numerous wetlands larger than 2 ha need to be evaluated, and number of Provincially Significant Wetlands is unknown (W. Selinger, pers. com., 1996)
St. Clair River		• evaluations complete
Lake St. Clair	1	• evaluations complete except Walpole Island (approximately 10,360 ha)
Detroit River		• evaluations complete
Lake Erie	3	• evaluations incomplete
Niagara River		• evaluations complete
Lake Ontario	5	• evaluations complete except Grafton Swamp West (approximately 20 ha) in Northumberland/Hastings County (B. Snider, pers. com., 1996) and several marshes in Bay of Quinte • difficult to estimate number to be evaluated in Bay of Quinte because there are many embayments with cattails or submerged vegetation (N. MacLean, pers. com.,1996) • there are probably no unevaluated Provincially Significant Wetlands on Lake Ontario
St. Lawrence River		• approximately seven wetlands larger than 2 ha have yet to be evaluated and all are probably Provincially Significant Wetlands (one on mainland, approx. 40 ha; and six associated with Akwesasne Islands, approximately 100 ha) (M. Eckersely, pers. com., 1996)
Total	173	

Table 4: Summary of Significant Species Reported in Ontario Great Lakes Coastal Wetlands

Lake/ Connecting Channel	Total Evaluated Wetlands	Total PSW[1]	Total NPSW[2]	Total area of evaluated wetlands (ha)	Number of Significant Species [4] by Group [5] (% of total listed in Atlas by group)					Total Estimated Unevaluated wetlands [6]	Total ANSIs [7] Evaluated (Unevaluated)	Total Other Designations[8] (PWA, NWA, IBP, Ramsar) Evaluated (Unevaluated)
					Plant	Bird	Reptile / Amphibian	Fish	Lepidopteran			
Lake Superior	11	3	8	1,080.6 [3]	5 (5.1)	5 (20.8)	0 (0)	0 (0)	0 (0)	13	(2)	(1)
St. Marys River	48	44	11	3,567.0 [3]	1 (1.0)	2 (8.3)	0 (0)	0 (0)	0 (0)	54	(1)	
Lake Huron	7			7,459.0 [3]	48 (48.5)	12 (50)	6 (54.5)	5 (50)	2 (66.7)	97	22 (29)	17 (6)
St. Clair River	4	4	1	87.2	5 (5.1)	1 (4.2)	3 (27.3)	2 (20)	0 (0)			
Lake St. Clair	5	5	0	2,522.9 [3]	19 (19.2)	12 (50)	4 (36.4)	6 (60)	1 (33.3)	1	1 (1)	2
Detroit River	5	4	0	1,136.3	17 (17.2)	3 (12.5)	5 (45.5)	2 (20)	2 (66.7)		1	
Lake Erie	30	26	4	19,329.8	66 (66.7)	16 (66.7)	11 (100)	7 (70)	3 (100)	3	14 (2)	7 (2)
Niagara River	82	68	18	84.5	9 (9.1)	1 (4.2)	0 (0)	3 (30)	0 (0)		1	2
Lake Ontario	4			11,334.5 [3]	20 (20.2)	11 (45.8)	3 (27.3)	3 (30)	2 (66.7)	5	30 (2)	6
St. Lawrence River	40	21	19	7,017.7 [3]	7 (7.1)	5 (20.8)	1 (9.1)	3 (30)	1 (33.3)		11	6
Total	236	175	61	53,619.5	197	68	33	30	11	173	79 (37)	57 (8)

[1] PSW = Provincially Significant Wetland
[2] NPSW = Non-Provincially Significant Wetland
[3] Evaluations incomplete; see also Table 3
[4] NHIC rank S1 to S3S4; see also Appendix D
[5] From Appendices P to U
[6] From Natural Areas, Environmental Sensitivity Atlases, and Other
[7] ANSI= Area of Natural and Scientific Interest
[8] PWA= Provincial Wildlife Area; NWA= National Wildlife Area; IBP= International Biological Program Site; Ramsar = Wetland of International Importance.
Note: An individual wetland may have more than one designation; see also Table 1

5.0 Results

5.1 Lake Superior

5.1.1 Setting

Lake Superior is the largest and deepest of the Great Lakes. Its surface area is 82,100 km^2 and the shoreline extends 5,105 km (International Joint Commission, 1993). St. Ignace Island and Michipicoten Island are the largest of the many islands in Lake Superior. Its drainage basin is 138,586 km^2 in size and is mostly forested (95%) with very small areas of agricultural land (1%), urban and industrial area (0.1%) and other land uses (4%) (PLUARG, 1978).

The north shore of Lake Superior is a high-energy environment with few areas of sediment deposition. Wetlands are rare here and restricted to the large sheltered embayments of Goulais Bay and Batchawana Bay in the northeast, and Thunder Bay, Black Bay and Nipigon Bay in the northwest. Due to their rarity, those that do exist are particularly important to fish and wildlife populations. Small lacustrine marshes are the most dominant wetland type, however there are also some large swamps and peatlands (e.g. Black Bay and Goulais River). The number and area of coastal wetlands along the north shore are not known. There are at least 21 coastal wetlands (Environment Canada, 1993a), but only 11 of these have been evaluated by the OMNR, mostly along the northwestern shoreline (Appendix E; Figure 1). They total approximately 1,081 ha and range in size from just under 5 ha to 429 ha (Appendix E). At least 3,500 ha of coastal wetland have not been evaluated, including several large wetlands such as the Goulais River Wetland complex and the Black Bay Peatlands (K. Cullis, pers. com., 1996; Table 3; Appendix F). The large Goulais River Wetland complex is probably the most significant wetland on the north shore of Lake Superior.

5.1.2 Significant Features

Several provincially significant plant species are found in Lake Superior coastal wetlands such as Wiegand's Sedge and Large Water Starwort in shallow water marshes, and Black Sedge in swamps. Other significant plant species found in Lake Superior coastal wetlands are Ram's-head Lady's Slipper and Water Awlwort (Appendix P).

Forty-one fish species have been identified in the coastal wetlands of Lake Superior. These wetlands provide spawning, nursery and feeding habitat for fish (Ball and Tost, 1992; Jude and Pappas, 1992; Entwistle, 1986). Northern Pike, Walleye and Yellow Perch are the primary sportfish that use Lake Superior coastal wetlands. The only Muskellunge populations along the north shore are found at the large wetlands at the mouth of the Goulais River (OMNR, 1991). No provincially significant fish species have been reported for north shore Lake Superior coastal wetlands (Sutherland, 1994; Mandrak and Crossman, 1992; Appendix Q).

Little is known about the amphibian and reptile populations utilizing Lake Superior coastal wetlands. Snapping Turtles and Bullfrogs are present in all Thunder Bay marshes (Entwistle, 1986). No provincially significant amphibian or reptile species were reported for north shore Lake Superior coastal wetlands (Appendix R).

Lake Superior coastal wetlands provide important breeding and migratory habitat for waterfowl. Along the north shore of the lake, many migrating waterfowl use the wetlands on the shores of Batchawana Island and the Goulais River Wetland complex in the southeast, and Mission Marsh in Thunder Bay in the northwest (Smith, 1987). Tens of thousands of waterfowl and other water birds pass through the Thunder Bay Harbour marshes during spring and fall migration (Entwistle, 1986). The most abundant migratory waterfowl include Canada Geese, scaup, other diving ducks, and dabbling ducks.

Colonial birds such as the Great Blue Heron, Double-crested Cormorant and American Bittern are common summer residents in these coastal wetlands and breed in Thunder Bay marshes (Entwistle, 1986). Large numbers of Great Blue Heron utilize the wetlands on the shores of Batchawana Island (Environment Canada, 1993a) and the Sandhill Crane breeds in the Goulais River Wetland complex in Goulais Bay (Environment Canada, 1993a). Provincially significant bird species reported in Lake Superior coastal wetlands during breeding season include Bald Eagle and Peregrine Falcon, while the Yellow-headed Blackbird use these areas during migration (Appendix S). Other provincially significant species breeding or using these wetlands include Northern Shoveler and Red-necked Grebe (Appendix S).

No provincially significant lepidopteran species were reported for north shore Lake Superior coastal wetlands (Appendix T).

5.1.3 Wetland Status

There are no comprehensive estimates of coastal wetland losses for Lake Superior. Along the north shore, large-scale losses have not occurred because the shoreline is remote and sparsely populated. The only reported wetland loss has occurred in Northern Wood Preservers Marsh in Thunder Bay Harbour as a result of shoreline modification and urban encroachment (K. Bray, pers. com., 1996). None of the wetlands outside the city of Thunder Bay in western Lake Superior have suffered significant wetland loss (S. Suke, pers. com., 1996).

Coastal wetlands along Lake Superior are comparatively less affected by human stressors than those of the other Great Lakes. Water level regulation is the most widespread stressor, affecting all coastal wetlands in Lake Superior. Water levels on Lake Superior have been regulated for much of the 20th century as a result of the locks at Sault Ste. Marie; thereby restricting the natural range of water levels as compared to Lake Huron and Lake Erie. Lake Superior's range of fluctuations and the cyclic nature of high and low lake levels have not been altered as significantly as Lake Ontario. However, extreme low water conditions during summer are not frequent enough to allow cyclic, regenerative processes to occur (Wilcox *et al.*, 1993).

Other, more site-specific stressors of some Lake Superior coastal wetlands are nutrient enrichment and toxic contamination of waters and sediments. Four Areas of Concern (AOC) are located along the Canadian shore but only the Thunder Bay AOC has significant areas of coastal wetland which are potentially affected. Adjacent industrial land use in the harbour has been reported to stress these wetlands (Appendix E).

Along the northwest shore, other site specific stresses on coastal wetlands include recreational use, cottaging and associated roads, especially in Cloud Bay, Pine Bay and Sturgeon Bay to the west of Thunder Bay; these may result in incremental loss of wetland area (Appendix E). Similarly, ongoing recreational use and cottage development along the northeast shore continually exert pressure on coastal wetlands (Appendix E).

5.2 St. Marys River

5.2.1 Setting

The St. Marys River extends 112 km, draining Lake Superior into Lake Huron. It drops 6.7 m along its length, mostly at the 1.2 km long St. Marys Rapids in Sault Ste. Marie (Duffy *et al.*, 1987). Several islands occur in the river, including Sugar Island, Neebish Island, St. Joseph Island and Drummond Island. The river flows through several channels around these islands and through several large lakes including Lake Nicolet, Lake George and Munuscong Lake. Its shoreline stretches 292 km on the Canadian side and 390 km on the U.S. side (International Joint Commission, 1993). The river itself has several tributaries, draining a watershed of 2,830 km^2, yet the water entering from these tributaries is only a small fraction of the drainage from Lake Superior (Kauss, 1991). Most of this watershed is forested (95%) (Kauss, 1991); the small urban and industrial areas are concentrated in Sault Ste. Marie, Ontario and Sault Ste. Marie, Michigan.

The upper river above the St. Marys Rapids has sandy and rocky shores, with emergent wetlands occurring only in sheltered areas (Duffy *et al.*, 1987). The lower river is bordered by extensive emergent marshes in the shallow areas of large lakes, bays and islands (Kauss, 1991; Duffy *et al.*, 1987). These are exposed to the river and often grade inland to palustrine wetlands, mostly marshes and swamps. Extensive emergent wetlands are found, especially along the shores of Lake George and St. Joseph Island (Environment Canada, 1994e).

Seven wetlands have been evaluated by OMNR, totalling 3,567 ha and ranging from 42 ha to 2,275 ha in size (Figure 2; Appendix G), but at least 130 other wetlands greater than 2 ha have not yet been evaluated in the lower river (Table 3). The largest evaluated wetlands include Hay Marsh along the southwest shore of St. Joseph Island (2,275 ha) and Echo Bay in Lake St. George (710 ha) (Appendix G).

5.2.2 Significant Features

The emergent wetland areas of the St. Marys River serve as spawning, nursery and feeding habitat for 44 fish species (Duffy *et al.*, 1987). Sportfish such as Northern Pike, Muskellunge, Smallmouth Bass, Largemouth Bass, Yellow Perch, and Walleye are highly dependent on these marshes (Bray, 1993). No provincially significant fish were reported for St. Marys River coastal wetlands (Appendix Q).

The St. Marys River wetlands have been identified as a significant area of waterfowl production in the Great Lakes basin (Prince *et al.*, 1992). Common breeding species include Canada Goose, Mallard, Blue-winged Teal, Black Duck and Common Merganser (Duffy *et al.*, 1987). The wetlands are also important migratory staging areas, especially for diving ducks such as Ring-necked Duck, Redhead and scaup species (Prince *et al.*, 1992; Duffy *et al.*, 1987). Provincially significant bird species breeding in these wetlands include Bald Eagle and Black Tern (Appendix S).

One provincially significant plant species, Water Awlwort was reported in St. Marys River coastal wetlands (Appendix P). No provincially significant lepidopteran species, reptile species nor amphibian species were reported for St. Marys River coastal wetlands (Appendix T; Appendix R). However, not all evaluation data on significant species were available for analysis for this area.

5.2.3 Wetland Status

Historically, wetlands along the St. Marys River shoreline have not suffered significant loss due to human influence (Bray, 1992; Williams and Lyon, 1991). The extent of human stressors affecting St. Marys River coastal wetlands is not clearly understood, but these wetlands appear to be less impacted than other connecting channels downstream. There has been site-specific loss of wetland area along the shoreline of the city of Sault Ste. Marie from dredging, filling, and sediment contamination (Bray, 1992). More recently, most of the evaluated wetlands on the Canadian side have also suffered some loss, primarily from shoreline modification, dredging, filling, channelization and cottage development (S. Jones, pers. com., 1996; Appendix G).

The entire river has been declared an Area of Concern due to elevated concentrations of contaminants in the water, localized sediment contamination, the presence of fish tumours, localized impairment of the benthos and localized high bacterial counts (Hartig and Thomas, 1988). These impacts are especially heavy along the Canadian shore, downstream of Sault Ste. Marie, Ontario to Little Lake St. George (Burt *et al.*, 1991; Kauss, 1991; Nichols *et al*., 1991). Local wetlands in these areas are likely stressed to some degree from contaminants in the sediments, but the extent of these impacts is not clear.

Commercial shipping continues to stress wetlands in the St. Marys River. The passing of large commercial vessels in the shipping channels causes increased current speed, greater wave action, more erosion and turbidity in these coastal wetlands, affecting plant rooting and growth and associated invertebrates and other fauna (Kauss, 1991). Dredging of the river also affects the currents and sediment deposition patterns in the river, but the impacts on the sediment supply to coastal wetlands and their functions are not clear. Tributaries to the St. Marys River can also produce excessive turbidity in nearshore areas during major runoff events as a result of the fine clay soils in their watersheds, especially in Munuscong Lake in the lower river (Kauss, 1991). The excessive turbidity negatively impacts coastal wetlands by reducing water clarity, plant growth and faunal interactions.

Cottaging also produces site-specific stresses on coastal wetlands. These stresses are associated with hardening of the shoreline and dredging and channelization for boat slips and marinas (A. Dupont, pers. com., 1996).

5.3 Lake Huron

5.3.1 Setting

Lake Huron is the second largest Great Lake. Its surface area is 59,500 km^2, with a shoreline that extends 6,373 km (International Joint Commission, 1993, 1989). It has many islands ranging from large ones such as Manitoulin Island (the largest freshwater island in the world) to the many small islets of eastern Georgian Bay. Its drainage basin is 128,863 km^2 and is predominantly forested (66%), especially on the Canadian side, with lesser amounts of agricultural land (22%), residential and industrial land (10%) and other land uses (2%) (PLUARG, 1978).

Wetlands along the Canadian shore of Lake Huron are common in the sheltered environments of embayments and creek mouths and in the lee of large islands (Environment Canada, 1994b). However, an accurate estimate of wetland area along the Canadian shore of Lake Huron has not been determined. Forty-eight wetlands have been evaluated by the OMNR in Lake Huron totalling approximately 7,459 ha and ranging in size from 5 ha to 807 ha (Figure 2; Appendix G). More than 100 wetlands greater than 2 ha in size still need to be evaluated, especially in the North Channel, along Manitoulin Island and in Georgian Bay (Table 3; Appendix H). Bookhout *et al.* (1989) estimated that 12,600 ha of wetlands occurred in Georgian Bay alone. Evaluated wetlands of Lake Huron are generally smaller but more numerous than those in the southern Great Lakes and over half are wetland complexes. Marshes and swamps are equally dominant, and many have significant fen components (Figure 2; Appendix G).

Only six small coastal wetlands occur between Sarnia and Point Clark along the southeast Canadian shore, which reflect the high-energy shoreline environments. They are predominantly swamps, with a total area of approximately 340 ha (Figure 2; Appendix G). From Point Clark to the base of the Bruce Peninsula, the shoreline is mostly exposed, but 5 wetlands totalling approximately 913 ha are found in sheltered bays. They are primarily palustrine swamp and fen wetland complexes extending back from the shore (Figure 2; Appendix G).

The western shore of the Bruce Peninsula and southern shore of Manitoulin Island have exposed irregular shorelines, with wide and shallow, boulder-strewn, limestone bedrock shelves, and many small islands, reefs, and sheltered bays. The irregular coast and islands provide many sheltered, low energy and bay environments where wetlands can develop (Environment Canada, 1994b). Thirteen wetlands have been evaluated on the western side of the Bruce Peninsula, primarily large wetland complexes with swamp, marsh and fen components, totalling approximately 1,765 ha (Figure 2; Appendix G). At least 17 unevaluated wetlands occur on the southern shore of Manitoulin Island which appear to possess similar characteristics to those of the western side of the Bruce Peninsula (Natural Heritage Information Centre, 1995; Environment Canada, 1994b; Figure 2; Appendix H).

The eastern shoreline of the Bruce Peninsula in Georgian Bay is rugged with steep nearshore slopes that, prevent the development of extensive wetlands. The long, mostly sandy shore of Nottawasaga Bay also lacks wetlands except in interdunal areas, a few harbours, and river mouths. Southern Georgian Bay is rocky, but a number of shoreline marshes have developed where sheltered embayments occur (e.g., Matchedash Bay) (Figure 2; Appendix G). Twenty-one wetlands totalling approximately 3,871 ha have been evaluated between Tobermory and the French River (Figure 2; Appendix G). They are primarily lacustrine wetlands and palustrine marshes with large swamp components. A few of these wetlands also have minor bog and fen components.

The shoreline of the North Channel and northern Georgian Bay is extremely complex with bedrock outcrops, islands and bays. The mainland coast is very sheltered from wind and wave action due to numerous islands, headlands and embayments (Environment Canada, 1994b). Wetlands develop in the protected embayments of the islands and the mainland. There are at least 60 wetlands in this area, but only three have been evaluated: Marsh Bay Island 9 Wetland near Blind River (254 ha), Spanish River Delta Marsh (305 ha), and Whites Cove (11 ha) (Figure 2; Appendix G). Unevaluated wetlands occur primarily in the protected bays of St. Joseph's Channel, along the north shore of Manitoulin Island, near Barrie Island, Strawberry Island, La Cloche Islands and in McGregor Bay (Environment Canada, 1994b).

5.3.2 Significant Features

Wetlands in Lake Huron have more complex vegetation communities than those in the southern Great Lakes. The large amount of fen and swamp habitat, the diversity of wetland types, the variations in geomorphology and the calcareous soils all contribute to this complexity (Smith *et al.*, 1991). The fens which commonly occur in Lake Huron and Georgian Bay wetlands, also known as coastal meadow marshes, have been identified as globally imperilled communities (Natural Heritage Information Centre, 1995). Over 40 species of provincially significant plants have been found in coastal wetlands of Lake Huron (Wilcox, 1995; Appendix P). For example, the coastal meadow marshes of Lake Huron and Georgian Bay support some of Ontario's rarest plant species, including Bluehearts, Round-stemmed Purple False Foxglove, Twining Bartonia and Rigid Yellow Flax (Appendix P). Of those significant plant species that are found in coastal wetlands in Ontario, one species, Bluehearts, has only been reported for Lake Huron (Appendix P).

Fifty-nine fish species utilize the coastal wetlands of Lake Huron (Severn Sound Remedial Action Plan, 1993a; Prince *et al.,* 1992). Over half are permanent residents while the remainder use them on a temporary basis for feeding, shelter, spawning, nursery, and dispersal of young. Largemouth Bass, Rock Bass, Bluntnose Minnow, Pumpkinseed and Banded Killifish are the most common permanent residents (Severn Sound Remedial Action Plan, 1993a). Sportfish such as Northern Pike, Walleye, Muskellunge and Smallmouth Bass also depend on these wetlands along with many species of bait fish. The five provincially significant fish species that use these coastal wetlands are Pugnose Shiner, Lake Chubsucker, Grass Pickerel, Black Bullhead and Longear Sunfish (Appendix Q).

Lake Huron wetlands also provide important habitat for amphibians and reptiles. The amphibians use them for breeding, nursery and feeding. Reptiles nest on uplands, but many species spend the remainder of their life cycle in these wetlands. Five provincially significant reptile species have been found in the coastal wetlands of Lake Huron and Georgian Bay: Spotted Turtle, Eastern Spiny Softshell Turtle, Queen Snake, Eastern Fox Snake and Eastern Massasauga Rattlesnake (Appendix R). One provincially significant amphibian species, Jefferson Salamander, has been reported in the coastal wetlands of Lake Huron and Georgian Bay (Appendix R).

Prince *et al.* (1992) identified the marshes of Georgian Bay as significant areas of waterfowl production for the Great Lakes. At least 2,100 pairs of dabbling ducks nest in Georgian Bay wetlands. The wetlands of Lake Huron are also important during migration for provincially significant species such as the Red-necked Grebe, Northern Shoveler, and Redhead (Appendix S). In terms of coastal wetland use for breeding in Lake Huron and Georgian Bay, 12 provincially significant species have been reported, including Great Egret, Redhead, Ruddy Duck, and Little Gull. See Appendix S for complete listings.

Two provincially significant lepidopteran species, Mulberry Wing and Two-spotted Skipper, have been reported in Lake Huron coastal wetlands (Appendix T).

Lake Huron wetlands provide habitat for many fur-bearing mammals including Mink, Beaver, River Otter, Raccoon, Red Fox and Muskrat. In south and central Lake Huron, the coastal swamps provide significant winter cover for White-tailed Deer. Moose occur in the wetlands along the north shore of Georgian Bay.

5.3.3 Wetland Status

No comprehensive estimates of coastal wetland loss are available for the Canadian shore of Lake Huron. Loss of wetland habitat on a large scale has not occurred because most of the shoreline is sparsely populated and remote. Most loss tends to be concentrated around the small urban centres that dot the shore. Within the last 15 years, there has been incremental and site-specific loss of wetland area from agricultural encroachment and cottage development. More than half of the wetlands along the central coast, the western coast of the Bruce Peninsula and southern Georgian Bay have suffered recent loss of acreage (Appendix G). A study of wetland loss in Severn Sound in southern Georgian Bay indicated that wetland habitats have decreased by 68% and 18% in Penetanguishene and Hog Bay respectively since 1951 (Severn Sound Remedial Action Plan, 1993b). The main causes of these wetland losses are shoreline modification, road construction, filling for urban and cottage development and dredging and channelization associated with marina development (Severn Sound Remedial Action Plan, 1993a). The wetlands along the shoreline of the North Channel and northern Georgian Bay have only suffered small losses, however cottaging, and marina and subdivision development continually put pressure on these coastal wetlands through dredging and modification of the shoreline (W. Selinger, pers. com., 1996). Along the rest of the Canadian shore, remaining wetlands do not appear to be as impacted by human stresses as compared to the southern Great Lakes. Stresses appear to be site-specific and localized.

In addition to outright wetland loss, urban encroachment, cottaging and marinas cause multiple stresses on remnant wetlands. On the western Bruce Peninsula and southern Georgian Bay, these stressors include shoreline modification, road crossings, dredging and channelization. Shoreline modification prevents the landward migration of remnant wetlands during high water periods. Road crossings alter wetland hydrology and, along with dredging, filling and channelization, fragment the remaining wetland habitat.

Wetlands in the bays of southeastern Georgian Bay are affected by nutrient and sediment loading from watersheds. Excessive phosphate inputs to these bays originate from point and non-point sources associated with urban areas and agriculture (Severn Sound Remedial Action Plan, 1993a). Excess sediment loadings originate mostly from non-point source inputs, mainly agricultural runoff (Severn Sound Remedial Action Plan, 1993a).

Non-indigenous species including Purple Loosestrife, Common Carp and Zebra Mussels are also localized stressors in Georgian Bay. Purple Loosestrife is especially a problem in southern Georgian Bay (G. Allen, pers. com., 1996).

5.4 St. Clair River

5.4.1 Setting

The St. Clair River drains Lake Huron into Lake St. Clair. It forms a large bird-foot delta with many distribution channels and wetlands where it meets the lake. This delta is a transitional environment between the river and the lake. For the sake of clarity in the Atlas, the delta and its coastal wetlands are covered under the assessment of wetlands of Lake St. Clair. The first 43 km of the St. Clair River are considered here, between Lake Huron at Sarnia-Port Huron and the first distribution channel of the delta, Chenal Ecarte across from Algonac.

The river above the delta is a uniform channel with very few bends or meanders, no cut-off channels nor oxbow lakes and only two islands, Stag Island and Fawn Island (Edsall *et al.*, 1988). The river drops only 1.4 m between Lake Huron and the beginning of the delta at Chenal Ecarte, but it has relatively high flows, with an average flow velocity reaching 3.2 km/hr. The natural shoreline has a bank 1.5 to 5 m high (International Joint Commission, 1989), but most of this shoreline is now artificial (Ontario Ministry of the Environment and Michigan Department of Natural Resources, 1991).

The overwhelming majority of the flow in the river comes from Lake Huron. Including the delta, the drainage basin of the river is 3,368 km^2 and is mostly agricultural (69%). The urban areas are concentrated in a narrow zone along the river with the larger centres being Sarnia, Ontario and Port Huron, Michigan. Much of the industry is concentrated in Ontario in the first 14 km of the river between Sarnia and Corunna, a stretch of shoreline known as “Chemical Valley”.

The lack of shoreline complexity along with the fast current, the depth of the river and wave forces generated by the passage of large commercial vessels limits wetland development along the banks of the river (Bookhout *et al.*, 1989; Edsall *et al.*, 1988). Wetlands occur primarily on the shallow submerged shoals of the river and tributary channels and consist mostly of submergent macrophyte beds (Griffiths *et al.*, 1991; Edsall *et al.*, 1988).

There is no clear estimate of the area of coastal wetland in the St. Clair River above the delta. Edsall *et al.*, (1988) identified 550 ha of coastal wetlands in the entire St. Clair River based on navigation charts and topographic maps, but did not provide the location and size of individual wetlands. Bookhout *et al.* (1989) identified 96 ha of coastal wetland along the Ontario shore. Extensive submergent macrophyte beds are known to occur in Sarnia Bay, around Stag and Fawn Islands and along the Canadian shoreline near these islands (Griffiths *et al.*, 1991). OMNR has evaluated five wetlands for the St. Clair River totalling 87 ha. In Ontario, just over 13 ha of wetlands have been evaluated along the river itself, namely the Stag Island Marsh and the Point Edward Marsh. These estimates indicate that coastal wetlands are uncommon habitats in the St. Clair River above the delta (Figure 3; Appendix I). The remaining wetlands are therefore particularly important habitats for plants, fish and wildlife in the river.

5.4.2 Significant Features

Coastal wetlands of the St. Clair River are primarily composed of submergent species, but emergent macrophytes also occur (Griffiths *et al*., 1991; Edsall *et al.*, 1988). Five provincially significant plant species have been found in the shallow water and meadow marshes: Angled Spike-rush, Winged Loosestrife, Swamp Rose Mallow, Riddell’s Goldenrod and Walter's Barnyard Grass (Appendix P).

Unlike Lake St. Clair and the delta of the river, the wetlands of the river above the delta are not important breeding sites or migration corridors for waterfowl (Bookhout *et al.*, 1989). Waterfowl overwinter in wetlands in the river when nearby marshes with less current are frozen since thermal pollution and current keep the river open. Common species are Common Merganser, Redhead, Canvasback, American Widgeon, Mallard and scaup. One provincially significant bird species, Forster's Tern, has been reported to breed in the wetlands of the St. Clair River (Appendix S).

Forty-five species of fish have been recorded using the wetlands of the St. Clair River (Mandrak and Crossman, 1992; Edsall *et al.* 1988). Over half of these are permanent residents, with Brown Bullhead, Common Carp and White Perch being the most abundant. Other species use the wetlands on a temporary basis for spawning, nursery and feeding; the most abundant species include the White Sucker, Alewife, Rainbow Smelt, Gizzard Shad and Rock Bass. Several important sport fish also use the wetlands on a temporary basis including Northern Pike, Muskellunge, Walleye, Yellow Perch, Smallmouth Bass and Largemouth Bass (Edsall *et al.*, 1988). Two provincially significant fish species, the Pugnose Minnow and Black Bullhead, have been reported in St. Clair River coastal wetlands (Appendix Q).

Many species of amphibians and reptiles, including salamanders, frogs, toads, snakes, lizards and turtles, also occur in these wetland habitats (Edsall *et al.* 1988). Three provincially significant reptiles inhabit St. Clair River wetlands, namely the Eastern Spiny Softshell Turtle, Butler's Garter Snake and the Eastern Fox Snake (Appendix R).

No provincially significant lepidopteran species were reported for St. Clair River coastal wetlands (Appendix T).

Mammals commonly found in coastal wetlands of the St. Clair River include the Virginia Opossum, Eastern Cottontail Rabbit, Muskrat, Striped Skunk and White-tailed Deer (Edsall *et al.,* 1988).

5.4.3 Wetland Status

Some wetland loss appears to have occurred along the shores of the St. Clair River above the delta, but there is no comprehensive estimate of the extent of this loss. In Ontario, there are known wetland losses of 3 ha at Point Edward Marsh and 40 ha at Stag Island Marsh.

Almost all of the U.S. shoreline and most of the Canadian shoreline have been extensively modified and consist of residential, recreational and industrial developments (Edsall *et al.*, 1988). The river is also an important port. As such, wetland loss in the river appears to be largely related to extensive bulkheading, shoreline hardening, filling, channelization and dredging along the shores of the river. These activities also fragment the few remaining wetlands along the river. Urban encroachment continues to cause wetland loss and impairment on the Canadian side (D. Hector, pers. com., 1996).

Several other human activities stress remnant wetlands along the river. The river is a busy seaway and port. Ship wakes from large commercial vessels are a significant stressor to shoreline habitats, including remnant coastal wetlands, eroding the shoreline and hampering the establishment of aquatic macrophytes.

The St. Clair River was declared an Area of Concern (AOC) as a result of the excessive levels of toxic substances in the water, contaminated sediments, impaired benthos and bacterial contamination (Hartig and Thomas, 1988). Industry is the main source, but municipal sewage treatment plants, other point and non-point sources of pollution are also concerns (St. Clair River Remedial Action Plan, 1995). Remnant wetlands are particularly vulnerable to contamination by toxic chemicals since they are located in sediment accumulation zones along the shore.

5.5 Lake St. Clair

5.5.1 Setting

Lake St. Clair is a shallow productive lake located between the St. Clair River and the Detroit River. Where the St. Clair River meets Lake St. Clair, an expansive bird-foot delta has formed which has many distribution channels, islands and wetlands. This delta is included in the assessment of the coastal wetlands of Lake St. Clair.

Lake St. Clair is heart-shaped with a surface area of 1,115 km^2 (Edsall *et al.*, 1988). The basin is very shallow and has a maximum natural depth of 6.5 m, although a commercial shipping channel has been dug across the lake to a depth of 8.5 m. The shoreline, excluding the distributary channels in the delta, extends 272 km (Edsall *et al.*, 1988). Several large tributaries flow into the lake including the Sydenham River and the Thames River in Ontario and the Clinton River in the United States. Together they drain a watershed of 12,616 km^2, in which agricultural land uses predominate (Edsall *et al.*, 1988). These tributaries contribute 2% of the flow to the lake; the remainder flows from the St. Clair River.

The St. Clair River enters the lake in the northeast forming a large delta. The topography is very flat and the river drops 0.2 m over 17 km through the delta (Edsall *et al.*, 1988). There are numerous distribution channels, but the majority of the flow (92%) passes through the western half of the delta through the North, Middle and South Channels. This delta is the product of long-term geological and riverine processes; its development is linked to the deposition of sediments as the river slows to meet the lake. Sediments that continue to feed this delta originate from the nearshore areas of southern Lake Huron (Edsall *et al.*, 1988).

Lake St. Clair and the St. Clair Delta contain some of the largest coastal wetlands in the Great Lakes. There are many estimates of the aerial extent of these wetlands. However, since the topography surrounding much of the lake and especially in the delta is almost flat, water level fluctuations greatly affect their extent and position. Large changes in wetland area are especially great between years of high and low water levels (Herdendorf *et al.*, 1986). While these changes are important for the diversity of habitat, they make it difficult to compare different estimates of wetland extent in the lake.

The largest wetlands in the lake are found in the St. Clair Delta, which harbours a vast complex of lacustrine, riverine and palustrine wetlands. On the Canadian side of the St. Clair Delta, there are at least 12,769 ha of coastal wetlands (D. Hector, pers. com., 1996). The majority of wetlands, approximately 10,360 ha are on Walpole Island First Nation and have not been evaluated (Appendix J). Five other wetlands, totalling approximately 2,522 ha, have been evaluated on the Canadian side of the delta ranging from just under 4 ha to 2,335 ha, the largest being the St. Clair Marshes Complex in Mitchell's Bay (2,335 ha) (Figure 3; Appendix I). Of these wetlands, approximately one third of the area has been diked for intensive waterfowl management (Bookhout *et al.*, 1989).

Beyond the delta, remnant lacustrine marshes occur primarily near mouths of rivers and creeks along the northern and eastern shores of the lake. Very few wetlands occur along the highly developed southern and western shores. In Ontario, three wetlands are located along the eastern shore totalling 159 ha and ranging from 4 ha to 131 ha; the largest occurs at the mouth of the Thames River (131 ha) (Figure 3; Appendix I). Many of these wetlands are diked (Herdendorf *et al.*, 1986). Only one small wetland, Ruscom Shores Marsh (29 ha), is found on the southern shore.

5.5.2 Significant Features

Herdendorf *et al.* (1986) identified twelve different wetland habitats in Lake St. Clair and the delta, each with different vegetation and environmental characteristics. As a result of this range of habitats and the size of the wetlands, Lake St. Clair has some of the most diverse wetlands in the Great Lakes for plants, fish and wildlife. These wetlands provide habitat for many common species, but also provide some of the most important habitat for rare flora and fauna.

Nineteen provincially significant plant species have been found in the coastal wetlands of Lake St. Clair (Appendix P). These include the very rare Angled Spike-rush, as well as Southern Tickseed, Honey Locust, American Lotus, Many-fruited False Loosestrife, Round-stemmed Purple False Foxglove, Pale Purple False Foxglove, Hairy Fimbristylis and the globally rare Eastern Prairie White-fringed Orchid. Of those significant plant species that are found in coastal wetlands in Ontario, one species, Hairy Fimbristylis has only been reported for Lake St. Clair (Appendix P).

Lake St. Clair marshes provide habitat for more than 65 species of fish (Mandrak and Crossman, 1992; Edsall *et al.*, 1988). Two-thirds of the fish species are permanent residents; the most common species are Rock Bass, Bluegill, Black Bullhead, Yellow Bullhead, Channel Catfish, Alewife**,** White Perch and Common Carp. Other fish use the wetlands on a temporary basis for spawning, nursery, shelter or feeding; common species include White Sucker, and Rainbow Smelt. Several sportfish also commonly use these wetlands, including Northern Pike, Muskellunge, Walleye, Yellow Perch, Smallmouth Bass, Crappie and sunfish species (Jude and Pappas, 1992; Edsall *et al.*, 1988). Lake St. Clair is one of only two sites with large Muskellunge populations in the Great Lakes (Edsall *et al.*, 1988). The only large spawning area left for Muskellunge in Lake St. Clair is in Anchor Bay, Michigan, while the shallow marshes of the delta are the only known nursery areas for Muskellunge in the entire St. Clair River, Lake St. Clair and Detroit River system (Edsall *et al.*, 1988). Six provincially significant fish species, Pugnose Shiner, Pugnose Minnow, Lake Chubsucker, Grass Pickerel, Black Bullhead, and Longear Sunfish, have been reported in Lake St. Clair coastal wetlands (Appendix Q).

Many species of amphibians and reptiles also occur in the wetland habitats of Lake St. Clair, including salamanders, frogs, toads, snakes, lizards and turtles (Edsall *et al.*, 1988). Four provincially significant reptile species inhabit Lake St. Clair coastal wetlands: Eastern Fox Snake, Queen Snake, Spotted Turtle and Eastern Spiny Softshell Turtle (Appendix R).

The St. Clair Delta has been identified as one of the most significant areas for waterfowl production, staging and migration in the Great Lakes (Prince *et al.*, 1992; Bookhout *et al.*, 1989). Approximately 16% of all Great Lakes coastal wetlands of importance to waterfowl are found in the St. Clair Delta (Prince *et al.*, 1992). In terms of breeding waterfowl, the highest densities of Mallard, Black Duck, Blue-winged Teal and Green-winged Teal in the Great Lakes basin are found in the wetlands of the St. Clair Delta. Redhead is the only species of diving duck that breeds regularly in the Great Lakes, and the St. Clair Delta wetlands produce up to 4,000 Redheads annually (Prince *et al.*, 1992). Delta wetlands also provide nesting habitat for Canada Geese and Ruddy Duck. Furthermore, the St. Clair Delta lies in major migration corridors of both dabbling and diving ducks (Bookhout *et al.*, 1989). They provide one of the most important staging and feeding grounds for post-breeding and migratory Canada Geese, Tundra Swans and dabbling ducks on the Great Lakes. The delta is also one of the major fall staging areas in North America for Canvasback and Redhead (Prince *et al.*, 1992).

Lake St. Clair coastal wetlands provide habitat for many other species of birds. American Coot, Herring Gull, Common Tern, Red-tailed Hawk and Northern Harrier are commonly observed in Lake St. Clair marshes (Herdendorf, 1992). Waterbirds such as Great Blue Heron, American Bittern, Least Bittern, King

Rail, Great Egret and Black-crowned Night Heron breed here. Large nesting colonies of Great Blue Heron and Black-crowned Night-Heron occur in the marshes of Walpole Island (Smith *et al*., 1991). Walpole Island marshes also support the largest number of nesting pairs of Forster's Tern on the Great Lakes and provide nesting habitat for the Black Tern (Smith *et al*., 1991). Eleven provincially significant bird species breed in the coastal wetlands of Lake St. Clair. Some of the more notable species include Great Egret, Canvasback, Least Bittern, King Rail, Ruddy Duck and Redhead (Appendix S). See Appendix S for complete listing.

One provincially significant lepidopteran species, Duke's Skipper, has been reported in Lake St. Clair coastal wetlands (Appendix T).

More than a dozen species of mammals use the Lake St. Clair wetlands. The Virginia Opossum, Eastern Cottontail Rabbit, Muskrat, Striped Skunk and White-tailed Deer are common (Edsall *et al.,* 1988). Muskrat and Raccoon are important furbearers and are extensively trapped in the region.

5.5.3 Wetland Status

Lake St. Clair and the St. Clair delta have been extensively studied in terms of wetland loss. Overall, these wetlands were reduced by 9,139 ha or by 41% between 1868 and 1973. The most extensive losses have occurred at the mouth of the Clinton River, in the St. Clair Delta and along the eastern shore of the lake (Herdendorf *et al*., 1986).

Along the Ontario shoreline, 4,764 ha or 34% of coastal wetlands have been lost in the delta and the lake between 1873 and 1968 (Edsall *et al*., 1988). In 1873, the wetlands along the eastern shoreline of the lake were approximately 2.5 km wide, but by 1968, wetlands were reduced in width to approximately 0.8 km. Much of this loss was due to large scale conversion of wetlands to agricultural land. More recently, between 1965 and 1984, wetlands along the east shore of the lake, from the mouth of the Thames River to Chenal Ecarte, further dwindled by 1,064 ha (McCullough, 1985). This loss was mostly a result of agricultural drainage (89%), but some loss was due to marina and cottage development (11%). The wetlands on the Ontario side of the St. Clair Delta are intact in many places, but shoreline development, dredging and placement of dredge spoils have taken their toll. Between 1965 and 1978, 508 ha or 4.5% of the wetlands on Walpole Island were lost (McCullough, 1982). Recently, wetland loss to agricultural and urban development has continued in the lake and delta, albeit at a slower pace (D. Hector, pers. com., 1996).

Urban, recreational and agricultural encroachment have not only caused wetland loss but also stress remaining wetlands. In many cases, shoreline hardening such as breakwaters, jetties, and bulkheading restrict the landward migration of wetland communities during high water periods. This causes a backstopping effect that reduces the size and diversity of wetland communities. Recreational and urban developments also fragment the remaining wetland area.

Another major stress is the diking of wetlands. About half of the wetlands in Lake St. Clair and the St. Clair Delta have been diked (Bookhout *et al*., 1989). They are managed mainly for waterfowl hunting at the expense of other wetland functions (Jude and Pappas 1992; Herdendorf *et al.,* 1986). Diking isolates these wetlands from the upland and lake environments, and many wetland functions are impaired. Their use by fish for spawning, nursery or feeding is impeded or cannot take place. Many of the fish species in the lake are dependent on wetlands for part of their life cycle (Edsall *et al*., 1988). Diking also reduces organic material inputs into the lake thereby disrupting the food chain in the lake (Herdendorf *et al*., 1986). Other stresses to these wetlands include sediment and nutrient loading from tributaries and invasive species such as Reed Canary Grass and Purple Loosestrife (D. Hector, pers. com., 1996).

5.6 Detroit River

5.6.1 Setting

The Detroit River connects Lake St. Clair to Lake Erie. It is 51 km long and drops 0.9 m along its length (Manny *et al.*, 1988). The shoreline stretches 107 km on the Canadian side and 127 km on the U.S. side (International Joint Commission, 1989). Several islands occur in the river, with the largest, Grosse Ile, near its mouth. About 95% of the total flow in the river enters from Lake St. Clair (Manny *et al.*, 1988), and the remainder flows from tributaries and sewer systems, draining a watershed of 1,844 km^2 (Manny and Kenaga, 1991). The Canadian portion of this watershed is largely agricultural (90%), and the remainder consists of urban, residential and industrial lands, centred around Windsor in the northern reaches of the river (Manny and Kenaga, 1991). Over five million people live in the Detroit River watershed. The natural shoreline consists of clay banks, but 20% of the Canadian shoreline is now artificial with revetments and other shoreline hardening structures (International Joint Commission, 1993; Manny and Kenaga, 1991).

Along the Canadian shore, four coastal wetlands have been evaluated by OMNR, primarily in the middle reaches of the river. They total approximately 1,136 ha and range in size from 32 ha to 575 ha (Figure 3; Appendix I). The Detroit River Marshes near Fighting Island represent the largest wetland complex (575 ha). One small wetland is found on Fighting Island, and the remaining wetlands are associated with tributaries entering the river, including the large Canard River Marshes wetland complex (416 ha) and the Turkey Creek Marsh (32 ha). Approximately half of the Canard River wetland is diked for intensive waterfowl management (Manny *et al.*, 1988).

5.6.2 Significant Features

Typically, coastal wetlands along the Detroit River are riverine and river-mouth marshes, sometimes with a small swamp component (Smith *et al.*, 1991). They are often dominated by submergent macrophyte communities (Manny *et al.*, 1988). Seventeen provincially significant plants have been found in these wetlands, including Seedbox, Southern Tickseed, and Honey Locust (Appendix P). See Appendix P for complete listings.

At least 45 species of fish inhabit Detroit River wetlands, 21 of which are permanent residents (Herdendorf, 1992; Mandrak and Crossman, 1992). The most abundant species are Northern Pike, Gizzard Shad, Bowfin, Common Carp, Goldfish, Carp-Goldfish hybrids, Golden Shiner, Blacknose Shiner, White Sucker, Brook Silverside, Rock Bass, Pumpkinseed, Black Crappie and Yellow Perch (Herdendorf, 1992). Other species which use these wetlands for spawning include Lake Sturgeon, Muskellunge, Channel Catfish, Largemouth Bass, Smallmouth Bass, Bluegill and Walleye (Herdendorf, 1992). Two provincially significant species of fish, the Black Bullhead and Pugnose Minnow, also use the wetlands (Appendix Q).

Many species of reptiles and amphibians inhabit Detroit River wetlands. These coastal wetlands offer particularly important habitat since the surrounding landscape has been dramatically altered. Five provincially significant species of reptiles have been identified in these wetlands: the Eastern Fox Snake, Eastern Massasauga Rattlesnake, Queen Snake, Butler's Garter Snake and the Eastern Spiny Softshell Turtle (Appendix R).

The wetlands of the Detroit River are significant for Great Lakes waterfowl production (Prince *et al.*, 1992; Bookhout *et al.*, 1989). The marshes provide important resting and feeding grounds for post-breeding and migratory Canada Geese, Tundra Swan and dabbling ducks. These birds are especially attracted to the diked wetlands of the Canard River along the Canadian shore where there are large areas of emergent wetlands with controlled water levels and adjacent agricultural fields. Many waterfowl winter in wetlands of the Detroit River because they remain open from commercial navigation and thermal pollution (Manny *et al.*, 1988). For instance, about 11,700 and 4,500 ducks wintered in the wetlands of the Detroit River in 1980 and 1981, respectively (Bookhout *et al.*, 1989). The wetlands also provide habitat for many other bird species. Provincially significant bird species reported to breed in these wetlands include Least Bittern, Northern Shoveler and White-eyed Vireo (Appendix S).

Two provincially significant lepidopteran species, Two-spotted Skipper and Mulberry Wing, have been reported in Detroit River coastal wetlands (Appendix T).

5.6.3 Wetland Status

No comprehensive estimate of the extent of wetland loss along the shores of the Detroit River exists. From depth surveys of the river in the 1870s, wetlands and large submergent macrophyte beds were nearly continuous along the shores of the river in historic times. A fringe of emergent vegetation occurred all along the shores of the river in waters 0.3 m to 2.0 m deep (Manny *et al.*, 1988). Emergent marshes extended inland from these depths and were sometimes over 1 km wide, especially near the mouths of tributaries. Today, around 87% of the U.S. shoreline of the Detroit River has been filled and bulkheaded (Manny and Kenaga, 1991), and more than 20% of the Canadian shoreline is artificial with revetments and hardened shorelines, especially in the northern sections of the river in Windsor (International Joint Commission, 1993). Consequently, many of the historic coastal wetlands have been lost through dredging, bulkheading and/or backfilling. The remaining wetlands mostly occur on islands in the river. In recent years, loss of wetland along the shores has diminished, but incremental loss from agricultural conversion, shoreline modification, marina development, and urban encroachment is still a concern (Appendix I).

Many human stressors continue to impact remaining wetlands, including erosion from shipping, shoreline modification, dredging and channelization, excess nutrients, contamination of water and sediments with toxic chemicals, agricultural and urban encroachment and invasive non-indigenous species (D. Hector, pers. com., 1996; Manny and Kenaga, 1991; Manny *et al.*, 1988).

The Detroit River is one of the busiest shipping channels in the Great Lakes. Commercial and recreational vessels cause excess wave action, changes in shoreline currents, and erosion of wetlands along the shores (Manny *et al.*, 1988). Shoreline hardening is the common solution to this erosion. Where this hardening occurs adjacent to remaining wetlands, it restricts their connection to upland habitats and prevents upslope migration during high water periods, greatly reducing the diversity of habitats.

The shipping channel is dredged each year for navigation, substantially altering the river morphology (Manny *et al*., 1988). Sediment dynamics in the river are altered, but it is not known how these changes affect the distribution and status of wetlands. Dredging and channelization associated with the numerous smaller marinas, canals and boat slips also stress remaining wetland areas through wetland loss, fragmentation, changes in sediment dynamics, and increased erosion from wave action (D. Hector, pers. com., 1996).

The busy nature of the port, the large urban areas and the numerous industries contribute to the pollution of the river and its wetlands. The Detroit River has been identified as an Area of Concern. Excessive phosphates from combined sewers and other sources have caused the eutrophication of wetland communities which reduces plant and wildlife diversity. As well, sediments in many stretches of the river are contaminated with heavy metals, oils, and PCBs, especially along the U.S. side of the river (Manny *et al.* 1991; Nichols *et al.*, 1991). Wetlands and other nearshore habitats are especially vulnerable to toxic substances since they are deposition zones for sediments (Manny *et al.*, 1988). Submergent plants have been found to concentrate these contaminants and are used as food sources for fauna, including waterfowl (Manny *et al.*, 1991). Toxic effects and bioaccumulation are therefore important stressors to wetlands in the Detroit River.

Several exotic species are present in Detroit River wetlands that affect the composition and structure of wetland communities. Invasive plant species of concern include Eurasian Water Milfoil and Curled Pondweed (Manny *et al.*, 1988). Large populations of Common Carp are also now established in the river, and destroy submergent macrophyte beds, increase turbidity and displace native fish species (Manny *et al.*, 1988).

The diking of wetlands, such as parts of the Canard River Marshes, provides high quality habitat for waterfowl and some other fauna, but unfortunately also isolates them from the river, reducing their function in the river ecosystem (Manny *et al.*, 1988).

5.7 Lake Erie

5.7.1 Setting

Lake Erie has a surface area of 25,657 km^2 and a shoreline that extends 1,402 km (Herdendorf, 1992). Several large sand spits project into the lake, including Long Point, Turkey Point, Rondeau Peninsula, and Point Pelee, and a series of small islands occurs in the western part of the lake (Figure 4). The lake basin can be naturally divided into three sub-basins: the western basin to the west of Point Pelee, the central basin between Point Pelee and Long Point, and the eastern basin to the east of Long Point. Lake Erie is the shallowest of the Great Lakes, and is particularly subject to the effects of storms, wind tides, and seiches (Bedford, 1992).

Lake Erie, together with the St. Clair River, Lake St. Clair, and the Detroit River, has a watershed of 78,769 km^2 (PLUARG, 1978). Most of this watershed is agricultural (59%); the remaining land is forested (17%), residential or industrial (15%) or under other land uses (9%) (PLUARG, 1978). Only approximately10% of the flow entering the lake comes from tributaries, while the remainder flows from the Detroit River (Herdendorf, 1987).

Extensive coastal wetlands have developed behind the large sand spits and at river and creek mouths. In total, 30 wetlands occur covering approximately 19,330 ha, and ranging in size from just over 3 ha to 13,465 ha (Figure 4; Appendix K). Over half are wetland complexes, consisting mostly of marshes with some swamp and latitudinaly rare fen and bog components. In the western basin, there are 10 coastal wetlands covering approximately 3,033 ha (D. Hector, pers. com., 1996). The largest are barrier beach marshes at Point Pelee (1,175 ha) and drowned rivermouth marshes at Big Creek (1,000 ha), Cedar Creek (250 ha) and Hillman Creek (362 ha). Smaller wetlands are also found on Pelee Island and East Sister Island. In the central basin, five wetlands totalling 1,751 ha are found along the Canadian shoreline, with the marsh and swamp in Rondeau Provincial Park (930 ha) being the largest (D. Hector, pers. com., 1996). In the eastern basin, there are 15 wetlands along the Canadian shoreline, totalling approximately 14,543 ha (Appendix K). The most important wetlands of the eastern basin are the wet meadows, forested swamps, deep-water cattail marshes and shallow-water grass and sedge marshes and ponds protected by Long Point (Prince *et al.* 1992). These Long Point wetlands encompass 13,465 ha and include more than 70% of the total wetland area along the north shore of Lake Erie (R. Thompson, pers. com., 1996). The remaining wetlands along the eastern basin occur primarily at river and creek mouths, including the Dunnville Marsh complex (518 ha) at the mouth of the Grand River (G. Birch, pers. com., 1996).

5.7.2 Significant Features

The coastal wetlands of Lake Erie support the largest diversity of plant and wildlife species in the Great Lakes. As reported in the wetland evaluations, of all the Great Lakes and connecting channels in Ontario, the greatest number of provincially significant reptile and amphibian, vascular plant, lepidopteran, bird and fish species have been reported for Lake Erie wetlands (Appendices P to U).

The moderated climate and more southern latitude of Lake Erie allow many species not found along the northern Great Lakes to exist here. For instance, over 300 species of plants have been identified in the aquatic and wetland habitats of western Lake Erie (Herdendorf, 1992). In the open water of the lake and larger bays, submergent species predominate, including several species important to wildlife, such as Wild Celery, and Sago Pondweed (Herdendorf, 1992). Water lilies such as the White Water Lily, Yellow

Water Lily and the American Lotus are not common, but where they do grow they form extensive colonies.

The diverse coastal wetlands of Lake Erie provide habitat for many rare species of flora. Rare wetland communities such as coastal meadow marsh (fen) occur at several locations including Long Point. Sixty-one provincially significant plant species have been found in the coastal wetlands of Lake Erie (Appendix P). Some of the most provincially significant species found in these wetlands include, Scarlet Ammannia, Winged Oval Sedge, Small White Lady's Slipper, Engelmann's Spike-rush, Rigid Yellow Flax and Bayberry (Appendix P). Other examples of provincially significant plant species include Crested Arrow-head, American Lotus, Riverbank Sedge, Swamp Rose Mallow, and Eastern Prairie White Fringed Orchid (Appendix P). Of those significant plant species that are in coastal wetlands in Ontario, seven species, Winged Oval Sedge, Horsetail Spike-rush, Knee Spike-rush, Leafy Blue-flag, American Water-willow, Spotted Pondweed, and Bushy Cinquefoil have only been reported for Lake Erie (Appendix P).

Coastal wetlands of Lake Erie are important to fish production because they provide spawning and nursery habitat for many wetland dependent species, cover for juvenile and forage fish, and feeding areas for predatory fish. Many are important recreational or commercial fish species. Forty-six species of fish have been captured in Lake Erie wetlands. An additional eighteen species captured in open water are known to use wetlands during some part of their life cycle (Jude and Pappas, 1992). The most abundant permanent residents of Lake Erie coastal wetlands are White Crappie, Gizzard Shad, Black Bullhead, White Perch, White Bass, Log Perch and Freshwater Drum. Other species such as White Sucker, Common Carp, Emerald Shiner, Spottail Shiner and Yellow Perch are abundant temporary residents (Jude and Pappas, 1992). Many fish species in these wetlands are rare in the Great Lakes, including the provincially significant Spotted Gar, Lake Chubsucker, Longear Sunfish, Grass Pickerel and Warmouth (Appendix Q).

Many species of snakes, turtles, frogs and salamanders are dependent on Lake Erie wetlands. Twenty-eight species of amphibians and twenty-seven species of reptiles inhabit the Lake Erie region, most of which are found in coastal wetlands for part of their life cycle (Herdendorf, 1992). The four provincially significant amphibian species found in Lake Erie coastal wetlands are Jefferson's Salamander, Smallmouth Salamander, Fowler's Toad, and Blanchard's Cricket Frog (Herdendorf, 1992; Appendix R); the last three species are restricted in Canada to the shores of Lake Erie. Seven provincially significant reptile species have also been found: Spotted Turtle, Eastern Spiny Softshell Turtle, Queen Snake, Eastern Fox Snake, Lake Erie Water Snake, Butler's Garter Snake and Eastern Massasauga Rattlesnake (Appendix R). In Canada, the Lake Erie Water Snake is confined to the western shores of Lake Erie, and is predominantly found in coastal wetlands.

Wetlands of Lake Erie support a wide diversity of bird life. Waterfowl, wading birds, shore birds, gulls and terns, raptors and perching birds use Lake Erie wetlands for migration, nesting and feeding. The wetlands in western Lake Erie from the mouth of the Detroit River to Sandusky Bay, and those at Point Pelee, Rondeau Bay and Long Point have been identified as some of the most important waterfowl habitat complexes in the Great Lakes (Prince *et al.*, 1992). For instance, large numbers of post-breeding dabbling ducks and Canada Geese, and thousands of Tundra Swans stop annually in southwestern Lake Erie coastal wetlands (Prince *et al.*, 1992). As well, Long Point is one of the major staging areas in North America for Canvasback and Redhead. Wetlands of southwestern Lake Erie and Long Point also provide a major stop over point for diving ducks such as migrating Bufflehead, Common Goldeneye, Red-breasted Merganser, Common Mergansers and Ruddy Duck (Prince *et al.,* 1992). The provincially significant Ruddy Duck and Northern Shoveler have also been reported to nest in the coastal wetlands of Lake Erie (Appendix S).

In terms of other bird species, wetlands adjacent to the large sand spits such as Point Pelee, Rondeau Peninsula, and Long Point attract many migratory species that cross the lake. Several provincially significant bird species also occur in Lake Erie coastal wetlands. Bald Eagles nest near these wetlands, feed in them and also use them during migration. The swampy woodlands associated with the marshes support rare species such as Great Egret and Black-crowned Night-Heron. Other provincially significant birds nesting in Lake Erie wetlands include Wilson's Phalarope, King Rail, Least Bittern, Little Gull, Forster's Tern, Black Tern, Acadian Flycatcher, White-eyed Vireo, Prothonotary Warbler, Louisiana Waterthrush, Cerulean Warbler and Yellow-headed Blackbird (Appendix S).

Three provincially significant lepidopteran species, Mulberry Wing, Two-spotted Skipper and Duke's Skipper, have been reported in the coastal wetlands of Lake Erie (Appendix T).

About 20 species of mammals utilize Lake Erie marshes (Herdendorf, 1992). Furbearers such as Raccoon and Mink can be found near the marshes where they feed, and Muskrat are common throughout. White-tailed Deer are common around the upland edges of many of these wetlands.

5.7.3 Wetland Status

Estimates of the loss of coastal wetlands along the Canadian side of Lake Erie are not comprehensive. Loss of coastal wetland area has mostly occurred in the vicinity of the large sand spits such as Point Pelee. Agricultural land drainage has been identified as the most significant factor in the decline of these wetlands (Lynch-Stewart, 1983). For instance, the area of Point Pelee Marsh declined by 71%, from 3,878 ha in 1880 to 1,126 ha in the mid-1970s (Rutherford, 1979). The bulk of wetland drainage occurred in the 1890s when 50% of Point Pelee Marsh was converted into agricultural lands. Large portions of remaining coastal marshes are either parks or are privately-owned and managed for waterfowl hunting. Although wetland loss has slowed in recent decades, site-specific incremental loss is still a concern.

In addition to actual loss of coastal wetland acreage along the shores of Lake Erie, the quality of many remaining wetlands has been degraded by numerous stressors, especially excessive loading of sediment and nutrients, contaminants, shoreline modification, changes in sediment budgets, exotic species and diking of wetlands.

Turbidity and excessive suspended solids are significant stressors to coastal wetlands of Lake Erie (Herdendorf ,1992, 1987; Jude and Pappas, 1992; Appendix K). The waters of marshes and many bays have become turbid in the last century as a result of erosion from agriculture, dredging, diking and drainage of many large wetlands, shoreline modification and the introduction of Common Carp (Herdendorf, 1987). Many tributaries of western Lake Erie have watersheds dominated by clay soils; the western basin is consequently more turbid than the waters of the rest of the lake (Herdendorf, 1987). Although there have been efforts to reduce suspended solid inputs from tributaries, especially in western Lake Erie, they have not declined significantly in the last two decades (Richards and Baker, 1993).

Excessive nutrient loading is a common stressor in Lake Erie coastal wetlands in the U.S. and Canada (Herdendorf, 1987; Appendix K). Excess phosphorus is associated with excess inputs of suspended solids. Loadings of phosphorus to the watershed from point and non-point sources have reduced over the last two decades due to control measures (Dolan, 1993; Richards and Baker, 1993). However, nitrogen loading from non-point sources, mainly agricultural runoff, has increased in several watersheds (Richards and Baker, 1993). Wetlands with inflowing tributaries and barrier beaches are particularly prone to stresses from excess nutrients.

Pesticide loading from agricultural runoff has been identified as a significant stressor (Herdendorf, 1987); however, the impacts on coastal wetlands are not clear. As with phosphorus, it is associated with the suspended sediment load. Coastal wetlands with inflowing tributaries and barrier beaches are especially vulnerable.

Shoreline modification is a site-specific stressor when adjacent to coastal wetlands along the north shore of Lake Erie. It is mostly associated with urban encroachment and cottage development (Appendix K). Remaining wetlands suffer a backstopping effect from these revetments and dikes since the wetland communities cannot migrate upslope during high water years. This reduces wetland area during high water years and can also reduce the extent and long-term diversity of wetland communities. Storms during high water years can aggravate this problem by removing large areas of remaining wetland.

The extensive use of revetments, groynes and other structures which protect shoreline properties has also limited the supply of sediments in the littoral drift in western Lake Erie. Barrier beaches protecting wetlands must be replenished with these sediments. The few remaining natural wetlands with barrier beaches and sand spits are now losing this protection, as losses to erosion cannot be replenished from littoral sediment drift. As a result, these wetlands are becoming increasingly exposed to wave erosion.

Most of the remaining marshes along the U.S. shoreline are encompassed by dikes, while on the Canadian side, relatively few are diked. While diking allows for more intensive management for waterfowl and other fauna, it also isolates the wetland from the lake, impairing many wetland functions. For instance, many fish species, such as Northern Pike, which require wetlands for part of their life cycle can no longer access these wetlands. Other common stresses in coastal wetlands of Lake Erie are invasive non-indigenous species such as Purple Loosestrife, Zebra Mussels and Common Carp (R. Thompson, pers. com., 1996; D. Hector, pers. com., 1996).

5.8 Niagara River

5.8.1 Setting

The Niagara River drains Lake Erie into Lake Ontario. The river is 56 km long and drops 100 m along its course, most of which is at Niagara Falls. Its shoreline extends 60 km on the Canadian side and is much longer on the U.S. side, extending 112 km, as a result of the complex shoreline along Grand Island (International Joint Commission, 1993). The natural shoreline of the river consists of low banks in the upper portion of the river and a deep gorge cut through sedimentary deposits in the lower river below Niagara Falls.

Several tributaries flow into the river from the U.S. and Canada, draining a watershed of 3,251 km^2 (New York State Department of Environmental Conservation, 1994; Envirosearch Limited, 1992), but they contribute only a small fraction of flow to the river. On the Canadian side, land uses are dominated by agriculture (32%), abandoned agricultural land (23%), urban land (23%) and forests (16%) (Envirosearch, 1992).

The fast flow of the river has precluded the development of wetlands in many reaches of the river. However, wetlands and beds of submergent macrophytes are present in the upper reaches of the river (G. Birch, pers. com., 1996; Herdendorf, 1992). There are four small wetlands totalling approximately 85 ha, ranging in size from just under 5 ha to just over 37 ha (Figure 5; Appendix M). They are riverine in nature, sometimes with large palustrine components, and all but the Navy Island Marsh are associated with creek mouths. All have swamp and marsh components. The largest wetlands are the marshes on Navy Island (26 ha) and at Black Creek Wetland (37 ha).

5.8.2 Significant Features

Most of the provincially significant plant species found in the Niagara River are associated with coastal wetlands. Examples include Arrow-arum, Red-rooted Nut Sedge, Smith's Tufted Bulrush, Honey Locust, Swamp Rose Mallow, and Swamp Star Sedge (Appendix P). See Appendix P for complete listings.

Fifty-nine species of fish that use coastal wetlands on a permanent or temporary basis have been reported from the Niagara River (Mandrak and Crossman, 1992). The submerged vegetation of the wetlands in the upper river provides important spawning and nursery grounds for sportfish such as Muskellunge, Northern Pike, and Smallmouth Bass (Herdendorf, 1992). Niagara River wetlands also provide year-round habitat for three provincially significant fish species: Lake Chubsucker, Grass Pickerel and Black Bullhead (Appendix Q).

Coastal wetlands of the Niagara River also provide habitat for a wide range of amphibians, reptiles, birds and mammals. The only reported occurrence in Ontario for the Northern Dusky Salamander was in these wetlands (D. Sutherland, pers. com., 1996). No provincially significant amphibian, reptile or lepidopteran species were reported in Niagara River coastal wetlands (Appendix R; Appendix T).

Wetlands in the upper river are not heavily used by waterfowl for breeding or migration, but waterfowl numbers increase as winter approaches, when other wetlands in Lake Erie and Lake Ontario freeze (Bookhout, *et al.*, 1989). The dominant waterfowl include merganser species, Canvasback, Common Goldeneye, scaup species, Bufflehead, Mallard and Black Duck (Herdendorf, 1992; Bookhout *et al.*, 1989). Niagara River wetlands also provide important nesting habitat for the provincially significant Black-crowned Night-Heron (Appendix S).

5.8.3 Wetland Status

There is no comprehensive information on wetland loss on the Niagara River. Recent loss has been reported from one location, the Black Creek Wetland, as a result of urban development (Appendix M). Loss and stress on wetlands from shoreline modification and urban encroachment continue to be of concern (G. Birch, pers. com., 1996).

Several other human stressors affect remaining wetlands. The Niagara River and a tributary, the Buffalo River, have been declared Areas of Concern (AOCs) as a result of excessive toxic chemicals in the water, sediment contamination, fish edibility restrictions, the incidence of tumours in fish, degraded benthos and elevated phosphorus levels (Hartig and Thomas, 1988). Sources include industry outfalls, sewage treatment plants, other point sources, and non-point sources (New York State Department of Environmental Conservation, 1994; Envirosearch Limited, 1992; Hartig and Thomas, 1988). Wetlands near these sources are vulnerable to eutrophication and contamination from toxic chemicals. Nearshore areas, including wetlands, are deposition zones for sediments in the river and are therefore especially susceptible to sediment contamination (New York State Department of Environmental Conservation, 1994).

Water taking is another stress to coastal wetlands. More than half of the flow of the Niagara River is diverted for power production, causing dewatering of some marsh areas (G. Birch, pers. com., 1996; New York State Department of Environmental Conservation, 1994). This is exacerbated in some areas by road crossings that restrict wetland hydrology.

5.9 Lake Ontario

5.9.1 Setting

Lake Ontario is the smallest of the Great Lakes with a surface area of 18,960 km^2. However, it is relatively deep, and its average depth is second only to Lake Superior. The shoreline extends for 1,168 km and is particularly complex in the eastern third of the lake, with many embayments and peninsulas. The only islands occur in the eastern end of the lake, near its outlet. The Lake Ontario drainage basin is 60,600 km^2 (Fuller *et al.*, 1995) and is dominated by forests and agriculture, with lesser amounts of urban area and other land uses (PLUARG, 1978). Large urban centres occur in the western end of the lake around Toronto and Hamilton and at Rochester, New York. Water levels are controlled by dams and locks in the St. Lawrence Seaway along the St. Lawrence River.

Eighty-two coastal wetlands have been evaluated by the OMNR for Lake Ontario (not including wetlands in the Niagara River), totalling approximately 11,335 ha (Figure 5; Appendix M). There are several other significant wetland areas that have not been evaluated, but have been identified by OMNR biologists as in need of evaluation or that have been designated by the NHIC as Natural Areas (Figure 5; Appendix N). Wetlands are most abundant in the eastern portions of the lake. They occur at river mouths, nestled in embayments, and behind bars and barrier beaches. Wetlands are typically emergent and submergent marshes with a swamp or shrub-scrub component along the upland margins. The distribution of wetlands varies with shoreline geomorphology; from Niagara to Toronto, the shoreline consists mostly of bluffs and low cliffs except in the Hamilton area which has low-lying beaches (International Joint Commission, 1989). In this area, coastal wetlands are restricted to protected locations behind barrier beaches and in drowned mouths of rivers and creeks (Whillans *et al.*, 1992). Jordan Station Marsh in the Niagara Region is the largest wetland of western Lake Ontario, covering 136 ha. Many wetlands in western Lake Ontario have suffered from extensive filling and loss, especially around Toronto (Whillans, 1982). Remaining wetlands in the Toronto region include the Credit River Marshes (14 ha), Humber River Marshes (26 ha) and Rouge River Marshes (68 ha) at river mouths, and Rattray Marsh (10 ha) and the Toronto Island Wetland (22 ha) behind barrier beaches.

East of Toronto to Presqu'ile Point, the shore is steep with few wetlands; the majority that are present are found at river mouths and behind barrier beaches. Typical river mouth wetlands in this stretch of shoreline are Lynde Creek Marsh (110 ha) and Grafton Creek Swamp (62 ha); and Cranberry Marsh (32 ha) and Oshawa Second Marsh (105 ha) are examples of barrier beach wetlands.

From Presqu'ile Point to the mouth of the St. Lawrence River, the shoreline is complex with several channels, embayments, headlands, and islands. As a result, there are many protected sites suitable for wetlands. Thirty-nine wetlands (excluding Wolfe Island) totalling approximately 8,877 ha are found here; roughly 80% of the wetland area along the Canadian shore of the lake. The wetland along Presqu'ile Point (970 ha) is especially diverse, consisting mostly of marsh with some swamp and a small coastal meadow marsh (fen). The southwest shores of Prince Edward Peninsula are dominated by large marshes that are protected by bay mouth bars and are connected landward to lagoons. The largest areas include Wellers Bay Complex (363 ha), Pleasant Bay (299 ha), Hucyks Bay (245 ha), West Lake (706 ha) and East Lake (230 ha). The Bay of Quinte along the north and east side of the peninsula has a very complex shoreline, and extensive marshes have developed in the many sheltered bays, around islands and at creek mouths. The most notable are Pleasant Bay Marsh (299 ha), Big Island Marsh (858 ha), Sawguin Creek (2,093 ha), Dead Creek Marsh (359 ha), Big Marsh (400 ha), and Hay Bay Marsh (1,333 ha). Some of these coastal wetlands also include large palustrine components (Appendix M).

5.9.2 Significant Features

Coastal wetlands of Lake Ontario consist mostly of submergent and emergent marshes, swamps, and a few rare coastal meadow marsh (fen) communities (Natural Heritage Information Centre, 1995; Smith *et al.*, 1991; Herdendorf *et al.*, 1981). In many marsh, wet meadow or submergent habitats, invasive plant species are often introduced, such as Purple Loosestrife, Eurasian Water-milfoil, Reed Canary Grass and hybrid cattail (International Joint Commission, 1993; Wilcox *et al.*, 1993). Despite these problems, twenty provincially significant species of plants have been found in Lake Ontario's coastal wetlands (Appendix P). For instance, Hidden-fruited Bladderwort, Winged Loosestrife, Branching Burreed and Yellow Pond Lily occur in several marsh habitats. Other significant species such as Bushy Aster, Low Nut Rush and Smith's Tufted Bulrush are found in the few coastal meadow marshes along Lake Ontario (Appendix P).

Sixty-eight species of fish use the coastal wetlands of Lake Ontario, two thirds of which are permanent residents (Jude and Pappas, 1992; Stephenson, 1990). Gizzard Shad, White Perch and Freshwater Drum are the most abundant permanent residents, while Alewife, Rainbow Smelt, White Sucker, Smallmouth Bass, Spottail Shiner, Johnny Darter, Trout-Perch, Walleye and Yellow Perch are common species which use coastal wetlands on a temporary basis for spawning, nursery or feeding. Several important sportfish use these wetlands including Common Carp, Northern Pike, Muskellunge, Pumpkinseed, Bluegill, Black Crappie, White Crappie, Largemouth Bass, Smallmouth Bass, Walleye, Yellow Perch, and White Bass (Glooschenko *et al.*, 1987; Herdendorf *et al.*, 1981). Several species of fish in these coastal wetlands are considered provincially significant, including Eastern Silvery Minnow, Pugnose Shiner and Grass Pickerel (Appendix Q).

Lake Ontario coastal wetlands provide important habitat for reptiles and amphibians. Bullfrog, Green Frog, Northern Leopard Frog, Spring Peeper and Grey Tree Frog are common frogs which inhabit coastal marshes and swamps (M. Oldham, pers. com., 1996; Herdendorf *et al.*, 1981). The Mudpuppy and Red-spotted Newt are other amphibians commonly found in submerged macrophyte beds in coastal wetlands. Common reptiles include Snapping Turtle, Midland Painted Turtle, Northern Water Snake, Eastern Garter Snake and Eastern Milk Snake. As well, three provincially significant species of reptiles and amphibians have also been found: the Eastern Spiny Softshell Turtle, Spotted Turtle, and Jefferson Salamander (Appendix R).

Coastal wetlands along the northeast coast around Prince Edward Peninsula have been identified as important areas for waterfowl in the Great Lakes (Prince *et al.*, 1992). Prince Edward Peninsula in particular is the third most significant region for waterfowl in Ontario, after Long Point and the St. Clair Delta (Bookhout *et al.*, 1989). Their importance is mostly linked to providing staging habitats during spring and fall migration. Large numbers of diving ducks, especially scaup and merganser species, are attracted to these wetlands in the fall (Prince *et al.*, 1992). The provincially significant Northern Shoveler, Canvasback and Redhead can also be found in large numbers in the marshes and bays along the Prince Edward Peninsula. Wetlands in western Lake Ontario near Toronto have largely disappeared, but concentrations of dabbling ducks, diving ducks and Canada Geese still are present along the shoreline during fall and winter migration. Coastal wetlands of Lake Ontario are of lesser importance for breeding waterfowl, but many dabbling ducks do nest in them, including Mallard, Black Duck, Blue-winged Teal and Wood Duck (Prince *et al.*, 1992; Bookhout *et al.,* 1989). See Appendix S for a complete listing of significant waterfowl species found in Lake Ontario coastal wetlands.

Coastal wetlands of Lake Ontario provide feeding, nesting or migration habitat for many other bird species. Several raptors nest or migrate through these coastal wetlands including Peregrine Falcon, Bald Eagle, Sharp-shinned Hawk, Cooper's Hawk, Red-shouldered Hawk, and Northern Harrier (D. Sutherland, pers. com., 1996; Herdendorf *et al.,* 1981). Several species of waterbirds such as Double-crested

Cormorant, Great Blue Heron, American Bittern, and Green Heron have been recorded in these wetlands (Glooschenko *et al.*, 1987; Herdendorf *et al.*, 1981). Common Terns regularly breed in north shore wetlands, but are uncommon along the south shore. Caspian Terns are also common in wetlands along the northeast shore. Provincially significant species of birds nest and feed in these wetlands, including Least Bittern, Black-crowned Night-Heron, Black Tern, and Short-eared Owl (Appendix S). See Appendix S for complete listings.

Significant lepidopteran species including the Mulberry Wing and Two-spotted Skipper, are found in the coastal meadow marshes of Lake Ontario (Appendix T).

The coastal wetlands of Lake Ontario are important habitats for many mammals. Beaver, Muskrat, Mink and River Otter are highly dependent on these wetlands (Glooschenko *et al.,* 1987; Herendorf *et al.,* 1981). White-tailed Deer, Red Fox, Short-tailed Weasel, Raccoon and Coyote are examples of other species using Lake Ontario wetlands.

5.9.3 Wetland Status

The wetlands of Lake Ontario have suffered severe loss over the last two centuries (International Joint Commission, 1989; Lynch-Stewart, 1983; McCullough, 1982; Whillans, 1982). The main causes are agricultural drainage and urban encroachment. Between 1789 and 1979, Whillans (1982) estimated the loss of coastal marsh along the Canadian shore west of the Bay of Quinte to be 1,920 ha or 43% of the original marsh area. Similar estimates of wetland loss were reported by McCullough (1982). This loss was greatest from Toronto to the Niagara River where an estimated 1,518 ha of coastal marsh have been lost; this represents the loss of 73% to 100% of the original marsh along these shores (Whillans, 1982). The greatest losses occurred in the late 1800s and early 1900s when large marshes were filled and dredged for shipping, industrial and urban uses. East of Toronto, less marsh area has been lost. Between Toronto and Presqu'ile, 646 ha or 32% of the original marsh has been lost, while from Presqu'ile to the Bay of Quinte, only 347 ha or 7.5% has been lost. Large losses have occurred in the Bay of Quinte. Around 12,008 ha of wooded and emergent wetlands were lost prior to the 1960s within a 3.2 km strip inland from the bay, mainly due to agricultural drainage (Ontario Ministry of the Environment *et al*., 1990). Between 1967 and 1982, a further 412 ha of coastal wetlands were lost in this area, but since 1967, 542 ha have been reclaimed from agricultural use and restored to wetland. Wetland loss along the Canadian shores continues to be a concern as a result of urban encroachment (Appendix M).

Remaining wetlands are affected by several other human stressors. A major stressor to all coastal wetlands in Lake Ontario is water level regulation. Water levels have been regulated in the lake since construction of the St. Lawrence Seaway in 1959. Regulation of water levels seeks to reduce the occurrence of both high and low lake levels. Prior to regulation, the range of water level fluctuations during the 20th century was about 2 m. Between 1960 and 1976, following regulation, this range was reduced slightly and was further reduced to about 0.9 m after 1976 (Wilcox *et al.*, 1993). Regulation also prevented water levels from reaching record highs in 1986 as they did on all other lakes. The lack of alternating flooded and dewatered conditions at the upper and lower edges of the wetlands decreased wetland area and decreased the diversity of plant and wildlife communities (Wilcox *et al.*, 1993; Busch *et al.*, 1990; International Joint Commission, 1989). In general, upland species became more prevalent along the upper edges of the wetlands. Emergent communities declined, and submerged aquatic macrophyte beds increased. As well, invasive plants began to dominate wetland communities, for example extensive stands of cattail are now established in these wetlands, and some areas are dominated by Purple Loosestrife, Reed Canary Grass and various shrubs (Wilcox *et al.*, 1993).

High sediment loads and excess turbidity have been noted as stressors in several Lake Ontario coastal wetlands. Examples include Cootes Paradise in Hamilton (Painter *et al*., 1989; Simser, 1979), Oshawa Second Marsh (Cecile, 1983; Morris, 1983) and wetlands of the Bay of Quinte (Crowder and Bristow, 1988). Sources are site-specific and are mostly related to urban and agricultural runoff. Common Carp are also a serious related problem in Lake Ontario as they resuspend sediments, increase turbidity and destroy aquatic macrophytes (Painter *et al*., 1989).

Turbidity problems are compounded by excess nutrients that encourage algae and in turn decrease water clarity (Painter *et al*., 1989). Excess nutrients have also caused the eutrophication of wetland communities, reducing the diversity of wetland vegetation in some areas. These stressors are especially evident in the Bay of Quinte (Crowder and Bristow, 1988).

Contaminants are site-specific stressors to coastal wetlands. Several sites around Lake Ontario have been declared Areas of Concern including Hamilton Harbour, Toronto, Port Hope and the Bay of Quinte. Cootes Paradise in Hamilton and the Bay of Quinte have large areas of coastal wetlands and are therefore especially susceptible to contamination by toxic chemicals. Both these areas are known to have contaminated sediments or bioaccumulation of contaminants in biota (Bishop *et al*., 1991,1995; Crowder *et al*., 1989).

Shoreline modification is another site-specific stressor (Appendix M). Dikes or revetments not only fill wetlands but also prevent the migration of remaining wetland communities in response to fluctuating water levels.

5.10 St. Lawrence River

5.10.1 Setting

The St. Lawrence River drains Lake Ontario and is the outlet of the Great Lakes system. It extends 870 km in length from Lake Ontario to the Gulf of St. Lawrence (Grant, 1995). For the Atlas only, the 186 km section of the river from Wolfe Island at the outlet of Lake Ontario to the Quebec border is discussed. This includes the international section of the river and the Ontario shore of Lake St. Francis. Other studies examine the state of the river and its wetlands through Quebec to the Gulf of St. Lawrence (Centre St. Laurent, 1996a, b).

Water level and flows have been regulated in this section of the St. Lawrence River since the construction of the St. Lawrence Seaway in 1959. Since then, dams and water control structures have greatly changed the character of the river and its wetlands. This section of the St. Lawrence River can be divided into four distinct sections, each displaying different physical and biological characteristics: the Thousand Islands, Middle Corridor, Lake St. Lawrence, and Lake St. Francis (Grant, 1995; Busch and Patch, 1990). The Thousand Islands section lies in the uppermost reach of the river. It has a rocky shoreline and many islands, bays, shoals and quiescent areas with extensive wetlands. The Middle Corridor extends a distance of 49 km from just west of Brockville/Morristown downstream to the Iroquois Control Dam. This is the most riverine section of the St. Lawrence, with a single deep, wide channel and a relatively uniform shoreline. Currents are very strong and wetlands are restricted to small bays, shoreline indentations, and tributary mouths. At Iroquois, the water is shallower and there are some extensive vegetated shallow areas.

Lake St. Lawrence occurs in the lower reach of the international section of the river, extending from the Iroquois Control Dam to the Moses-Saunders Dam near Cornwall. This area was changed completely from a riverine environment to a lacustrine environment following the construction of the Seaway. It has numerous islands and shoals. Wetlands are relatively common in this section, however the extent of marshes is quite small compared to that of the Thousand Islands section. Below the Moses-Saunders Dam, there is a short stretch of river with fast current leading to Lake St. Francis. Lake St. Francis is a lacustrine environment with extensive wetlands located at creek mouths, in embayments and surrounding islands (Grant, 1995).

Along the Ontario shoreline, there are 40 evaluated wetlands totalling approximately 7,018 ha (Figure 6; Appendix O). The wetlands along the Ontario shoreline range in size from just under 4 ha to 1,398 ha. They are primarily riverine marshes with relatively small swamp components. More than 60% of the wetlands both in number and area are found in the Thousand Islands section of the river. The largest wetlands in this reach include the Greater Cataraqui Marsh (504 ha), the Wolfe Island Complex (1,398 ha), the Grenadier Island Complex (868 ha). The Wolfe Island Complex has a large bog component, one of only two in the lower Great Lakes. The Morrisburg Swamp (391 ha), the only swamp found along the Ontario St. Lawrence River shoreline, and the Upper Canada Migratory Bird Sanctuary (321 ha) are large wetlands in the Lake St. Lawrence Section. Along the Ontario shores of Lake St. Francis, Charlottenburg Marsh (851 ha) and Bainsville Bay Marsh (407 ha) are among the largest wetlands.

Although seven unevaluated coastal wetlands on the St. Lawrence River (Table 3) were identified through the 1996 OMNR District/Area Office Survey, these were not identified individually through Atlas methods and are not plotted on Figure 6, nor in an Appendix.

5.10.2 Significant Features

The coastal wetlands of the St. Lawrence River are predominantly cattail marshes with areas of submergents and floating plants such as water lilies, and occasional swamp components, mostly dominated by willow (Smith *et al.,* 1991). Seven provincially significant plant species have been recorded in the shallow water marshes and adjacent wet beaches of the St. Lawrence River including, Arrow-arum, Narrow-leaved Water-plantain and Smith's Tufted Bulrush (Appendix P). The other provincially significant plant species found in these coastal wetlands are Follicle Sedge, Eastern Prairie White Fringed Orchid, and Branching Bur-reed.

At least 64 species of fish inhabit wetlands of the St. Lawrence River, 42 of which are permanent residents (Jude and Pappas, 1992; Mandrak and Crossman, 1992; Patch and Busch, 1984). The major recreational fisheries support Muskellunge, Northern Pike, Brown Bullhead, Smallmouth Bass, Yellow Perch, Walleye and a variety of panfishes (Grant, 1995). Wetlands in the St. Lawrence River support one of only a few large self-sustaining populations of Muskellunge in North America (Grant, 1995). Three provincially significant species also depend on these wetlands to provide habitat on a permanent basis: the Eastern Silvery Minnow, Pugnose Shiner and Grass Pickerel (Sutherland, 1994; Mandrak and Crossman, 1992; Appendix Q).

The coastal shoreline wetlands of the St. Lawrence River provide notable migration and staging habitat for waterfowl. The St. Lawrence Lowlands have been identified in the North American Waterfowl Management Plan as an important waterfowl staging area. Wolfe Island in the Thousand Islands section of the river is located on a northwest-southeast migration route, and is surrounded by abundant shallow water areas with submerged vegetation. Large numbers of waterfowl, primarily scaup and teal, are found in this area during spring and fall migration (Ross, 1984). The Wolfe Island area is also an important staging area for Canada Geese. Provincially significant waterfowl species such as Northern Shoveler, and Redhead breed in St. Lawrence River wetlands (Appendix S). The St. Lawrence River wetlands also provide important nesting habitat for many colonial waterbirds. Several provincially significant bird species breed here including Least Bittern, Black Tern, and Short-eared Owl (Appendix S).

Many reptiles and amphibians use the wetlands along the St. Lawrence River for nesting and spawning, nursery and/or feeding sites. However, only one provincially significant species, the Spotted Turtle, has been recorded (M. Oldham, pers. com., 1996; Appendix R).

One provincially significant lepidopteran species, the Two-spotted Skipper, has been recorded for St. Lawrence River coastal wetlands (Appendix T).

A variety of mammal species are found in St. Lawrence River wetlands including Muskrat, Mink, Red Fox and Coyote. Several wetlands also provide regionally significant winter habitat for White-tailed Deer.

5.10.3 Wetland Status

The St. Lawrence River has experienced a wide variety of environmental disturbances since the first channel modifications in the late 18th century (Grant, 1995). The largest disturbance was associated with the construction and operation of the St. Lawrence Seaway. Prior to the construction of the Seaway, the river resembled a large riverine estuary in the Thousand Island section. The Middle Corridor and Lake St. Lawrence (to Cornwall) were part of a riverine system with many islands and shoals, and many rapids in the lower reaches of the international section (Busch and Patch, 1990). The creation of Lake St. Lawrence and the dredging for navigation and power production greatly altered these habitats. These changes have been monitored along the U.S. side (Busch and Patch, 1990; Patch and Busch, 1984).

Wetland change on the Canadian side of the St. Lawrence River is not well documented.

After the initial opening of the Seaway, relatively little change occurred along the U.S. shore in the Thousand Islands section of the river, but changes became apparent at Galop Island in the Middle Corridor section of the river and were most dramatic in Lake St. Lawrence. Numerous islands and shoals were flooded along with several major rapids, and there were large increases in deepwater and littoral habitat. Wetland habitats changed greatly. By 1962, shortly after the construction of the Seaway, there was a decline in wetland area of 11.4% along the U.S. shore (Patch and Busch, 1984). However by 1988, wetland area had increased by 106 ha (9%) along the U.S. shoreline as compared to the pre-Seaway condition (Busch and Patch, 1990). Between 1955 and 1988, there were losses of 174 ha (18%) and 10ha (40%) along the U.S. shoreline in the Thousand Islands and Middle Corridor sections, respectively. There was an increase of 448 ha (64%) on the U.S. side of Lake St. Lawrence. There were also large changes in wetland community structure as compared to the pre-Seaway condition as a result of the regulation and stabilization of water levels. Emergent wetlands decreased in area to the benefit of broad-leaved forested and shrub-scrub wetlands. In Lake St. Lawrence, wetlands are relatively common, but emergent wetland area is small, primarily due to the regulation of water levels.

Changes in wetland area and stressors due to human activities tend to be smaller scale and site-specific. In the Thousand Islands section of the river, recreational activities dominate with many cottages, picnic and camping areas, and marinas. Along the Canadian side of the river, shoreline modification from these activities has historically resulted in irretrievable direct losses of wetland habitat, although these losses have been greatly reduced over the last five to six years (R. Cholmondeley pers. com., 1996). Recent losses have been limited to development of occasional shoreline protection structures, although some illegal dredging still occurs. Pressures from these activities are ongoing, as marinas try to expand or dredge deeper to allow for bigger boats, or to compensate for fluctuating water levels. Recreational boats also stress remaining wetlands by creating wakes that disturb and erode emergent and submergent vegetation.

Wetland losses on the Canadian shore of the Thousand Islands section of the river have also resulted from the construction of roads such as the St. Lawrence Parkway as well as from numerous access roads to cottages (Appendix O). Not only is there wetland loss from filling of the roadbed, but many segments of wetlands are cut off from the river and wetland hydrology is altered.

Other stressors affect remaining wetlands in the Thousand Islands section. Water level regulation, which draws down water levels in the fall, and leads to plant freeze-out or ice scour has dramatically affected wetland vegetation (Appendix O). Nutrient and sediment loading from tributary creeks also act as local wetland stressors in the Thousand Islands. In addition, non indigenous species have taken their toll on wetlands. For instance, Zebra Mussels have increased water clarity, but there appears to be a consequent reduction in aquatic plant growth and an increase in filamentous algae (R. Cholmondeley, pers. com., 1996).

The Middle Corridor has been substantially altered by dredging and filling which accompanied the construction of the Iroquois Control Dam, locks and the Seaway navigational channel between 1954 and 1959 (Grant, 1995; Busch and Patch, 1990). Residential and industrial developments are common along the Canadian shoreline and few wetlands remain in this reach. Dredging and filling have been associated with these activities, resulting in direct losses in the past as well as concerns regarding future losses (R.

Grant, pers. com., 1996). These activities have also stressed remaining wetlands through sediment and nutrient loading (R. Grant, pers. com., 1996).

In Lake St. Lawrence, the greatest stresses relate to the construction and operation of the Moses-Saunders Dam, as detailed above. Stresses on existing wetlands in this area are site specific, and are primarily related to industrial, commercial, residential and recreational development (M. Eckersley, pers. com., 1996).

In Lake St. Francis, modifications to the hydrological regime have resulted in an increase of 36 cm in the mean water level, and there are no longer any annual water level fluctuations (Jean and Bouchard, 1991). The stable water levels mean that spring flooding does not occur in many wetlands (M. Eckersley, pers. com., 1996). Additionally, over the past 40 years, wetlands of Lake St. Francis have been subject to extensive urban, recreational and agricultural development (M. Eckersley, pers. com., 1996; Jean and Bouchard 1991). Between 1946 and 1983, a relatively low 7% of wetlands in Lake St. Lawrence disappeared. However wetlands in certain areas have been reduced by as much as 41% through conversion primarily to urban lands (Jean and Bouchard, 1991).

The Lake St. Francis section of the St. Lawrence River downstream of Cornwall, Ontario and Massena, New York has contaminant problems of concern for coastal wetlands. Bioaccumulation of PCBs has been observed to be very high in Red-Winged Blackbirds and Tree Swallows from coastal wetlands in Akwesasne downstream of Cornwall/Massena (Bishop *et al.*, 1995). This section of the river has been declared an Area of Concern as a result of excessive toxic substances in the water, contaminated sediments at Cornwall and at the mouth of the Grass River near Massena, fish consumption advisories, tumours in fish near Cornwall, degraded benthos, elevated faecal coliform bacteria counts, and eutrophication from elevated phosphorus downstream of Cornwall.

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