EVALUATION OF WATER LEVEL REGULATION INFLUENCES ON LAKE ONTARIO AND UPPER ST. LAWRENCE RIVER COASTAL WETLAND PLANT COMMUNITIES

FINAL PROJECT REPORT
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Executive Summary

Water-level fluctuations are a natural phenomenon in the Great Lakes due to natural climatic variability, and Great Lakes biological communities, by necessity, have evolved to adapt to the range of water levels and water-level changes that occur on several scales. The biological effects of water-level fluctuations in the lakes are greatest in shallow water where even small changes in water level can result in conversion of a standing water environment to an environment in which sediments are exposed to the air, or vice versa. The localized effects of this change in the environment are most evident in the plant communities that occur in wetlands. In fact, water-level change patterns are the driving environmental force that determines the overall diversity and condition of wetland plant communities and the faunal habitats they provide. Previous studies showed that regulation of Lake Ontario water levels for more than 40 years resulted in considerable alteration of wetland plant communities.

The overall objectives of this study were to demonstrate quantitative changes in plant communities, to determine water-level patterns that best maintain habitat diversity as determined by plant community diversity, abundance, and distribution, and to develop predictive models and performance indicators to evaluate proposed new regulation plans for the lake. The specific tasks included evaluating and quantifying vegetation changes by assessing historic aerial photographs; completing a wetland inventory and classification for Lake Ontario and the Upper St. Lawrence River; sampling wetland plant communities along transects at specific elevations that represent unique hydrologic histories; developing bathymetric/ topographic models for each of four Lake Ontario wetland geomorphic types that relate plant communities and faunal habitats to water depths, as determined by lake levels; developing preferred environmental criteria for water-level regulation based on vegetation study results, bathymetric/topographic models, fish and wildlife habitat requirements, and long-term lake-level changes; and using bathymetric/topographic models and study results to develop predictive tools and performance indicators to assess the potential effects on wetlands of all proposed new scenarios for water-level regulation.

The 32 study sites selected for this work were distributed across the Lake Ontario – Upper St. Lawrence River area and included eight wetlands of each of four geomorphic types: open embayment, protected embayment, barrier beach, and drowned river mouth wetlands. Half of the sites for each geomorphic type were in Canada and half were in the United States. These sites are intended to represent a total of 879 geomorphically distinct wetlands, totaling 25,847 hectares, identified in the wetland inventory.

Interpretation and analysis of Lake Ontario water-level data and aerial photo sets revealed an often substantial increase in the area and percent cover of cattail (Typha)- dominated wetland vegetation communities since water-level regulation began in 1958. At most sites, the increase in Typha-dominated area did not result from lakeward expansion; it was the result of Typha invasion into existing meadow marsh communities at higher elevations. Lack of low water levels since the mid-1960s has seemingly allowed Typha, which has a greater requirement for water, to displace meadow marsh at higher elevations. As a result, it is estimated that greater than 50% of the meadow marsh wetland area that occurred within Lake Ontario – Upper St. Lawrence River during the mid- to late 1960s has been displaced by Typha-dominated emergent marsh. At many study sites, the loss in area of meadow marsh vegetation since the 1960s exceeds 80%.

Analyses of wetland plant community data, collected by sampling along transects that followed seven elevation contours with different water-level histories, identified four major vegetation types. Three transects at higher elevations contained plant species associated with meadow marsh; a slightly lower transect contained a mixed community with meadow and emergent marsh species, including

Typha; two transects below this were emergent marsh dominated by Typha; and the lowest transect contained mostly submersed and floating-leaf species.

Bathymetric and topographic data were used to create individual elevation maps for all study wetlands that could be compared with mapped vegetation types. GIS methodologies were then used to generate bathymetric/topographic models for each of the four wetland types. These models are meant to represent all wetlands of each specific type for use in predictive modeling efforts, but not any individual site.

Predictive wetland vegetation models were developed for each wetland geomorphic type. Within a GIS format, area by elevation contour data were used to calculate annual estimates of vegetation community distribution for each year in a sequence of 101 years of water-level data, as presented in potential new regulation plans. The result is a series of annual predictions of the area and percent of vegetation/time classes that will occupy the elevation range (73.0-75.75m) given in the models. Within the models, assignment of the four vegetation types to various elevation ranges is based on the number of years since last flooded or the number of years since last dewatered, as determined by rules generated by analyzing data from sampling along the transects.

The predictive models for each of the four wetland geomorphic types were tested using several potential regulation plans for Lake Ontario. The plans tested were 1958D with deviations (1958DD) and two plans developed by using 1958DD as a base and adding a higher lake level (75.65m) in 1947 when basin supplies were high and lower lake levels in the 1910s, 1930s, 1960s, and late 1990s when basin supplies were low. Neither high nor low lake levels exceeded those that actually occurred during post-regulation. Over the 101-year regulation plan period, test results showed an increase in the average percent of meadow marsh (ABC) vegetation from 1958DD to the plan with additional low lake-level years to the plan with even more low lake-level years, which is the expected result.

A wetland habitat performance indicator (Area of Meadow Marsh) was then developed using study results. This indicator was selected because it is sensitive to hydrologic change, it represents a habitat that supports the greatest diversity of plant species, it can contain a diversity of structural habitats that support a wide range of fauna, and it is the plant community shown to have been affected most by regulation of lake levels. To make the performance indicator more sensitive to the hydrologic conditions that promote meadow marsh expansion, the 101-year period of evaluation was scaled back to include analyses for only those years in which low total basin supplies provided an opportunity for meadow marsh to expand. The resulting performance indicator measures the comparative ability of regulation plans to generate the low lake levels required by the meadow marsh community during time periods when water supplies are low and low lake levels are possible. The regulation plans used to test the predictive models were then evaluated both by individual geomorphic wetland type models described above and by the IERM, in which percentages of meadow marsh community across all geomorphic types were converted to area of meadow marsh for the entire Lake Ontario/Upper St. Lawrence River basin. Again, the percent of meadow marsh vegetation type increased from plan 1958DD to the other plans with increasing numbers of low lake-level years.

The abundance of other predicted wetland vegetation communities is also important in alternate plan evaluation. These habitat predictions have been incorporated into several faunal models. Faunal models such as the Black Tern and Virginia Rail Reproductive Index performance indicators are being used to compare the relative supply of deep and shallow emergent marsh habitats among alternate water-level regulation plans.

Overall, study results indicate that moderation of water-level fluctuations since water-level regulation began has significantly restricted the long-term hydrologic environment important to the maintenance of coastal wetland meadow marsh communities. Moderation of long-term water-level fluctuations has also created hydrologic conditions that supported the expansion of aggressive, dominant emergent and submersed plant species, resulting in a reduction of plant species richness and emergent marsh habitat quality. The reduction in habitat quality has likely been further magnified in wetlands that have also been impacted by other stressors, such as increased nutrient and sediment inputs due to surrounding land uses. However, consistency in plant survey results and historic trends across study site wetlands, many with predominately forested watersheds support the conclusion that water-level moderation due to regulation is having a major impact on coastal wetland habitat quality.

The development of quantitative relationships between water levels and wetland plant communities, generalized geometric wetland elevation models, and estimates of wetland area within the study region provide powerful predictive tools to evaluate potential impacts of alternate water-level regulation plans on Lake Ontario – Upper St. Lawrence coastal wetland habitats. Manipulations of the current Plan 1958DD water-level regulation criteria clearly demonstrate that small changes in specific criteria can have dramatic impacts on coastal wetland plant communities. If the Study Board desires to ensure that any alternate water-level regulation plan recommended to the IJC not only has no additional environmental impact, but also incorporates criteria focused on reducing environmental impacts of the current plan, the results of this study, which have been incorporated into the IERM developed by the Environmental Technical Working Group, can provide valuable information.

The regulation plans used for testing predictive models were developed with recognition that the Study Board must evaluate the interests of all stakeholders and avoid undue impacts to any interest. Therefore, they are potentially viable options that do not exceed extreme lake levels that would otherwise be produced under the current regulation plan. Instead, they change the frequency of high and low lake levels in concert with total basin supplies and represent realistic opportunities to address problems facing this important and complex ecosystem.

Sommaire Exécutif

Les fluctuations des niveaux d’eau sont un phénomène naturel dans les Grands Lacs attribuable à la variabilité climatique naturelle, et les communautés biologiques des Grands Lacs, par nécessité, ont évolué pour s’adapter aux changements des niveaux d’eau qui se produisent sur plusieurs échelles. Les effets biologiques des fluctuations des niveaux d’eau dans les lacs sont les plus importants en eau peu profonde où même un petit changement du niveau d’eau peut entraîner la conversion d’un environnement d’eau stationnaire à un environnement où les sédiments sont exposés à l’air, ou vice versa. Les effets localisés de ce changement dans l’environnement sont les plus évidents dans les communautés végétales des terres humides. En fait, les régimes de changement de niveau d’eau sont la force motrice environnementale qui détermine la diversité globale et la condition des communautés végétales des terres humides et des habitats fauniques qu’elles offrent. Des études antérieures ont démontré que la régulation des niveaux d’eau du Lac Ontario depuis plus de 40 ans a modifié considérablement les communautés végétales des terres humides.

Les objectifs globaux de cette étude étaient de démontrer les changements quantitatifs dans les communautés végétales afin de déterminer les régimes de niveau d’eau qui maintiennent le mieux la diversité de l’habitat, tel que déterminé par la diversité, l’abondance et la distribution des communautés végétales, et de développer des modèles de prévision et des indicateurs de rendement pour évaluer les nouveaux plans de régulation proposés pour le lac. Les tâches spécifiques comprenaient l’évaluation et la quantification des changements à la végétation en examinant les photographies aériennes historiques, un inventaire des terres humides et la classification pour le Lac Ontario et le haut Saint-Laurent, l’échantillonnage des communautés végétales des terres humides le long de transects à des élévations spécifiques qui représentent un historique hydrologique unique, le développement de modèles bathymétriques et topographiques pour chacun des quatre types géomorphologiques de terres humides ayant trait aux communautés végétales et aux habitats fauniques par rapport aux profondeurs d’eau, telles que déterminées par les niveaux du lac, l’établissement de critères environnementaux pour la régulation du niveau d’eau d’après les résultats des études sur la végétation, les modèles bathymétriques et topographiques, les besoins d’habitat du poisson et de la faune, et les changements de niveau du lac à long terme, et l’utilisation des modèles bathymétriques et topographiques et des résultats des études pour développer des outils de prévision et des indicateurs de rendement permettant d’évaluer les effets sur les terres humides de tous les nouveaux scénarios proposés pour la régulation du niveau d’eau.

Les 32 sites de l’étude sélectionnés pour ce travail sont distribués tant tout le Lac Ontario et le haut Saint-Laurent et comprennent huit terres humides de chacun des quatre types géomorphologiques : enfoncement ouvert, enfoncement protégé, lido et terres humides d’embouchure submergées. Pour la moitié, les sites de chaque type géomorphologique sont au Canada et l’autre moitié aux États-Unis. Ces sites visaient à représenter un total de 879 terres humides distinctes au plan géomorphologique, totalisant 25 847 hectares, identifiées dans l’inventaire des terres humides.

L’interprétation et l’analyse des données sur les niveaux d’eau du Lac Ontario et des séries de photos aériennes ont révélé une augmentation souvent substantielle dans la zone et un couvert en pourcentage de communautés végétales dominées par la massette (Typha) depuis le début de la régulation du niveau d’eau en 1958. Pour la plupart des sites, l’augmentation de la zone dominée par la massette n’est pas le résultat de l’expansion du lac; elle est le résultat de l’invasion de la massette dans les communautés des marais à des élévations supérieures. L’absence de niveaux d’eau bas depuis le milieu des années 1960 a vraisemblablement permis à la massette, qui a un besoin d’eau supérieur, de déplacer les marais à des élévations supérieures. En conséquence, on estime que plus de 50 % de la zone de terres humides et de marais du Lac Ontario et du haut Saint-Laurent du milieu à la fin des années 1960 a été déplacée par les marais émergents dominés par la

massette. En de nombreux sites de l'étude, la zone de végétation des marais depuis les années 1960 dépasse 80 %.

Les analyses des données sur les communautés végétales des terres humides, collectées par l'échantillonnage le long de transects qui suivent sept contours d'élévation ayant des historiques de niveaux d'eau différents ont permis d'identifier quatre types de végétation principaux. Trois transects à des élévations supérieures contiennent des espèces végétales associées aux marais; un transects de niveau légèrement inférieur contient une communauté mixte d'espèces des prés et des marais émergents, dont la massette; deux transects sous celui-ci sont des marais émergents dominés par la massette, et le transects le plus bas contient surtout des espèces submergées et de potamot flottant.

Les données bathymétriques et topographiques ont été utilisées pour créer des cartes d'élévation individuelles pour toutes les terres humides de l'étude qui pourraient être comparées aux types de végétation cartographiés. Les méthodologies du SIG ont ensuite été utilisées pour produire des modèles bathymétriques et topographiques pour chacun des quatre types de terres humides. Ces modèles visaient à représenter toutes les terres humides de chaque type spécifique pour utilisation dans les efforts de modélisation prédictive, mais non pour chaque site.

Des modèles de végétation des terres humides prédictifs ont été développés pour chaque type géomorphologique des terres humides dans un format de SIG, les données de contour d'élévation ont été utilisées pour calculer les estimations annuelles de la distribution des communautés végétales pour chaque année dans une séquence des données sur les niveaux d'eau sur 101 ans, telles que présentées dans les nouveaux plans de régulation éventuels. Le résultat est une série de prédictions annuelles de la zone et un pourcentage des catégories de végétation qui occuperont la zone d'élévation (73.0-75.75m) donnée dans les modèles. Dans ceux-ci, l'affectation des quatre types de végétation aux diverses zones d'élévation est basée sur le nombre d'années depuis la dernière inondation ou le nombre d'années depuis le dernier assèchement, tel que déterminé par les règles générées en analysant les données de l'échantillonnage le long des transects.

Les modèles prédictifs pour chacun des quatre types géomorphologiques de terres humides ont été vérifiés à l'aide de plusieurs plans de régulation éventuels pour le Lac Ontario. Les plans vérifiés étaient de 1958D avec des dérivations (1958DD) et deux plans établis en utilisant 1958DD comme base et en ajoutant un niveau supérieur (75.65m) en 1947 lorsque l'alimentation du bassin était élevée et les niveaux du lac plus bas dans les années 1910, 1930, 1960 et à la fin des années 1990 lorsque l'alimentation du bassin est devenue faible. Ni les niveaux élevés ni les niveaux bas du lac n'ont dépassé ceux qui se produisent en réalité après la régulation. Au cours de la période du plan de régulation de 101 ans, les résultats des tests ont montré une augmentation du pourcentage moyen de végétation des marais (ABC) de 1958DD au plan avec des années de bas niveau du lac au plan même avec des années de niveau encore plus bas, ce qui est le résultat attendu.

Un indicateur de rendement de l'habitat des terres humides (zone des marais) a ensuite été établi à l'aide des résultats de l'étude. Cet indicateur a été choisi parce qu'il est sensible au changement hydrologique, qu'il représente un habitat qui soutient la plus grande diversité d'espèces végétales, qu'il peut contenir une diversité d'habitats structurels qui soutiennent un vaste éventail d'espèces fauniques et qu'il est représentatif de la communauté végétale ayant été le plus affectée par la régulation des niveaux du lac. Pour rendre l'indicateur de rendement plus sensible aux conditions hydrologiques qui favorisent l'expansion du marais, la période de l'évaluation de 101 ans a été reprise à la baisse pour inclure des analyses seulement pour les années où l'alimentation totale du bassin offrait une possibilité d'expansion des marais. L'indicateur de rendement en découlant mesure la capacité comparative des plans de régulation de générer les niveaux bas requis par la communauté végétale des marais durant les périodes où l'alimentation en eau est faible et où des niveaux bas du lac sont possibles. Les plans de régulation utilisés pour tester les modèles prédictifs ont ensuite été évalués par chaque modèle de type géomorphologique de terres humides susmentionnés et par la méthode IERN selon les pourcentages de communauté des marais de tous les types géomorphologiques ont été convertis en zone de marais pour l'ensemble du bassin du Lac Ontario et du haut Saint-Laurent. Encore là, le pourcentage de type de végétation de marais a augmenté à partir du plan 1958DD par rapport aux autres plans avec une augmentation du nombre d'années de niveaux bas du lac.

L'abondance des autres communautés végétales des terres humides est également importante dans l'évaluation d'un plan de rechange. Ces prédictions des habitats ont été intégrées à plusieurs modèles fauniques. Des modèles fauniques comme les indicateurs de rendement de l'indice de reproduction de la guifette noire et du râle de Virginie ont été utilisés pour comparer l'alimentation relative des habitats de marais émergents profonds et peu profonds parmi les plans de rechange de régulation des niveaux d'eau.

Dans l'ensemble, les résultats de l'étude indiquent que la modération des fluctuations du niveau d'eau depuis le début de la régulation a limité considérablement l'environnement hydrologique à long terme important pour le maintien des communautés côtières des marais. La modération des fluctuations du niveau d'eau à long terme a également créé des conditions hydrologiques qui ont soutenu l'expansion d'espèces végétales agressives, émergentes et submergées, entraînant une réduction de la richesse des espèces végétales et de la qualité de l'habitat des marais émergents. La réduction de la qualité de l'habitat a probablement été accrue les terres humides qui ont également subi l'impact d'autres facteurs de stress, par exemple une augmentation des éléments nutritifs et des sédiments attribuable aux utilisations des terres environnantes. Toutefois, l'uniformité des résultats de l'étude sur les plantes et des tendances historiques de l'ensemble des terres humides de l'étude, un grand nombre d'entre elles étant dominées par des bassins hydrographiques boisés, soutient la conclusion que la modération du niveau d'eau attribuable à la régulation a un impact majeur sur la qualité de l'habitat côtier des terres humides.

L'établissement de relations quantitatives entre les niveaux d'eau et les communautés végétales des terres humides, les modèles géométriques généralisés d'élévation des terres humides et les estimations de la superficie des terres humides dans la région de l'étude offrent des outils de prévision puissants pour évaluer les impacts éventuels d'autres plans de régulation des niveaux d'eau sur les habitats marécageux côtiers du Lac Ontario et du haut Saint-Laurent. Les manipulations des critères de régulation des niveaux d'eau du plan actuel 1958DD démontrent clairement que de petits changements à des critères spécifiques peuvent avoir des impacts spectaculaires sur les communautés végétales des terres humides côtières. Si le comité de l'étude veut s'assurer que tout autre plan de régulation des niveaux d'eau recommandé à la CMI non seulement n'a aucun impact environnemental additionnel, mais intègre les critères axés sur la réduction des impacts environnementaux du plan actuel, les résultats de cette étude, qui ont été intégrés au IERM développé par le groupe de travail technique environnemental, peuvent offrir de l'information valable.

Les plans de régulation utilisés pour l'essai des modèles prédictifs ont été mis au point en reconnaissant que le comité de l'étude doit évaluer les intérêts de tous les intéressés et éviter les impacts indus pour ceux-ci. Par conséquent, il y a des options éventuellement viables qui ne dépassent pas les niveaux extrêmes du lac qui auraient autrement été produites selon le plan de régulation actuel. Elles changent plutôt la fréquence des niveaux du lac hauts et bas de concert avec une alimentation du bassin total et représentent des possibilités réalistes de régler les problèmes de cet écosystème important et complexe.

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1.0 Introduction

1.1 Background and Rationale

Water-level fluctuations are a natural phenomenon in the Great Lakes due to natural climatic variability. For example, Lake Michigan was less than half its current size during the mid-Holocene warming period about 6,000 years ago and has experienced other extreme high and low lake levels approximately every 150-160 years (Thompson and Baedke 1997, Baedke and Thompson 2000). The biological communities of the Great Lakes have, by necessity, evolved to adapt to the range of water levels and water-level changes that occur on several scales, ranging from wind-driven tides or seiches that can occur several times daily, to seasonal changes each year, to longer episodes.

The biological effects of water-level fluctuations in the lakes are greatest in shallow water where even small changes in water level can result in conversion of a standing water environment to an environment in which sediments are exposed to the air, or vice versa. The localized effects of this change in the environment are most evident in the plant communities that occur in wetlands. In fact, the patterns of water-level change are the driving force that determines the overall diversity and condition of wetland plant communities and the habitats they provide for a multitude of invertebrates, amphibians, reptiles, fish, birds, and mammals (Keddy and Reznicek 1986, Wilcox 1995, Wilcox and Meeker 1995, Maynard and Wilcox 1997, Keough et al. 1999).

Due to Lake Ontario regulation, high lake levels normally experienced during high water-supply periods have been lowered and low lake levels during low water-supply periods raised. The long-term lake-level graph of mean August water levels clearly indicates this moderating effect (Figure 1). This elevation range has been compressed from approximately 1.5 meters to 0.7 meters, or half of what it was prior to regulation or would have been without regulation. The result of water-level moderation is that the total nearshore area that experiences a flooding and dewatering cycle is reduced and wetland plant communities change. Shrubs and upland plants become established in the soils above the high water line, aggressive canopy-dominating larger plants such as cattails crowd out other emergent plant species in shallow water, and a few competitive submersed species dominate in deeper water. High water levels are required to kill many of the shrubs and invading upland plant species. High water levels also result in die back and opening in the lower extent of cattails and other canopy-dominating emergents when water depth growing tolerances are exceeded. When water levels recede, bare sediments are exposed to the air, and seeds of many other emergent plants are able to germinate and grow. The dominate plant species also grow from seed and eventually regain dominance. However, the diversity of habitat provided by a diverse plant community remains for a number of years, the plants are able to complete their life cycles and replenish the seed bank, which awaits the next cycle of high and low water levels. Extreme low water levels expose deeper nearshore areas to the air and kill the competitive submersed plant species; emergent plants grow from the exposed seed bank. When water levels go up again, many of the emergent species eventually die, a variety of submersed plants returns, and the competitive submersed species eventually dominate again, but habitat diversity for fish and other aquatic fauna has been increased for a number of years, and the cycle of wetland rejuvenation has been repeated again (Working Committee 2 1993, Wilcox 1995, Maynard and Wilcox 1997).

1.2 Project Objective

The overall objective of the wetland-related studies within the environmental assessment framework is to maintain, enhance, and restore healthy and diverse wetlands. The objective of this project was to determine water-level patterns that best maintain habitat diversity as determined by plant community diversity, abundance, and distribution. This information was then linked to habitat requirements for wetland fish and wildlife communities. Together, the information gained enabled development of water-regulation criteria important to wetland communities and assessment models for use in evaluating alternate water-regulation scenarios.

1.3 Project Framework

This project draws on past studies conducted in the early 1990s under the direction of the Natural Resources Task Group of Working Committee 2 of the IJC Levels Reference Study. These studies concluded that different wetland plant communities have developed at different topographic elevations in Lake Ontario in response to water-level history. Plant communities at a higher elevation that had not been flooded since 1952 were dominated by grasses, old field plants, and shrubs; over half of the taxa growing at that elevation were upland species. Plant communities at a lower elevation that had not been dewatered since 1964 had the lowest species richness and were dominated by several submersed species. At elevations that were alternately flooded and dewatered on a more frequent basis, species richness of wetland taxa was greatest. However, many of the dominant taxa across all elevations were introduced species (exotics) or otherwise considered undesirable because of invasive, weed-like habits. The lack of high lake levels in recent years was cited as the likely cause for dominance by invasive emergent taxa; the lack of low lake levels was the likely cause for dominance of submersed species (Wilcox et al. 1992). Altered seasonality of water-level changes was also noted (i.e., exaggerated wintertime drawdowns resulting in springtime water levels too low to flood wetlands) and cited as a deterrent to fish access to wetlands for spawning in the spring.

The Natural Resources Task Group sought to develop a draft regulation plan for Lake Ontario that increased the frequency and amplitude of high and low lake levels to approximate natural conditions more closely and thus reduce environmental impacts of regulation. A preliminary recommendation for accomplishing this task was developed based on pre-regulation lake-level variability. Modeling of this regulation plan was based on actual past inflows and resulted in modeled lake levels in several years in the 1970s and 1980s that would likely be considered unacceptable by other interests. Therefore, another preliminary recommendation was developed that used the highest and lowest lake level constraints of the current regulation plan but added more variability in water levels between years. When potential responses of wetland plant communities to this proposed plan were compared with other regulation plans under evaluation, the proposed plan showed some improvement in increasing the area of wetland subjected to both flooding and dewatering conditions and thus increased habitat diversity. However, development and testing of this plan was based on biological and topographic data collection at a limited number of actual field sites and was not quantitative. In addition, the required frequency of high and low water-level events was determined from the modern record, which is too short to show long-term trends. The development process for the plan was also unable to address the seasonality problem, in which many wetlands remain dewatered during the critical seasons when they are used by fish and wildlife, because the topography information was not suited to the task.

This project addressed the limitations identified previously by completing the following activities:

1) evaluation and quantification of interactions between long-term lake levels and wetland communities, and effects of past water-level regulation by

- a) completing a historic vegetation change analysis through comparison of current air photos with pre-regulation and intervening air photos
- c) completing a wetland inventory and classification
- d) sampling wetland plant communities along transects at specific elevations that represent unique hydrologic histories.

2) developing bathymetric/topographic models for each of four Lake Ontario wetland geomorphic types that relate plant communities and faunal habitats to water depths, as determined by lake levels, and can be used to predict habitat changes associated with changes in the regulation plan;

3) developing preferred environmental criteria for water-level regulation based on vegetation study results, bathymetric/topographic models, fish and wildlife habitat requirements, and long-term lake-level changes; and

4) using bathymetric/topographic models and study results to develop predictive tools to assess the potential effects on wetlands of all proposed new scenarios for water-level regulation.

2.0 Study Design

2.1 Study Sites

Although lake-level fluctuations are a key factor in the distribution of wetland plant communities along an elevation gradient, several other environmental variables also influence the plant community distribution and abundance within a wetland. These include coastal dynamics, local geology, watershed inputs, and human influences on these environmental variables (Keddy 2000). The interactions among lake and watershed hydrology, and shoreline geomorphology result in a diverse array of coastal features and wetland types within the Great Lakes (Keough et al. 1999, Albert et al. 2005). Within Lake Ontario – Upper St. Lawrence River, four distinct hydrogeomorphic types are common and include wetlands protected from wave attack by barrier beaches, thus retaining organic sediments and developing a flatter topographic profile; protected wetlands in river mouths that are back-flooded by the lake and also have organic sediments and a flatter topographic profile; wetlands exposed to wave attack in open embayments, thus having predominantly inorganic sediments and a steeper topographic profile; and wetlands of intermediate wave exposure in protected embayments. Eight wetlands of each type were selected in the Lake Ontario basin for the completion of detailed site-level wetland plant community research. The 32 wetlands, half being located in each country, are considered to be representative of the other Lake Ontario - Upper St. Lawrence River wetlands. Hydrologic associations and predictive models developed using data from the study sites were extrapolated to a basin-level wetland database to allow estimation of basin-level trends.

2.2 Lake Ontario - Upper St. Lawrence Coastal Wetland Database

A seamless, digital, vector-based coastal wetland database was created for the entire Lake Ontario basin and Upper St. Lawrence using a combination of existing Ontario and New York wetland databases and photointerpretation. The Ontario Great Lakes Coastal Wetland Atlas (Environment Canada and Ontario Ministry of Natural Resources 2003) was used as a basis for development of the Canadian IJC study specific database. The majority of Canadian Lake Ontario and Upper St. Lawrence wetland atlas data was created from Provincial Wetland Evaluations that are based upon standard provincial protocols to map and evaluate Ontario wetlands (Ontario Ministry of Natural Resources 1993). Additional coastal wetlands were identified using the Ontario Ministry of Natural Resources (OMNR) Natural Resource Values Information System (NRVIS) waterpoly coverage digitized from the Ontario Base Mapping Program in combination with aerial photographs. For coastal wetlands that did not have suitable digital data, polygons were generated by delineating the wetland boundary using standardized air photo interpretation techniques (Owens and Hop 1995) and on-screen digitizing using ArcGIS 8.2. A combination of OMNR spot height elevation data and aerial photographs were used to identify wetlands that are hydrologically connected and influenced by lake levels.

For the U.S. component of the data series, Lake Ontario - Upper St. Lawrence coastal wetlands were extracted from the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1981-2001). Digital Elevation Models (U.S. Geological Survey 2001) were used to select wetlands situated at an elevation at least partially below historic high lake-levels, and infrared aerial photos (USACE 1988/1990) were interpreted to identify wetlands hydrologically connected to Lake Ontario by open-channel flow. Wetlands identified in aerial photos but not included in the NWI data set were identified and digitized using Digital Enhanced OrthoImagery (NYS Department of State 1999). The New York State Department of Environmental Conservation Regulatory Wetlands database was consulted as necessary (NYSDEC 1999).

Aerial photointerpretation was used to classify all wetlands in the coastal wetland database into one of the four hydrogeomorphic groups; barrier beach, drowned river mouth, open embayment, or protected embayment using a standard protocol (Albert et al.2005).

2.3 Historic Trends in Wetland Vegetation Abundance

Aerial photointerpretations of historic wetland vegetation patterns were made from pre-regulation to recent years (1930s – 2001). The aerial photo time series was used to map major vegetation types distinguishable through standardized photointerpretation techniques (Owens and Hop 1995) using a modified version of the southern Ontario Ecological Land Classification (Lee et al. 1998) and project specific guidelines (Appendix A). All vegetation maps were vectorized and orthorectified using ESRI products. The current time series vegetation map for each wetland study site was ground-truthed in 2002, and vegetation polygon classifications updated accordingly. Signatures of the current vegetation types were used to assist in interpretation of historic vegetation types by back-tracking through the photo time series.

2.4 Current Distribution of Wetland Vegetation along a Hydrologic Gradient

In 2002, transects perpendicular to the shore were established 50 m apart at each of two randomly selected locations along the perimeter of each study wetland. The topographic cross-sections along each of these perpendicular transects were surveyed using a laser transit. Since permanent benchmarks are generally not available near study sites, the current lake level was used to establish altitudes. Lake level at the recording station nearest the study site was obtained by telephone from offices of the National Oceanographic and Atmospheric Administration or Canadian Hydrographic Service on the morning of the survey. Specific elevations with ecological significance based on past water-level history were located along each transect by surveying, marking with flagged stakes, and GPS. Since the existing wetland vegetation in the lake developed in response to the history of high and low lake levels, the selected elevations reflect unique water-level histories. Surveyed elevations (IGLD85) were: A) 75.60 m, last flooded 30 years ago; B) 75.45 m, last flooded 10 years ago; C) 75.35 m, last flooded 5 years ago; D) 75.0 m, last flooded 1 year ago and last dewatered during growing season 2 years ago (variable flooding and dewatering over past 5 years); E) 74.85 m, last dewatered during growing season 4 years ago; F) 74.7 m last dewatered during growing season 38 years ago; G) 74.25 m, last dewatered during growing season 68 years ago. (Figure 2).

In late July- early August 2003, sampling was conducted at both plots within each study site. Ten 0.5 x 1.0 m quadrats were randomly placed along transects that follow the contours for each specific elevation (parallel to the shoreline) and running between the two transects surveyed in perpendicular to the shoreline. The quadrats were placed on the landward side of the contour transect lines. Such placement allowed the quadrats to adhere to the water-level history of each elevation according to the sampling design. In each quadrat, the plant species present were identified and percent cover estimations made by visual inspection. Plant taxonomy followed Gleason and Cronquist (1991). Substrate types and canopy cover were also noted or measured and recorded at each quadrat location. Importance Values (IV) were calculated for all taxa within each transect as the sum of relative frequency and relative cover ratings; these values were placed in Non-metric Multi-Dimensional Scaling (NMDS) ordinations. Correlation between specific elevations and accompanying plant communities were assessed across all wetlands sampled to determine the range of elevations in which the most diverse plant communities occur and to identify unique hydrologic associations of individual plant species, including invasive taxa. Any correlations with other physical habitat parameters were identified also.

2.5 Wetland Study Site and Generalized Elevation Models

The Information Management Working Group (formerly Common Data Needs WG) was identified to oversee collection of appropriate elevation data for the 32 wetland study sites. Topographic and bathymetric data for each study site were acquired using a combination of existing detailed Flood Damage Reduction Mapping, photo-interpreted topographic contours, airborne LIDAR, and boat-based sounding techniques. The bathymetric and topographic data were used to develop digital elevation models of each wetland study site within a GIS modeling framework. A variety of interpolation methods were evaluated for use with point elevation data from varying sources. A generalized digital elevation model for each of the four wetland types was created by integrating data from the eight study sites for each hydrogeomorphic wetland type. The generalized model and coastal wetland database were used to quantify estimates of change using the various wetland performance indicators and metrics.

3.0 Results and Discussion

3.1 Study Sites

Study sites were distributed throughout the Lake Ontario – Upper St. Lawrence River (Figure 3). Factors considered in selection of study sites included current distribution of wetlands, representative characteristics, accessibility, and topographic/bathymetric data collection limitations within the study. More study sites were located within the eastern half of the study area due to the fact that over 80 % of the current coastal wetland area occurs in this region (see Section 3.2) and acquisition of topographic/bathymetric data was restricted to certain reaches of the shoreline by the Common Data Needs Working Group. A total area of 4,108 hectares of wetland was mapped within the 32 study sites (Table 1). Study-site size varied significantly ranging from 7 to 543 hectares, with the mean wetland area for each wetland type ranging between 104 and 180 hectares (Table 1). Wetland area within the 32 study sites represents approximately 16% of the total estimated coastal wetland area within the Lake Ontario – Upper St. Lawrence River region.

3.2 Lake Ontario - Upper St. Lawrence Coastal Wetland Database

A total of 879 geomorphically distinct wetlands were identified within the Lake Ontario – Upper St. Lawrence River area, totaling 25,847 hectares (Appendix B). Drowned river mouth wetlands account for the largest area of wetland, followed by barrier beach, protected embayment, and open embayment (Table 2). Wetland size ranged from 0.02 to 1,157.2 hectares with an average size of 29.4 hectares. The availability of higher resolution wetland data in New York enabled identification of many wetlands less than 2 hectares in size (n=283). Ontario wetland data were typically not available to this resolution, and fewer small wetlands (<2.0 hectares) were identified on the Canadian side (n=56). Although the different resolutions do have an impact on the accuracy of current wetland distribution within the study, these wetlands have only a small influence on the total wetland area by type. The total wetland area was used to extrapolate study site based generalized models to basin-level impacts.

Distribution of wetlands along the shoreline is dictated by surficial geology, watersheds, and coastal processes. The eastern half of Lake Ontario (east of shoreline units CND8 and US3 to RIV1) supports over 21,000 ha of wetland or greater than 80% of the estimated current coastal wetland area (Figure 4). Within the eastern basin, shoreline units CND9, CND11, US4, US7, and RIV1, specifically, contain a geomorphology that supports a very high density of embayment and barrier beach wetlands (>18,000 ha) (Figure 4, 5).

Drowned river mouth wetlands make up the majority of wetlands that occur in the western basin of Lake Ontario. The highest concentrations of barrier beach wetlands are located along the southeastern shoreline of Lake Ontario (US4, US7, and US8) and outer shoreline of Prince Edward County (CND9), Ontario (Figure 5). The greatest densities of protected and open embayment wetlands occur within the Bay of Quinte (CND11), and within the island network occurring at the outlet of Lake Ontario and Thousand Island region within the St. Lawrence River (US8, RIV1).

3.3 Historic Trends in Wetland Vegetation Abundance

Interpretation and analysis of Lake Ontario water-level data and aerial photo series revealed an often substantial increase in the area and percent cover of *Typha*-dominated wetland vegetation communities since water-level regulation began in 1958. Aerial photo sets in the late 1950s and mid- to late 1960s revealed meadow marsh vegetation to be common in most study sites during this time period, which corresponds to low water levels in 1958-1959, and again in 1964-65. Over the course of this low water-level period, meadow marsh also expanded downslope, displacing emergent marsh at higher and dryer elevations in several locations (Figure 6). In other locations, the area of meadow and emergent marsh generally remained constant during this period. Since this low water period, there has been an often substantial increase in the area and percent cover of emergents and typically *Typha*-dominated wetland vegetation communities. At most sites, the increase in *Typha*-dominated area did not result from outward expansion of the wetland; it was the result of *Typha* invasion into existing meadow marsh communities (Figure 6, 7). The most dramatic increase in *Typha* was observed in the late 1970s photo set that was taken during a time of extended high-water levels. Lack of low water levels since the mid-1960s has seemingly not allowed meadow marsh to displace *Typha* at higher elevations. As a result, it is estimated that the greater than 50% of the meadow marsh wetland area that occurred within Lake Ontario – Upper St. Lawrence River during the mid- to late 1960s has been displaced by *Typha*-dominated emergent marsh. At many study sites, the loss in area of meadow marsh vegetation since the 1960s exceeds 80%. After the extreme highs in the mid-1970s, relatively static, moderate water levels in the 1980s and 1990s have maintained a somewhat constant area of meadow marsh. *Typha*, however, continued to expand into shallow pools and channels, resulting in a reduction in emergent habitat heterogeneity and emergent-open water edge (Figure 6). The floating-leaf communities have also increased in area at many sites since the 1970s due to the lack of extremely high or low water levels.

It should be noted that Great Lakes coastal wetlands have been impacted by a variety of human activities over the last 40 years. Surrounding land uses such as agriculture, have increased nutrient and sediment inputs, and are supporting the expansion of Typha in many Lake Ontario coastal wetlands. It is likely that degree of loss in habitat heterogeneity, diversity, and dominance of aggressive plant species such as Typha and other exotic species has been magnified in coastal wetlands that have experienced cumulative stresses. The moderation of water levels due to water regulation however, is a basin wide and significant stressor to the coastal wetland communities.

3.4 Current Distribution of Wetland Vegetation along a Hydrologic Gradient

Of the seven elevations that were sampled, the three transects at higher elevations (A, B, and C) had the most species in all four geomorphic types (Table 3). Differences in species richness between transects D, E, F, and G varied by geomorphic type and wetland. The number of wetland obligate species will be considered in future analyses.

When vegetation data were analyzed by species prominence and non-metric multidimensional scaling (NMDS), transects A, B, and C showed similarities across geomorphic types, and E and F were similar in all types except protected embayments. Data were analyzed to ascertain similarities among wetlands of the same geomorphic type for use in the model.

Open embayment.

Analysis of the most prominent species in open-embayment wetlands, determined by mean percent cover greater than 2.0 for at least one transect, showed similarities among transects A, B, and C in species composition consisting of sedges, grasses, and upland species (Table 4). In transect D, sedge and grass species, as well as emergent vegetation present in E and F (e.g., *Typha*), comprised the prominent species. Transects E and F showed similar species composition, largely *Typha*-dominated emergent vegetation, with some submersed species and sedges and grasses. In transect G, floating-leaf vegetation (e.g., *Nymphaea*) and submersed vegetation were more prominent than emergent vegetation, and sedges and grasses were not observed (Table 2). The NMDS ordination of species importance values provided a separate approach at analyzing the same open-embayment vegetation data. The initial ordination analysis (Wilcox et al. 2004) sorted the vegetation of each wetland transect according to similarities, dissimilarities, and co-occurrences. The transects largely fell into distinct groups having similarities to prominent species patterns observed in

Table 4. One study site (Robinson Cove) proved to be a partial outlier, and the transect D data point for that site was thus excluded from the D grouping within the ordination (see Wilcox et al. 2004). The resulting ordination diagram (Figure 8) showed transects A, B, and C in close proximity to each other and transect G isolated from others, an indication of unique species composition. Although a minor overlap was observed between the D- and E-transect groups, transects E and F fell very close to each other, whereas transect D fell farther away; it was apparent that the E and F transects had similar species composition, while the D transects had a dissimilar species composition (Figure 8). The prominent species calculations (Table 4) and the ordinations, although a separate means of analyzing the vegetation data, gave the same results. Accordingly, for open embayment wetlands, vegetation at transects A, B, and C was treated as one community; transect D vegetation was a second community; vegetation at transects E and F comprised a third community; and vegetation at transect G was a fourth. The four communities were used in subsequent analyses. For each vegetation structural category defined for faunal studies, a mean cover for the four transect groupings was calculated (Table 5). Forbs, grasses, trees/shrubs, and sedges had the highest mean cover values in the ABC community. Thin-stem persistent emergent vegetation was prominent in both the D and EF communities. However, forbs followed in prominence in the D community, whereas floating-leaf vegetation followed in the EF community. Submersed narrow-leaf vegetation dominated the G community. Unlike the ABC and G communities, the D and EF communities contained vegetation in most structural categories (Table 5).

Protected embayment.
Like open embayments, analysis of the prominent species in protected-embayment wetlands showed similar grass and sedge species composition in transects A, B, and C (Table 6). Transect D had sedges and grasses but was dominated by *Typha*. Transect G again was dominated by floating-leaf and submersed vegetation and lacked sedges and grasses. Unlike the open embayments, however, the protected-embayment wetland vegetation was distinct in transects E and F. Although *Typha* was most prominent in both transects, the presence of grasses differentiated E from F, and distinctions between D and E were due to greater prominence of trees and shrubs in D and floating-leaf vegetation in E (Table 6). The initial NMDS ordination of the wetland vegetation (Wilcox et al. 2004) showed similar results. Two study sites were identified as partial outliers. When the ordination was run again without Black River Bay South and the data point for transect E from Parrot Bay was excluded from the E grouping, transects A, B, and C overlapped almost completely, and the other four transects were mostly distinct (Figure 9). As in the open-embayment wetlands, the prominent species and ordination analyses produced similar results. For protected embayment wetlands, transects A, B, and C were treated as one community, and transects D, E, F, and G were considered four individual communities. These five communities were used in subsequent analyses. For the faunal study, mean cover of vegetation structural categories was calculated for the communities described, and calculations excluded Black River Bay south (Table 7). Forbs and trees/shrubs dominated the ABC community. Thin-stem persistent emergents and grasses were prominent in the D and E communities, with an increase in floating-leaf vegetation differentiating E from D. The F community was similar to E except that it had fewer grasses and more floating-leaf vegetation. Finally, submersed narrow-leaf, floating leaf, and algae dominated the G community.

Barrier beach.
Prominent species analysis of barrier-beach wetland vegetation indicated similarities between transects A, B, and C, whose predominant species composition consisted of grasses, ferns, and shrubs (Table 8). Although transects D, E, and F were dominated by *Typha*, transect D had more grasses than transects E and F, which had similar species compositions. Transect G was dominated by floating-leaf and submersed vegetation (Table 8). The initial NMDS ordination of transect vegetation (Wilcox et al. 2004) gave similar results, with transects A, B, and C overlapping and G a distinct group. Two study sites were partial outliers (Wilcox et al. 2004). The ordination was run again with the Port Britain data removed, and the data point for the E transect at Big Sand Bay was excluded from the E grouping. The resulting ordination diagram (Figure 10) showed transects A, B, and C overlapping, E and F overlapping, G distinct, and D mostly distinct. Thus, by prominent

species and ordination analyses, transects A, B, and C were treated as one community in subsequent analyses. Transect D was considered a second community, combined E and F transects formed a third community, and transect G was the fourth. The mean cover for structural categories used in faunal studies was calculated for the four communities described above (Table 9). The ABC community was dominated by trees/shrubs, forbs, ferns, and grasses. Thin-stem persistent emergent species were dominant in the D and EF communities. However, the EF communities had more floating-leaf vegetation, whereas the D community had grasses. Prominent structural categories in the G community included narrow-leaf, floating leaf, and algae.

3.5 Wetland Study Site and Generalized Elevation Models

Topographic and bathymetric data formats and sources varied for the 32 study sites. An Inverse Distance Weighting (IDW) interpolation method with a power value of 2.4 and weighting value of 8 meters was used to create individual elevation surface maps for each of the study wetlands (Figure 12). This method was chosen as the best method to minimize jagged edges associated with bathymetric data collection methods and varying point density. To meet the needs of the IJC study, four models representing the four wetland geomorphic types were developed to provide the required predictive capability. The generalized models were developed by determining the relative areal proportion of each individual wetland that lies above, below, or between selected contour intervals (Table 12). ArcGIS 3D Analyst was used to generate generalized geometric models for each of the four wetland types studied based on the elevation surface maps from the groups of wetlands for each wetland geomorphic type. The resultant models for open embayment, protected embayment, barrier beach, and drowned river mouth wetlands are meant to represent all wetlands of each specific type but not any individual site (Figure 13a, b, c, d).

The uniqueness of the four wetland geomorphologies elevation profiles is evident within the cumulative percent area distributions along the model elevation range (Figure 14). Within the open and protected embayment geometric models lower elevation contours account for more of the total model area. Relative to the other wetland types, embayment wetlands are more exposed to wave attack and ice scour, which reduces the rate of organic sediment deposition. For this reason, embayment wetlands are expected to have a steeper topographic profile within the upper contour elevations and shallower slopes at lower elevation contours. Drowned river-mouth and barrier-beach wetlands are typically well-protected from wave attack. The river channel and beach barrier protection features allow for thick sediment accumulation and result in a shallower topographic profile within the upper elevation contours of the model range.

4.0 Predictive Models and Performance Indicators

4.1 Predictive Habitat Models for Assessing Alternate Water Regulation Plans

The predictive model was developed in the first year of this study using hypothetical topographic/bathymetric data. Within a GIS format, the model calculated the land-surface area between any selected elevation contour lines and converted such areas to percent of total wetland area using the following general procedures. Making use of the new regulation plan provided for evaluation, and starting with the most recent year in that plan, the hypothetical model used mathematical routines to **a**) identify the highest past lake level that occurs in the plan (e.g., 75.4m IGLD), **b**.) determine the wetland area (and percent wetland) between that elevation and the upper limit of the topographic/bathymetric model (75.75m), **c**) determine the number of years from the year being analyzed and the year in which the highest lake level (75.4m) occurred, and **d**) assign the area/percent wetland results to the appropriate vegetation/ time class (e.g., always dewatered, so *last flooded >30 years ago*).

Next, starting at the previously identified highest lake level (75.4m), the mathematical routines did the following: $\mathbf{a_1}$) identify the next highest lake level shown in the regulation plan that occurs **after** the previously identified 75.4m high (e.g., 75.2m), **b_2**) determine the wetland area (and percent wetland) between that elevation and the 75.4m elevation, **c**) determine the number of years from the year being analyzed and the year in which the next highest lake level (75.2m) occurred, and **d**) assign the area/percent wetland results to the appropriate vegetation/ time class (e.g., last flooded 16 years ago, so last flooded *5-30 years ago*). The routine identified above is continued until the next identified high lake level is less than 5 years in the past, as determined in step **c**.

A routine similar to that identified above is then used to **a_2**) identify the lowest summertime peak lake level (e.g., 74.2m), **b_2**) determine the area and percent wetland between that elevation and the lower limit of the topographic/bathymetric model (73.0m), **c_2**) determine the number of years from the year being analyzed and the year in which the lowest summertime peak lake level (74.2m) occurred, and **d**) assign the area/percent wetland results to the appropriate vegetation/ time class (e.g., always flooded in summer, so *last dewatered in summer >40 years ago*). Routines similar to those above then continue to address low summertime peak lake levels until the next identified low summertime peak lake level is less than 4 years in the past. All wetland elevations (and corresponding areas/percents) that were flooded less than 5 years or dewatered less than 4 years in the past from the year being analyzed are assigned to the vegetation/ time class *flooded less than 5 years and/or dewatered in summer more recently than 4 years ago*.

The above steps are then repeated for the next most recent year shown in the regulation plan and continue sequentially backwards through the first year of the plan. When evaluating early years in a regulation plan, there are limited numbers of prior years from which to make calculations. This problem is overcome by attaching a copy of the regulation plan at the beginning of the plan under evaluation because the regulation plan is considered to be a repetitive sequence of lake-level patterns.

The hypothetical model output is annual predictions of the area and percent of vegetation/time classes that will occupy the elevation range (73.0-75.75m) given in the model. These predictions are then time-weighted by summing the areas/percents for each vegetation/time class and dividing by the number of years analyzed. The final output is time-weighted percent of wetland expected to fall into each vegetation/time class during the period portrayed by the proposed regulation plan. This model was tested and found to function according to design. However, it represented a hypothetical wetland and could not be used for actual predictions of wetland plant community response to regulation plans. Application of the four study generated geometric models representing the wetland geomorphic types required minor modifications of the hypothetical model because water-level data were presented in quarter-monthly (QM) form. As described in Section 3.4, the vegetation types were also defined more clearly, based on actual field data from sampling along transects.

Assignment of vegetation types (ABC, D, EF (E and F are separate for protected embayments only), or G) to various elevation ranges is based on the number of years since last flooded or the number of years last dewatered among the transect elevations used for sampling and grouped together as individual vegetation types. Professional judgment based on discussions among prominent Great Lakes wetland scientists was used to determine break points between classes.

Estimations of the number of years since last flooded and/or dewatered for each elevation increment are calculated based on the following process.

For "last flooded" determinations of A, B, C, D :

- All portions of elevation model above the highest peak identified across the entire regulation plan are never flooded by the lake and are automatically assigned to U (transition to Upland) up to 75.75m
- For other peaks, locate peak Quarter Month (QM).

- Identify 3 adjacent (4 total) highest QMs (doesn't matter which side of peak).
- Select elevation of the QM that is lowest of the 4.
- In most cases, this selects an elevation that has been flooded for 3 QMs.

IF: the most recent "last-flooded" peak year selected is <5 years ago and its elevation selected from the 4 highest QMs as described above is less than the most recent dewatered year elevation, then use the single peak QM for the "last flooded" elevation determination, rather than the elevation selected from the 4 highest QMs.

For "last dewatered in summer" determinations of D, E, EF, F, G :

- Use annual peak QM elevation.
- All portions of the elevation model below the lowest summertime peak identified across the entire regulation plan are continuously flooded and automatically assigned to G down to 73.0m.
- This procedure selects an elevation that largely remained dewatered during the entire growing season, although it could be flooded short term if the peak QM elevation reported did not represent the actual peak day. In addition, this elevation could periodically be flooded by seiches.

Vegetation assignments to various elevations ranges are based upon the following vegetation rules-based models:

Open Embayment Wetlands
Not flooded >30 years: assign to U (transition to Upland) and go up to elevation of 75.75m
Not flooded 5-30 years: assign to (A+B+C)
Not flooded <5 years or Not dewatered <4 years: assign to (D)
Not dewatered 4-39 years: assign to (E+F)
Not dewatered 40 years or more: assign to (G) and go down to elevation of 73.0m

Protected Embayment Wetlands
Not flooded >30 years: assign to U (transition to Upland) and go up to elevation of 75.75m
Not flooded 5-30 years: assign to (A+B+C)
Not flooded <5 years or Not dewatered <4 years: assign to (D)
Not dewatered 4-20 years: assign to (E)
Not dewatered 21-39 years: assign to (F)
Not dewatered 40 years or more: assign to (G) and go down to elevation of 73.0m

Barrier Beach Wetlands
Not flooded >30 years: assign to U (transition to Upland) and go up to elevation of 75.75m
Not flooded 5-30 years: assign to (A+B+C)
Not flooded <5 years or Not dewatered <4 years: assign to (D)
Not dewatered 4-39 years: assign to (E+F)
Not dewatered 40 years or more: assign to (G) and go down to lowest elevation in model

Drowned River Mouth Wetlands
Not flooded >30 years: assign to U (transition to Upland) and go up to elevation of 75.75m
Not flooded 5-30 years: assign to (A+B+C)
Not flooded <5 years or Not dewatered <4 years: assign to (D)
Not dewatered 4-39 years: assign to (E+F)
Not dewatered 40 years or more: assign to (G) and go down to lowest elevation in model

The four new models were tested using several potential regulation plans for Lake Ontario. The plans were very similar, but differed in summertime peak water levels in certain years in a manner that would be expected to result in a change in model output for meadow marsh vegetation (ABC). The plans tested were 1958D with deviations (1958DD) (Figure 15), and two plans developed by using 1958DD as a base and adding a higher lake level (75.65m) in 1947 when basin supplies were high and lower lake levels in the 1910s, 1930s, 1960s, and late 1990s when basin supplies were low. Neither high nor low lake levels exceeded those that actually occurred during post-regulation.

Plan 0809c (Figure 16) added low summertime peak levels around 74.7m in 1910, 1911, 1934, 1935, 1964, 1965, and 1999 to provide the perceived opportunity for meadow marsh vegetation (ABC) to recolonize portions of the elevation gradient otherwise occupied largely by *Typha* (D, E, F, EF). Following those low summertime peak levels, intermediate summertime peak levels of about 74.8m were invoked in 1912, 1913, 1936, 1937, 1966, 1967, and 2000 to sustain the ability of the meadow marsh vegetation type (ABC) to occupy a wider elevation range.

Plan 0924 (Figure 17) was similar to plan 0809c except that the intermediate summertime peak levels of about 74.8m were extended to 1914, 1915, 1938, 1939, 1968, and 1969 to increase the ability to sustain the meadow marsh vegetation type (ABC). Thus, the expected response of model results would be an increase in ABC from plan 0809c to 0924, both of which should have more ABC than 1958DD.

When the regulation plans were tested by the models, the 101-year average for meadow marsh (ABC) vegetation increased from 1958DD to 0809c to 0924 in the drowned river mouth, barrier beach, and open embayment models. ABC results in plans 0809 and 0924 were equivalent in the protected embayment model but greater than results for 1958DD (Table 13). Full model results are presented in Appendix C and D.

4.2 Wetland Habitat Performance Indicators

Many aspects of the Lake Ontario - Upper St. Lawrence River coastal wetland flora and fauna are being evaluated by members of an Environmental Technical Working Group (ETWG). The ETWG used a variety of predictive models to develop metrics and Performance Indicators (PIs) for use in an environmental evaluation of alternate water regulation plans. Annual estimates of several unique wetland habitat types are being predicted as a percentage of the geometric wetland models (Figure 18). The percentage values were multiplied by wetland type total area estimates to generate basin level area estimates of wetland habitat types. The abundance of other predicted wetland vegetation communities are also important in alternate plan evaluation. These habitat predictions have been incorporated into several faunal models. Faunal models such as the Black Tern and Virginia Rail Tern Reproductive Index performance indicators, incorporate estimates of emergent marsh area that are flooded during the breeding season (DesGranges et al. 2005). As such, these two PIs are being used to compare the relative supply of deep and shallow emergent marsh habitats among alternate water regulation plans.

Analyses of historic aerial photos showed that the extent of meadow marsh plant communities decreased substantially following regulation of lake levels. Ensuring that meadow marsh plant communities are not additionally impacted under proposed alternate regulation plans is a specific priority of the wetland research. The following performance indicator was developed specifically for meadow marsh habitats. It uses the models described above and applies the results to total area of wetland in each geomorphic type, as determined by the wetland inventory.

Area of meadow marsh - Meadow marsh vegetation (ABC) typically develops between the maximum long-term high water level and the long-term mean. Plant species within this community are intolerant of prolonged flooding, but occasional flooding is required to prevent woody plant species from expanding down slope into the meadow marsh community. In addition, periodic low water levels are also required to stop the expansion of aggressive emergent plants upslope, and allow meadow marsh plant species to expand into elevations that are temporarily unsuitable to maintain emergent plants. Meadow marsh habitats support a very diverse group of meadow-specific plant species but typically also contain some emergent, shrub, or upland plant species. The relative amount of these species is dictated by the years since the last high or low water-level cycle. For this reason, the meadow marsh community supports the greatest diversity of plant species and can contain a diversity of structural habitats that support a wide range of fauna. However, the meadow marsh occurs in a relatively narrow hydrologic range in comparison to the other wetland vegetation communities.

Water-level-regulation plans that maximize the expansion of meadow marsh in the 101-year average area estimates are considered better for the environment. However, when the extent of meadow marsh is averaged over the 101-year period, the data include years with high total basin supplies, which should result in high lake levels not amenable to meadow marsh expansion. A performance indicator based on the 101-year period would not represent the actual potential for meadow marsh expansion. Therefore, the performance indicator was scaled to include analyses for only those years in which low total basin supplies provided an opportunity for meadow marsh to expand. The resulting performance indicator measures the comparative ability of regulation plans to generate the low lake levels required by the meadow marsh community during time periods when water supplies are low and low lake levels are possible.

The periods selected for analyses under this performance indicator were determined by analyzing total basin supplies during the pre-regulation period and comparing them with the actual lake levels that occurred during the same time period. The quarter-monthly total basin supplies for January to June were then summed for those years and averaged. As a result of this procedure, the performance indicator measures meadow marsh response in the years following a low supply period in which the January-June quarter month net total supply is less than 6,792 m3/s and continues until the year when the same average exceeds 7,917 m3/s).

Regulation plans 1958DD, 0809c, and 0924 were then evaluated both by individual geomorphic wetland type models described above and by the IERM, in which percentages of meadow marsh community across all geomorphic types were converted to area of meadow marsh for the entire Lake Ontario/Upper St. Lawrence River basin. Again, the percent of meadow marsh vegetation type increased from plan 1958DD to 0809c to 0924 in models for all geomorphic types (Table 14). Within the IERM, the total area of meadow marsh in the basin increased from 5,225 ha for plan 1958DD to 5,897 ha for plan 0809c to 6,327 ha for plan 0924.

5.0 Conclusions

Intensive plant community surveys within coastal wetlands representative of the study area confirm previous conclusions that the distribution of plant communities in Lake Ontario – Upper St. Lawrence River coastal wetlands is highly correlated to water-level history (Wilcox et al. 1992). The wetland plant community type observed at specific elevations was consistent among sites within and across the wetland geomorphic types. Analyses of historic aerial photographs also confirm that plant communities have responded to interannual water-level cycles, with communities shifting up- and down-slope, based upon hydrologic preferences, during high and low water-level cycles, respectively. Study results also indicate that moderation of water-level fluctuations since water regulation, has significantly restricted the long-term hydrologic environment important to the maintenance of coastal wetland meadow marsh communities. Moderation of long-term water-level fluctuations has also created hydrologic conditions that supported the expansion of aggressive, dominant emergent and submergent plant species, resulting in a reduction of plant species richness and emergent marsh habitat quality. It is likely that the reduction in habitat quality has also been influenced and magnified in wetlands that have been impacted by increased nutrient and sediment inputs due to surrounding land uses. However, intensive surveys and historic aerial photo evaluations provide very similar results across all of the study sites, including sites with largely natural (forested) watersheds. The consistency in study results support the conclusion that water-level moderation due to water regulation is having a major impact on coastal wetland habitat quality.

The development of quantitative relationships between water levels and wetland plant communities, generalized geometric wetland elevation models, and estimates of wetland area within the study region provide powerful predictive tools to evaluate potential impacts of alternate water-level regulation plans on Lake Ontario – Upper St. Lawrence coastal wetland habitats. Manipulations of the current Plan 1958DD water regulation criteria clearly demonstrate that small changes in specific criteria can have dramatic impacts on coastal wetland plant communities. If the Study Board desires to ensure that any alternate water-level regulation plan recommended to the IJC not only has no additional environmental impact but also incorporates criteria focused on reducing environmental impacts of the current plan, the results of this study, which have been incorporated into the IERM developed by the Environmental Technical Working Group, can provide valuable information. The regulation plans shown in Figures 16 and 17 were developed to test the wetland plant community model, but they were developed with recognition that the Study Board must evaluate the interests of all stakeholders and avoid undue impacts to any interest. Therefore, they are potentially viable options that do not exceed extreme lake levels that would be produced under the current regulation plan. Instead, they change the frequency of high and low lake levels in concert with total basin supplies and represent realistic opportunities to address problems facing this important and complex ecosystem.

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Tables

Table 1. Size characteristics of the 32 Lake Ontario - Upper St. Lawrence River wetland study sites.

Wetland Type	Count	Total Area (ha)	Mean Area (ha)	Min. Area (ha)	Max. Area (ha)
Barrier Beach	8	836.8	104.6	11.9	178.3
Drowned River Mouth	8	1,442.7	180.3	27.4	543.1
Open Embayment	8	880.6	110.1	7.7	346.0
Protected Embayment	8	948.3	118.5	15.3	371.1
Total	32	4,108.4			

Table 2. Estimate of Lake Ontario - Upper St. Lawrence River coastal wetland area (hectares) by shoreline unit and wetland type. Barrier beach (BB), drowned river mouth (DRM), open embayment (OE), and protected embayment (PB) geomorphic types.

SHL UNIT	BB	DRM	OB	PB	SHL UNIT TOTAL
CND1	-	190	5	-	195
CND3	-	226	-	-	226
CND4	11	46	-	-	57
CND5	4	-	-	14	18
CND7	323	529	-	-	852
CND8	187	139	-	-	326
CND9	1,197	997	473	634	3,301
CND10	23	71	63	11	168
CND11	67	3,059	695	2,184	6,004
CND12	543	781	-	73	1,397
Subtotal	**2,356**	**6,038**	**1,236**	**2,915**	**12,545**
US1	33	184	0	-	218
US2	587	551	162	94	1,393
US3	-	8	1	-	9
US4	880	626	0	443	1,950
US5	82	14	3	-	99
US6	149	4	0	-	154
US7	1,954	324	0	305	2,584
US8	361	249	218	96	924
Subtotal	**4,046**	**1,961**	**386**	**938**	**7,331**
R1	431	1,163	1,392	1,580	4,566
R2	-	56	103	156	315
R3	39	69	220	762	1,090
Subtotal	**470**	**1,288**	**1,714**	**2,498**	**5,971**
TOTAL	**6,872**	**9,287**	**3,337**	**6,352**	**25,847**

Table 3. Species richness by transect for each wetland study site.

Geomorphic Type	Site		Transect						
			A	B	C	D	E	F	G
Barrier beach	2.	Lynde Creek	32	33	37	15	7	8	2
	4.	Port Britain	27	27	27	13	9	4	-
	6.	Huycks Bay	22	18	16	20	20	24	12
	8.	Big Sand Bay	38	38	38	26	29	16	-
	26.	Lakeview Pond	53	53	52	30	17	18	19
	27.	South Colwell Pond	48	39	38	20	14	27	29
	29.	Maxwell Bay	40	46	43	24	18	15	13
	30.	Round Pond	23	25	28	19	6	9	17
Drowned river mouth	1.	Jordan Station	32	23	18	16	7	3	8
	3.	Wilmot Creek	28	26	26	14	11	12	6
	10.	Hay Bay north	35	39	36	20	16	16	17
	13.	Little Cataraqui	27	35	30	22	16	23	14
	17.	Crooked Creek	40	57	61	42	23	21	25
	21.	Kents Creek	50	44	32	11	7	9	16
	25.	Stony Creek	40	48	39	21	14	15	24
	32.	Brush Creek	38	28	22	9	6	8	14
Open embayment	7.	South Bay	32	29	21	13	15	14	6
	9.	Robinson Cove	20	25	21	11	13	16	14
	11.	Hay Bay south	42	40	39	17	18	10	11
	15.	Button Bay	49	50	39	15	11	15	11
	20.	Eel Bay	54	61	65	33	27	24	21
	22.	The Isthmus	45	39	34	13	27	17	14
	23.	Black River Bay north	67	65	62	24	13	35	20
	31.	Braddock Bay	33	26	33	16	14	18	12
Protected embayment	5.	Presqu'ile Bay	37	41	34	27	26	18	15
	12.	Parrot Bay	34	39	42	24	16	24	17
	14.	Bayfield Bay	27	32	31	32	24	25	16
	16.	Hill Island East	39	38	37	31	27	33	20
	18.	Goose Bay	48	54	45	23	16	16	25
	19.	Point Vivian Bay	23	33	29	23	16	10	15
	24.	Black River Bay south	32	28	27	17	9	13	18
	28.	north North Pond	37	38	31	16	17	27	17

Table 4. Most prominent species among open-embayment wetlands by mean percent cover for all transects.

TAXA	MEAN % COVER						
	A	B	C	D	E	F	G
Calamagrostis canadensis (Michx.) P. Beauv.	12.89	12.82	12.06	2.42	0.09	0.12	
Anemone canadensis L.	5.32	5.50	1.98				
Viburnum lentago L.	4.80	3.92	2.23				
Cornus sericea L.	3.98	2.27	0.58				
Rubus idaeus L.	2.60	1.09	0.58				
Lathyrus pratensis L.	2.31	0.69	0.02				
Impatiens capensis Meerb.	2.23	3.85	5.85	8.44	0.25	0.18	
Phalaris arundinacea L.	2.21	5.41	10.00	10.52	7.03	4.49	
Vitis riparia Michx.	2.18	1.04	2.63				
Carex stricta Lam.	2.12	3.91	4.92	0.15			
Lonicera x*bella* Zabel	2.10	0.94	0.15				
Lysimachia nummularia L.	2.00	3.19	3.16	0.09			
Onoclea sensibilis L.	1.44	2.78	0.39			0.03	
Cornus racemosa Lam.	1.38	1.31	3.21	0.65			
Typha x*glauca* Godr.	0.09	1.09	3.81	16.19	12.03	6.11	0.04
Typha angustifolia L.	0.01	0.06	0.09	11.12	13.84	23.94	0.42
Typha spp.		0.04	0.18	2.19			
dead *Typha* spp.			0.01	32.32	20.20	9.57	
Lemna minor L.				2.43	0.89	3.98	0.01
Hydrocharis morsus-ranae L.				1.22	9.33	5.07	0.63
Sparganium eurycarpum Engelm.				0.25	1.26	3.33	0.42
Lemna trisulca L.				0.19	1.94	5.49	0.32
Vallisneria americana L.				0.02	0.16	0.84	11.02
Ceratophyllum demersum L.					0.30	1.01	5.18
Potamogeton pusillus L.					0.21	0.70	2.78
Chara spp.					0.17	2.41	10.08
Myriophyllum spicatum L.					0.10	0.06	3.82
Najas flexilis (Willd.) Rostkov and Schmidt					0.02	0.64	8.19
Potamogeton zosteriformis Fern.						0.12	3.96
Potamogeton pectinatus L.						0.01	4.48

Table 5. Open-embayment wetland mean cover by combined transects for unique structural groups.

Structural Category	**A,B,C MEAN COVER (*480 quads*)**	**D MEAN COVER (*160 quads*)**	**E,F MEAN COVER (*320 quads*)**	**G MEAN COVER (*160 quads*)**
Broad-Leaf Emergent	0.49	0.58	1.73	0.10
Thin-Stem Emergent	0.81	0.38	2.33	0.77
Thin-Stem Persistent Emergent	2.17	40.98	42.11	2.54
Submerged Broad-Leaf	0.00	0.00	0.01	1.52
Submerged Narrow-Leaf	0.00	0.02	3.50	44.24
Floating Leaf	0.00	3.84	13.73	2.16
Algae	0.00	1.38	2.03	3.53
Grasses	22.39	6.48	6.00	0.04
Sedges	9.24	1.99	0.22	0.00
Forbs	24.15	10.51	0.90	0.01
Moss	0.10	0.00	0.00	0.00
Ferns	1.79	0.45	0.02	0.00
Trees/Shrubs	17.85	0.67	0.02	0.00
Vines	5.70	1.85	1.48	0.00
Miscellaneous	3.48	0.07	0.00	0.00
Total Mean Cover	88.18	69.18	74.09	54.91

Table 6. Most prominent species among protected-embayment wetlands by mean percent cover for all transects.

TAXA	MEAN % COVER						
	A	B	C	D	E	F	G
Onoclea sensibilis L.	7.04	5.33	2.69	0.03	0.13		
Calamagrostis canadensis (Michx.) P. Beauv.	6.26	4.42	7.82	10.49	9.66	2.40	0.04
Lysimachia ciliata L.	3.82	3.43	1.75				
Cornus sericea L.	3.06	3.37	1.43	3.63			
Impatiens capensis Meerb.	2.62	1.65	3.69	1.19	0.06	0.003	
Solidago spp.	2.29	2.09	1.13				
Viburnum lentago L.	2.21	2.18	0.95				
Viburnum spp.	2.20	1.33	1.42				
Cornus drummondii C. A. Meyer.	1.44	1.20	3.03				
Carex stricta Lam.	1.34	2.23	5.24	0.97	0.28	1.20	
Thelypteris palustris Schott	1.02	2.25	3.42	3.32	0.37		
Carex spp.	0.88	1.58	3.77	2.02	0.68	0.07	
Cornus racemosa Lam.	0.40	0.46	2.03	0.13			
Phalaris arundinacea L.	0.21	0.36	0.28	1.87	2.26	2.23	
Typha x*glauca* Godr.	0.19	0.32	0.61	8.06	7.41	3.01	
Typha angustifolia L.		0.03		8.67	19.10	23.02	5.88
dead *Typha* spp.			0.06	21.10	31.66	20.10	0.25
Hydrocharis morsus-ranae L.				3.11	9.08	23.84	1.46
Lemna minor L.				0.58	1.96	8.24	2.03
Sagittaria latifolia Willd.				0.17	1.13	1.29	3.56
Potamogeton pectinatus L.				0.11		0.11	9.71
Lemna trisulca L.					1.18	4.04	2.72
Nymphaea odorata Aiton					0.08	0.48	9.13
Ceratophyllum demersum L.					0.06	1.01	6.07
Utricularia vulgaris L.						1.16	4.86
Vallisneria americana L.						0.34	6.39
Potamogeton pusillus L.						0.02	5.37
Najas flexilis (Willd.) Rostkov and Schmidt						0.01	9.00
Chara spp.							6.47
filamentous algae							2.93
Zosterella dubia (Jacq.) Small							2.13

Table 7. Protected-embayment wetland mean cover by combined transects for unique structural groups (excludes South Black River Bay).

Structural Category	A,B,C MEAN COVER (*420 quads*)	D MEAN COVER (*140 quads*)	E MEAN COVER (*140 quads*)	F MEAN COVER (*140 quads*)	G MEAN COVER (*140 quads*)
Broad-Leaf Emergent	0.1738	1.5643	2.3929	3.2036	6.0321
Thin-Stem Emergent	0.36	1.15	1.29	1.70	0.21
Thin-Stem Persistent Emergent	0.82	30.10	45.25	46.36	7.01
Submerged Broad-Leaf	0.00	0.00	0.00	0.00	2.25
Submerged Narrow-Leaf	0.00	0.13	0.14	3.98	51.21
Floating Leaf	0.00	4.34	14.39	41.86	16.20
Algae	0.00	0.00	0.00	0.00	9.99
Grasses	9.04	18.20	16.05	5.59	1.15
Sedges	9.31	6.10	3.13	1.56	0.00
Forbs	22.65	4.23	1.63	2.16	0.04
Moss	0.45	0.00	0.00	0.00	0.00
Ferns	5.30	3.62	0.56	0.00	0.00
Trees/Shrubs	14.35	7.41	0.04	0.00	0.00
Vines	3.17	1.95	1.07	0.71	0.00
Miscellaneous	4.89	0.48	0.00	0.00	0.00
Total Mean Cover	70.51	79.27	85.93	107.14	94.08

Table 8. Most prominent species among barrier-beach wetlands by mean percent cover for all transects.

TAXA	MEAN % COVER						
	A	B	C	D	E	F	G
Calamagrostis canadensis (Michx.) P. Beauv.	7.32	6.33	8.74	5.12	1.13	0.23	
Onoclea sensibilis L.	6.88	10.82	8.69				
Phalaris arundinacea L.	5.91	4.36	3.27	5.22	2.82	0.34	
Rosa multiflora Thunb.	5.00	4.47	1.36				
Cornus sericea L.	4.51	5.09	5.43	0.26	0.19		
Impatiens capensis Meerb.	3.47	6.00	6.58	0.53	0.04	0.003	
Dryopteris carthusiana (Villars) H. P. Fuchs	3.41	2.06	0.25				
Toxicodendron radicans (L.) Kuntze	2.33	1.87	0.04				
Rubus idaeus L.	1.95	2.18	0.69				
Alnus serrulata (Aiton) Willd.	1.66	2.13	1.83	0.16			
Rhamnus frangula L.	1.39	2.07	2.78				
Cornus racemosa Lam.	1.33	3.15	0.08				
Spiraea alba Duroi	1.03	2.31	2.15	0.53			
Typha angustifolia L.	0.20	0.23	0.43	1.17	2.06	4.57	
Typha x *glauca* Godr.	0.03	0.31	2.64	19.85	22.13	12.83	0.15
Lythrum salicaria L.		1.62	1.81	0.96	2.75	1.32	
dead *Typha* spp.			2.97	24.77	26.66	8.52	
Sparganium eurycarpum Engelm.			0.22	4.71	5.20	2.68	0.03
Lemna minor L.			0.06	7.03	7.42	16.85	5.81
Sagittaria latifolia Willd.			0.01	1.48	2.13	1.55	
Hydrocharis morsus-ranae L.				11.73	8.31	3.84	0.003
algae				2.34	5.48	2.63	
Eleocharis palustris L.				0.63	0.28	2.09	
Utricularia vulgaris L.				0.29	0.45	0.56	2.41
Nymphaea odorata Aiton				0.16	1.38	6.43	9.37
Ceratophyllum demersum L.				0.12	0.74	2.36	4.50
Chara spp.				0.01		2.14	8.20
Pontederia cordata L.					0.07	0.35	2.95
Zizania palustris L.					0.03	0.30	2.31
Najas flexilis (Willd.) Rostkov and Schmidt						0.61	2.20
Nuphar variegata Durand							5.75
filamentous algae							5.23

Table 9. Barrier-beach wetland mean cover by combined transects for unique structural groups (excludes Port Britain).

Structural Category	A,B,C MEAN COVER (*420 quads*)	D MEAN COVER (*140 quads*)	E,F MEAN COVER (*280 quads*)	G MEAN COVER (*140 quads*)
Broad-Leaf Emergent	0.14	3.67	3.73	3.38
Thin-Stem Emergent	0.60	7.31	6.30	0.18
Thin-Stem Persistent Emergent	0.57	46.83	43.71	0.47
Submerged Broad-Leaf	0.00	0.00	0.02	0.35
Submerged Narrow-Leaf	0.00	0.49	6.16	16.85
Floating Leaf	0.02	10.95	17.54	16.88
Algae	0.00	0.47	4.51	16.13
Grasses	10.45	11.55	2.76	2.65
Sedges	1.30	1.34	1.28	0.00
Forbs	20.88	2.93	0.50	0.05
Moss	0.00	0.00	0.00	0.01
Ferns	12.85	0.21	0.01	0.00
Trees/Shrubs	27.72	3.69	0.46	0.00
Vines	1.52	1.27	0.27	0.00
Miscellaneous	0.57	0.04	0.23	0.02
Total Mean Cover	76.62	90.76	87.48	56.96

Table 10. Most prominent species among drowned river-mouth wetlands by mean percent cover for all transects.

TAXA	MEAN % COVER						
	A	B	C	D	E	F	G
Cornus sericea L.	6.17	7.14	6.94	2.33			
Calamagrostis canadensis (Michx.) P. Beauv.	5.72	4.18	8.49	2.37	1.27	0.67	
Impatiens capensis Meerb.	5.59	7.32	10.22	0.76	0.003	0.03	
Cornus racemosa Lam.	4.48	4.74	1.37	0.58			
Carex stricta Lam.	4.27	3.47	4.77	0.88	0.06	0.03	
Equisetum arvense L.	2.83	0.04					
Lysimachia nummularia L.	2.80	3.70	1.98	2.53			
Anemone canadensis L.	2.64	1.69	1.09				
Vitis riparia Michx.	2.40	2.68	2.18	0.60			
Aster spp.	2.19	2.14	0.83	0.01			
Phalaris arundinacea L.	1.55	2.59	5.39	4.82	7.88	5.60	
Cornus drummondii C. A. Meyer.	0.39	1.01	2.48	0.48			
Typha x*glauca* Godr.	0.21	1.16	1.47	12.25	15.65	12.08	0.25
Typha angustifolia L.		0.16	0.49	7.91	12.67	12.67	0.07
dead *Typha* spp.				31.32	38.06	26.18	0.05
Lemna minor L.				4.67	16.04	13.86	5.62
Hydrocharis morsus-ranae L.				2.90	13.99	27.79	1.99
Spirodela polyrhiza (L.) Schleiden				0.11	0.40	1.94	5.58
Ceratophyllum demersum L.						0.61	4.66
Potamogeton pectinatus L.						0.08	25.65
Nymphaea odorata Aiton						0.01	2.92
Potamogeton zosteriformis Fern.						0.01	2.70
Potamogeton pusillus L.						0.003	3.19
Chara spp.							10.58
filamentous algae							6.25
Vallisneria americana L.							4.21
Najas flexilis (Willd.) Rostkov and Schmidt							2.60

Table 11. Drowned river-mouth wetland mean cover by combined transects for unique structural groups (excludes Crooked Creek).

Structural Category	**A,B,C MEAN COVER (*420 quads*)**	**D MEAN COVER (*140 quads*)**	**E,F MEAN COVER (*280 quads*)**	**G MEAN COVER (*140 quads*)**
Broad-Leaf Emergent	0.21	0.37	0.41	0.19
Thin-Stem Emergent	2.97	0.25	0.39	0.02
Thin-Stem Persistent Emergent	1.42	50.91	39.36	0.55
Submerged Broad-Leaf	0.00	0.00	0.00	0.55
Submerged Narrow-Leaf	0.00	0.00	0.64	36.67
Floating Leaf	0.00	8.68	25.73	20.99
Algae	0.00	0.00	0.00	21.18
Grasses	13.71	8.19	8.19	0.09
Sedges	7.96	1.96	0.26	0.00
Forbs	28.74	4.77	0.57	0.00
Moss	0.07	0.00	0.00	0.01
Ferns	1.16	0.00	0.00	0.00
Trees/Shrubs	18.99	3.78	0.07	0.00
Vines	5.29	0.78	0.84	0.00
Miscellaneous	1.39	0.82	0.04	0.00
Total Mean Cover	81.92	80.51	76.49	80.26

Table 12. Percentage of total generalized area in 5 cm intervals across the model elevation range (73.0-75.75 meters IGLD) for barrier beach (BB), drowned river mouth (DRM), open embayment (OE), and protected embayment (PE) geomorphic models.

Contour Interval	Wetland Type			
	BB	DRM	OE	PE
73.00-73.05	0.3%	0.3%	0.2%	0.3%
73.05-73.10	0.4%	0.2%	0.5%	0.3%
73.10-73.05	0.6%	0.2%	0.8%	0.3%
73.15-73.20	0.8%	0.2%	1.1%	0.4%
73.20-73.25	2.8%	0.3%	1.4%	1.8%
73.25-73.30	1.4%	0.2%	1.2%	1.1%
73.30-73.35	1.5%	0.2%	1.4%	1.1%
73.35-73.40	1.6%	0.2%	1.6%	1.2%
73.40-73.45	1.8%	0.3%	1.7%	1.2%
73.45-74.50	1.9%	3.7%	1.9%	1.3%
73.50-73.55	1.0%	0.7%	1.9%	1.3%
73.55-73.60	1.0%	0.7%	2.1%	1.4%
73.60-73.65	1.1%	0.7%	2.2%	1.4%
73.65-73.70	1.1%	0.7%	2.4%	1.5%
73.70-73.75	1.1%	0.7%	2.5%	1.5%
73.75-73.80	0.8%	1.0%	2.1%	2.2%
73.80-73.85	0.8%	1.2%	2.2%	2.2%
73.85-73.90	0.8%	1.2%	2.3%	2.3%
73.90-73.95	0.8%	1.0%	2.4%	2.4%
73.95-74.00	0.9%	1.2%	2.5%	2.5%
74.00-74.05	0.8%	2.4%	3.0%	3.3%
74.05-74.10	0.8%	2.4%	3.1%	3.5%
74.10-74.15	0.8%	2.4%	3.2%	3.6%
74.15-74.20	0.8%	2.6%	3.3%	3.8%
74.20-74.25	0.8%	2.4%	3.5%	3.9%
74.25-74.30	0.7%	1.4%	2.1%	1.7%
74.30-74.35	0.8%	1.4%	2.2%	1.7%
74.35.74.40	0.8%	1.6%	2.2%	1.8%
74.40-74.45	0.8%	1.4%	2.3%	1.8%
74.45-74.50	0.8%	1.4%	2.3%	1.8%
74.50-74.55	0.9%	0.9%	0.6%	0.6%
74.55-74.60	0.9%	0.9%	0.6%	0.6%
74.60-74.65	0.9%	0.7%	0.6%	0.6%
74.65-74.70	0.9%	0.9%	0.6%	0.6%
74.70-74.75	0.9%	0.9%	0.6%	0.6%
74.75-74.80	1.2%	2.4%	0.5%	0.7%
74.80-74.85	1.2%	2.6%	0.5%	0.7%
74.85-74.90	1.2%	2.6%	0.5%	0.7%
74.90-74.95	1.2%	2.6%	0.5%	0.7%
74.95-75.00	1.2%	2.4%	0.5%	0.7%
75.00-75.05	3.1%	3.7%	3.4%	1.5%
75.05-75.10	3.2%	3.5%	3.5%	1.5%
75.10-75.15	3.3%	3.7%	3.6%	1.5%
75.15-75.20	3.4%	3.5%	3.7%	1.5%
75.20-75.25	3.5%	3.7%	3.7%	1.5%
75.25-75.30	4.3%	3.3%	2.3%	4.2%
75.30-75.35	4.5%	3.3%	2.3%	4.3%
75.35-75.40	4.6%	3.5%	2.3%	4.4%
75.40-75.45	4.8%	3.3%	2.4%	4.5%
75.45-75.50	4.9%	3.5%	2.4%	4.6%
75.50-75.55	3.7%	2.8%	0.7%	1.8%
75.55-75.60	3.8%	2.8%	0.7%	1.8%
75.60-75.65	3.9%	2.8%	0.7%	1.8%
75.65-75.70	4.0%	2.8%	0.7%	1.8%
75.70-75.75	4.1%	2.7%	0.7%	1.8%

Table 13. Modeled percent of wetland in meadow marsh vegetation type (ABC) in barrier beach (BB), drowned river mouth (DRM), open embayment (OE), and protected embayment (PE) geomorphic types for three regulation plans tested, averaged over the 101-year modeling period.

	Wetland Type			
Regulation Plan	**BB**	**DRM**	**OE**	**PE**
1958DD	18.2	14.3	9.4	13.8
0809c	19.9	16.0	11.0	15.1
0924	20.2	16.9	11.5	15.1

Table 14. Modeled percent of wetland in meadow marsh vegetation type (ABC) in barrier beach (BB), drowned river mouth (DRM), open embayment (OE), and protected embayment (PE) geomorphic types for three regulation plans tested, averaged for years with low water supplies.

	Wetland Type			
Regulation Plan	**BB**	**DRM**	**OE**	**PE**
1958DD	22.3	19.0	14.7	16.6
0809c	23.7	20.8	16.4	17.2
0924	25.2	23.1	17.5	18.1

Figures

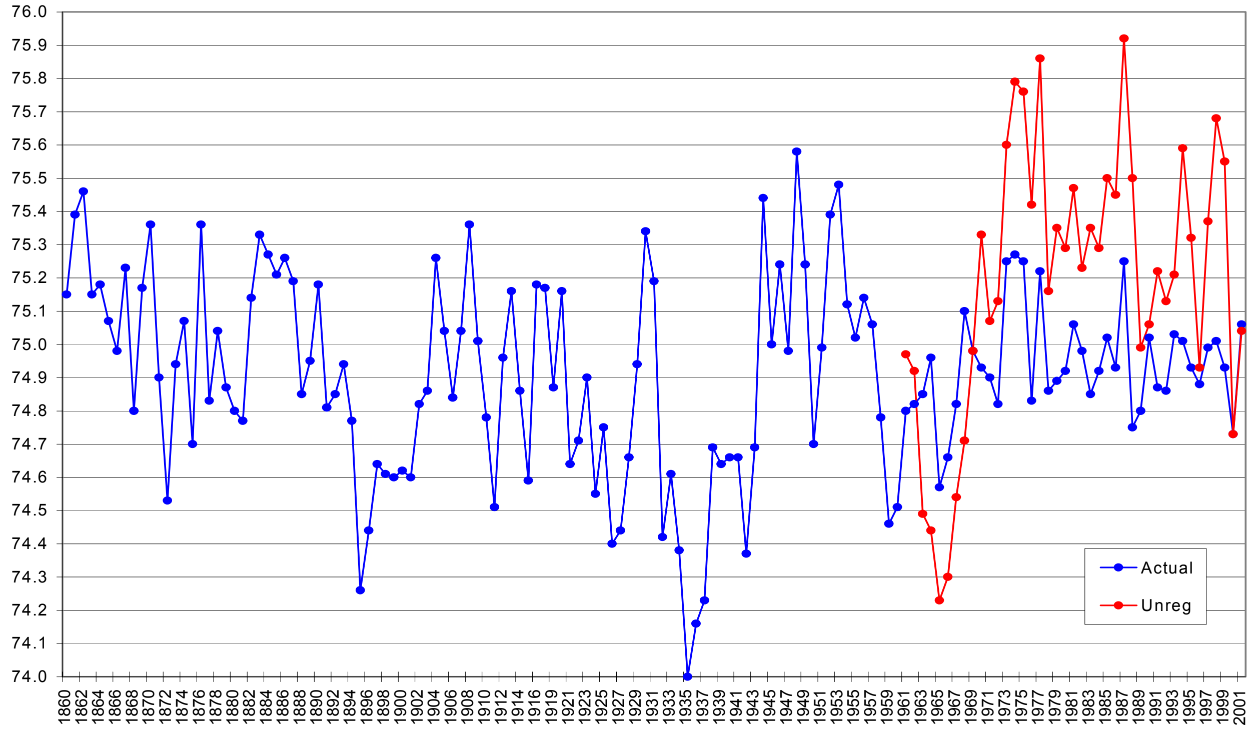

Figure 1. Mean August Lake Ontario water level record (1860-2001) and estimated unregulated August water levels (1960-2001) (IGLD).

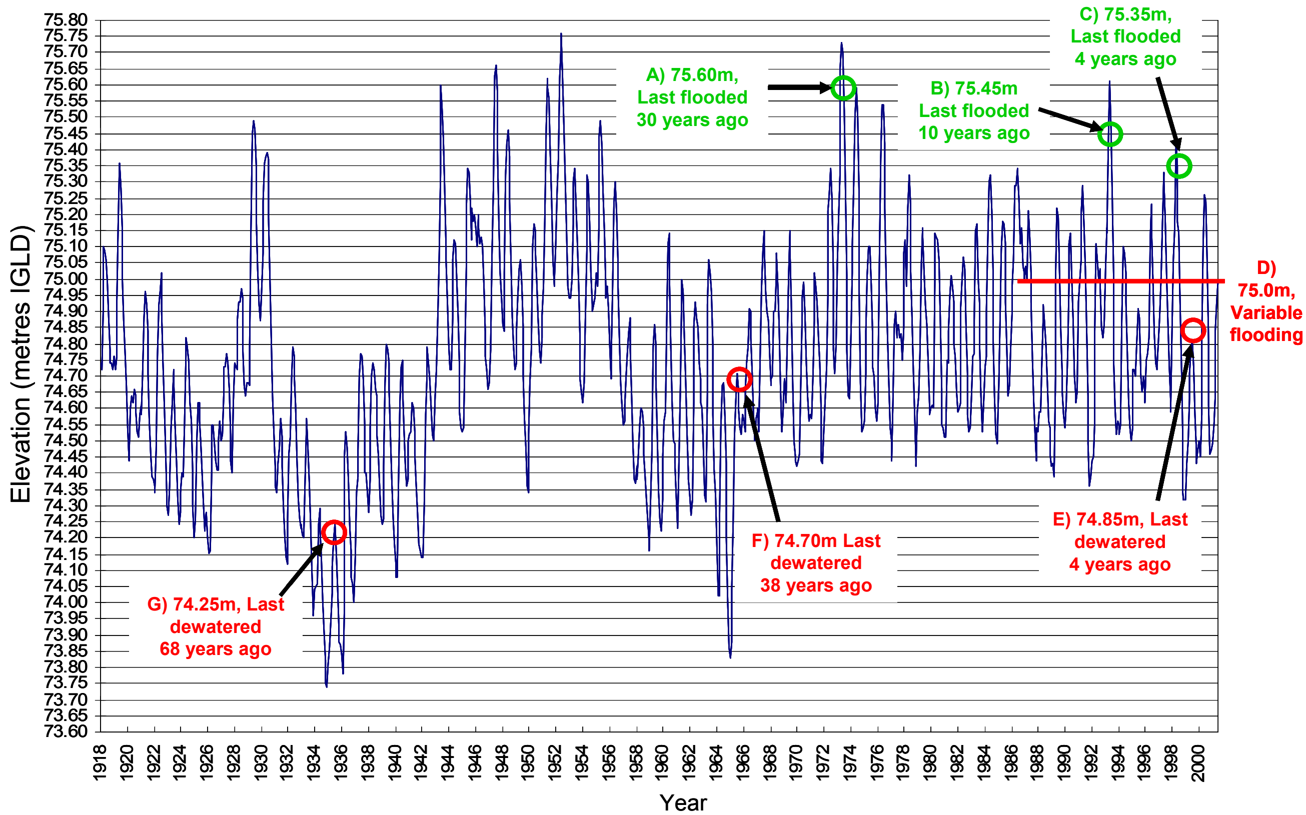

Figure 2. Lake Ontario water level history and the seven unique hydrologic sampling elevations (IGLD).

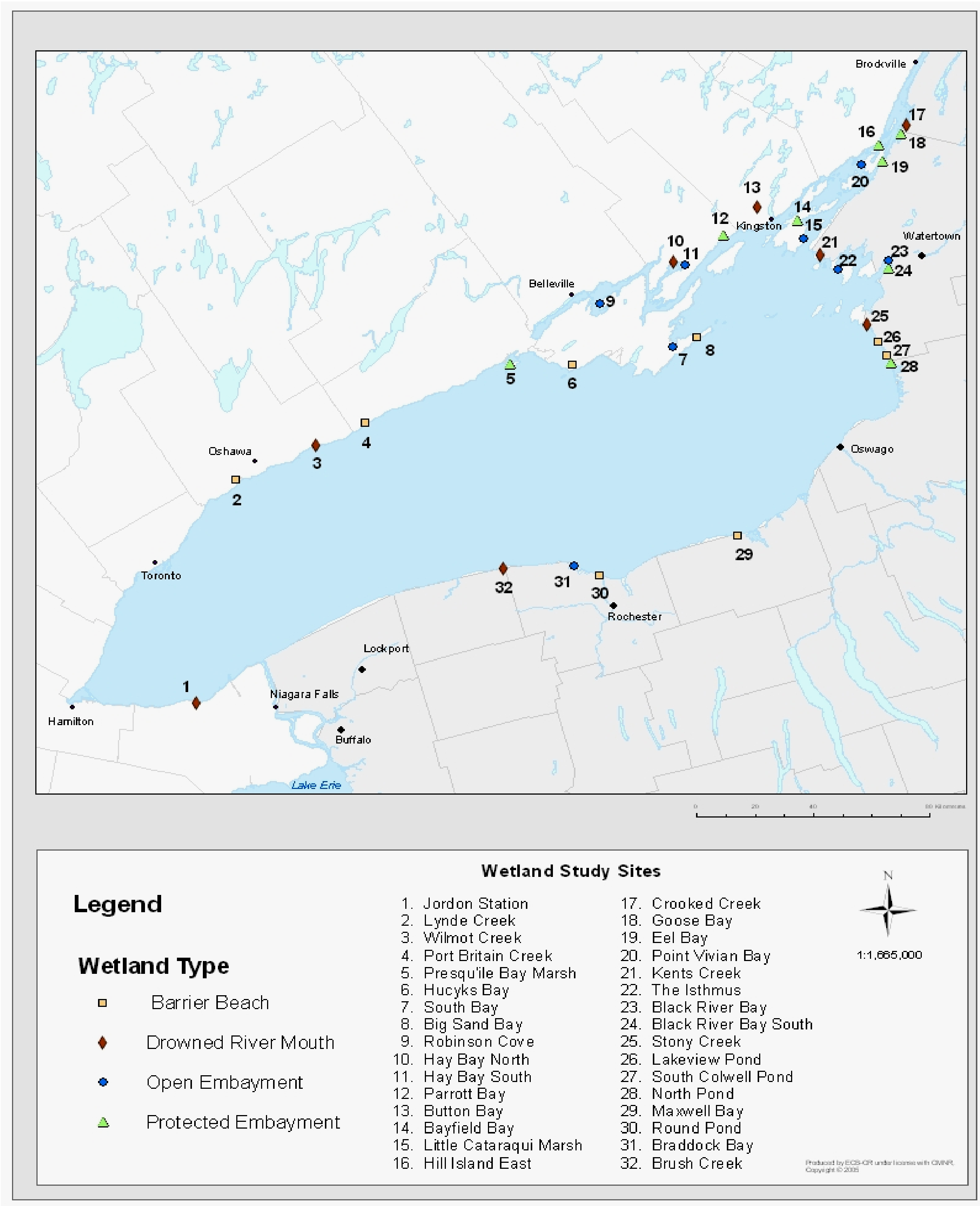

Figure 3. Distribution of the 32 Lake Ontario - Upper St. Lawrence River coastal wetland study sites by geomorphic type.

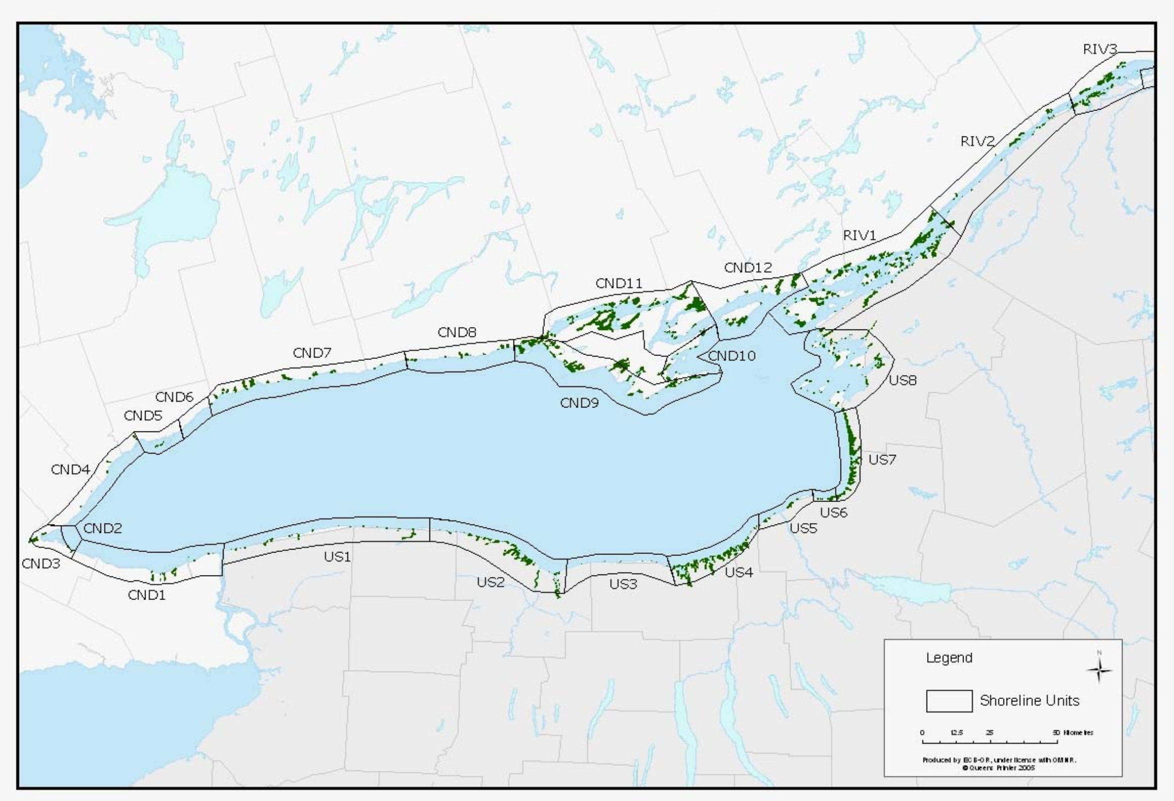

Figure 4. Distribution of coastal wetland area by shoreline unit in the Lake Ontario - Upper St. Lawrence River system.

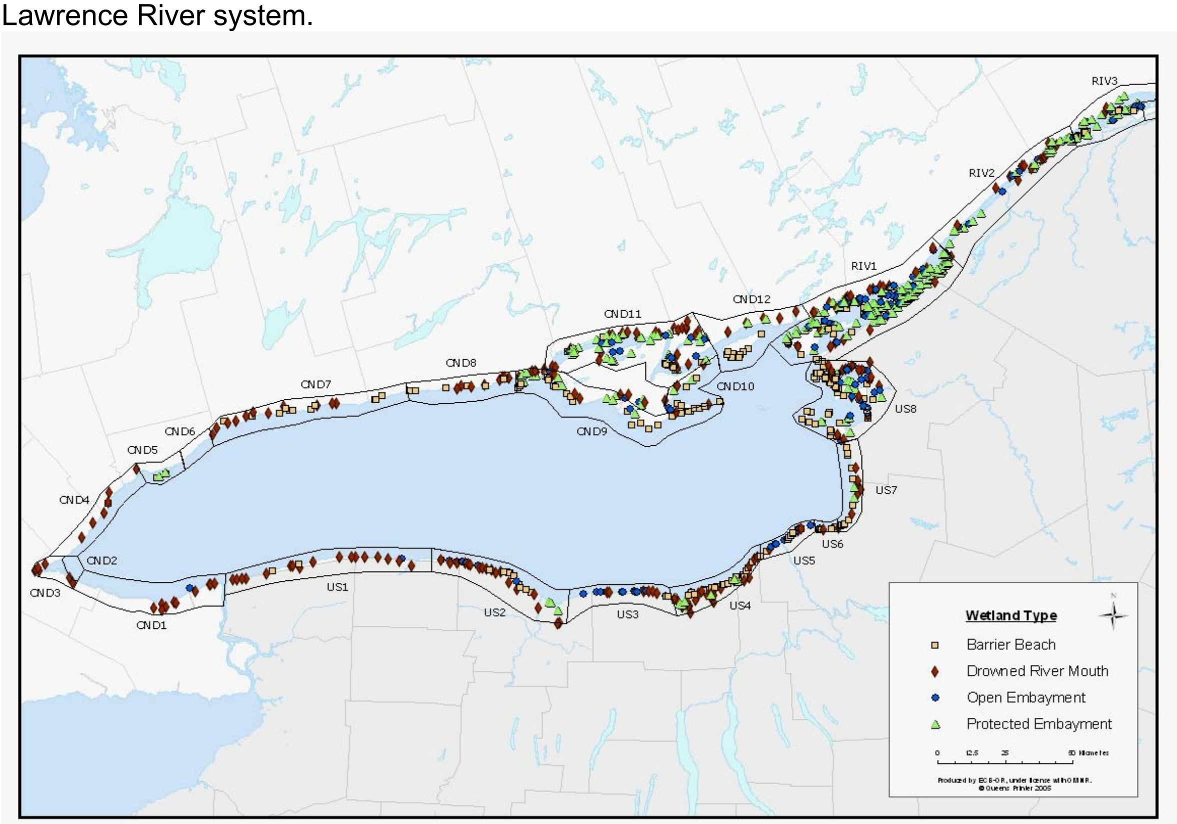

Figure 5. Distribution of coastal wetland geomorphic type by shoreline unit in the Lake Ontario - Upper St. Lawrence River system.

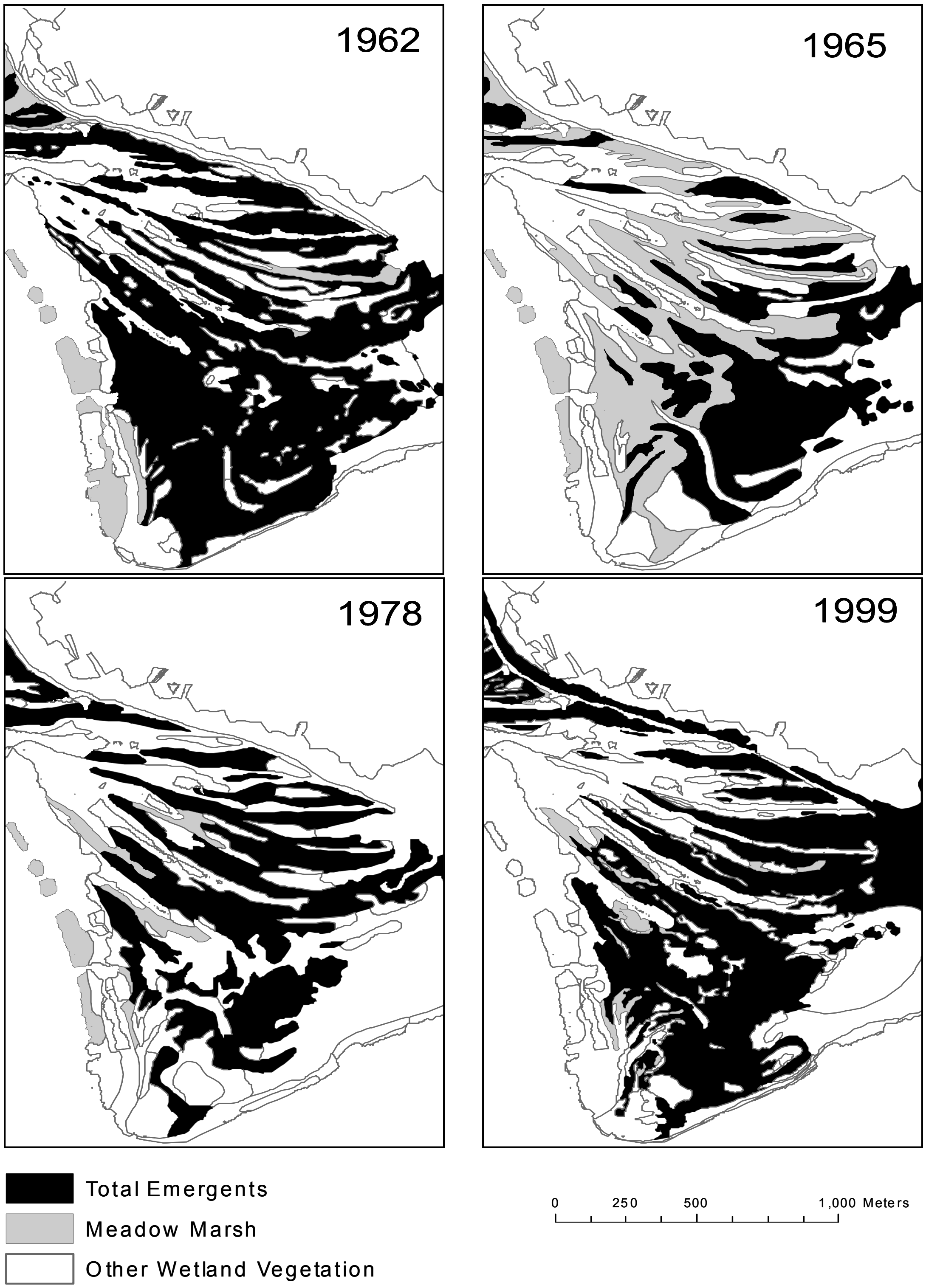

Figure 6. Changes in historic distribution of meadow marsh and emergent marsh habitats within Presqu'ile Bay, a protected-embayment wetland post water level regulation.

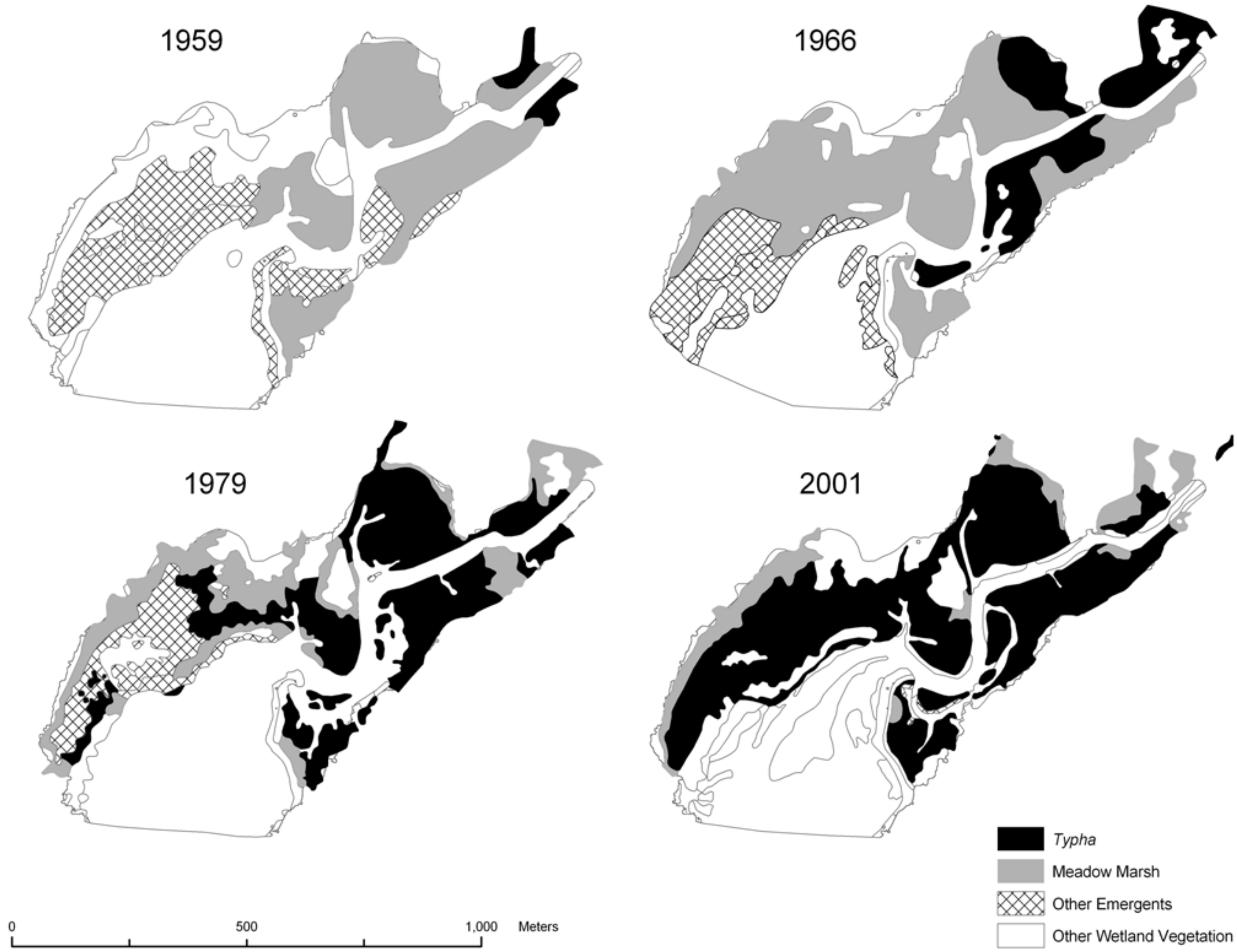

Figure 7. Changes in historic distribution of meadow marsh and emergent marsh habitats within Stony Creek, a drowned river-mouth wetland post water level regulation.

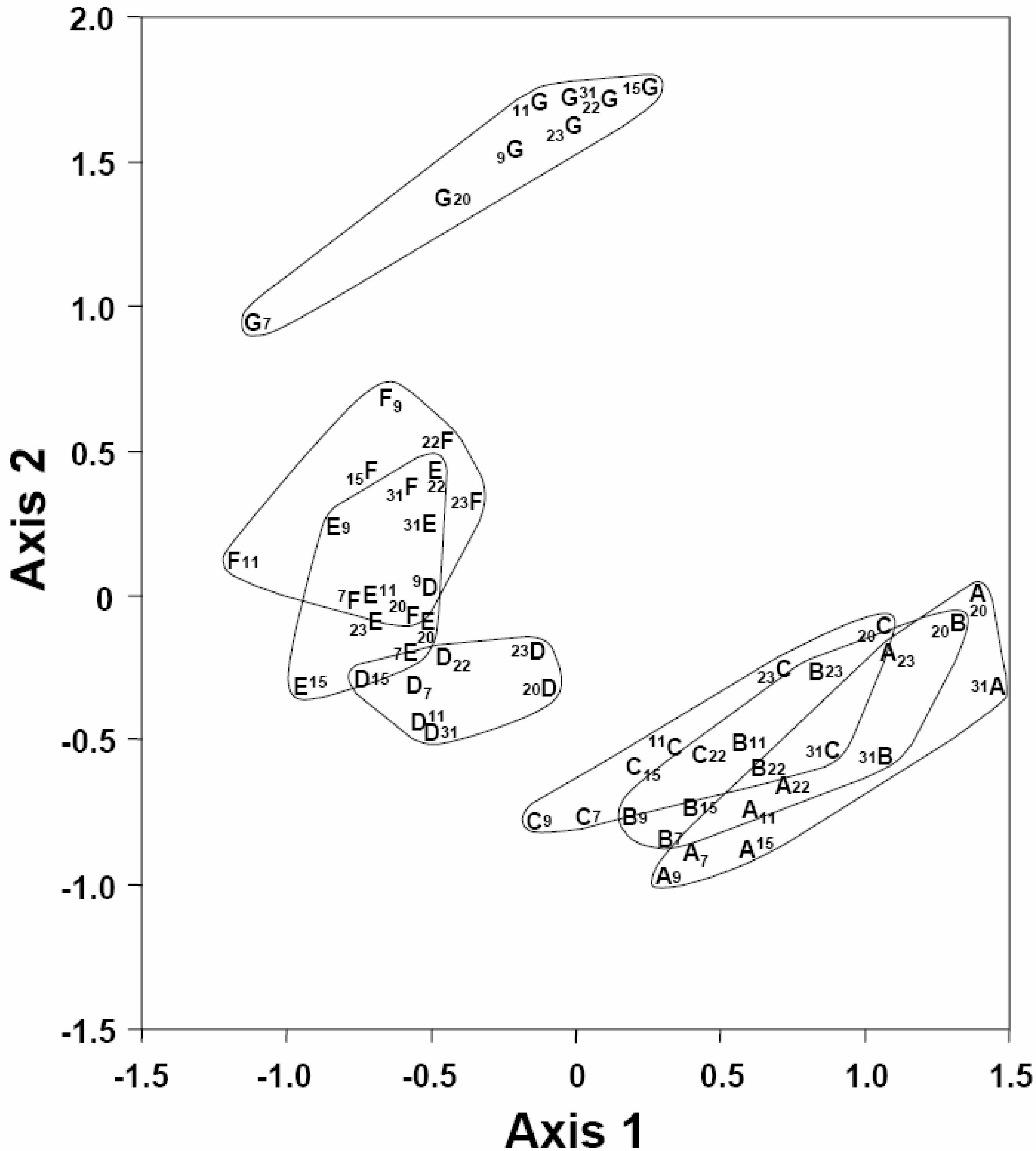

Figure 8. Non-metric multidimensional scaling (NMDS) ordination of open-embayment wetland vegetation sampled along seven transects that followed elevation contours with specific histories of past dewatering and flooding (A = highest elevation, G = lowest elevation). No outlier sites were observed for this wetland type; however, Transect D at Robinson Cove (9) was an outlier and was excluded from the D-transect grouping.

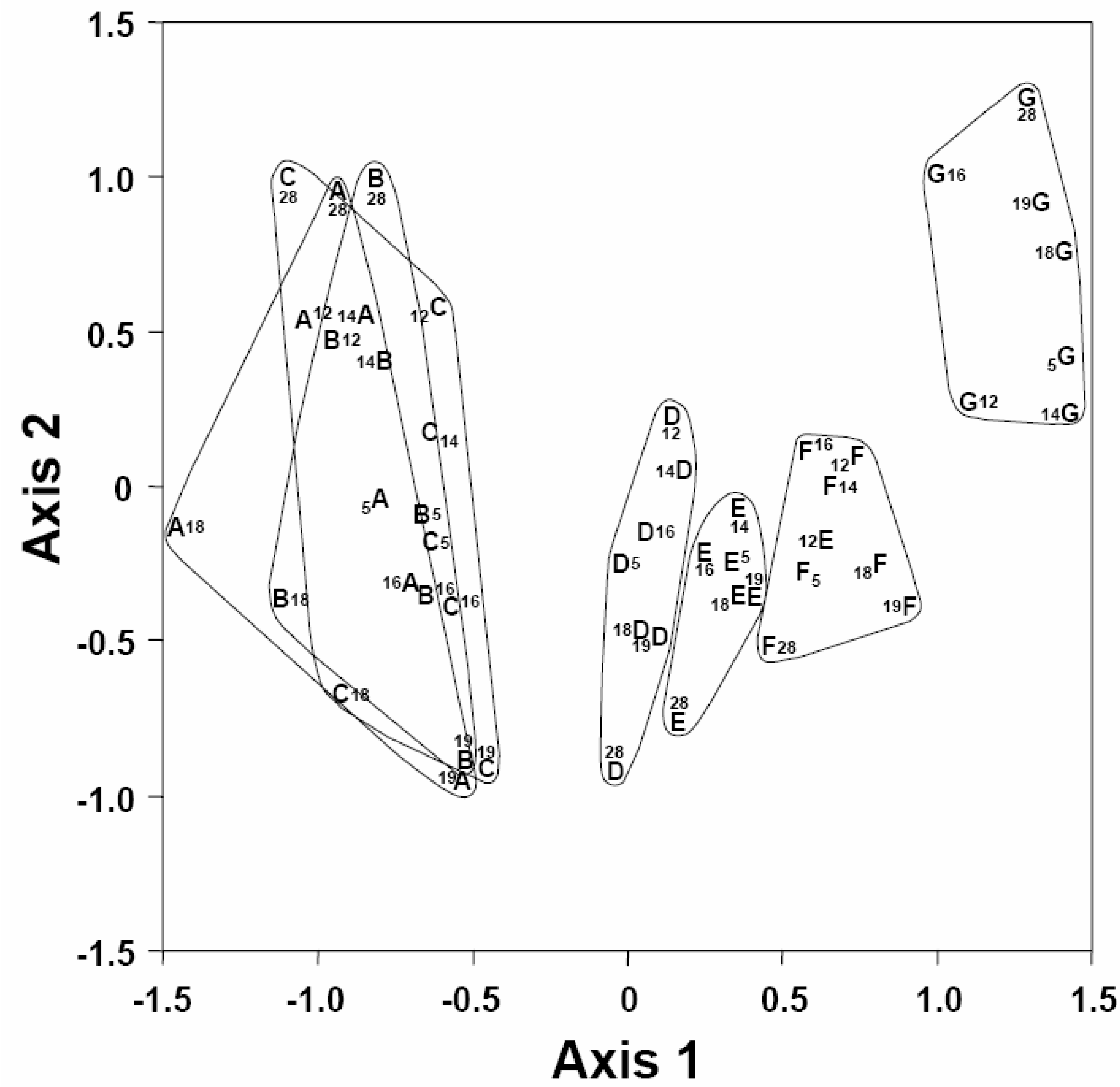

Figure 9. Non-metric multidimensional scaling (NMDS) ordination of protected-embayment wetland vegetation sampled along seven transects that followed elevation contours with specific histories of past dewatering and flooding (A = highest elevation, G = lowest elevation). Ordination excludes the outlier Black River Bay south (24). Transect E at Parrot Bay (12) also was an outlier and excluded from the E-transect grouping.

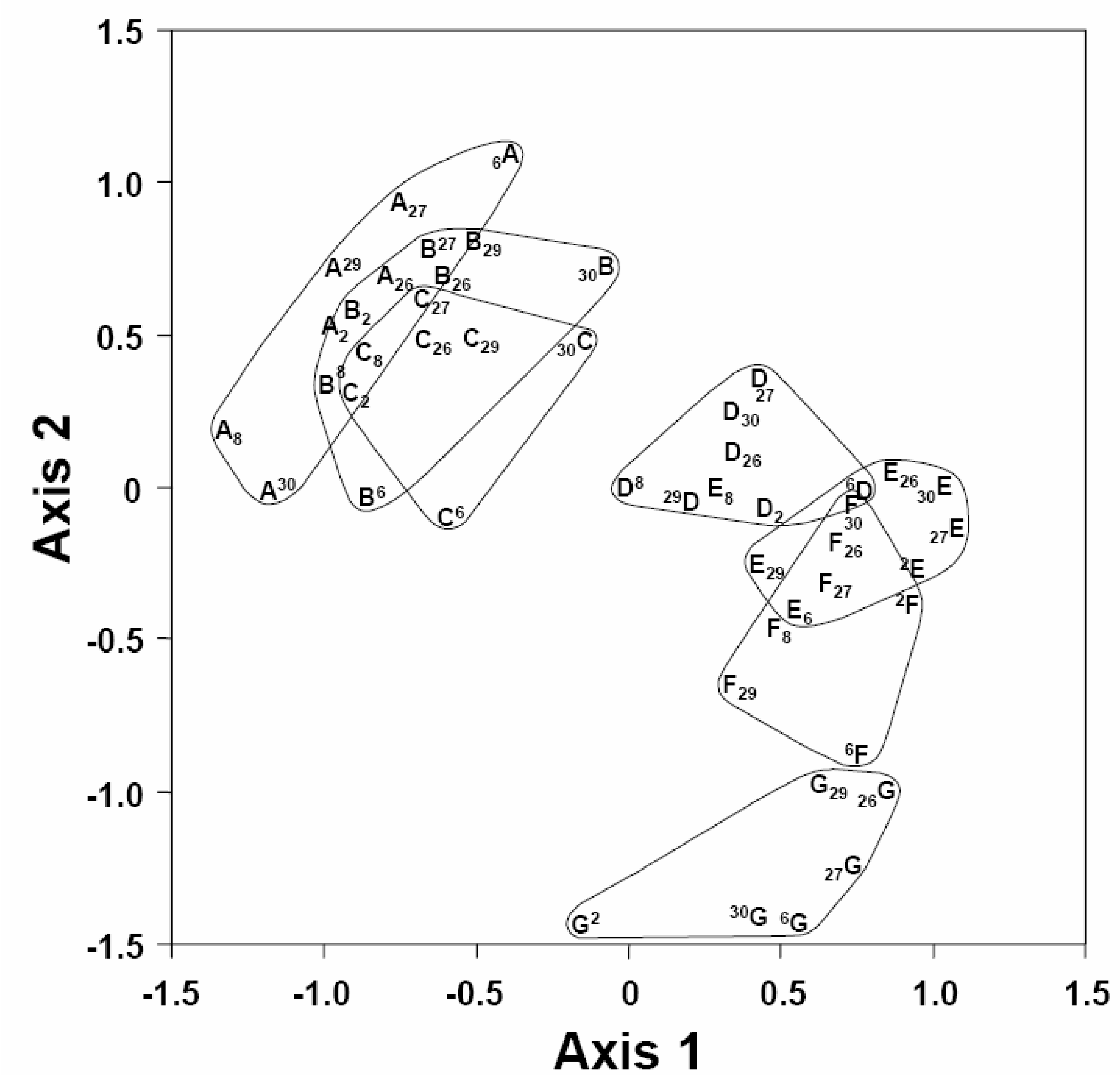

Figure 10. Non-metric multidimensional scaling (NMDS) ordination of barrier-beach wetland vegetation sampled along seven transects that followed elevation contours with specific histories of past dewatering and flooding (A = highest elevation, G = lowest elevation). Ordination excludes the outlier Port Britain (4). Transect E at Big Sand Bay (8) was an outlier and was excluded from the E-transect grouping.

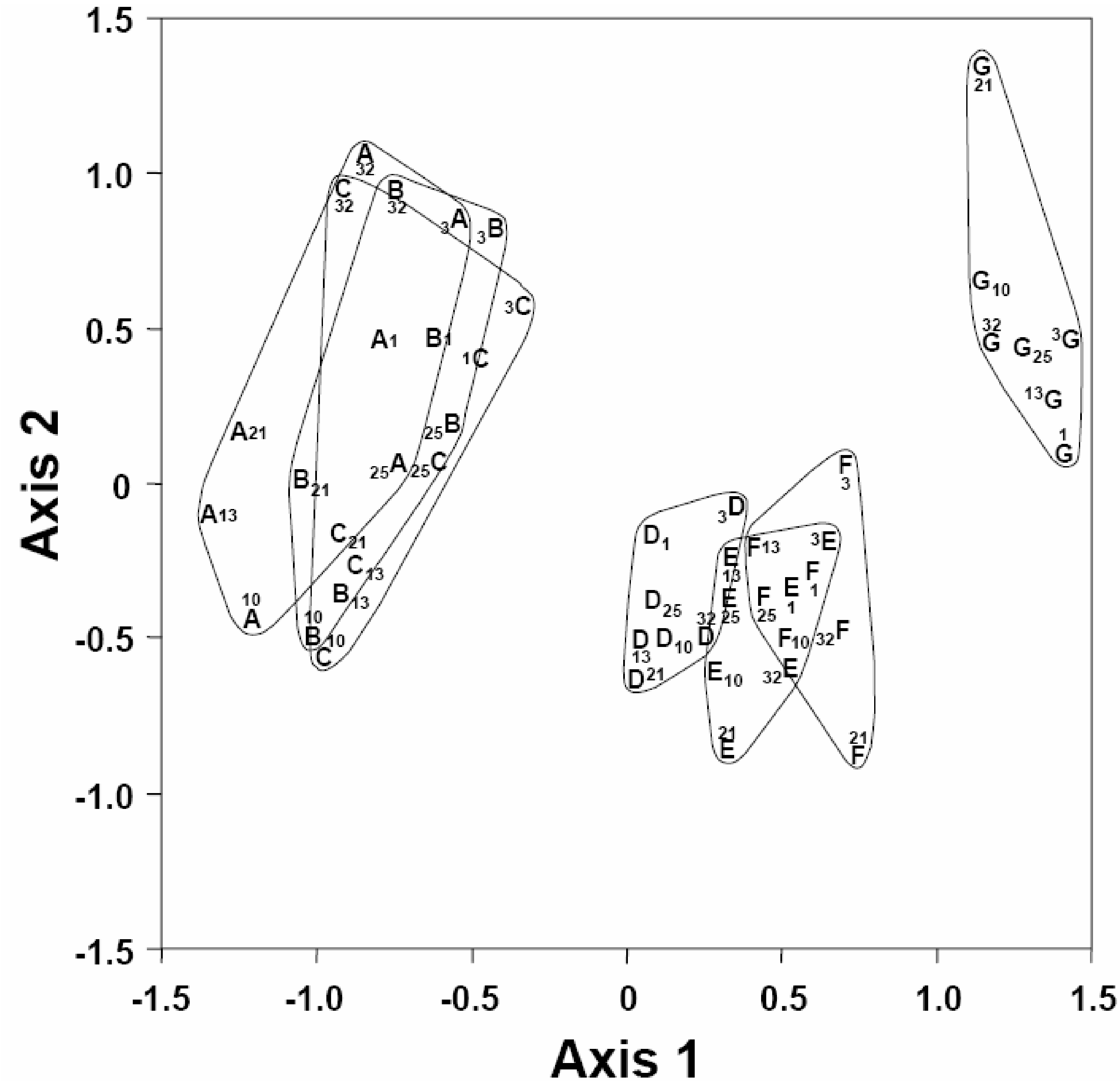

Figure 11. Non-metric multidimensional scaling (NMDS) ordination of drowned river-mouth wetland vegetation sampled along seven transects that followed elevation contours with specific histories of past dewatering and flooding (A = highest elevation, G = lowest elevation). Ordination excludes the outlier Crooked Creek (17).

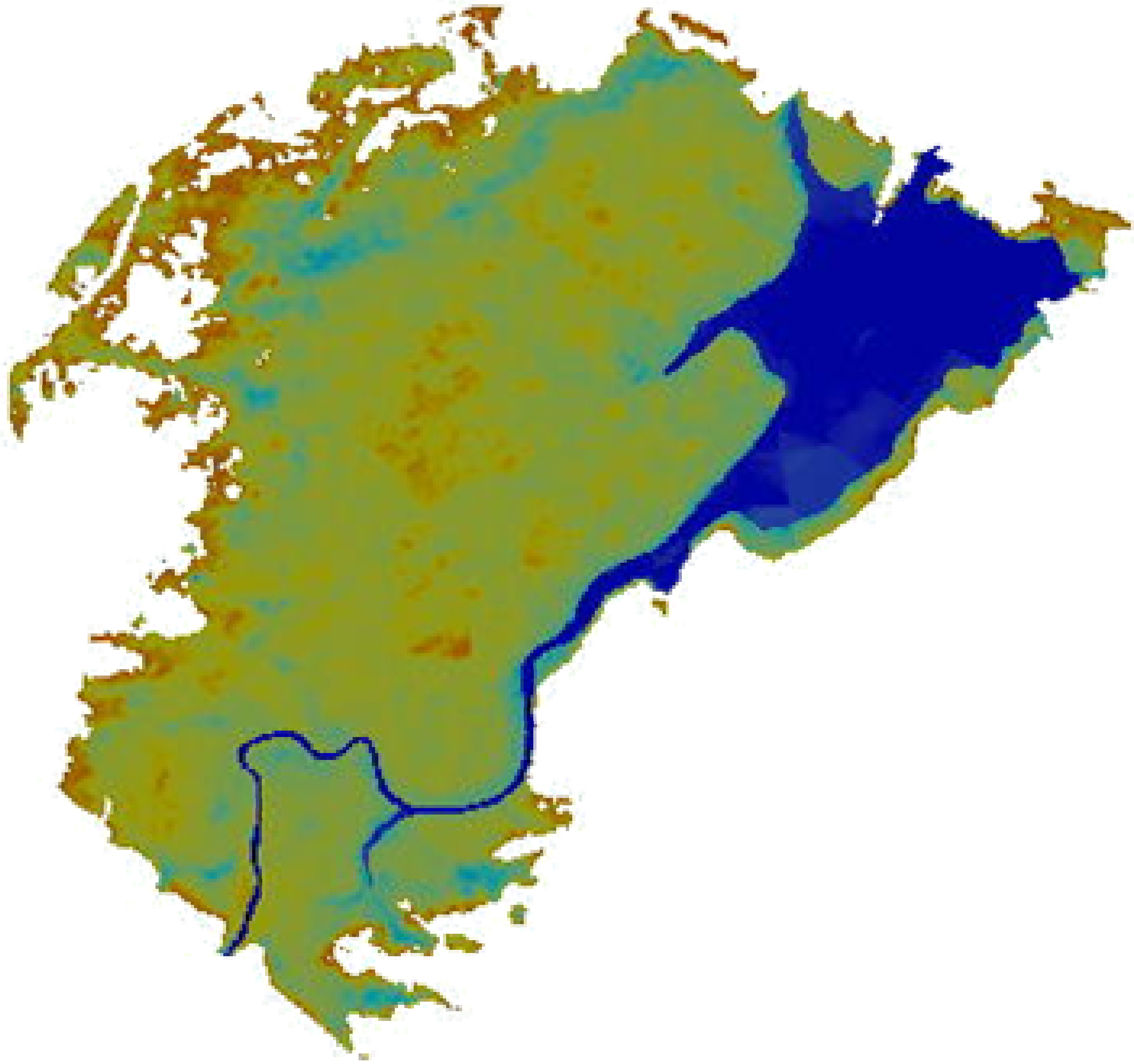

Figure 12. Example of wetland study site specific digital elevation model Round Pond, Barrier-beach wetland. Elevation range, upper bound (brown) was set at 75.75 m (IGLD) and the lower range set at 73.0 m (IGLD).

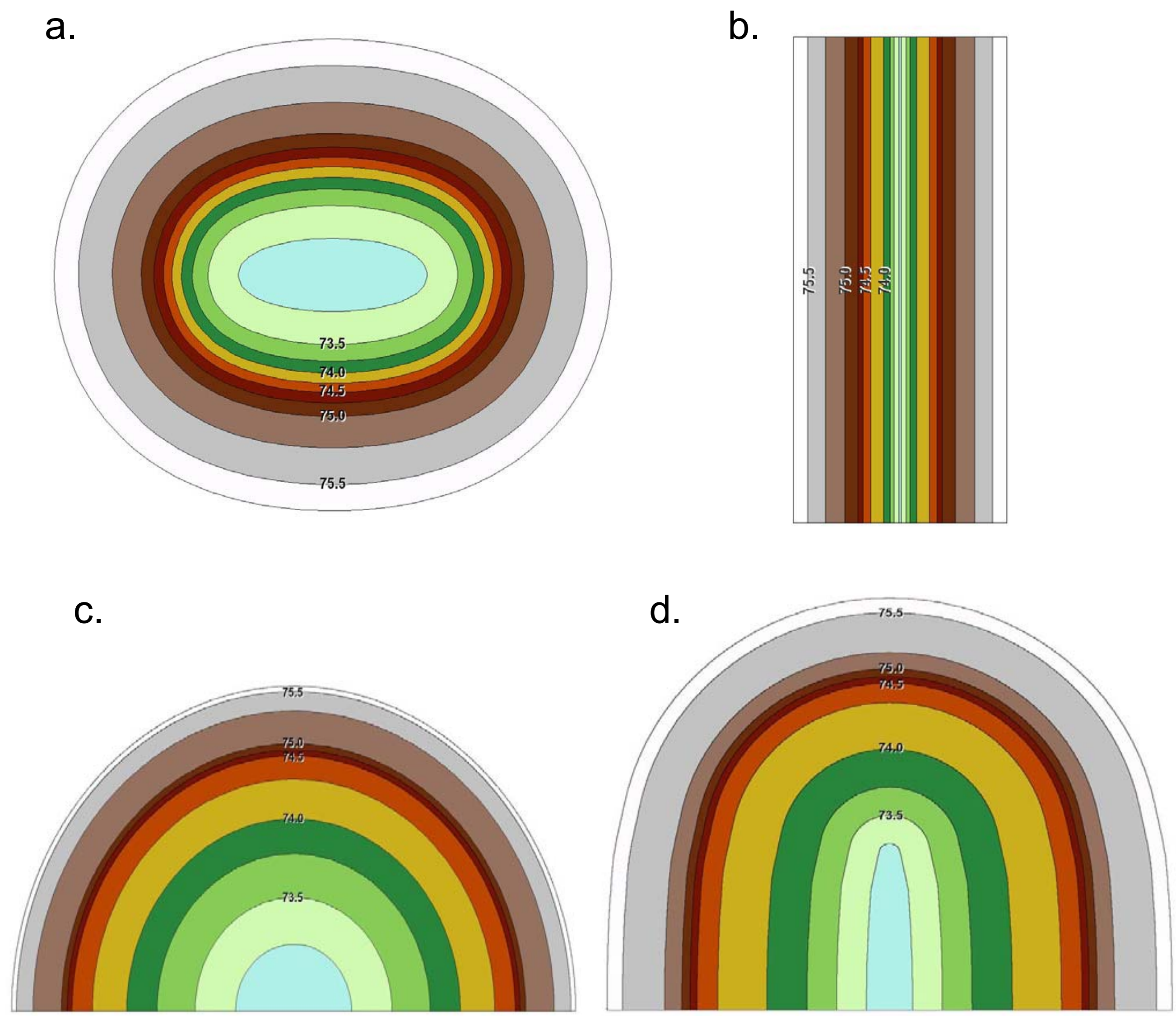

Figure 13. Generalized geometric wetland models of the barrier beach (a), drowned river mouth (b), open embayment (c), and protected embayment (d) wetland types.

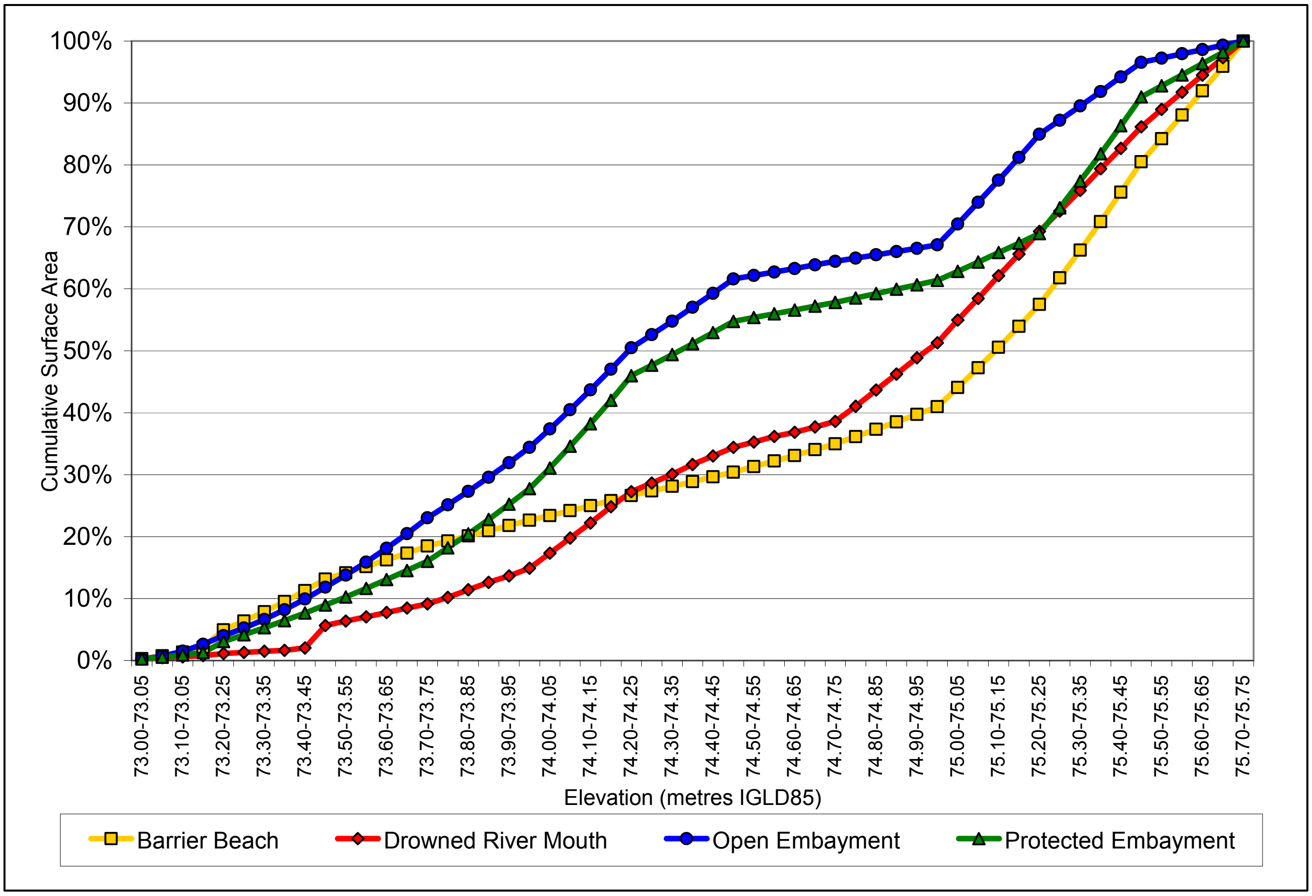

Figure 14. Cumulative percent area by 5 cm contour intervals across the elevation model range (73.0-75.75 meters IGLD85) by wetland type.

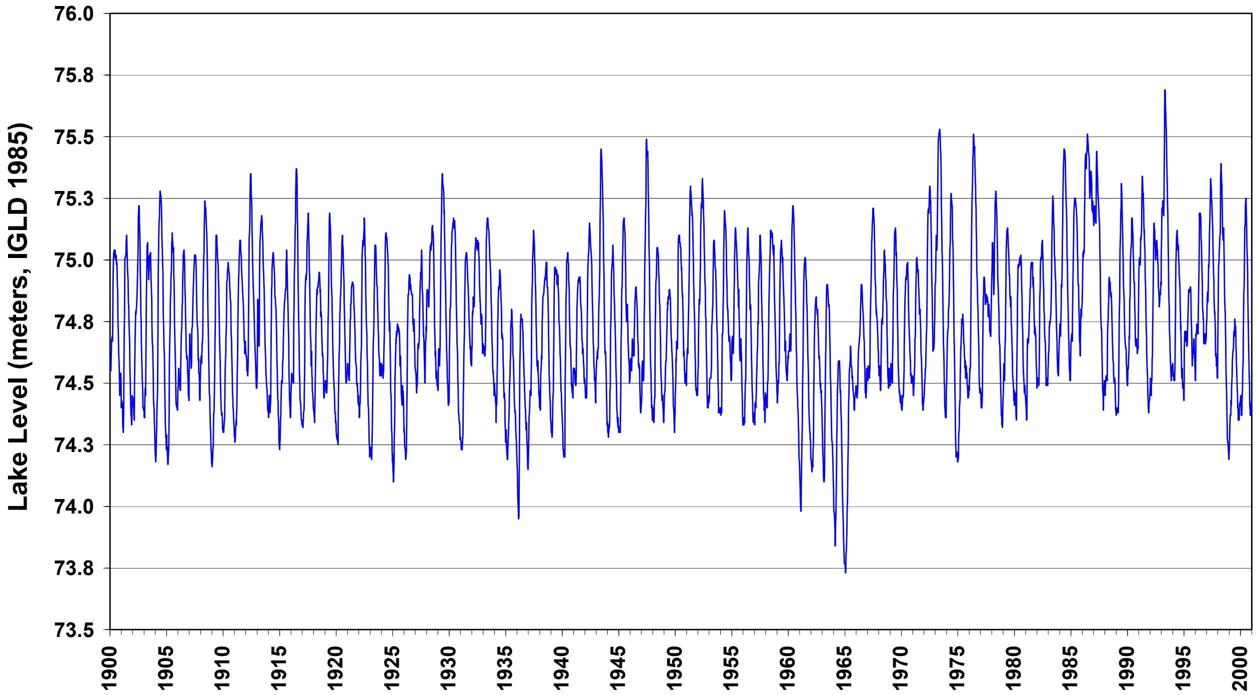

Figure 15. Predicted Lake Ontario water levels produced when regulation plan 1958DD is applied to total basin supplies for the period 1900 to 2000.

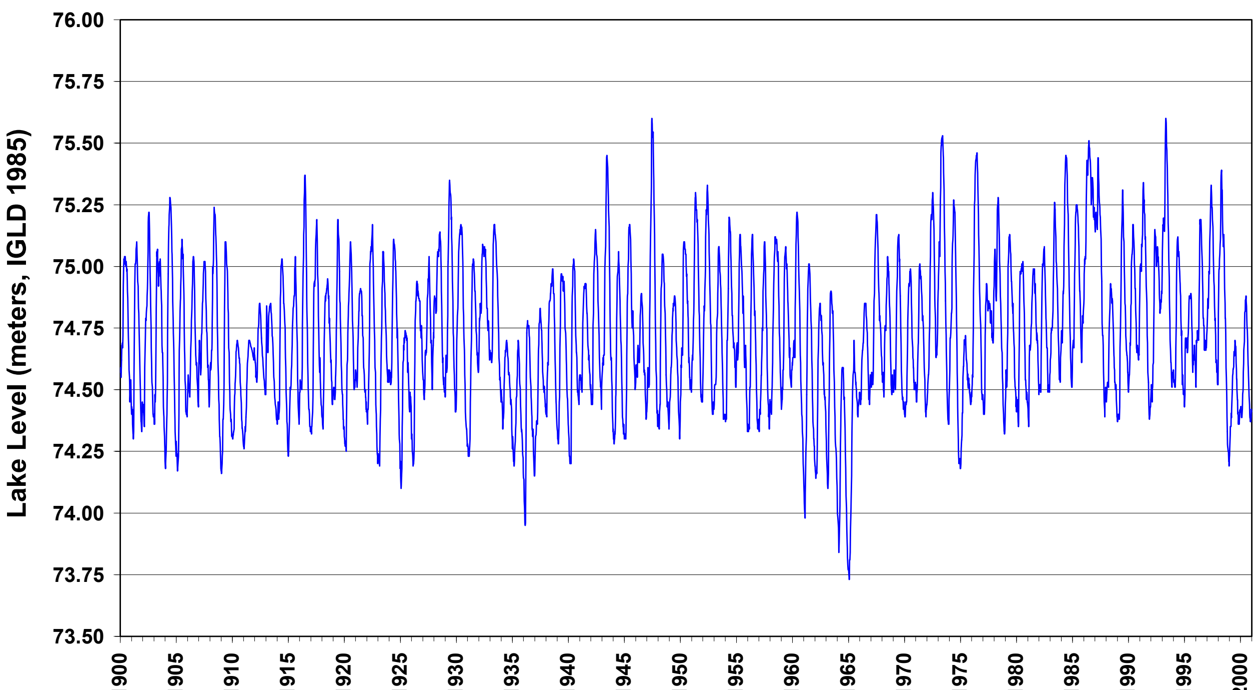

Figure 16. Predicted Lake Ontario water levels produced when regulation plan 0809c is applied to total basin supplies for the period 1900 to 2000. The graph shown has been modified slightly from the original version of 0809c to smooth out the rise to summer-time highs in low supply years.

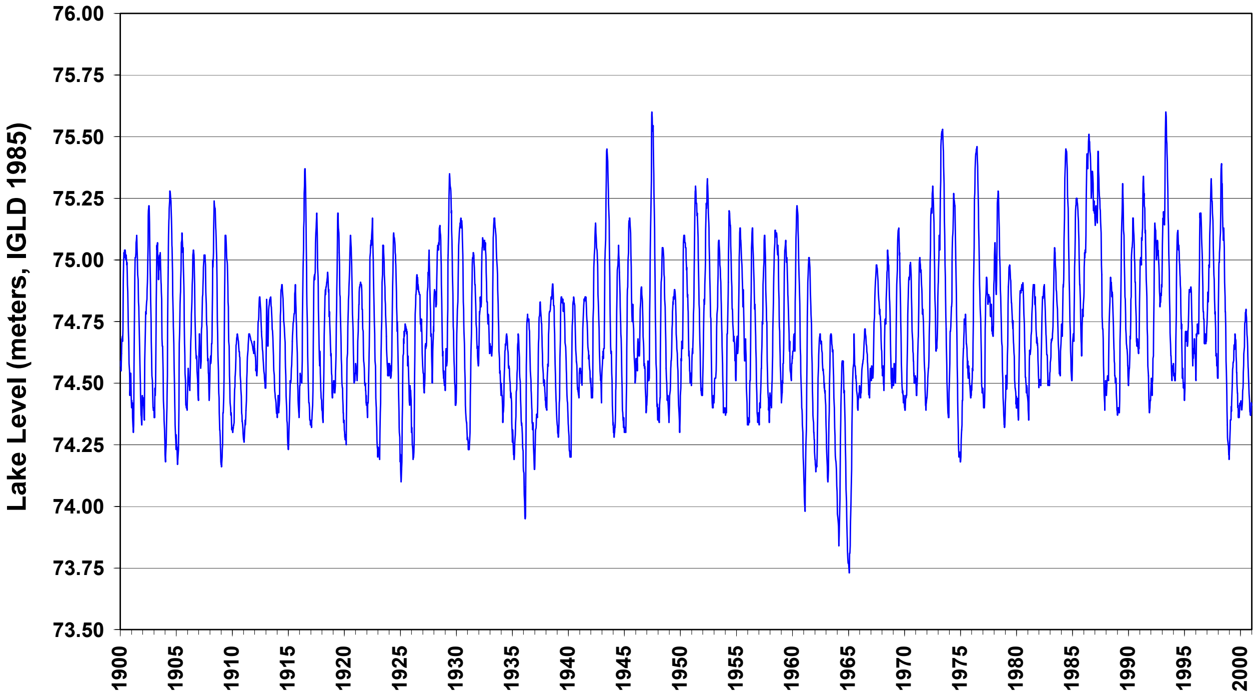

Figure 17. Predicted Lake Ontario water levels produced when regulation plan 0924 is applied to total basin supplies for the period 1900 to 2000. The graph shown has been modified slightly from the original version of 0924 to smooth out the rise to summer-time highs in low supply years.

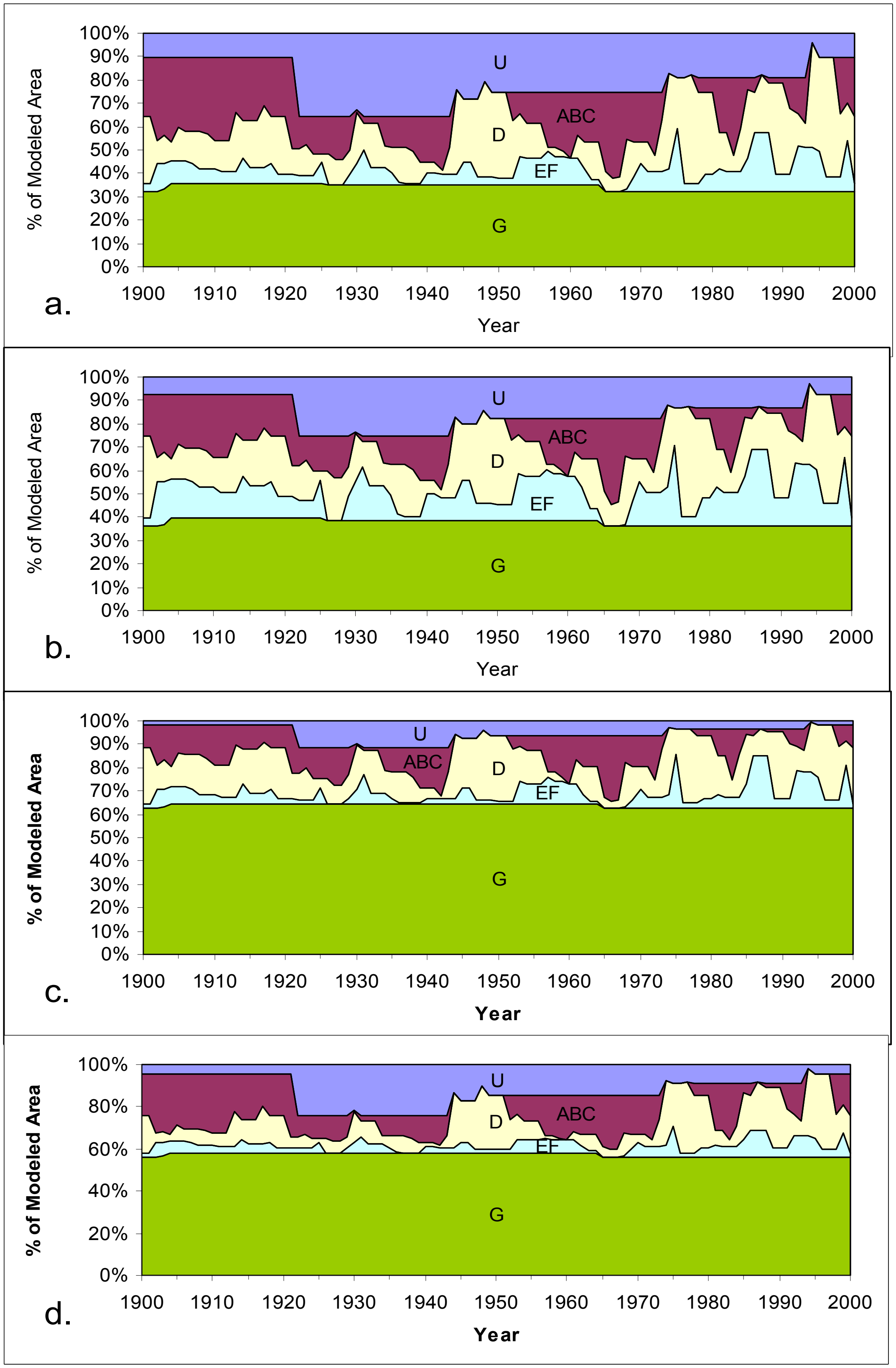

Figure 18. Predicted annual estimates of vegetation communities as a percentage of the geometric wetland model for barrier beach (a), drowned river mouth (b), open embayment (c), and protected embayment (d). 100 year water-level scenario, under Plan 1958DD.

Appendices

Appendix A. Wetland vegetation mapping rules and classification system.

1. Minimum Map Unit: Will be $1mm^2$ (for 1:10,000). Anything less then that will not be classified. When there are several polygons in close proximity and are ~$1mm^2$ (i.e., water lily patches) the preference is to group the small patches and assign a density code (See Rule 4) to the polygon.

2. Level of Classification: Polygons will be classified to Vegetation Type or the lowest possible level based on available information.

3. Organic/Inorganic: For photo interpretation purposes, drowned river mouths and barrier beaches will be considered organic, while protected and unprotected bays will be considered inorganic, unless a site determination can be made.

4. Density: The ELC requires that a vegetation type must be at greater than 25% to be classified, so for density determinations the following rules apply:
   - 0-25% vegetation: leave density field blank
   - 26-50% vegetation: a
   - 51-75% vegetation: b
   - 76-100% vegetation: c

5. Dominance: When two vegetation types occur together, the following apply:
   - If one vegetation type exists at 90% or higher, it is considered to be purely that type
   - If one vegetation type occurs between 89% and 11% it is considered mixed. No dominance is given.

6. Road Delineation: When delineating a road, it will be treated as the dominant feature despite overhanging trees. However, if the road crosses a water feature, the water feature will be delineated and considered the dominant feature.

7. Grouping: When several houses occur in close proximity to each other, they will be grouped into one large polygon labeled residential. For large industrial areas, the entire area including buildings, lawns, parking lots and landscaped trees, will be grouped into a large polygon labeled industrial.

Appendix A. Wetland vegetation mapping rules and classification system (con't).

DB_code	Veg Type/Cover Type	Description	ELC CODE	Old Photo Code
1	Open Water	Water>2m; <25% veg cover	OAO	1
2	Open Water Shallow	Water<2m	SA	2
3	Floating Vegetation	Floating<25% veg cover	SAF	3
300	Floating Vegetation	Floating 26-50% veg cover	SAF	3A
301	Floating Vegetation	Floating 51-75% veg cover	SAF	3B
302	Floating Vegetation	Floating 76-100% veg cover	SAF	3C
4	Mixed Float/Submerged	Floating & Submerg each >25%	SAM	4
5	Submerged Vegetation	>25% total veg	SAS	5
6	Beach	Tree<25; shrub<25;	BBO	6
7	Shrub Beach/Bar	Tree<25%; shrub>25%	BBS	7
8	Treed Beach Bar	25%<tree<60%	BBT	8
9	Exposed Sediment		MA	9
10	Exposed Sediment/Typha		MAS	10
11	Typha Mineral	Cattail Mineral Shallow Marsh <25% veg cover	MAS	11
1100	Typha Mineral	Cattail Mineral Shallow Marsh 26-50% veg cover	MAS	11A
1101	Typha Mineral	Cattail Mineral Shallow Marsh 51-75% veg cover	MAS	11B
1102	Typha Mineral	Cattail Mineral Shallow Marsh 76-100% veg cover	MAS	11C
12	Typha Organic	Cattail Organic Shallow Marsh <25% veg cover	MAS	12
1200	Typha Organic	Cattail Organic Shallow Marsh 26-50% veg cover	MAS	12A
1201	Typha Organic	Cattail Organic Shallow Marsh 51-75% veg cover	MAS	12B
1202	Typha Organic	Cattail Organic Shallow Marsh 76-100% veg cover	MAS	12C
13	Typha/Mixed Emergent Mineral		MAS	13
14	Typha/Mixed Emergent Organic		MAS	14
15	Typha/Phragmites Mix		MAS	15
16	Phragmites Mineral		MAS	16
17	Phragmites Organic		MAS	17
18	Meadow Marsh Mineral (grasses, etc.)	Meadow Marsh Mineral <25% veg cover	MAM	18
1800	Meadow Marsh Mineral (grasses, etc.)	Meadow Marsh Mineral 26-50% veg cover	MAM	18A
1801	Meadow Marsh Mineral (grasses, etc.)	Meadow Marsh Mineral 51-75% veg cover	MAM	18B
1802	Meadow Marsh Mineral (grasses, etc.)	Meadow Marsh Mineral 76-100% veg cover	MAM	18C
19	Meadow Marsh Organic (grasses, etc.)	Meadow Marsh Organic <25% veg cover	MAM	19
1900	Meadow Marsh Organic (grasses, etc.)	Meadow Marsh Organic 26-50% veg cover	MAM	19A

1901	Meadow Marsh Organic (grasses, etc.)	Meadow Marsh Organic 51-75% veg cover	MAM	19B
1902	Meadow Marsh Organic (grasses, etc.)	Meadow Marsh Organic 76-100% veg cover	MAM	19C
20	Emergent-Unknown-Organic	Emergent-Unknown-Organic <25% veg cover	MAS	20
2000	Emergent-Unknown-Organic	Emergent-Unknown-Organic 26-50% veg cover	MAS	20A
2001	Emergent-Unknown-Organic	Emergent-Unknown-Organic 51-75% veg cover	MAS	20B
2002	Emergent-Unknown-Organic	Emergent-Unknown-Organic 76-100% veg cover	MAS	20C
21	Residential		CU	21
22	Lawn/residential grasses		CU	22
23	Residential other (tennis court)		CU	23
24	Roads		CU	24
25	Agriculture		CU	25
26	Pasture		CU	26
27	Tree-Deciduous	Deciduous trees>75% of canopy	FOD	27
28	Dead Trees		SW	28
29	Tree-Deciduous/Shrub Mix		FOD	29
30	Shrub		CUT	30
31	Upland Mix	Meadow, shrub, some trees, upland	CUT	31
32	Typha/Meadow Marsh-Organic		MAS	32
33	Typha/Shrub Mix- Organic		SWT	33
34	Industrial		CU	34
35	Constructed Wetland	Waste water, SWM, Agricultural dugout, etc.	CU	35
36	Cultural Tree	Tree Plantations	CUP	36
37	Mixed Emergent and Floating	Mixed Emergent and Floating <25% veg cover	MAS	37
3700	Mixed Emergent and Floating	Mixed Emergent and Floating 26-50% veg cover	MAS	37A
3701	Mixed Emergent and Floating	Mixed Emergent and Floating 51-75% veg cover	MAS	37B
3702	Mixed Emergent and Floating	Mixed Emergent and Floating 76-100% veg cover	MAS	37C
38	Mixed Shrub Meadow-Organic		SWT	38
39	Coniferous/Deciduous Tree Mix		FOM	39
40	Emergent-Unknown-Mineral	Emergent-Unknown- Mineral <25% veg cover	MAS	40
4000	Emergent-Unknown-Mineral	Emergent-Unknown- Mineral 26-50% veg cover	MAS	40A
4001	Emergent-Unknown-Mineral	Emergent-Unknown- Mineral 51-75% veg cover	MAS	40B
4002	Emergent-Unknown-Mineral	Emergent-Unknown- Mineral 76-100% veg cover	MAS	40C
41	Coniferous-Deciduous shrub		CUT	41

	mix			
42	Typha/Shrub-Mineral		SWT	42
43	Typha/Meadow Marsh-Mineral		MAS	43
44	Wild Rice- Mineral	Wild Rice - Mineral <25% veg cover	MAS	44
4400	Wild Rice- Mineral	Wild Rice - Mineral 26-50% veg cover	MAS	44A
4401	Wild Rice- Mineral	Wild Rice - Mineral 51-75% veg cover	MAS	44B
4402	Wild Rice- Mineral	Wild Rice - Mineral 76-100% veg cover	MAS	44C
45	Mixed shrub meadow-Mineral		SWT	45
46	Sand Dunes		SD	46
47	Floating/Submerged/Emergent-Mineral		MAS	47
48	Rock Outcroppings		RB	48
49	Typha/Floating- Mineral		MAS	49
50	Marsh – mineral		MAS	50
51	Marsh – organic		MAS	51
52	Dead Typha		MAS	52
53	Emergent Submerged		MAS	53
54	Trees in Water		SW	54
503	Meadow Marsh – Calamagrostis		MAM	503
504	Meadow Marsh - Phalaris		MAM	504
505	Floating/Short Emergent		MAS	505
506	Meadow Marsh - Sedge		MAM	506
507	Emergent - Short		MAS	507
50700	Emergent - Short		MAS	507a
50701	Emergent - Short		MAS	507b
50702	Emergent - Short		MAS	507c
508	Typha/Lythrum salicaria		MAS	508
509	Meadow Marsh - Lythrum salicaria		MAS	509
510	Typha/Short Emergent		MAS	510
511	Typha/Calamagrostis		MAS	511
512	Deciduous Tree Swamp		SWD	512
513	Deciduous Shrub Thicket		SWT	513
514	Coniferous Tree Swamp		SWC	514
515	Mixed Coniferous Deciduous Tree Swamp		SWM	515

Appendix A. Wetland vegetation mapping rules and classification system (con't).

ELC Code	Community Class	Community Series
BBO	Beach / Bar	Beach / Bar -Open
BBS	Beach / Bar	Beach / Bar -Shrub
BBT	Beach / Bar	Beach / Bar -Treed
CU	Cultural	Cultural
CUP	Cultural	Cultural -Plantation
CUT	Cultural	Cultural -Thicket
FOD	Forest	Forest -Deciduous
FOM	Forest	Forest -Mixed
MA	Marsh	Marsh
MAM	Marsh	Marsh -Meadow
MAS	Marsh	Marsh -Shallow Marsh
OAO	Open Water	Open water -Open Aquatic
RB	Rock Barren	Rock Barren
SA	Shallow Water	Shallow Water
SAF	Shallow Water	Shallow Water -Floating-leaved Shallow Aquatic
SAM	Shallow Water	Shallow Water -Mixed Shallow Aquatic
SAS	Shallow Water	Shallow Water -Submerged Shallow Aquatic
SD	Sand Dune	Sand Dune
SW	Swamp	Swamp
SWC	Swamp	Swamp -Coniferous
SWD	Swamp	Swamp -Deciduous
SWM	Swamp	Swamp -Mixed
SWT	Swamp	Swamp -Thicket
XXX	Unknown	Unknown

Appendix B. Lake Ontario – Upper St. Lawrence River coastal wetland database

WETLAND_NAME	COUNTRY	SHL_UNIT	SITECLASS	AREA_HA
Barnesdale Marsh	Canada	CND1	DRM	5.33
Eight Mile Creek Estuary	Canada	CND1	DRM	7.08
Eighteen Mile Creek	Canada	CND1	DRM	4.90
Fifteen Mile Creek	Canada	CND1	DRM	40.86
Four Mile Creek Estuary	Canada	CND1	DRM	6.55
Four Mile Pond	Canada	CND1	DRM	6.46
Jordan Station Marsh	Canada	CND1	DRM	73.42
Martindale Pond	Canada	CND1	DRM	34.86
Port Weller	Canada	CND1	OB	4.82
Sixteen & Seventeen Mile Creeks Terrace Valley	Canada	CND1	DRM	8.52
Two Mile Pond	Canada	CND1	DRM	2.05
Battlefield Creek Wetland	Canada	CND3	DRM	5.29
Cootes Paradise 1	Canada	CND3	DRM	166.55
Cootes Paradise 2	Canada	CND3	DRM	5.71
Cootes Paradise 3	Canada	CND3	DRM	5.35
RBG- Hendrie Valley (Lambs Holllow Wetland)	Canada	CND3	DRM	27.28
Van Wagners Marsh	Canada	CND3	DRM	15.95
Bronte Creek Marsh	Canada	CND4	DRM	4.79
Credit River Marshes	Canada	CND4	DRM	7.85
Humber River Marshes	Canada	CND4	DRM	25.10
Joshua's Creek	Canada	CND4	DRM	0.28
Oakville Marsh (Sixteen Mile Creek)	Canada	CND4	DRM	3.52
Rattray Marsh	Canada	CND4	BB	11.41
Turtle Creek- Reed Swamp	Canada	CND4	DRM	4.26
Toronto Island Wetlands 1	Canada	CND5	BB	0.99
Toronto Island Wetlands 2	Canada	CND5	PB	12.33
Toronto Island Wetlands 3	Canada	CND5	BB	3.34
Toronto Island Wetlands 4	Canada	CND5	PB	1.62
Carruthers Creek Marsh	Canada	CND7	DRM	124.43
Corbett Creek Mouth Marsh	Canada	CND7	DRM	21.27
Cranberry Marsh	Canada	CND7	BB	47.29
Crysler Point Wetland (Wesleyville Marsh) 1	Canada	CND7	BB	7.21
Crysler Point Wetland (Wesleyville Marsh) 2	Canada	CND7	BB	3.45
Duffins Creek Lakeshore Marsh	Canada	CND7	DRM	71.99
Frenchman's Bay Marsh	Canada	CND7	BB	32.35
Harmony Creek Wetland	Canada	CND7	DRM	19.88
Highland Creek Wetland	Canada	CND7	DRM	6.97
Hydro Marsh	Canada	CND7	DRM	24.33
Lynde Creek Marsh	Canada	CND7	BB	130.03
McLaughlin Bay Wetland 1	Canada	CND7	BB	40.18
McLaughlin Bay Wetland 2	Canada	CND7	BB	1.55
Oshawa Second Marsh	Canada	CND7	BB	112.80
Port Britain Wetland	Canada	CND7	BB	20.45
Port Darlington Marsh	Canada	CND7	DRM	28.70
Port Newcastle Wetland Complex	Canada	CND7	DRM	8.19
Pumphouse Marsh	Canada	CND7	BB	7.25
Raby Head Wetland # 1	Canada	CND7	BB	5.26
Rouge River Marsh	Canada	CND7	DRM	67.60
Westside Beach Marsh	Canada	CND7	BB	45.12

Wilmot Creek Marsh	Canada	CND7	DRM	25.87
Brookside Wetland	Canada	CND8	BB	7.99
Carrs Marsh (Peters Rock Marsh)	Canada	CND8	BB	70.63
Colborne Creek 1	Canada	CND8	DRM	4.75
Colborne Creek 2	Canada	CND8	BB	12.88
Grafton Swamp	Canada	CND8	DRM	53.04
Hortop Creek	Canada	CND8	DRM	0.67
Peter Rock #2 Wetland	Canada	CND8	BB	2.52
Popham Bay	Canada	CND8	DRM	54.26
Salem Creek Wetland	Canada	CND8	DRM	4.37
Spencer Point 1	Canada	CND8	DRM	16.21
Spencer Point 2	Canada	CND8	DRM	2.80
Spencer Point 3	Canada	CND8	BB	45.14
Wicklow Bay Wetland	Canada	CND8	BB	47.72
Wicklow Gravel Pit	Canada	CND8	DRM	2.65
Big Sand Bay 1	Canada	CND9	BB	9.37
Big Sand Bay 2	Canada	CND9	BB	122.46
Bluff Island Wetland	Canada	CND9	BB	1.11
East Lake Marsh 1	Canada	CND9	BB	8.18
East Lake Marsh 2	Canada	CND9	OB	42.93
East Lake Marsh 3	Canada	CND9	OB	10.31
East Lake Marsh 4	Canada	CND9	PB	100.16
East Lake Marsh 5	Canada	CND9	PB	8.88
East Lake Marsh 6	Canada	CND9	PB	8.52
East Lake Marsh 7	Canada	CND9	DRM	7.45
Gravelly Bay Wetland	Canada	CND9	BB	10.32
Gravelly Point	Canada	CND9	BB	3.23
Gull Island Wetland	Canada	CND9	BB	0.54
Gull Pond Wetland	Canada	CND9	BB	7.25
Hucyks Bay 1	Canada	CND9	BB	155.57
Hucyks Bay 2	Canada	CND9	DRM	240.84
Litlle Popular Point	Canada	CND9	BB	7.94
North Bay Wetland	Canada	CND9	BB	30.82
Owen Point Wetland	Canada	CND9	BB	4.34
Petticoat Wetland	Canada	CND9	BB	14.42
Pleasant Bay 1	Canada	CND9	BB	290.48
Pleasant Bay 2	Canada	CND9	DRM	33.97
Point Petre	Canada	CND9	BB	9.78
Presqu'ile Bay Marsh 1	Canada	CND9	DRM	25.71
Presqu'ile Bay Marsh 10	Canada	CND9	DRM	56.45
Presqu'ile Bay Marsh 11	Canada	CND9	PB	73.95
Presqu'ile Bay Marsh 12	Canada	CND9	PB	36.92
Presqu'ile Bay Marsh 13	Canada	CND9	PB	18.24
Presqu'ile Bay Marsh 2	Canada	CND9	BB	68.50
Presqu'ile Bay Marsh 3	Canada	CND9	BB	26.22
Presqu'ile Bay Marsh 4	Canada	CND9	PB	112.95
Presqu'ile Bay Marsh 5	Canada	CND9	BB	1.98
Presqu'ile Bay Marsh 6	Canada	CND9	PB	0.62
Presqu'ile Bay Marsh 7	Canada	CND9	PB	155.19
Presqu'ile Bay Marsh 8	Canada	CND9	DRM	34.72
Presqu'ile Bay Marsh 9	Canada	CND9	DRM	19.89

Rocky Point Wetland	Canada	CND9	BB	15.21
Salmon Point	Canada	CND9	BB	79.11
Soup Harbour	Canada	CND9	BB	67.52
South Bay Coastal Wetland 1	Canada	CND9	BB	171.45
South Bay Coastal Wetland 2	Canada	CND9	DRM	68.27
Wellers Bay Wetland 1	Canada	CND9	DRM	4.49
Wellers Bay Wetland 11	Canada	CND9	BB	15.37
Wellers Bay Wetland 12	Canada	CND9	BB	45.73
Wellers Bay Wetland 14	Canada	CND9	PB	14.44
Wellers Bay Wetland 2	Canada	CND9	PB	16.30
Wellers Bay Wetland 3	Canada	CND9	BB	2.06
Wellers Bay Wetland 4	Canada	CND9	BB	25.71
Wellers Bay Wetland 5	Canada	CND9	OB	23.55
Wellers Bay Wetland 6	Canada	CND9	DRM	26.55
Wellers Bay Wetland 7	Canada	CND9	DRM	57.10
Wellers Bay Wetland 8	Canada	CND9	PB	72.46
Wellers Bay Wetland 9	Canada	CND9	BB	2.24
West Lake Wetland 1	Canada	CND9	PB	0.95
West Lake Wetland 2	Canada	CND9	PB	2.97
West Lake Wetland 3	Canada	CND9	PB	11.80
West Lake Wetland 4	Canada	CND9	DRM	409.99
West Lake Wetland 5	Canada	CND9	OB	396.18
West Lake Wetland 6	Canada	CND9	DRM	11.59
Black Creek Wetland	Canada	CND10	DRM	67.10
Cape Vasey 1	Canada	CND10	PB	2.57
Cape Vasey 2	Canada	CND10	BB	5.99
False Ducks Island	Canada	CND10	BB	5.64
Halfmoon Bay Wetland	Canada	CND10	BB	3.26
Little Bluff Wetland	Canada	CND10	BB	6.90
Long Point Harbour Wetland	Canada	CND10	DRM	1.90
South Bay Marsh 1	Canada	CND10	OB	21.12
South Bay Marsh 2	Canada	CND10	OB	39.12
Waupoos Creek Swamp 1	Canada	CND10	PB	8.49
Waupoos Creek Swamp 2	Canada	CND10	OB	2.62
Waupoos Creek Swamp 3	Canada	CND10	DRM	1.91
Waupoos Island Wetland	Canada	CND10	BB	1.45
12 O'Clock Point	Canada	CND11	DRM	24.94
Adolphus Reach Wetland	Canada	CND11	OB	20.73
Adolphustown Marsh 1	Canada	CND11	BB	2.35
Adolphustown Marsh 2	Canada	CND11	PB	15.67
Adolphustown Marsh 3	Canada	CND11	DRM	9.68
Airport Creek Marsh	Canada	CND11	DRM	29.15
Bayside Wetland 1	Canada	CND11	BB	0.46
Bayside Wetland 2	Canada	CND11	OB	5.99
Bayside Wetland 3	Canada	CND11	DRM	5.75
Bayside Wetland 4	Canada	CND11	PB	3.13
Bayside Wetland 5	Canada	CND11	BB	1.74
Bayside Wetland 6	Canada	CND11	PB	4.07
Bayside Wetland 7	Canada	CND11	PB	3.22
Bell Creek Swamp Complex	Canada	CND11	DRM	1.34
Belleville Marsh 1	Canada	CND11	BB	1.64

Belleville Marsh 2	Canada	CND11	PB	16.04
Belleville Treatment Plant Marsh	Canada	CND11	PB	1.37
Big Bay Wetland	Canada	CND11	BB	4.00
Big Island Marsh	Canada	CND11	PB	685.46
Blessington Creek Marsh 1	Canada	CND11	DRM	5.68
Blessington Creek Marsh 2	Canada	CND11	PB	95.96
Blessington Creek Marsh 3	Canada	CND11	PB	12.27
Bluff Point 1	Canada	CND11	OB	0.21
Bluff Point 2	Canada	CND11	BB	31.28
Bluff Point 3	Canada	CND11	PB	3.61
Bygotts Bay Wetland 1	Canada	CND11	PB	1.30
Bygotts Bay Wetland 2	Canada	CND11	BB	1.90
Carnachan Bay Wetland 1	Canada	CND11	PB	2.43
Carnachan Bay Wetland 2	Canada	CND11	DRM	3.91
Carnachan Bay Wetland 3	Canada	CND11	DRM	9.09
Carnachan Bay Wetland 4	Canada	CND11	DRM	0.88
Carnachan Bay Wetland 5	Canada	CND11	BB	2.69
Carrying Place	Canada	CND11	DRM	4.34
Cole Point Wetland	Canada	CND11	DRM	3.80
Cressy Marsh	Canada	CND11	BB	10.60
Cressy Swamp 1	Canada	CND11	DRM	122.97
Cressy Swamp 2	Canada	CND11	PB	1.24
Dead Creek Marsh	Canada	CND11	DRM	330.36
Duck Creek Wetland	Canada	CND11	DRM	3.95
Forester's Island	Canada	CND11	PB	10.15
Grassy Point Wetland	Canada	CND11	OB	3.60
Hay Bay Marsh 1	Canada	CND11	PB	18.44
Hay Bay Marsh 2	Canada	CND11	OB	216.42
Hay Bay Marsh 3	Canada	CND11	DRM	494.29
Hay Bay Marsh 4	Canada	CND11	DRM	79.01
Hay Bay Marsh 5	Canada	CND11	PB	383.14
Hay Bay Marsh 6	Canada	CND11	PB	65.95
Hay Bay Marsh 7	Canada	CND11	OB	121.96
Hay Bay Marsh 8	Canada	CND11	PB	112.63
Lower Napanee River 1	Canada	CND11	DRM	16.14
Lower Napanee River 2	Canada	CND11	BB	3.11
Lower Napanee River 3	Canada	CND11	DRM	64.06
Lower Napanee River 4	Canada	CND11	DRM	79.65
Lower Napanee River 5	Canada	CND11	DRM	36.41
Lower Napanee River 6	Canada	CND11	DRM	9.44
Lower Napanee River 7	Canada	CND11	DRM	59.77
Lower Salmon River Wetland 1	Canada	CND11	DRM	12.90
Lower Salmon River Wetland 2	Canada	CND11	PB	4.00
Lower Salmon River Wetland 3	Canada	CND11	DRM	82.57
Lower Sucker Creek 1	Canada	CND11	PB	9.17
Lower Sucker Creek 2	Canada	CND11	DRM	30.62
Lower Sucker Creek 3	Canada	CND11	PB	2.35
Lower Sucker Creek 4	Canada	CND11	PB	11.31
Makatewis Island	Canada	CND11	PB	1.19
Mallory Bay 1	Canada	CND11	BB	4.46
Mallory Bay 2	Canada	CND11	BB	1.01

Mallory Bay 3	Canada	CND11	BB	1.41
Marysville Creek Wetland	Canada	CND11	DRM	351.99
Pine Point Wetland 1	Canada	CND11	PB	17.41
Pine Point Wetland 2	Canada	CND11	PB	11.73
Point Anne Wetland	Canada	CND11	PB	1.03
Robinson Cove Marsh	Canada	CND11	OB	8.83
Sawguin Creek Marsh 1	Canada	CND11	DRM	1157.21
Sawguin Creek Marsh 10	Canada	CND11	PB	34.70
Sawguin Creek Marsh 2	Canada	CND11	PB	72.83
Sawguin Creek Marsh 3	Canada	CND11	OB	148.17
Sawguin Creek Marsh 4	Canada	CND11	PB	7.34
Sawguin Creek Marsh 5	Canada	CND11	OB	89.76
Sawguin Creek Marsh 6	Canada	CND11	DRM	26.19
Sawguin Creek Marsh 7	Canada	CND11	PB	546.06
Sawguin Creek Marsh 8	Canada	CND11	OB	78.58
Sawguin Creek Marsh 9	Canada	CND11	PB	19.22
Shermans Point	Canada	CND11	PB	3.26
Solmesville	Canada	CND11	PB	2.47
The Pines	Canada	CND11	DRM	2.80
Willow Point 1	Canada	CND11	OB	0.74
Willow Point 2	Canada	CND11	PB	3.40
Willow Point 3	Canada	CND11	OB	0.25
Amererst Bar Wetland	Canada	CND12	BB	10.19
Bath Point Wetland	Canada	CND12	DRM	11.16
Collins Creek Wetlands 1	Canada	CND12	DRM	1.30
Collins Creek Wetlands 2	Canada	CND12	PB	43.99
Duck Club Marsh	Canada	CND12	BB	111.63
Emeric Point Wetland	Canada	CND12	BB	5.05
Greater Cataraqui Marsh	Canada	CND12	DRM	488.53
Gull Point 1	Canada	CND12	BB	0.76
Gull Point 2	Canada	CND12	BB	1.13
Little Cataraqui Creek	Canada	CND12	DRM	279.21
Long Point Bay Marsh 1	Canada	CND12	BB	349.80
Long Point Bay Marsh 2	Canada	CND12	BB	11.78
Nut Island Wetland	Canada	CND12	BB	5.57
Parrott Bay Wetland 1	Canada	CND12	DRM	1.10
Parrott Bay Wetland 2	Canada	CND12	PB	28.59
Pig Point Wetland	Canada	CND12	BB	1.56
Wemps Bay Marsh	Canada	CND12	BB	45.73
Eighteenmile Creek	USA	US1	DRM	24.48
Fish Creek	USA	US1	DRM	2.65
Fourmile Creek	USA	US1	DRM	4.61
Golden Hill Creek	USA	US1	DRM	6.10
Hopkins Creek	USA	US1	DRM	3.88
Johnson Creek	USA	US1	DRM	8.22
Keg Creek	USA	US1	DRM	5.16
Lomond Shore	USA	US1	OB	0.08
Marsh Creek	USA	US1	DRM	0.68
Oak Orchard Creek	USA	US1	DRM	84.93
Rock Ledge Beach	USA	US1	OB	0.40
Sixmile Creek	USA	US1	DRM	10.54

Stream at county line	USA	US1	DRM	0.51
Stream at Harrison Grove	USA	US1	DRM	1.18
Stream at Lomond Shore	USA	US1	DRM	0.30
Stream at Marshall Road	USA	US1	DRM	0.76
Stream at North Beebe Road	USA	US1	DRM	1.77
Stream at Towers Corners	USA	US1	DRM	0.79
The Marsh	USA	US1	DRM	3.49
Tuscarora Bay	USA	US1	BB	32.11
Twelvemile Creek	USA	US1	DRM	24.34
West of Eighteenmile Creek	USA	US1	BB	0.89
Bald Eagle Creek	USA	US2	DRM	8.35
Benedict Beach east	USA	US2	DRM	17.90
Benedict Beach west	USA	US2	DRM	1.99
Bluff Beach 1	USA	US2	OB	0.10
Bluff Beach 2	USA	US2	OB	0.13
Braddock Bay	USA	US2	OB	160.82
Brush Creek	USA	US2	DRM	84.88
Buck Pond	USA	US2	BB	222.05
Cowsucker Creek	USA	US2	DRM	15.14
Cranberry Pond	USA	US2	BB	90.60
Davidson Beach east	USA	US2	BB	11.06
Davidson Beach west	USA	US2	BB	2.39
Devils Nose 1	USA	US2	OB	0.04
Devils Nose 2	USA	US2	OB	0.13
Durand Eastman Park stream	USA	US2	PB	1.77
Durand Eastmand Park	USA	US2	PB	0.64
East Creek	USA	US2	DRM	12.47
East of Bogus Point 1	USA	US2	BB	21.99
East of Bogus Point 2	USA	US2	BB	3.05
Genessee River	USA	US2	DRM	110.87
Hamlin Beach	USA	US2	DRM	0.10
Irondequoit Bay	USA	US2	PB	91.53
Irondequoit Creek	USA	US2	DRM	126.97
Long Pond	USA	US2	BB	45.55
Northrup Creek	USA	US2	DRM	3.40
Onteo Beach	USA	US2	OB	0.06
Payne Beach	USA	US2	BB	58.51
Round Pond	USA	US2	BB	114.11
Sandy Creek	USA	US2	DRM	31.96
Shore Acres	USA	US2	BB	17.25
Shore at Troutberg	USA	US2	OB	0.12
Shore east of Bald Eagle Creek	USA	US2	OB	0.44
Slater Creek	USA	US2	DRM	7.07
Stream at Bluff Beach	USA	US2	DRM	3.08
Stream at Float Bridge	USA	US2	DRM	5.51
Stream at Troutberg	USA	US2	DRM	0.79
West Creek	USA	US2	DRM	77.51
Yanty Marsh	USA	US2	DRM	42.72
Dennison Creek	USA	US3	DRM	0.16
East of Boller Point	USA	US3	OB	0.11
East of Bootleggers Point	USA	US3	DRM	3.22

East of Dufloo Road	USA	US3	DRM	1.20
East of Fischer Road	USA	US3	OB	0.06
East of Mink Creek	USA	US3	OB	0.03
East of Ninemile Point 1	USA	US3	OB	0.06
East of Ninemile Point 2	USA	US3	OB	0.06
East of Salmon Creek	USA	US3	OB	0.46
Ginna Nuclear Plant	USA	US3	OB	0.10
Holland Cove	USA	US3	OB	0.12
Mill Creek	USA	US3	DRM	0.34
Mink Creek	USA	US3	DRM	1.93
Ontario on the Lake 1	USA	US3	OB	0.07
Ontario on the Lake 2	USA	US3	OB	0.07
Ontario on the Lake 3	USA	US3	OB	0.10
Pultneyville 1	USA	US3	OB	0.05
Pultneyville 2	USA	US3	OB	0.09
West of Bootleggers Point	USA	US3	DRM	0.88
West of Mill Creek	USA	US3	OB	0.06
West of Stony Lonesome Road	USA	US3	OB	0.04
Beaver Creek	USA	US4	DRM	101.76
Between Blind and Little Sodus Bays	USA	US4	BB	0.36
Black Creek	USA	US4	BB	160.27
Blind Sodus Bay	USA	US4	PB	9.80
Blind Sodus Creek	USA	US4	DRM	6.69
Brush Marsh 1	USA	US4	DRM	10.50
Brush Marsh 2	USA	US4	BB	25.55
Clark Creek	USA	US4	DRM	8.71
Dutch Street Road	USA	US4	BB	1.09
East Bay	USA	US4	BB	195.77
East Bay tribuatry 2	USA	US4	DRM	14.11
East Bay tributary 1	USA	US4	DRM	58.36
East of Brown Road 1	USA	US4	BB	0.57
East of Brown Road 2	USA	US4	BB	0.47
East of Fair Haven Beach	USA	US4	BB	2.60
East of McIntyres Bluff	USA	US4	BB	9.26
East of Port Bay 1	USA	US4	DRM	2.87
East of Port Bay 2	USA	US4	BB	8.09
East of Port Bay 3	USA	US4	DRM	36.50
East of Port Bay 4	USA	US4	BB	4.30
East of Scotts Bluff 1	USA	US4	BB	1.99
East of Scotts Bluff 2	USA	US4	BB	9.38
East of Sodus Bay 1	USA	US4	DRM	0.56
East of Sodus Bay 2	USA	US4	DRM	2.08
East of Sodus Bay 3	USA	US4	DRM	2.20
East of West Ninemile Point	USA	US4	OB	0.08
Eightmile Creek	USA	US4	DRM	4.75
Fair Haven Beach	USA	US4	BB	288.89
Fair Haven Beach tributary	USA	US4	DRM	14.85
First Creek	USA	US4	DRM	7.77
Juniper Pond	USA	US4	BB	14.22
Little Sodus Bay	USA	US4	PB	49.16
Maxwell Bay	USA	US4	BB	12.43

Mudge Creek	USA	US4	DRM	17.89
Ninemile Creek	USA	US4	DRM	6.40
Port Bay	USA	US4	PB	158.99
Red Creek	USA	US4	DRM	138.35
Root Swamp	USA	US4	BB	43.48
Second Creek	USA	US4	PB	27.15
Snake Swamp	USA	US4	BB	50.46
Sodus Bay	USA	US4	PB	189.49
Sodus Creek	USA	US4	DRM	104.26
Sprong Bluff	USA	US4	BB	1.15
Sterling Creek	USA	US4	DRM	12.29
Third Creek	USA	US4	DRM	18.47
West Lake Road	USA	US4	BB	18.32
West of Blind Sodus Bay	USA	US4	BB	28.35
West of Chimney Bluff 1	USA	US4	OB	0.04
West of Chimney Bluff 2	USA	US4	BB	0.41
West of Moon Beach	USA	US4	BB	3.04
West of Port Bay 1	USA	US4	DRM	1.80
West of Port Bay 2	USA	US4	DRM	2.33
West of Sodus Bay 1	USA	US4	PB	5.55
West of Sodus Bay 2	USA	US4	PB	1.91
West of Sodus Bay 3	USA	US4	PB	0.11
West of Sodus Bay 4	USA	US4	DRM	0.35
West of Sodus Bay 5	USA	US4	DRM	2.59
West of Sodus Bay 6	USA	US4	PB	0.04
West of Sodus Bay 7	USA	US4	DRM	0.76
West of Sodus Bay 8	USA	US4	PB	1.04
Wheeler Road wetland outlet	USA	US4	DRM	0.29
Wolcott Creek	USA	US4	DRM	48.99
East of Burt Point	USA	US5	OB	0.04
East of stream at Lake View Road	USA	US5	BB	0.58
East of Walker creek 1	USA	US5	BB	5.47
East of Walker creek 2	USA	US5	BB	6.36
Fort Ontario	USA	US5	OB	0.17
Lake View 1	USA	US5	OB	0.57
Lake View 2	USA	US5	BB	1.87
Lake View 3	USA	US5	OB	0.69
Lake View 4	USA	US5	OB	0.13
Oswego Beach 1	USA	US5	OB	1.23
Oswego Beach 2	USA	US5	OB	0.61
Rice Creek	USA	US5	DRM	12.15
Stream at Lake View	USA	US5	DRM	1.57
Stream at Lake View Road	USA	US5	DRM	0.33
Stream at Walker	USA	US5	BB	49.55
West of stream at Walker	USA	US5	BB	16.71
West of Wine Creek	USA	US5	OB	0.03
Wine Creek	USA	US5	BB	1.17
Butterfly Swamp	USA	US6	BB	136.43
Catfish Creek	USA	US6	DRM	4.47
East of Pleasant Point	USA	US6	OB	0.02
Otter Branch	USA	US6	BB	11.71

Shore at Butterfly Swamp	USA	US6	OB	0.04
Shore at Otter Branch	USA	US6	OB	0.11
Sunset Bay	USA	US6	OB	0.06
West of Catfish Road	USA	US6	BB	1.12
Black Pond	USA	US7	BB	165.41
Blind Creek	USA	US7	DRM	21.04
Cranberry Pond	USA	US7	BB	51.35
Deer Creek Marsh	USA	US7	BB	534.02
Grindstone Creek	USA	US7	BB	62.95
Jefferson Park	USA	US7	BB	7.34
Lindsey Creek	USA	US7	DRM	5.05
Little Sandy Creek	USA	US7	DRM	29.38
Mud Brook	USA	US7	DRM	10.03
North Pond	USA	US7	PB	279.76
S Colwell to Lakeview Pond	USA	US7	BB	1006.53
Sage Creek	USA	US7	BB	13.53
Sage Creek Road 1	USA	US7	BB	1.96
Sage Creek Road 2	USA	US7	BB	14.99
Salmon Creek	USA	US7	DRM	20.90
Salmon River	USA	US7	DRM	133.78
Sawyer Point	USA	US7	OB	0.41
Skinner Creek	USA	US7	DRM	58.07
Snake Creek	USA	US7	BB	45.33
South Pond	USA	US7	PB	25.49
Southwick Beach	USA	US7	BB	30.45
Stony Creek	USA	US7	DRM	45.87
West of Mexico Point 1	USA	US7	BB	6.12
West of Mexico Point 2	USA	US7	BB	14.21
Adams Cove Road	USA	US8	BB	0.32
Association Island north	USA	US8	PB	1.32
Association Island soutwest	USA	US8	OB	0.89
Backus Road	USA	US8	DRM	0.39
Baird Point	USA	US8	BB	0.61
Barnes Bay	USA	US8	OB	10.29
Base of Gleason Peak	USA	US8	BB	2.04
Basin Harbor	USA	US8	BB	2.92
Bedford Creek	USA	US8	DRM	18.44
Black River Bay 1	USA	US8	PB	63.19
Black River Bay 2	USA	US8	OB	106.73
Boultons Beach	USA	US8	OB	7.29
Calf Island	USA	US8	BB	8.34
Carrying Place Road	USA	US8	DRM	2.14
Chaumont River	USA	US8	DRM	23.22
Cherry Island	USA	US8	OB	0.70
Clines Point	USA	US8	PB	1.70
East of Shaver Creek	USA	US8	DRM	0.55
East of the Isthmus	USA	US8	OB	0.37
Everleigh Point	USA	US8	OB	0.10
Fir Island	USA	US8	OB	0.67
Fox Creek	USA	US8	DRM	8.21
Fox Island central 1	USA	US8	OB	15.51

Fox Island central 2	USA	US8	BB	19.06
Fox Island north point	USA	US8	BB	0.23
Fox Island northwest	USA	US8	BB	0.11
Fox Island south	USA	US8	BB	0.39
Fuller Bay	USA	US8	BB	1.79
Galloo Island north	USA	US8	BB	9.16
Galloo Island North Pond	USA	US8	BB	19.93
Galloo Island south	USA	US8	BB	13.30
Gravely Bay 1	USA	US8	BB	4.78
Gravely Bay 2	USA	US8	BB	0.34
Grenadier Island north 1	USA	US8	BB	1.21
Grenadier Island north 2	USA	US8	BB	0.29
Grenadier Island north 3	USA	US8	BB	0.99
Grenadier Island south	USA	US8	BB	0.66
Grenadier Island southwest	USA	US8	BB	2.45
Guffin Creek	USA	US8	DRM	21.72
Henderson Bay east	USA	US8	OB	51.00
Henderson Harbor	USA	US8	PB	2.51
Horse Island east	USA	US8	PB	0.24
Horse Island west	USA	US8	OB	1.59
Kents Creek	USA	US8	DRM	91.32
Lighthouse Road 1	USA	US8	BB	0.20
Lighthouse Road 2	USA	US8	BB	0.19
Little Fox Creek	USA	US8	DRM	23.07
Little Galloo Island 1	USA	US8	BB	0.33
Little Galloo Island 2	USA	US8	BB	0.23
Little Galloo Island 3	USA	US8	BB	0.17
Little Galloo Island 4	USA	US8	BB	0.08
Long Bay	USA	US8	PB	0.35
Long Carrying Place 1	USA	US8	PB	7.77
Long Carrying Place 2	USA	US8	OB	0.99
Marina at Three Mile Bay	USA	US8	OB	0.58
Marsh Point	USA	US8	PB	0.95
Moffett Road 1	USA	US8	OB	0.15
Moffett Road 2	USA	US8	OB	0.25
Mud Bay	USA	US8	BB	5.04
North of Little Fox Creek	USA	US8	BB	0.94
North of the Islthmus 1	USA	US8	BB	0.24
North of the Isthmus 2	USA	US8	PB	1.88
North of Wilson Point	USA	US8	BB	2.47
North Shore 1	USA	US8	BB	0.30
North Shore 2	USA	US8	BB	5.72
North Shore 3	USA	US8	BB	0.29
North Shore 4	USA	US8	BB	0.20
North shore of Black Bay	USA	US8	OB	0.05
North Shore Road wetland 1	USA	US8	BB	1.57
North Shore Road wetland 2	USA	US8	BB	0.65
North Shore Road wetland 3	USA	US8	BB	1.05
Perch River	USA	US8	DRM	24.73
Point Peninsula east	USA	US8	PB	8.15
Point Peninsula north 1	USA	US8	OB	0.29

Point Peninsula north 2	USA	US8	OB	3.13
Point Peninsula southeast	USA	US8	BB	0.74
Point Peninsula west 1	USA	US8	BB	128.79
Point Peninsula west 2	USA	US8	BB	0.47
Point Peninsula west 3	USA	US8	BB	9.91
Ray Bay north	USA	US8	BB	0.40
Ray Bay south	USA	US8	BB	5.73
Reeds Bay 1	USA	US8	DRM	1.31
Reeds Bay 2	USA	US8	OB	0.17
Sawmill Bay	USA	US8	OB	0.97
Shaver Creek	USA	US8	DRM	2.42
Sherwin Creek	USA	US8	DRM	16.65
Six Town Point	USA	US8	OB	1.74
Snowshoe Bay	USA	US8	PB	6.44
South of Basin Harbor	USA	US8	BB	4.81
South of Boultons Beach 1	USA	US8	BB	1.23
South of Boultons Beach 2	USA	US8	OB	0.03
South of Campbell Point	USA	US8	BB	0.23
South of Fox Creek	USA	US8	BB	0.37
South of Little Fox Creek 1	USA	US8	DRM	0.10
South of Little Fox Creek 2	USA	US8	DRM	0.63
South of Little Fox Creek 3	USA	US8	BB	0.33
South of Long Carrying Place	USA	US8	BB	0.08
Stony Island north point	USA	US8	BB	3.45
Stony Island northeast	USA	US8	BB	1.22
Stony Island south 1	USA	US8	PB	0.16
Stony Island south 2	USA	US8	PB	0.32
Stony Island southeast	USA	US8	BB	5.23
Stoors Harbor Road	USA	US8	BB	0.83
Stream at Barnes Bay	USA	US8	DRM	2.19
Stream at Ray Bay	USA	US8	DRM	9.37
The Isthmus	USA	US8	OB	9.89
Three Mile Bay	USA	US8	OB	2.27
Three Mile Bay north 1	USA	US8	OB	1.13
Three Mile Bay north 2	USA	US8	DRM	2.07
Three Mile Point Road	USA	US8	DRM	0.53
Tibbetts Point	USA	US8	BB	0.13
Toad Hole Cove	USA	US8	BB	2.99
West of Guffin Creek 1	USA	US8	BB	1.37
West of Guffin Creek 2	USA	US8	OB	0.58
West of Guffin Creek 3	USA	US8	OB	0.81
West of Long Point	USA	US8	PB	0.56
West of Pillar Point	USA	US8	BB	1.31
Westcott Beach State Park	USA	US8	BB	2.38
Wilson Bay	USA	US8	BB	80.49
Abraham Point Wetland	Canada	R1	PB	1.60
Across form Endymion Island	USA	R1	PB	0.16
Across from Grants Island 1	USA	R1	PB	0.82
Across from Grants Island 2	USA	R1	PB	1.85
Across from Grants Island 3	USA	R1	PB	0.08
Across from Little Ironsides Islands	USA	R1	PB	1.22

Across from Netley Island	USA	R1	PB	0.15
Across from Niagara Island	USA	R1	PB	0.05
Across from Round Island 1	USA	R1	OB	0.25
Across from Round Island 2	USA	R1	DRM	0.10
Aunt Janes Bay	USA	R1	PB	3.34
Barnett Marsh	USA	R1	PB	61.52
Barrett Bay	Canada	R1	PB	40.17
Bartlett Point	USA	R1	PB	0.38
Bateau Channel Wetland	Canada	R1	PB	0.65
Bayfield Bay Wetland 1	Canada	R1	PB	444.23
Bayfield Bay Wetland 2	Canada	R1	DRM	12.25
Bayfield Bay Wetland 3	Canada	R1	PB	18.48
Beatle Point	USA	R1	PB	1.71
Big Sandy Bay	Canada	R1	BB	405.77
Big Thurso Bay	USA	R1	PB	35.05
Blind Bay north	USA	R1	PB	2.90
Blind Bay south	USA	R1	PB	10.12
Bostwick Island Complex 1	Canada	R1	OB	13.01
Bostwick Island Complex 2	Canada	R1	OB	21.05
Bostwick Island Complex 3	Canada	R1	OB	8.53
Bostwick Island Complex 4	Canada	R1	OB	0.66
Brooks Point	USA	R1	PB	0.17
Browns Bay Complex	Canada	R1	OB	1.38
Browns Bay Wetland 1	Canada	R1	PB	4.82
Browns Bay Wetland 2	Canada	R1	OB	2.91
Buck Bay	USA	R1	OB	0.73
Button Bay 1	Canada	R1	PB	2.77
Button Bay 2	Canada	R1	OB	100.56
Canoe Point and Picnic Point State Park 1	USA	R1	PB	0.13
Canoe Point and Picnic Point State Park 2	USA	R1	PB	0.08
Carleton Island north	USA	R1	BB	0.17
Carriage Bay east	USA	R1	PB	3.28
Carriage Bay west	USA	R1	PB	2.55
Carrier Bay 1	USA	R1	PB	0.55
Carrier Bay 2	USA	R1	PB	0.76
Cassidy's Bay 1	Canada	R1	PB	3.67
Cassidy's Bay 2	Canada	R1	PB	2.58
Chippewa Bay south	USA	R1	PB	0.21
Chippewa Creek	USA	R1	DRM	137.08
Chippewa Point	USA	R1	PB	2.06
Collier Island Wetland	Canada	R1	PB	18.08
Collins Landing Wildlife Management Area 1	USA	R1	OB	2.10
Collins Landing Wildlife Management Area 2	USA	R1	OB	6.15
Constance Road	USA	R1	OB	0.75
Crooked Creek	USA	R1	DRM	225.70
Crows Nest	USA	R1	PB	1.38
Customs House 1	USA	R1	PB	0.45
Customs House 2	USA	R1	PB	5.21
Delack Point	USA	R1	PB	0.11
Delaney Bay	USA	R1	PB	59.24
Densmore Bay 1	USA	R1	PB	0.16

Densmore Bay 2	USA	R1	OB	0.23
Duck Cove	USA	R1	PB	0.69
Eagers Bay	USA	R1	OB	0.82
East of Webster Point	USA	R1	PB	0.86
Eel Bay east	USA	R1	OB	5.85
Eel Bay north	USA	R1	OB	19.21
Firman's Creek Wetland	Canada	R1	DRM	11.41
Flynn Bay 1	USA	R1	OB	0.90
Flynn Bay 2	USA	R1	OB	17.45
Flynn Bay 3	USA	R1	OB	9.82
French Creek	USA	R1	DRM	236.79
French Creek Bay west	USA	R1	PB	0.10
Garden Island Wetland	Canada	R1	PB	0.62
Gillespies Point Wetlands 1	Canada	R1	PB	3.83
Gillespies Point Wetlands 2	Canada	R1	PB	2.70
Gillespies Point Wetlands 3	Canada	R1	OB	1.76
Gillespies Point Wetlands 4	Canada	R1	PB	2.26
Goose Bay	USA	R1	PB	194.98
Goose Bay 1	USA	R1	OB	0.69
Goose Bay 2	USA	R1	PB	0.38
Granite Peak	USA	R1	PB	0.21
Grass Bay 1	USA	R1	OB	0.41
Grass Bay 2	USA	R1	DRM	0.92
Grass Creek 1	Canada	R1	DRM	34.24
Grass Creek 2	Canada	R1	PB	8.76
Grass Creek Point Wetland	Canada	R1	PB	1.32
Grass Point State Park	USA	R1	PB	1.15
Gray's Creek Wetland	Canada	R1	DRM	20.80
Greens Creek	USA	R1	PB	0.18
Grenadier Island Complex 1	Canada	R1	OB	52.49
Grenadier Island Complex 10	Canada	R1	DRM	49.23
Grenadier Island Complex 2	Canada	R1	OB	544.43
Grenadier Island Complex 3	Canada	R1	PB	68.15
Grenadier Island Complex 4	Canada	R1	PB	2.75
Grenadier Island Complex 5	Canada	R1	DRM	1.45
Grenadier Island Complex 6	Canada	R1	PB	7.02
Grenadier Island Complex 7	Canada	R1	OB	7.88
Grenadier Island Complex 8	Canada	R1	PB	10.08
Grenadier Island Complex 9	Canada	R1	PB	30.84
Halstead Bay Marsh 1	Canada	R1	OB	9.58
Halstead Bay Marsh 2	Canada	R1	OB	69.93
Halstead Creek Marsh	Canada	R1	DRM	7.36
Harder Road	USA	R1	PB	0.20
Hay Island Marsh	Canada	R1	OB	53.59
Hill Island East	Canada	R1	PB	67.92
Hill Island West	Canada	R1	PB	20.70
Holliday Bay Wetland 1	Canada	R1	PB	17.55
Holliday Bay Wetland 2	Canada	R1	PB	5.11
Holliday Bay Wetland 3	Canada	R1	PB	1.55
Holliday Bay Wetland 4	Canada	R1	OB	39.09
Indian Point	USA	R1	PB	18.08

International Rift	USA	R1	PB	9.79
Irvine Bay Wetland 1	Canada	R1	PB	5.46
Irvine Bay Wetland 2	Canada	R1	PB	8.27
Irvine Bay Wetland 3	Canada	R1	OB	47.16
Irvine Bay Wetland 4	Canada	R1	PB	5.54
Irving Wetland	Canada	R1	BB	1.85
Ivy Lea Wetland Complex 1	Canada	R1	OB	11.38
Ivy Lea Wetland Complex 2	Canada	R1	DRM	19.96
Ivy Lea Wetland Complex 3	Canada	R1	OB	1.23
Ivy Lea Wetland Complex 4	Canada	R1	PB	20.29
Ivy Lea Wetland Complex 5	Canada	R1	OB	0.91
Johnson Bay 1	Canada	R1	DRM	70.60
Johnson Bay 2	Canada	R1	PB	1.30
Johnson Bay 3	Canada	R1	PB	34.38
Johnson Bay 4	Canada	R1	PB	41.90
Johnson Bay 5	Canada	R1	OB	148.35
Jones Creek Marsh	Canada	R1	DRM	175.28
Keewaydin Point	USA	R1	PB	1.09
Lake of the Isles north 1	USA	R1	OB	0.15
Lake of the Isles north 2	USA	R1	OB	29.89
Lake of the Isles south 1	USA	R1	OB	1.79
Lake of the Isles south 2	USA	R1	OB	1.65
Lake of the Isles south 3	USA	R1	PB	1.00
Landon Bay Marsh	Canada	R1	DRM	43.91
Legges Creek Marsh	Canada	R1	DRM	35.06
Lewis Bay Wetland	Canada	R1	PB	12.11
Little Hammond Point	USA	R1	PB	0.93
Little Thurso Bay east	USA	R1	PB	0.46
Little Thurso Bay west	USA	R1	PB	0.38
Lower Town Landing	USA	R1	PB	0.31
Lucas Point Wetland	Canada	R1	PB	4.32
MacGregor Bay Wetland 1	Canada	R1	PB	4.76
MacGregor Bay Wetland 2	Canada	R1	OB	40.17
MacGregor Bay Wetland 3	Canada	R1	BB	0.49
Madoma Marsh 1	Canada	R1	DRM	3.57
Madoma Marsh 2	Canada	R1	PB	60.18
Madoma Marsh 3	Canada	R1	DRM	0.49
Mason Point	USA	R1	OB	1.88
McDonnell Bay Wetland 1	Canada	R1	PB	4.99
McDonnell Bay Wetland 2	Canada	R1	PB	3.53
McDonnell Bay Wetland 3	Canada	R1	PB	1.55
McDonnell Bay Wetland 4	Canada	R1	PB	6.54
Mill Point Wetland	Canada	R1	PB	8.19
Millen Bay	USA	R1	DRM	1.25
Morgan Island	USA	R1	PB	0.18
Morristown Bay	USA	R1	PB	3.14
Murray Isle east 1	USA	R1	PB	0.56
Murray Isle east 2	USA	R1	PB	0.47
Murray Isle south	USA	R1	PB	0.15
North of Allens Point	USA	R1	OB	4.42
North of Buck Bay	USA	R1	BB	6.04

North of Schermerhorn Landing 1	USA	R1	PB	1.79
North of Schermerhorn Landing 2	USA	R1	PB	1.10
North of Sheephead Point	USA	R1	OB	1.81
Northeast of Murdoch Point	USA	R1	PB	0.83
Oak Island north 1	USA	R1	PB	5.55
Oak Island north 2	USA	R1	PB	2.34
Oak Island south 1	USA	R1	PB	2.42
Oak Island south 2	USA	R1	PB	1.15
Oak Island south 3	USA	R1	PB	0.74
Oak Island south 4	USA	R1	PB	1.13
Oak Island south 5	USA	R1	PB	1.45
Oak Point Wetland 1	Canada	R1	BB	5.97
Oak Point Wetland 2	Canada	R1	BB	1.49
Oak Point Wetland 3	Canada	R1	OB	12.89
Otter Creek	USA	R1	PB	5.73
Owatonna Island	USA	R1	PB	0.11
Picton Island	USA	R1	PB	0.48
Pitts Ferry Wetland	Canada	R1	OB	4.45
Plumtree Marsh	USA	R1	PB	8.16
Point Angiers	USA	R1	PB	0.15
Point Marguerite	USA	R1	PB	0.09
Point Vivian Bay	USA	R1	PB	18.02
Point Vivian east	USA	R1	PB	0.31
Rabbit Island	USA	R1	PB	1.33
Reeds Bay 1	Canada	R1	OB	6.71
Reeds Bay 2	Canada	R1	DRM	10.19
Rush Bay Wetland	Canada	R1	BB	4.56
Rusho Bay	USA	R1	PB	0.47
Sand Bay	USA	R1	BB	0.38
Sand Bay 1	Canada	R1	OB	13.29
Sand Bay 2	Canada	R1	DRM	19.95
Sand Bay 3	Canada	R1	OB	4.94
Sand Bay 4	Canada	R1	BB	4.35
Schermerhorn Landing	USA	R1	PB	0.35
Seburns Creek Wetland 1	Canada	R1	PB	2.54
Seburns Creek Wetland 2	Canada	R1	DRM	14.28
Seburns Creek Wetland 3	Canada	R1	DRM	1.70
Seburns Creek Wetland 4	Canada	R1	DRM	1.30
Seburns Creek Wetland 5	Canada	R1	OB	13.18
Simcoe Island Wetland	Canada	R1	PB	3.44
South Bay	USA	R1	OB	6.66
South of Crows Nest	USA	R1	PB	0.56
South of Point Angiers	USA	R1	PB	1.17
South of Poplar Tree Bay	USA	R1	DRM	0.13
South of Sheephead Point	USA	R1	OB	5.24
Spicer Bay	USA	R1	PB	15.31
St. Margarettes Island	USA	R1	PB	0.16
Stave Island Marsh 1	Canada	R1	PB	4.18
Stave Island Marsh 2	Canada	R1	PB	10.76
Sturgeon Point	USA	R1	PB	0.20
Swan Bay east	USA	R1	PB	2.06

Swan Bay west	USA	R1	PB	8.09
The Narrows	USA	R1	PB	0.06
Thompsons Bay Wetland	Canada	R1	PB	1.11
Thousand Island Country Club	USA	R1	PB	1.53
Thousand Islands Resort	USA	R1	PB	0.03
Turkey Peak	USA	R1	PB	0.14
Waterloo	USA	R1	PB	1.49
Webster Point	USA	R1	PB	0.64
Wellesley Island landing strip	USA	R1	PB	22.85
West of Grossman Point	USA	R1	OB	0.07
West of McRay Point	USA	R1	BB	0.16
West of Moore Landing	USA	R1	PB	0.45
West of Swiftwater Point	USA	R1	PB	0.37
Westminster Park 1	USA	R1	OB	0.43
Westminster Park 2	USA	R1	OB	6.98
Whitehouse Marsh	USA	R1	OB	3.95
Willowbank Marsh 1	Canada	R1	DRM	11.34
Willowbank Marsh 2	Canada	R1	OB	29.76
Willowbank Marsh 3	Canada	R1	DRM	16.36
Wolfe Island Cut Wetland	Canada	R1	PB	2.01
Wolfe Island Wetland	Canada	R1	PB	5.17
Bradleys Creek Marsh	Canada	R2	DRM	3.93
Doran Creek Marsh 1	Canada	R2	PB	10.34
Doran Creek Marsh 2	Canada	R2	DRM	22.91
Doran Creek Marsh 3	Canada	R2	OB	4.01
Doran Creek Marsh 4	Canada	R2	PB	12.22
East of Chimney Point	USA	R2	DRM	3.38
East of Iroquois Dam	USA	R2	PB	0.24
East of Keystone Road 1	USA	R2	OB	0.10
East of Keystone Road 2	USA	R2	DRM	0.50
East of Sparrowhawk Point 1	USA	R2	DRM	1.03
East of Sparrowhawk Point 2	USA	R2	PB	0.04
East of Sparrowhawk Point 3	USA	R2	DRM	1.09
Grant's Creek 1	Canada	R2	PB	6.08
Grant's Creek 2	Canada	R2	OB	2.89
Grant's Creek 3	Canada	R2	DRM	8.58
Iroquois Dam 1	USA	R2	PB	0.23
Iroquois Dam 2	USA	R2	PB	2.93
Johnstown Marsh Complex 1	Canada	R2	DRM	3.99
Johnstown Marsh Complex 2	Canada	R2	OB	58.22
Johnstown Marsh Complex 3	Canada	R2	PB	80.78
Johnstown Marsh Complex 4	Canada	R2	OB	10.30
Keystone Road	USA	R2	DRM	0.38
Lisbon Beach	USA	R2	PB	0.43
Little Sucker Brook 1	USA	R2	PB	16.57
Little Sucker Brook 2	USA	R2	OB	0.46
McLachlan Creek Complex 1	Canada	R2	OB	24.25
McLachlan Creek Complex 2	Canada	R2	DRM	5.07
McLachlan Creek Complex 3	Canada	R2	DRM	2.43
Molly's Gut Complex 1	Canada	R2	PB	2.11
Molly's Gut Complex 2	Canada	R2	PB	6.52

North of Lisbon Beach	USA	R2	PB	4.59
Ogden Island central	USA	R2	PB	1.12
Ogden Island east 1	USA	R2	PB	0.05
Ogden Island east 2	USA	R2	PB	0.08
Ogden Island east 3	USA	R2	PB	0.06
Ogden Island east 4	USA	R2	PB	0.06
Ogden Island east 5	USA	R2	PB	0.17
Ogden Island west	USA	R2	PB	0.38
Ogdensburg	USA	R2	OB	1.93
South of Lisbon Beach	USA	R2	DRM	1.62
Sparrowhawk Point	USA	R2	OB	0.97
Stream at Keystone Road	USA	R2	DRM	0.82
Sucker Brook	USA	R2	PB	3.27
Taggart Road	USA	R2	PB	3.78
West of Leishman Point	USA	R2	DRM	0.48
Whitehouse Bay	USA	R2	PB	3.53
Brandy Brook 1	USA	R3	BB	0.55
Brandy Brook 2	USA	R3	PB	6.77
Brandy Brook 3	USA	R3	BB	7.88
Coles Creek 1	USA	R3	BB	0.22
Coles Creek 2	USA	R3	PB	86.76
Coles Creek 3	USA	R3	BB	0.56
Coles Creek Camping Area	USA	R3	PB	8.35
Croil Islands 1	USA	R3	BB	4.89
Croil Islands 2	USA	R3	PB	10.23
Croil Islands 3	USA	R3	BB	2.14
Croil Islands 4	USA	R3	OB	0.94
Croil Islands 5	USA	R3	OB	0.23
Croil Islands 6	USA	R3	BB	4.09
East of Brandy Brook	USA	R3	BB	1.05
East of Massena Power Canal	USA	R3	BB	0.60
East of Wilson Hill Island	USA	R3	PB	0.28
Eisenhower Lock	USA	R3	OB	3.64
Hoople Bay Marsh 1	Canada	R3	PB	32.68
Hoople Bay Marsh 2	Canada	R3	PB	42.89
Island west of Coles Creek 1	USA	R3	PB	1.06
Island west of Coles Creek 2	USA	R3	BB	0.41
Long Sault Islands 1	USA	R3	PB	1.63
Long Sault Islands 2	USA	R3	PB	2.51
Long Sault Islands 3	USA	R3	PB	1.10
Long Sault Islands 4	USA	R3	PB	0.60
Long Sault Islands 5	USA	R3	PB	0.47
Long Sault Islands 6	USA	R3	OB	1.14
Long Sault Islands 7	USA	R3	PB	0.14
Long Sault Islands 8	USA	R3	PB	0.06
Riverside Marsh 1	Canada	R3	OB	4.14
Riverside Marsh 2	Canada	R3	PB	54.82
Riverside Marsh 3	Canada	R3	OB	83.63
Riverside Marsh 4	Canada	R3	PB	0.18
Riverside Marsh 5	Canada	R3	PB	1.46
Tucker Terrace	USA	R3	PB	0.11

Upper Canada Migratory Bird Sanctuary (UCMBS) 1	Canada	R3	PB	153.46
Upper Canada Migratory Bird Sanctuary (UCMBS) 2	Canada	R3	DRM	56.66
Upper Canada Migratory Bird Sanctuary (UCMBS) 3	Canada	R3	DRM	12.60
Upper Canada Migratory Bird Sanctuary (UCMBS) 4	Canada	R3	OB	125.07
Upper Canada Migratory Bird Sanctuary (UCMBS) 5	Canada	R3	PB	156.78
West of Brandy Brook 1	USA	R3	BB	1.08
West of Brandy Brook 2	USA	R3	BB	0.33
West of Brandy Brook 3	USA	R3	BB	3.02
West of Coles Creek 1	USA	R3	BB	10.32
West of Coles Creek 2	USA	R3	BB	1.61
West of Long Sault Dam	USA	R3	OB	0.20
Whalen Road	USA	R3	OB	0.74
Whalen Road islands	USA	R3	PB	13.15
Wilson Hill	USA	R3	PB	186.61

Appendix C. Excerpt of full computer output file example for model testing of regulation plan 0924 using the drowned river mouth model. Data demonstrate the years and elevations selected by the mathematical portion of the model as "last dewatered" or "last flooded;" number of years since last dewatering or last flooding; resultant assignment to vegetation types U, ABC, D, EF, or G; and area and percent of wetland for each assignment. The summary of calculations for the 101-year planning period is posted at the end of the file.

Year		Elevation	Years	Class	AREA	Percentage	
Total WetLand Area		803586.7					
Calculation For Year 2000							
Dewater							
	1964	74.59	Forever	G	288734.7	35.9	
	1965	74.7	36	EF	14415.65	1.8	
	1999	74.71	35	EF	1310.51		0.2
Flood							
	1993	75.69	Forever	U	26750.63	3.3	
	1998	75.34	7	ABC	171904	21.4	
	1999	74.71	2	D	300569.3	37.4	
CLASS		1	2	3	4	5	Total
Area		26750.63	171904	300569.3	15726.16	288636.7	803586.7
(%)		3.33	21.39	37.4	1.96	35.92	100
Calculation For Year 1999							
Dewater							
	1964	74.59	Forever	G	288734.7	35.9	
	1965	74.7	35	EF	14415.65	1.8	
	1966	74.72	34	EF	2621.03		0.3
	1975	74.78	33	EF	16296.17	2	
	1995	74.89	24	EF	45336.97	5.6	
	1996	75.19	4	EF	154201.1	19.2	
	1997	75.33	3	D	77974.94	9.7	
	1998	75.39	2	D	32697.61	4.1	
Flood							
	1993	75.69	Forever	U	26750.63	3.3	
	1998	75.39	6	ABC	144655.9	18	
CLASS		1	2	3	4	5	Total
Area		26750.63	144655.9	110672.6	232870.9	288636.7	803586.7
(%)		3.33	18	13.77	28.98	35.92	100
Calculation For Year 1998							
Dewater							
	1964	74.59	Forever	G	288734.7	35.9	
	1965	74.7	34	EF	14415.65	1.8	
	1966	74.72	33	EF	2621.03		0.3
	1975	74.78	32	EF	16296.17	2	
	1995	74.89	23	EF	45336.97	5.6	
	1996	75.19	3	D	154201.1	19.2	
	1997	75.33	2	D	77974.94	9.7	
Flood							
	1993	75.69	Forever	U	26750.63	3.3	
	1997	75.33	5	ABC	177353.6	22.1	
CLASS		1	2	3	4	5	Total
Area		26750.63	177353.6	232176	78669.81	288636.7	803586.7
(%)		3.33	22.07	28.89	9.79	35.92	100
Calculation For Year 1997							
Dewater							
	1964	74.59	Forever	G	288734.7	35.9	
	1965	74.7	33	EF	14415.65	1.8	
	1966	74.72	32	EF	2621.03		0.3
	1975	74.78	31	EF	16296.17	2	
	1995	74.89	22	EF	45336.97	5.6	
	1996	75.19	2	D	154201.1	19.2	
Flood							
	1993	75.69	Forever	U	26750.63	3.3	
	1996	75.19	4	D	255328.5	31.8	
CLASS		1	3	4	5	Total	
Area		26750.63	409529.6	78669.81	288636.7	803586.7	
(%)		3.33	50.96	9.79	35.92	100	

Calculation For Year 1902							
Dewater							
	1863	74.59	Forever	G	288734.7	35.9	
	1864	74.7	39	EF	14415.65	1.8	
	1898	74.71	38	EF	1310.51		0.2
	1899	74.8	4	EF	25849.77	3.2	
	1900	75.04	3	D	105349.6	13.1	
	1901	75.1	2	D	34378.14	4.3	
Flood							
	1892	75.69	Forever	U	26750.63	3.3	
	1897	75.34	10	ABC	171904	21.4	
	1901	75.1	5	ABC	134991.8	16.8	
CLASS		1	2	3	4	5	Total
Area		26750.63	306895.7	139727.8	41575.93	288636.7	803586.7
(%)		3.33	38.19	17.39	5.17	35.92	100
Calculation For Year 1901							
Dewater							
	1863	74.59	Forever	G	288734.7	35.9	
	1864	74.7	38	EF	14415.65	1.8	
	1898	74.71	37	EF	1310.51		0.2
	1899	74.8	3	D	25849.77	3.2	
	1900	75.04	2	D	105349.6	13.1	
Flood							
	1892	75.69	Forever	U	26750.63	3.3	
	1897	75.34	9	ABC	171904	21.4	
	1900	75.04	4	D	169369.9	21.1	
CLASS		1	2	3	4	5	Total
Area		26750.63	171904	300569.3	15726.16	288636.7	803586.7
(%)		3.33	21.39	37.4	1.96	35.92	100
Calculation For Year 1900							
Dewater							
	1863	74.59	Forever	G	288734.7	35.9	
	1864	74.7	37	EF	14415.65	1.8	
	1898	74.71	36	EF	1310.51		0.2
	1899	74.8	2	D	25849.77	3.2	
Flood							
	1892	75.69	Forever	U	26750.63	3.3	
	1897	75.34	8	ABC	171904	21.4	
	1899	74.8	3	D	274719.5	34.2	
CLASS		1	2	3	4	5	Total
Area		26750.63	171904	300569.3	15726.16	288636.7	803586.7
(%)		3.33	21.39	37.4	1.96	35.92	100

Calculation Result for 101 Planning Year

CLASS	1 (U)	2 (ABC)	3 (D)	4 (EF)	5 (G)	Total
Sum	11466327	13712623	16724840	9203215	30055246	81162253
Ave	113528	135768.6	165592.5	91120.94	297576.7	803586.7
(%)	14.13	16.9	20.61	11.34	37.03	100

Appendix D. Example of yearly summary computer output file for model testing of regulation plan 0924 using the drowned river mouth model. Data are presented as percent of modeled drowned river mouth wetland predicted for vegetation types U, ABC, D, EF, and G in each year.

Year	U	ABC	D	EF	G
2000	3.33	21.39	37.4	1.96	35.92
1999	3.33	18	13.77	28.98	35.92
1998	3.33	22.07	28.89	9.79	35.92
1997	3.33	0	50.96	9.79	35.92
1996	3.33	0	50.96	9.79	35.92
1995	3.33	0	36.76	23.99	35.92
1994	3.33	0	34.63	26.13	35.92
1993	12.76	14.67	10.52	26.13	35.92
1992	12.76	11.96	11.81	27.55	35.92
1991	12.76	9.25	30.23	11.84	35.92
1990	12.76	2.47	37.01	11.84	35.92
1989	12.76	2.47	37.01	11.84	35.92
1988	12.76	2.47	15.6	33.26	35.92
1987	12.76	0.55	17.51	33.26	35.92
1986	12.76	5.18	27.15	19	35.92
1985	12.76	4.5	36.52	10.3	35.92
1984	12.76	32.32	8.69	10.3	35.92
1983	12.76	36.91	4.1	10.3	35.92
1982	12.76	18.06	22.95	10.3	35.92
1981	12.76	18.06	22.95	10.3	35.92
1980	12.76	4.5	34.98	11.84	35.92
1979	12.76	4.5	34.98	11.84	35.92
1978	12.76	4.5	42.67	4.15	35.92
1977	17.94	-5.18	47.17	4.15	35.92
1976	17.94	-5.18	47.17	4.15	35.92
1975	17.94	-5.18	16.71	34.61	35.92
1974	17.94	-5.73	35.73	16.14	35.92
1973	17.94	9.49	21.73	14.92	35.92
1972	17.94	22.87	8.36	14.92	35.92
1971	17.94	22.87	8.36	14.92	35.92
1970	17.94	21.44	10.29	14.41	35.92
1969	17.94	27.86	16.16	2.12	35.92
1968	17.94	31.74	12.61	1.79	35.92
1967	17.94	44.02	2.12	0	35.92
1966	17.94	44.35	1.79	0	35.92
1965	17.94	30.71	15.43	0	35.92
1964	17.94	16.45	27.9	0	37.71
1963	17.94	16.45	27.9	0	37.71
1962	17.94	16.45	13.55	14.35	37.71
1961	17.94	15.02	9.98	19.34	37.71
1960	17.94	25.01	0	19.34	37.71
1959	17.94	21.44	2.14	20.77	37.71
1958	17.94	18.59	4.99	20.77	37.71
1957	17.94	18.59	2.85	22.91	37.71
1956	17.94	9.49	15.51	19.34	37.71
1955	17.94	9.49	15.51	19.34	37.71
1954	17.94	9.49	15.51	19.34	37.71
1953	17.94	7.46	16.12	20.77	37.71
1952	17.94	9.49	27.37	7.48	37.71
1951	17.94	0	36.87	7.48	37.71

1950	17.94	0	36.87	7.48	37.71
1949	17.94	0	36.35	8	37.71
1948	8.32	0	45.97	8	37.71
1947	19.3	0	35	8	37.71
1946	19.3	0	25.08	17.92	37.71
1945	19.3	0	25.08	17.92	37.71
1944	17.26	0	39.08	5.94	37.71
1943	24.72	13.23	18.39	5.94	37.71
1942	24.72	31.62	0	5.94	37.71
1941	24.72	31.62	0	5.94	37.71
1940	24.72	31.62	1.03	4.92	37.71
1939	24.72	31.62	3.59	2.35	37.71
1938	24.72	32.65	4.92	0	37.71
1937	24.72	12.52	25.05	0	37.71
1936	24.72	12.52	25.05	0	37.71
1935	24.72	12.52	25.05	0	37.71
1934	24.72	11.81	9.98	15.78	37.71
1933	24.72	2.03	19.76	15.78	37.71
1932	24.72	2.03	19.76	15.78	37.71
1931	24.72	2.03	11.91	23.62	37.71
1930	24.72	-0.68	21.75	16.49	37.71
1929	24.72	13.95	13.06	10.56	37.71
1928	24.72	17.51	19.4	0.65	37.71
1927	24.72	17.51	19.4	0.65	37.71
1926	24.72	15.37	21.54	0.65	37.71
1925	24.72	15.37	4.28	17.92	37.71
1924	24.72	15.37	13.17	9.02	37.71
1923	24.72	10.38	18.16	9.02	37.71
1922	3.33	34.63	15.31	9.02	37.71
1921	3.33	34.63	13.26	11.07	37.71
1920	3.33	21.39	26.49	11.07	37.71
1919	3.33	21.39	26.49	11.07	37.71
1918	3.33	21.39	29.06	8.51	37.71
1917	3.33	19.36	31.09	8.51	37.71
1916	3.33	50.45	2.56	5.94	37.71
1915	3.33	50.45	2.56	5.94	37.71
1914	3.33	53.01	5.94	0	37.71
1913	3.33	38.9	20.05	0	37.71
1912	3.33	30.35	28.61	0	37.71
1911	3.33	30.35	28.61	0	37.71
1910	3.33	30.35	13.55	14.9	37.88
1909	3.33	28.21	15.69	14.9	37.88
1908	3.33	26.82	17.08	14.9	37.88
1907	3.33	26.82	15.65	16.33	37.88
1906	3.33	26.82	13.51	18.47	37.88
1905	3.33	25.46	14.87	18.47	37.88
1904	3.33	31.06	9.27	18.47	37.88
1903	3.33	29.63	12.83	16.49	37.71
1902	3.33	38.19	17.39	5.17	35.92
1901	3.33	21.39	37.4	1.96	35.92
1900	3.33	21.39	37.4	1.96	35.92