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2016 Progress Report of the Parties

U.S. spelling is used throughout this report except when referring to Canadian titles. Units are provided in both metric and U.S. customary units.

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EXECUTIVE SUMMARY

The Great Lakes are an invaluable resource. Not only do they hold roughly 20% of the world's fresh water supply, but they also constitute an ecological, aesthetic, economic, and recreational treasure upon which tens of millions of people (and countless other species) rely. The governments of Canada and the United States – and their provincial, state, tribal, first nation, Metis, municipal, business, environmental, academic and other partners – have long recognized this, and formally signified this recognition in 1972 by co-signing the Great Lakes Water Quality Agreement ("Agreement" or "GLWQA").

The 2012 version of the Agreement included a new requirement that the United States and Canada prepare a Progress Report of the Parties (Report) "to document actions relating to this Agreement." This reporting requirement strengthened the accountability provisions of the Agreement, with the Report to be provided to the public and the International Joint Commission. Consistent with that requirement, the Parties are pleased to release this first Progress Report of the Parties, documenting the actions taken since the 2012 Agreement took effect in February of 2013.

"Operationalizing" the Agreement

Significant effort was required to develop and put into place the organizational structure and processes required to implement the Agreement. The Great Lakes Executive Committee – the binational committee tasked with supporting the implementation of the Agreement – was called to order, Annex Subcommittees and their task teams were staffed and organized, activities were prioritized, policies debated, and responsibilities assigned. Further, given the cooperative approach that underpins the Agreement, these structural activities were not limited to the Parties; they required the very active participation of the Parties' many partners, including states and provinces and Indigenous peoples on both sides of the border. Ultimately, as of the writing of this Report, the Parties can state that much of the necessary administrative and organizational work is finished. Consequently, in the upcoming triennial cycle of 2017-2019, the Parties will be able to concentrate even more heavily on the implementation of substantive restoration and protection activities.

Key Actions Completed Under the Agreement

Notwithstanding the efforts needed to operationalize the 2012 Agreement, during the past three years the Parties, together with the many partners who also play important roles in restoring and protecting the Great Lakes, were able to undertake and complete a host of actions in furtherance of the Agreement's purpose: *restoring and maintaining the chemical, physical, and biological integrity of the waters of the Great Lakes*. It is impossible to describe in detail the full range of actions implemented across the various jurisdictions which share responsibility for the Great Lakes; however, this report provides an overview of activities undertaken since the Agreement took effect. Some accomplishments are especially noteworthy by the Parties with exceptional help from their state, provincial, tribal, first nation, metis, municipal, environmental business, academic and other partners:

- Established the Great Lakes Executive Committee, comprised of members and observers representing some of the region's most forward-thinking leaders, to ensure that Agreement implementation is coordinated and effective.

- Effectively implemented a new system, under Agreement Article 6(c), for providing notification to the Great Lakes Executive Committee members and observers, as well as other interested parties, of planned activities that could lead to a pollution incident or that could have a significant cumulative impact on the waters of the Great Lakes.

- The United States "delisted" the Presque Isle (Pennsylvania), Deer Lake (Michigan) and White Lake (Michigan) Areas of Concern, signifying that remedial actions were completed and elimination of environmental impairments was confirmed. In addition, all necessary remedial actions were completed at other AOCs in the United States: Sheboygan Harbor (Wisconsin), Waukegan Harbor (Wisconsin), Ashtabula River (Ohio), St. Clair River (Michigan), and River Raison (Michigan, expected completion this month).

- Canada completed all required actions to restore the Nipigon Area of Concern and began remediation of the Randle Reef contaminated sediment site in the Hamilton Harbour Area of Concern, the largest sediment remediation project ever undertaken in Canada.

- Developed a "Nearshore Framework", which provides a mechanism for undertaking a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses.

- Developed a Lakewide Action and Management Plan for Lake Superior.

- Designated eight chemicals as the first *Chemicals of Mutual Concern* under the Agreement.

- Set phosphorus load reduction targets for the western and central basin of Lake Erie after extensive analysis of phosphorous sources and loads and have begun to develop Domestic Action Plans to achieve the 40% reduction.

- Significantly reduced the risk of the introduction of aquatic invasive species to the Great Lakes via ballast water discharges from saltwater vessels. As a consequence of compatible ballast water exchange regulations between Canada and the United States and stringent binational enforcement, no new invasive species attributable to the ballast water of these ships have been reported in the Great Lakes since 2006. In addition, the Parties continue to prevent and address other discharges from vessels that potentially may impact the waters of the Great Lakes.

- Undertook a host of invasive species control and prevention measures (including the development and implementation of an AIS early detection and rapid response initiative) and no new non-native species are known to have become established in the Great Lakes during the last three years.

- Oversaw the development and implementation of lakewide habitat and species protection and restoration conservation strategies (i.e., Biodiversity Conservation Strategies) for all five of the Great Lakes.

- Led the development of a report entitled *Groundwater Science Relevant to the Great Lakes Water Quality Agreement: A Status Report*, which summarizes the relevant and available Great Lakes groundwater science and advances understanding of the effects of groundwater on Great Lakes water quality.

- Led the development of a report entitled *State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic and Ecological Effects* which synthesizes the state of climate change impacts in the Great Lakes basin and identifies key knowledge gaps.

- Updated and revised the suite of ecosystem indicators used to evaluate and report on the state of the Great Lakes to better align the indicators with the General Objectives of the 2012 GLWQA.

These highlighted actions, while significant, represent only the first tangible steps in restoring and protecting the waters of the Great Lakes under the 2012 Agreement. More importantly, they reflect the vigor with which the Parties intend to implement the Agreement over the next three years.

INTRODUCTION

The Great Lakes contain a significant portion of the world's freshwater, containing one fifth of global fresh surface water. The Great Lakes are immensely important to both Canada and the United States, environmentally, economically, and socially.

The Canada-United States Great Lakes Water Quality Agreement ("GLWQA" or "Agreement") was first signed in 1972. Over the course of its more than forty-year history (shown in Figure 1), the Agreement has served as an important mechanism for coordination of actions by Canada and the United States, working in cooperation with other levels of government, non-governmental organizations, industry, Indigenous peoples, and the public to address threats to Great Lakes water quality and ecosystem health.

Over the last 45 years, Canada and the United States have taken action to address many threats to Great Lakes water quality and ecosystem health. In many locations, water quality has greatly improved. Most notably, releases of many persistent toxic substances (for example, mercury, PCBs, dioxins and furans, as well as banned pesticides such as DDT) in the Great Lakes have been reduced by more than 90 percent. As a result, the frequency of deformities in colonial nesting birds, commonly seen in the 1970s, has now been significantly reduced. Sentinel species such as the Bald Eagle, once extirpated from the Great Lakes, now thrive along Great Lakes shorelines. The rapid recovery of a "dead" Lake Erie is another globally-known success story. In the decades leading up to the 1970s, loadings of nutrients, particularly phosphorus, caused significant algal blooms and degraded Lake Erie. Stirred by public concern, governments responded with vigor to reduce loadings from municipal sewage treatment plants and other anthropogenic sources, resulting in measurable reductions in phosphorus inputs and a steep reduction in algal blooms. These controls of phosphorus inputs to the lakes represented an unprecedented success in producing environmental results through international cooperation.

Despite these past successes, the lakes continue to face threats posed by nutrient discharges, releases of toxic substances, invasive species, loss of wetland and other habitat, climate change and other factors. Continued action is required to address these existing threats, as well as to anticipate and prevent new threats to water quality and ecosystem health.

In 2012, the Parties amended and strengthened the GLWQA. The 2012 Agreement updates approaches to science and management and reaffirms existing commitments to: restore degraded Areas of Concern; address the threats posed by excess nutrients, chemicals of mutual concern, and discharges from vessels; and undertake vital scientific coordination and research. In addition, the new Agreement includes new commitments to address other significant challenges to Great Lakes water quality, including threats from aquatic invasive species and climate change, as well as the loss of habitat and species.

One of the new commitments made by Governments in the Agreement is to enhance accountability and reporting by, for the first time, requiring the production of a Progress Report of the Parties. In accordance with the GLWQA, Canada and the U.S. have prepared this Progress Report of the Parties in consultation with representatives of state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and other local public agencies. The Progress Report of the Parties contains an overview of binational and domestic activities

that have contributed to the achievement of GLWQA objectives.

This document represents the first Progress Report of the Parties prepared under the 2012 Great Lakes Water Quality Agreement. Subsequent Progress Report of the Parties will be issued every three years.

Binational activities are coordinated through the Great Lakes Executive Committee. Following signing of the GLWQA in September of 2012, a significant amount of effort was devoted to the establishment of management processes and structures necessary to drive the Agreement's implementation. Annex Subcommittees and Task Teams have been created to engage a large and diverse group of organizations, institutions and experts in carrying out the necessary activities to support undertaking the commitments laid out in the Agreement.

Within Canada, the principal mechanism for coordination of Great Lakes activities is the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, 2014 (COA), which entered into force in December, 2014. A series of Canada-Ontario Agreements date back over forty years and have provided a framework for cooperation and coordination of actions between Ontario and Canada to restore, protect and conserve Great Lakes water quality and ecosystem health.

Within the United States the principal mechanism for coordination and implementation of Great Lakes activities is the Great Lakes Restoration Initiative (GLRI). In 2009, the Administration proposed and Congress appropriated $475,000,000 for Great Lakes restoration and protection work and the formation of an Interagency Task Force and Regional Working Group chaired by the United States Environmental Protection Agency. The Interagency Task Force and its Regional Working Group consist of nearly federal departments or agencies, which work closely together to: 1) recommend to the Task ForceGreat Lakes restoration and protection priorities; 2) make project funding decisions; and 3) keep track of and report on project results.

For those wishing additional information on Great Lakes activities, including how to get involved in helping to restore and protect the Great Lakes, additional information is available at the following websites: www.ec.gc.ca/greatlakes; www.epa.gov/greatlakes; and www.binational.net.

This Report follows the structure of the 2012 Agreement. Part one addresses progress of the Parties in relation to the thirteen Articles of the Agreement, which set forth the overall goals and "mechanics" of the Agreement. Part two addresses progress of the Parties in relation to each of the ten Annexes of the Agreement, each of which addresses a particular threat (e.g., invasive species, climate change) or provides specific direction on the implementation of the Agreement (e.g., Lakewide Action and Management Plans, Science).

Figure 1 – The history of the Great Lakes Water Quality Agreement.

November 22, 1978
While reaffirming and building upon the 1972 GLWQA, the 1978 GLWQA introduced the ecosystem approach to the management of Great Lakes water quality. It also called for the virtual elimination of persistent toxic substances in the Great Lakes ecosystem by adopting a philosophy of "zero discharge" of inputs and established a list of toxic chemicals for priority action.

November 18, 1987
The 1987 GLWQA called for: 1) the adoption of ecosystem objectives for the lakes; 2) the development and implementation of Remedial Action Plans to restore significantly degraded areas around the Great Lakes identified as Areas of Concern; and 3) Lakewide Management Plans to address whole lake contamination by persistent toxic substances. The 1987 GLWQA was further broadened through new annexes addressing: non-point contaminant sources; contaminated sediment; airborne toxic substances; contaminated groundwater; and associated research and development.

April 15, 1972
Prime Minister Pierre Trudeau and President Richard Nixon sign the first Canada-United States Great Lakes Water Quality Agreement (GLWQA).

The 1972 GLWQA committed Canada and the United States to restore and enhance water quality in the Great Lakes ecosystem and established basin-wide water quality objectives and binational commitment on the design, implementation and monitoring of water quality programs.

The focus of the 1972 GLWQA was on phosphorus loadings and visible pollution.

October 16, 1983
A Phosphorus Load Reduction Supplement was added to Annex 3 of the 1978 GLWQA, outlining measures to reduce phosphorus loading throughout the basin. As a result, detailed plans to reduce phosphorus loading to receiving waters were developed and adopted by each jurisdiction in the basin.

September 7, 2012
Canadian Minister of the Environment Peter Kent and United States Environmental Protection Agency Administrator Lisa Jackson sign the 2012 GLWQA.

The 2012 GLWQA comprehensively addresses today's Great Lakes water quality issues: 1) modernizing provisions related to excessive algae growth, chemicals, pollution from ships, and scientific research; 2) incorporating new commitments to address significant challenges such as the degradation of the nearshore, the threat from aquatic invasive species and climate change, and the loss of habitat and species; and 3) strengthening provisions for governance, accountability, and engagement of government and non-government entities and the public.

2012 GREAT LAKES WATER QUALITY AGREEMENT ARTICLES

The GLWQA contains 13 Articles. Article 2 identifies the purpose of the Agreement, as well as principles and approaches to be used in the Agreement's implementation. Articles 3, 5, and 6 contain specific commitments to be delivered by the Parties.

Article 2: Purpose, Principles and Approaches.

- The overall Purpose of the Agreement has remained virtually unchanged since 1972, a testament to the timeless statement by both countries and their partners to "restore and maintain the chemical, physical, and biological integrity of the Waters of the Great Lakes."

- Conversely, many of Article 2's "Principles and Approaches" are new with the 2012 Agreement. Others represent a characterization of what had before been implicit policy ideals. Like the Purpose, however, they help drive the planning and implementation of the remaining Articles and Annexes. For example, Article 2(4)(j) commits the Parties to anticipate and prevent "pollution and other threats" to achieving the Agreement's Purpose. This places an onus on the Parties to "think ahead" and "act ahead," such as with efforts to keep invasive species like Asian carp, from entering the Lakes in the first place. Other specific examples of how the Parties are achieving Article 2's mandates are provided throughout this Report.

- "Public engagement" is one of these new principles in the 2012 GLWQA. The Parties have committed to incorporating public opinion and advice, as appropriate and providing information and opportunities for the public to participate in activities that contribute to the achievement of the objectives of the 2012 Agreement. Efforts to significantly enhance transparency and accountability have been central to planning and implementation of the 2012 GLWQA and include a revitalized website (binational.net) to document the implementation of the Agreement, issue-specific webinars and other participatory opportunities, and open meetings of the Great Lakes Executive Committee. A list of binational engagement opportunities, past and present, is maintained at binational.net (https://binational.net/engagement-participation/). Specific examples of the Parties' engagement, outreach and education efforts are highlighted throughout this Report.

Article 3: Progress in achieving General Objectives, Lake Ecosystem Objectives and Substance Objectives.

- The 2012 GLWQA commits the United States and Canada to maintaining a set of comprehensive, science-based ecosystem indicators in order to assess and report to the public on the state of the Great Lakes. Binational reporting on the state of the Great Lakes has been ongoing since 1994. Over the past three years the Parties have updated and revised the suite of ecosystem indicators used to report on the state of the Great Lakes to align the indicators to the General Objectives of the 2012 GLWQA. This significant change to the way in which the Parties assess and report on the state of the Great Lakes allows the suite of ecosystem indicators to be used to assess whether progress is being made in relation to accomplishing the objectives set out by the Governments of the United States and Canada in the 2012 GLWQA. Information on the state of the Great Lakes will be presented at the Great Lakes Public Forum in October, 2016 for public review and comment. A

final *State of the Great Lakes* report will be available in 2017.

- The 2012 GLWQA also calls for the development of lake-specific ecosystem objectives, to serve as benchmarks against which to assess status and trends in ecosystem health. Work has begun on development of Lake Ecosystem Objectives for Lake Erie. Finalization of these objectives will include extensive consultation and engagement. Work to develop Lake Ecosystem Objectives for lakes Huron, Ontario, Michigan and Superior will follow.

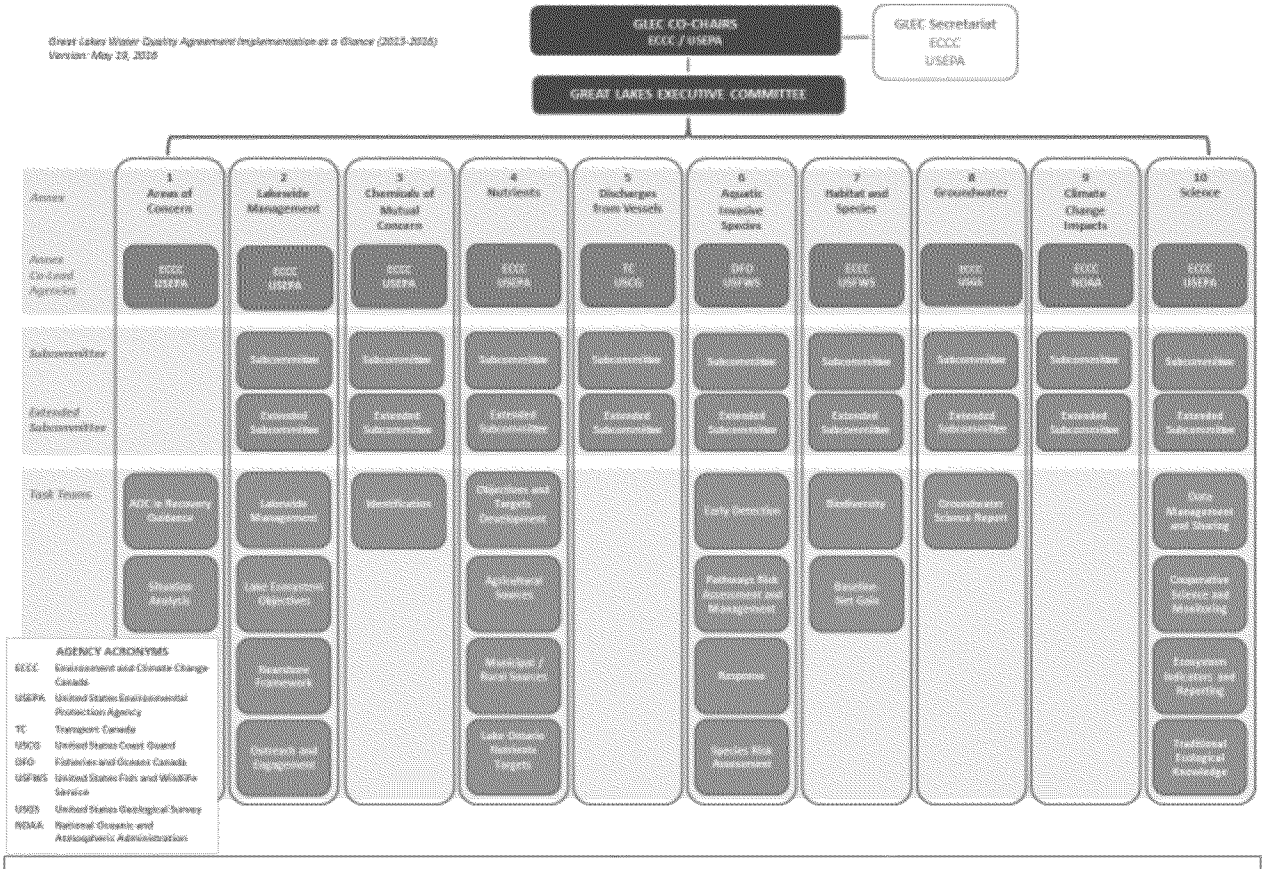
Article 5(2)(a) & (b): Establishing the Great Lakes Executive Committee.

- A Great Lakes Executive Committee (GLEC) was established to replace the former Binational Executive Committee. The GLEC has a significantly expanded membership and now includes senior-level representatives from the Governments of the United States and Canada, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and other local public agencies. The inaugural meeting of the GLEC was held on December 5-6, 2012 in Toronto, Ontario. The GLEC has met biannually since then, alternating meeting locations between Chicago, Illinois, and Toronto, Ontario. Summaries of the past GLEC meetings are available at binational.net (http://binational.net/category/mtg-ru/).

- The GLEC provides a forum for members to share information and discuss issues relevant to the implementation of the Agreement. The meetings have been instrumental in coordinating the activities of departments, agencies, organizations and peoples represented in the GLEC membership. Meetings are open to the public and regularly attract attendance from observers – such as the International Joint Commission, the Great Lakes Commission, the Great Lakes Fishery Commission, the Province of Quebec, environmental non-governmental organizations, industry representatives and members of the interested public – which have provided significant contributions and advice to the GLEC.

- The GLEC has created a formal subcommittee structure to engage member organizations and others in working binationally to plan and coordinate actions to implement the ten Annexes contained in the 2012 GLWQA. Annex-specific subcommittees are co-led by a United States and Canadian representative. Extended subcommittees have been created to advise and provide input to the Annex Co-Leads and to the Annex Subcommittee. Task Teams, reporting to the Subcommittee have been formed to perform specific tasks required to meet the Annex's commitments. The Annex Subcommittee structure, through its engagement of a large number of organizations and individuals, has allowed a significant amount of work to be accomplished over the first three years of the implementation of the 2012 GLWQA. This work will be discussed in subsequent chapters of this report. Figure 2 depicts the Annex Subcommittees, Extended Subcommittees, and the Task Teams that existed for each Annex between 2013 and 2016.

Figure 2 – Great Lakes Water Quality Agreement Implementation at a Glance (2013-2016).



Subcommittees, consisting of representatives from GLEC member agencies and organizations, assist the Annex Co-Leads in coordinating and undertaking activities in support of meeting commitments of the Annexes.

Extended Subcommittees, consisting of representatives from GLEC member agencies and organizations and other entities, advise and provide input to the Annex Co-Leads and Subcommittees.

Task Teams, consisting of representatives from GLEC member agencies and organizations and others entities, are established to perform specific tasks over a specified period of time, as required to meet Annex commitments.

Article 5(2)(c): Creating Binational Priorities for Science and Action.

- The process of developing binational priorities builds consensus on the essential science and action required to restore and protect Great Lakes water quality and ecosystem health. In addition, communicating clear priorities enables GLEC members to engage others in working cooperatively to achieve the science and action priorities. The United States and Canada presented proposed binational priorities for science and action for public input at the 2013 Great Lakes Public Forum on September 9-10, 2013. The 2014-2016 binational priorities for science and action were subsequently finalized and posted on binational.net (www.binational.net/2014/03/20/psa-pasa-2014) in March, 2014.

- The Parties' proposed binational priorities for science and action for 2017-2019 will be presented at

the 2016 Great Lakes Public Forum for public input.

Article 5(1): Convening a Great Lakes Public Forum.

- The United States and Canada held the first Great Lakes Public Forum on September 9-10, 2013. The Forum provided an opportunity for the United States and Canada to discuss and seek public comment on the state of the lakes and binational priorities for science and action. The 2013 Forum also provided an opportunity for the International Joint Commission to discuss the Parties' progress reporting and the Commission's assessment of progress. Further information on the 2013 Forum, including the agenda and other materials are available at binational.net (www.binational.net/2013/10/01/great-lakes-public-forum-2013).

- The second Great Lakes Public Forum will be held on October 4-6, 2016 in Toronto, Canada. The Forum will provide an opportunity for public input on: progress in relation to the implementation of the 2012 GLWQA; the state of the Great Lakes; and priorities for science and action.

Article 5(3): Convening a Great Lakes Summit.

- The GLWQA commits the United States and Canada to convening "summits" between the Parties to the GLWQA and the Great Lakes related commissions: the Great Lakes Commission, the Great Lakes Fishery Commission and the International Joint Commission. The purpose of these meetings is to promote increased coordination and effectiveness in the environmental management of the Great Lakes. The first meeting was held on September 11, 2013, and included discussion of: 1) the missions, roles and responsibilities of the Commissions in relation to the GLWQA; 2) opportunities for enhanced collaboration between the Commissions and the United States and Canada on Lakewide Action and Management Plans; 3) coordination of the science and monitoring undertaken by the United States, Canada and the Commissions; and, 4) use of emerging tools and gap analyses in addressing excessive nutrient levels in Lake Erie.

- Building on the commitment to hold formal Summit meetings, the United States and Canada have increased their engagement with the Commissions by holding meetings with the Commissions in conjunction with the biannual GLEC meetings, as well as holding other *ad hoc* meetings to discuss GLWQA-related issues. A special focus of attention has been enhancing coordination and cooperation between the Parties and the Commissions on Lakewide Management activities under Annex 2.

- A 2016 Great Lakes Summit will occur in conjunction with the October, 2016 Great Lakes Public Forum to continue the successful dialogue between the United States and Canada and the Commissions.

Article 6: Providing Notification of Planned Activities that Could Lead to a Pollution Incident or have a Significant Cumulative Impact on the Waters of the Great Lakes.

- Pursuant to Article 6(c), the United States and Canada have implemented procedures to provide for

notification of planned activities that could lead to a pollution incident or that could have a significant cumulative impact on the Waters of the Great Lakes. Proposed notifications are solicited from GLEC members and observers on a quarterly basis. A list of notifications is available at http://binational.net/2015/05/06/notifications/.

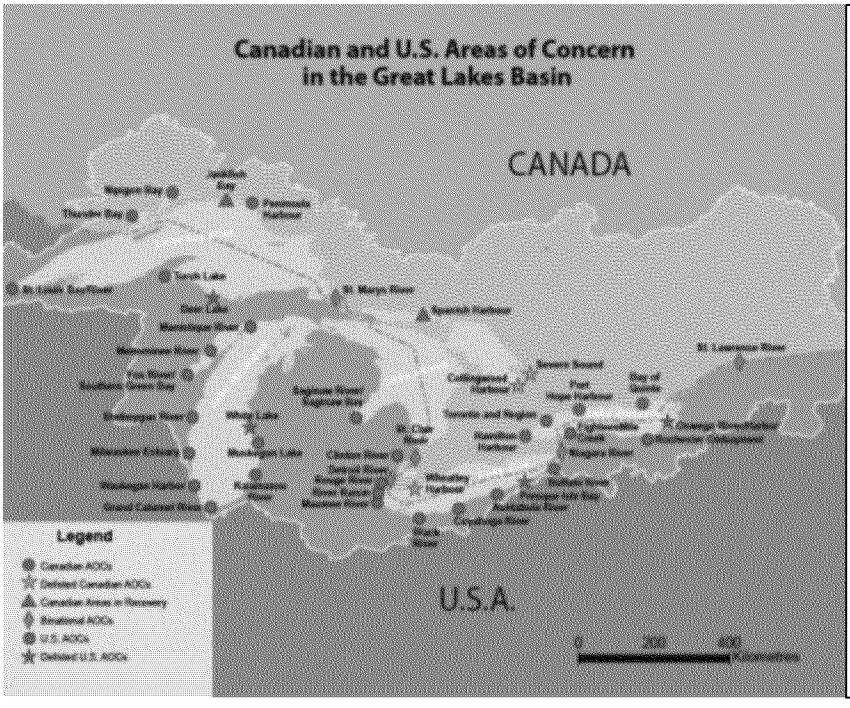
- The notification process has been successful in ensuring that GLEC members and observers are aware of significant events and development occurring within the Great Lakes basin and of opportunities to engage in applicable review and approval processes.

AREAS OF CONCERN ANNEX

OVERVIEW

Pursuant to the 1987 GLWQA, the Parties designated a total of 43 Areas of Concern (AOCs), 12 in Canada, 26 in the United States, and five that are shared by both countries (as seen in Figure 3). AOCs are regarded as the most environmentally degraded sites within the Great Lakes, based upon a systematic assessment of "beneficial use impairments", and contribute to degradation on a lakewide and Great Lakes ecosystem wide basis. The 2012 GLWQA reaffirms the commitment of Canada and the United States to restore water quality and ecosystem health in Great Lakes AOCs. The Parties have made significant progress under this Annex in the last three years. Implementation of the Area of Concern Annex is co-led by Environment and Climate Change Canada and the United States Environmental Protection Agency.

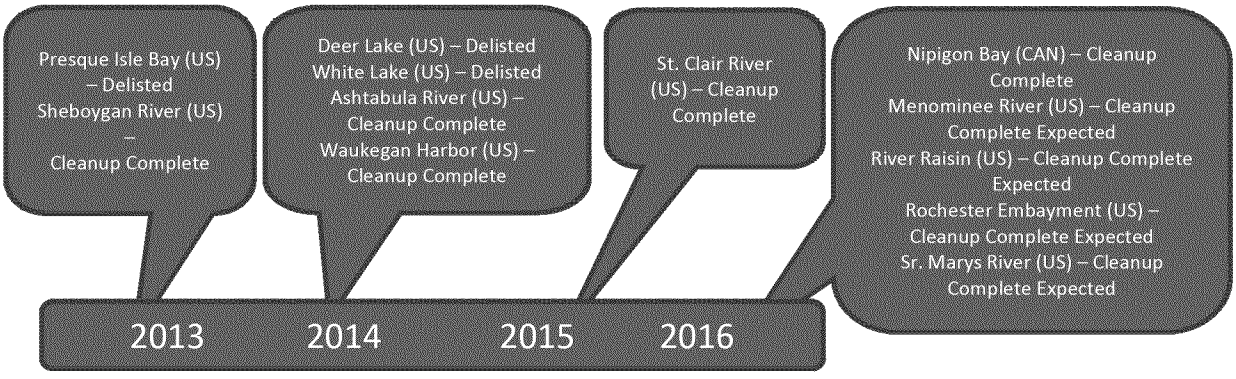
Figure 3 – Canadian and U.S. Great Lakes Areas of Concern.



Fourteen Beneficial Use Impairments (BUIs) contributing to a location's designation as an AOC:

- Restrictions on fish and wildlife consumption;
- Tainting of fish and wildlife flavour;
- Degradation of fish wildlife populations;
- Fish tumours or other deformities;
- Bird or animal deformities or reproduction problems;
- Degradation of benthos (organisms living on lake and river bottoms);
- Restrictions on dredging activities;
- Eutrophication or undesirable algae;
- Restrictions on drinking water consumption, or taste and odour problems;
- Beach closings;
- Degradation of aesthetics (visual appearance and odour);
- Added costs to agriculture or industry;
- Degradation of phytoplankton and zooplankton populations (organisms that provide a crucial source of food to fish);
- Loss of fish and wildlife habitat.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



- Prior to 2013, the Parties restored beneficial uses and delisted four of the 43 AOCs: three in Canada (Collingwood Harbour in 1994; Severn Sound in 2003; and Wheatley Harbour in 2010) and one in the United States (Oswego River in 2006).

- Canada also designated two Canadian AOCs as AOCs in Recovery prior to 2013, signifying that all remedial actions have been completed and monitoring of natural recovery is in progress (Spanish Harbour in 1999 and Jackfish Bay in 2011).

- Between 2013 and 2016, the United States delisted the Presque Isle Bay (Pennsylvania), Deer Lake (Michigan) and White Lake (Michigan) AOCs, signifying that remedial actions were completed and elimination of beneficial use impairments was confirmed through environmental monitoring and assessment.

- The Parties have completed all remedial actions at five other AOCS: Nipigon Bay in Canada; and Sheboygan River (Wisconsin), Waukegan Harbor (Illinois), Ashtabula River (Ohio), and St. Clair River (Michigan) in the United States. With remedial work completed, these five AOCs are now being monitored to determine when the beneficial use impairments have been fully addressed and delisting can occur.

- Work to restore environmental quality is continuing in all remaining AOCs. By 2019, Canada projects completion of all remedial actions in four additional AOCs: Bay of Quinte, Peninsula Harbour, Niagara River and St. Lawrence River – Cornwall; while the United States expects to complete management actions necessary for delisting in nine additional AOCs: Menominee River, River Raisin, Rochester Embayment, St Marys River, Black River, Buffalo River, Clinton River, Manistique River and Muskegon Lake.

BINATIONAL ACTIONS TAKEN

- Efforts to restore the 43 AOCs have been underway for over 25 years. Working with provincial, state and local governments, tribes, First Nations and community members and stakeholders, Canada and the United States have made significant progress in assessing beneficial use impairments, identifying their causes, engaging local communities in developing remedial action plans, and in implementing actions to restore beneficial uses of the environment. Actions to restore Areas of Concern are primarily carried out domestically; however, Canada and the United States share information on approaches and lessons learned on an ongoing basis in order to increase the efficiency and effectiveness of AOC remediation efforts in both countries.

Supporting overall implementation of AOC remediation.

- A guidance document was developed to provide advice on the process, principles, challenges and roles and responsibilities for designating an AOC as an AOC in Recovery. The document identifies five factors to be considered in designating an AOC as an AOC in Recovery: 1) restoration actions needed; 2) achievability of delisting criteria; 3) monitoring; 4) estimated time for recovery; and 5) consideration of stakeholder input. The document will contribute to ensuring a consistent approach in future designations of AOCs in recovery.

- A Situation Analysis report was completed to document how AOC restoration activities are currently being implemented in Canada and the United States, including a review and comparison of agency roles and practices; status of and processes for RAPs, including delisting criteria, BUI removals, AOC delisting and public involvement; key challenges, targets and objectives; and recommendations on guidance needs and information sharing. The document will assist agencies in implementing continuous improvements to current practices.

DOMESTIC ACTIONS TAKEN

CANADA

- Within Canada, Environment and Climate Change Canada and the Ontario Ministry of Environment and Climate Change share the lead for implementation of AOC remediation efforts, with support from other federal departments (e.g., Fisheries and Oceans Canada), provincial ministries (e.g., Ministry of Natural Resources and Forestry), municipalities, conservation authorities, Indigenous peoples, and community stakeholders. Progress is being made in all Canadian AOCs. Table 1 shows that a total of 65 impairments of beneficial uses of the environment have been eliminated, with 81 impairments remaining. In 2016 to 2017, Canada anticipates removing up to 15 more beneficial uses currently deemed impaired, which will add to the 65 beneficial use impairments already removed across the 17 AOCs outlined in Table 1. Table 2 shows the categories of remaining actions required in each Canadian AOC and their status.

- In 2015, in-water construction began on the largest contaminated sediment remediation project ever undertaken in a Canadian AOC. Through a public-private partnership, the project will clean up 700,000 cubic meters of severely contaminated sediment in the Hamilton Harbour AOC. It will significantly improve water quality and fish and wildlife habitat, and also bring economic and social benefits to the community through enhanced shipping and port facilities, business development, job creation, and increased recreational opportunities.

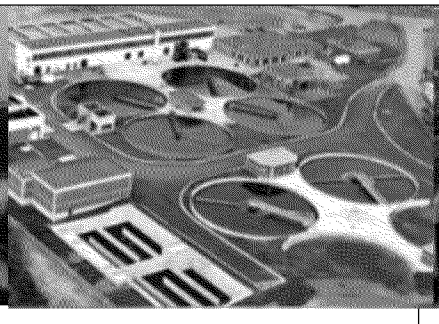
- Another major contaminated sediment remediation project in Canada is in the Port Hope AOC, where the Government of Canada has committed $1.28 billion over 10 years to the cleanup and safe

long-term management of 1.7 million cubic metres of historic low-level radioactive waste, which will restore beneficial uses of the ecosystem and result in the delisting of the Area of Concern. The Port Hope Area Initiative is on track with the Port Hope Harbour clean-up and dredging underway as planned. The harbor walls will be supported and repaired in 2019 with dredging, cleanup and placement of these materials into the long term waste management facility in 2020.

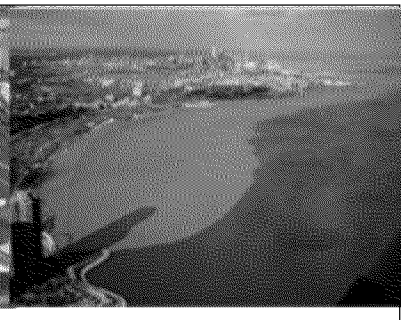
- Other notable accomplishments in Canadian AOCs during the 2013 to 2016 period include restoring close to 4 kilometers of shoreline habitat and enhancing almost 180 hectares of coastal wetlands and fish spawning grounds; investing almost $562 million in upgrades to municipal wastewater treatment plants to significantly reduce nutrients, suspended solids and pollutants entering AOC waterways; and improving water quality and aesthetics by better managing urban and rural non-point sources of pollution in a number of AOCs. There are many community groups engaged in cleaning up AOCs, and the success of many of the projects undertaken are in large part the result of enduring support and partnerships at all levels. More information on the status of beneficial use impairments in Canadian AOCs, projects completed, and remaining issues to be addressed, can be found at www.ec.gc.ca/raps and in Figure 4.

Figure 4 – Examples of habitat, wastewater and non-point source domestic actions in Canadian AOCs.

Habitat
To help improve aquatic habitat and fish populations, Canada and its partners restored close to 4 kilometers of shoreline habitat and almost 180 hectares of coastal wetlands and fish spawning grounds in a number of AOCs, which encompasses:
- 19 habitat enhancement projects in the Bay of Quinte AOC that created two ponds and wetlands, 675 meters of vegetative buffer zones, and naturalized 40 meters of shoreline;
- re-establishing a natural channel from the Nipigon River to a lagoon to restore 3.8 hectares of spawning and nursery habitat for fish in the Nipigon Bay AOC;



Wastewater
To help improve water quality and aesthetics Canada, Ontario and local governments invested almost $562 million in upgrades to municipal wastewater treatment plants in a number of AOCs, including:
- building a new facility in the St. Clair River AOC ($34.5 million);
- upgrading to secondary treatment a facility in the Nipigon River AOC and Detroit River AOC ($9 million and $34 million, respectively); and
- upgrading two facilities to tertiary treatment in the Hamilton Harbour AOC ($154 million for one in Burlington, $330 million for one in Hamilton now underway and to be



Non-point sources
To help improve water quality and aesthetics Canada and its partners are addressing non-point sources of pollution in a number of AOCs, including:
- implementing stormwater management plans and programs to better manage urban runoff and reduce pollution entering the waterways in the St. Marys River and Bay of Quinte AOCs;
- separating storm and sanitary sewers in the St. Clair River AOCs; and
- supporting citizen-driven efforts such as septic inspections and targeted Best Management Practices to

restoring 165 hectares of coastal wetland in the St. Clair River AOC; • restoring 3 kilometers of shoreline in the Toronto Region AOC and transforming a disposal site for contaminated sediment into 9.3-hectares of prime wetland on the Toronto waterfront once fully completed in 2018; and • through binational collaboration, constructing a second fish spawning reef in the Detroit River AOC adjacent to the existing one at Fighting Island that creates almost one hectare of new spawning habitat for fish.	completed in 2021).	reduce rural non-point source pollution in the Bay of Quinte AOC and community rain gardens to better manage rainfall and lower pressure placed upon storm sewers and wastewater treatment plants in the Detroit River AOC.

Table 1 – Status of Beneficial Use Impairments in the Canadian Great Lakes Areas of Concern.

Status of Beneficial Use Impairments in the Canadian Great Lakes Areas of Concern

AOC	Restrictions on fish & wildlife consumption	Tainting of fish & wildlife flavour	Degradation of fish & wildlife populations	Fish tumours or other deformities	Bird/animal deformities or reproduction problems	Degradation of benthos	Restrictions on dredging activities	Eutrophication or undesirable algae	Restrictions - drinking water consumption, taste/odour problems	Beach Closings	Degradation of aesthetics	Added costs to agriculture or industry	Degradation of phyto- and zooplankton populations	Loss of fish & wildlife habitat	Original Total	Total Removed	Remaining Total
Thunder Bay												2004			10	1	9
Nipigon Bay **Completed**		1995	2016	1995		2016	1995	2016			2016			2016	8	8	0
Jackfish Bay **In Recovery**				2010	2010		1998								8	3	5
Peninsula Harbour				2012			2012								6	2	4
St. Marys River					2016										10	1	9
Spanish Harbour **In Recovery**			1999		1999					1999		1999	1999	1999	9	6	3
Severn Sound **Delisted**	2002		2002				2002	2002			2002			2002	6	6	0
Collingwood Harbour **Delisted**	1994		1994		1994	1994	1994	1994		1994	1994		1994	1994	10	10	0
St. Clair River		2011									2016	2012			9	3	6
Detroit River		2014							2011	2016	2016	2011			12	5	7
Wheatley Harbour **Delisted**	2010		2010			2010	2010	2010						2010	6	6	0
Niagara River				2009	2009		2009								9	3	6
Hamilton Harbour															10	0	10
Toronto and Region				2011	2011	2016	2016								10	4	6
Port Hope Harbour															1	0	1
Bay of Quinte															10	0	10
St. Lawrence River		1997			2007	2007	2007		1997		1997	1997			12	7	5
Original Total	15	4	15	9	9	15	17	10	4	11	12	5	4	16	146		
Total Removed	3	4	5	5	7	5	9	4	2	3	6	5	2	5		65	
Remaining Total	12	0	10	4	2	10	8	6	2	8	6	0	2	11			81

BUI Removed BUI Impaired

[Source Excel file for production: All AOC BUI status MASTER July 2016 ur]

Table 2 – Status of Actions in Canadian Great Lakes Areas of Concern.

Canadian Areas of Concern – Status of Actions

AOC	Sediment Cleanup / Remediation	Habitat Restoration	Municipal / industrial WW treatment	Non-point-source pollution mgmt.	Studies/ Investigations	BUI Evaluation/ Assessment	Follow-up Monitoring	Year RAP actions were or will be completed	AOC Weblink
Thunder Bay								beyond 2020	For Canadian and binational AOCs, go to: www.ec.gc.ca/raps
Nipigon Bay								Delisting expected in 2016	
Jackfish Bay (in recovery)				N/A				beyond 2020	
Peninsula Harbour				N/A				2019	
St. Marys River								beyond 2020	
Spanish Harbour (in recovery)								beyond 2020	
St. Clair River								2020	
Detroit River								2020	
Niagara River								2019	
Hamilton Harbour								beyond 2020	
Toronto Region								beyond 2020	
Port Hope		N/A	N/A	N/A				beyond 2020	
Bay of Quinte								2019	
St. Lawrence River (at Cornwall)								2019	

These Canadian AOCs are already delisted: Collingwood Harbour (1994), Severn Sound (2003), and Wheatley Harbour (2010).

All Actions Completed (100%) | Majority of Actions Completed (75+%) | Actions Well Underway (50+%) | Actions Required or to be Determined (<50%)

[Source Word file for production: glwqa Progress Report of the Parties]

- AOC clean-up efforts in the U.S. are led by United States Environmental Protection Agency, with significant contributions from other federal agencies (i.e., National Oceanic and Atmospheric Administration, the United State Army Corps of Engineers), states, local governments and communities, and non-governmental organizations. Table 3 shows that a total of 62 impairments of beneficial uses of the environment have been removed, with 193 impairments remaining. Table 4 shows the categories of remaining actions required in each U.S. AOC and their status. Between 1987 and 2010, only one U.S. AOC was delisted. However, since the inception of GLRI, three additional AOCs have been delisted and management actions have been completed at 4 additional U.S. AOCs. In addition, the Environmental Protection Agency projects that management actions will be completed at 9more AOCs by 2019. This remarkable pace of AOC restoration is due to the GLRI. First, the GLRI appropriation language makes clear that cleaning up and restoring AOCs is a priority. Second, federal agencies have been able to utilize over $650M in GLRI funding to pay for this work.

Table 3 – Status of Beneficial Use Impairments in the U.S. Great Lakes Areas of Concern.

Status of Beneficial Use Impairments in the US Great Lakes Areas of Concern

Updated 5/9/16

AOC	State	Restriction on fish & wildlife consumption	Tainting of fish & wildlife flavor	Degraded fish & wildlife populations	Fish tumor or other deformities	Bird & animal deformities or reproduction problems	Degradation of benthos	Restrictions on dredging activities	Eutrophication or undesirable algae	Restrictions – drinking water consumption, taste/odor problems	Beach Closings	Degradation of aesthetics	Added costs to agriculture or industry	Degradation of phyto- and zooplankton	Loss of fish and wildlife habitat	Original Total	Total Removed	Remaining Total
Waukegan Harbor	IL							2014			2011				2013	6	3	3
Grand Calumet River	IN									2012			2011			14	2	12
Clinton River	MI															8	0	8
Deer Lake	MI	2014				2011			2011							3	3	0
Detroit River	MI		2013							2011						11	2	9
Kalamazoo River	MI										2011	2012				8	2	6
Manistique River	MI						2007				2010				2008	5	3	2
Muskegon Lake	MI	2013						2011		2013	2015					9	4	5
River Raisin	MI			2015					2013		2013	2012			2015	9	5	4
Rouge River	MI															9	0	9
Saginaw River & Bay	MI		2008							2008					2014	12	3	9
Torch Lake	MI				2007											3	1	2
White Lake	MI	2013		2014			2012	2011	2012	2014		2014			2014	8	8	0
St. Clair River	MI/ON		2010				2015	2011				2012	2012			10	5	5
St. Marys River	MI/ON					2014						2014				10	2	8
Menominee River	MI/WI										2011					6	1	5
Buffalo River	NY															9	0	9
Eighteenmile Creek	NY															5	0	5
Oswego River	NY	2006		2006					2006						2006	4	4	0
Rochester Embayment	NY				2015					2011			2011			14	3	11
Niagara River	NY/ON				2016											7	1	6
St. Lawrence River	NY/ON													2015		7	1	6
Ashtabula River	OH	2014		2014											2014	6	3	3
Black River	OH															9	0	9
Cuyahoga River	OH															9	0	9
Maumee River	OH												2015			10	1	9
Presque Isle	PA				2013			2007								2	2	0
Fox River/ S Green Bay	WI															13	0	13
Milwaukee Estuary	WI															11	0	11
Sheboygan River	WI							2015	2016							9	2	7
St. Louis River & Bay	WI/MN											2014				9	1	8
Original Total		30	7	25	18	17	27	27	18	8	20	19	4	8	27	255		
Total Removed		5	3	4	4	2	3	6	5	6	6	6	4	1	7		62	
Remaining Total		25	4	21	14	15	24	21	13	2	14	13	0	7	20			193

BUI Removed BUI Impaired

Table 4 – Status of Actions in U.S. Great Lakes Areas of Concern.

U. S. Areas of Concern – Status of Actions

Updated 5/11/16

AOC	State	Sediment Remediation	Habitat Restoration	Hydrologic Controls/Diversions Implemented	Safe Drinking Water Provided	Engineering Design	Studies/Investigations	Other Regulatory Action	BUI Evaluation/Assessment	Year all remediation and restoration actions were or will be completed	AOC Weblink
Waukegan Harbor	IL			N/A	N/A					2014	For additional information on United States and binational Areas of Concern; go to : https://www.epa.gov/great-lakes-aocs/list-aocs
Grand Calumet River	IN			N/A	N/A					2020	
Clinton River	MI	N/A		N/A	N/A			N/A		2017	
Deer Lake	MI				N/A					Delisted 2014	
Detroit River	MI			N/A	N/A					2023	
Kalamazoo River	MI			N/A	N/A					2030+	
Manistique River	MI		N/A	N/A	N/A			N/A		2018	
Muskegon Lake	MI			N/A	N/A			N/A		2018	
River Raisin	MI			N/A	N/A			N/A		2016	
Rouge River	MI			N/A	N/A					2021	
Saginaw River & Bay	MI									2030+	
Torch Lake	MI		N/A	N/A	N/A	N/A				2030+	
White Lake	MI			N/A	N/A	N/A		N/A		Delisted 2014	
St. Clair River	MI/ON	N/A		N/A	N/A			N/A		2015	
St. Marys River	MI/ON			N/A	N/A			N/A		2016	
Menominee River	MI/WI				N/A					2016	
Buffalo River	NY			N/A	N/A					2017	
Eighteenmile Creek	NY		N/A		N/A					2026+	
Oswego River	NY	N/A	N/A		N/A	N/A				Delisted 2006	
Rochester Embayment	NY				N/A					2016	
Niagara River	NY/ON			N/A	N/A					2026+	
St. Lawrence River	NY/ON			N/A	N/A					2026+	
Ashtabula River	OH			N/A	N/A	N/A		N/A		2013	
Black River	OH			N/A	N/A			N/A		2017	
Cuyahoga River	OH			N/A	N/A					2021	
Maumee River	OH			N/A	N/A			N/A		2025	
Presque Isle	PA			N/A	N/A	N/A		N/A		Delisted 2013	
Fox River/ S Green Bay	WI				N/A					2026+	
Milwaukee Estuary	WI			N/A	N/A					2026+	
Sheboygan River	WI			N/A	N/A					2013	
St. Louis River & Bay	WI/MN			N/A	N/A					2020	

All Actions Completed (100%) | Majority of Actions Completed (75+%) | Actions Well Underway (50+%) | Actions Required or to be Determined (<50%)

LAKEWIDE MANAGEMENT ANNEX

OVERVIEW

The Great Lakes are comprised of five of the twenty largest lakes in the world by volume: Superior (3), Michigan (7), Huron (8), Ontario (12) and Erie (18). The Great Lakes are connected and discharge through major river systems: the St. Marys, St. Clair (including Lake St. Clair), Detroit, Niagara and St. Lawrence. Given the size and ecological complexity of the lakes, restoring and protecting Great Lakes water quality and ecosystem health sometimes requires an approach that is specifically tailored to an individual lake.

In the Lakewide Management Annex of the 2012 GLWQA, the United States and Canada commit to establishing Lakewide Action and Management Plans (LAMPs) for each of the five Great Lakes and their connecting river systems. These individualized plans will serve as blueprints for action, as they will identify and prioritize desired restoration and protection activities on each of the Great Lakes.

This Annex's implementation is supported by the Lakewide Management Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include: Chippewa-Ottawa Resource Authority, Conservation Ontario, Dept. of Fisheries and Oceans, Great Lakes Indian Fish and Wildlife Commission, Great Lakes-St. Lawrence Cities Initiative, Illinois Department of Natural Resources, McMaster University, Métis Nation of Ontario, Michigan Department of Environmental Quality, Minnesota Pollution Control Agency, National Oceanic and Atmospheric Administration, New York State Dept. of Environmental Conservation, Ohio Environmental Protection Agency, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario Ministry of Natural Resources and Forestry, Ontario Ministry of the Environment and Climate Change, Parks Canada, Pennsylvania Dept. of Environmental Protection, U.S. Army Corps of Engineers, United States Geologic Survey, Wisconsin Dept. of Natural Resources, Alliance for the Great Lakes, Ontario Federation of Anglers and Hunters [logos to be inserted].

PROGRESS TOWARD MEETING GLWQA COMMITMENTS

2012	2013	2014	2015	2016
• Published LAMP Annual Reports. • Established Lake Ontario Science and Monitoring Priorities • Finalized Lake Michigan Biodiversity	• Published LAMP Annual Reports. • Established Lake Michigan Science and Monitoring Priorities • Finalized Lake Erie Biodiversity Conservation	• Published LAMP Annual Reports. • Established Lake Superior Science and Monitoring priorities	• Published LAMP Annual Reports. • Established Lake Huron Science and Monitoring priorities • Finalized Lake Superior Biodiversity	• Published LAMP Annual Reports. • Finalized Lake Superior LAMP. • Finalized Nearshore Framework.

Conservation Strategy.	Strategy		Conservation Strategy.	

BINATIONAL ACTIONS TAKEN

Developing a nearshore framework to identify areas of high ecological value and those that are or may become subject to severe stress due to the cumulative effects of multiple stressors.

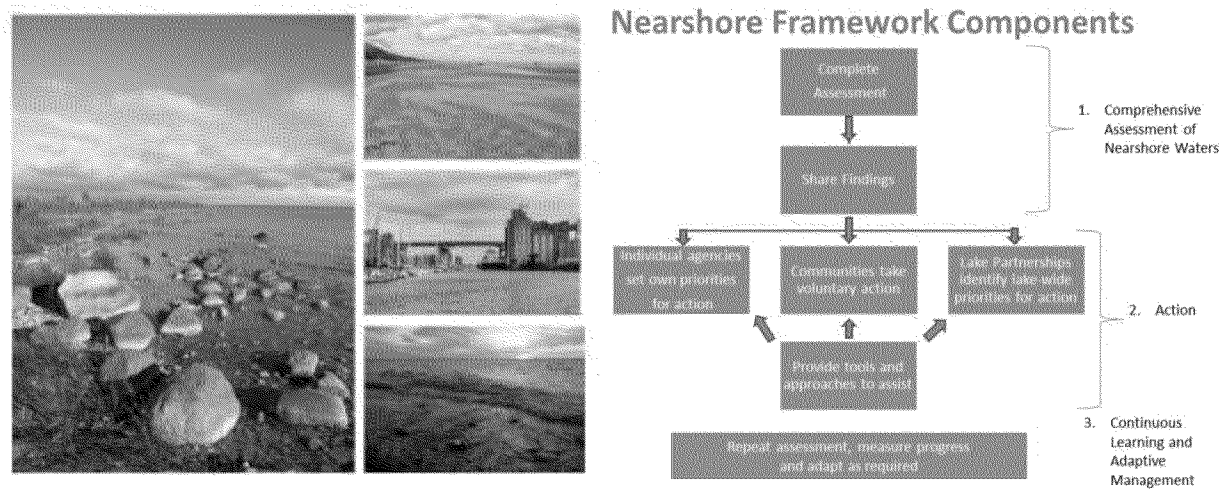
- The fragility of the nearshore as a key issue in the Great Lakes basin was highlighted in 2005 by more than 250 Great Lakes scientists who signed on to a report entitled *Prescription for Great Lakes Ecosystem Protection and Restoration (Avoiding the Tipping Point of Irreversible Changes)* (http://www.miseagrant.umich.edu/downloads/habitat/Prescription-for-the-Great-Lakes-08-2006.pdf).

- To develop the nearshore framework, the United States and Canada undertook a three-year process to engage a wide range of people and organizations throughout the Great Lakes basin. The resulting Nearshore Framework was approved by the United States and Canada in July 2016. Components of the Nearshore Framework are identified in Figure 5. The Parties will pilot test implementation of the framework in Lake Erie beginning in 2017.

- The framework provides a mechanism for undertaking a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses.

- Building on the information provided by the assessment, federal, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, local public agencies and the public, individually and collectively, will be able to identify management priorities, take action to protect nearshore areas of high ecological value, protect water quality, and restore degraded areas.

Figure 5 – Components of the Great Lakes Nearshore Framework.



Developing the Lake Superior Lakewide Action and Management Plan.

- The schedule for the development and release of Lakewide Action and Management Plans (LAMPs) was confirmed in 2014. The Lake Superior LAMP was approved in June of 2016, and is the first LAMP completed under the 2012 GLWQA and the authoritative source for information on the Lake Superior ecosystem.

- The Lake Superior LAMP was developed with the help of over 30 science-based government agencies and involvement from over 50 other organizations, representing thousands of people and many diverse interests.

- The Lake Superior ecosystem continues to be in good condition, as exemplified by the good condition of the fisheries which is supported by a robust lower food web, in particular the self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon; good ecological status of most major habitats on a lakewide scale, including coastal wetlands; and generally decreasing or stable concentrations of legacy contaminants. The LAMP also details ongoing and emerging threats to the ecosystem, including aquatic invasive species, climate change, loss of habitat connectivity, and chemical contaminants.

- Science priorities identified in the Lake Superior LAMP include: confirming lower food-web health and stability; determining progress being made on reducing nine persistent, bioaccumulative and toxic substances; determining progress being made on Lake Sturgeon rehabilitation; providing information needed to support implementation of fish rehabilitation plans; assessing baseline water quality conditions in areas of critical habitat and potentially significant land-use change; and identifying vulnerable cold-water tributaries to Lake Superior from various stressors such as climate change.

- To maintain the good condition of the Lake Superior ecosystem, and address threats to water quality and ecosystem health, the LAMP includes priority actions in the form of 29 projects that will be undertaken over the next five years through cooperative implementation among government agencies and others. Actions that the public can take are also identified.

Establishing Lake Ecosystem Objectives for each Great Lake, including its connecting river systems, as a benchmark against which to assess status and trends in water quality and lake ecosystem health.

- In October of 2014 a draft guidance document for the development of Lake Ecosystem Objectives (LEOs) and a draft framework linking the LEOs to the Agreement's General Objectives and the State of the Great Lakes Indicators were developed.

- The guidance suggests that LEOs should:
  - be practical and attainable or achievable within a 20-year timeframe;
  - provide sufficient direction for implementing LAMP actions;
  - have support from the agencies that implement the programs used to achieve the objective;
  - be based on sound, readily available data, so they can be reported on every five years; and,
  - taken together, be a comprehensive suite which addresses each 2012 GLWQA General Objective and lake stressor.

- A binational team has been formed to develop a draft suite of LEOs for Lake Erie for consultation.

- LEOs for the other lakes will be developed during the next reporting cycle (2017 to 2019).

Undertaking the lakewide management actions in cooperation and consultation with others.

- The United States and Canada have undertaken outreach and engagement activities through the work of the Lake Partnerships and the Annex Subcommittee.

- In 2015, eight webinars involving over 800 participants were held to update the basin-wide and individual lake stakeholder communities about progress under the Lakewide Management Annex, and to discuss possible approaches to outreach and engagement. Outreach and Engagement sub-committees were formed under each Lake Partnership to develop and implement an outreach and engagement strategy for each lake.

- In 2016, the Parties solicited interest from stakeholders in participating with the Lake Partnerships, including providing input on LAMP development and other Partnership activities to simply being kept apprised of Lake Partnership activities and receiving notice of requests for input on specific issues. The solicitation was sent through existing Great Lakes-related email distribution lists including GLIN-Announce, and the United States Environmental Protection Agency's and Environment and Climate Change Canada's Great Lakes email databases in order to reach a wide breadth of stakeholders.

- In 2016 the Parties also advised the Great Lakes community that the Lake Huron LAMP was being developed, and offered opportunities for input.

- In 2013, 2014, and 2015, LAMP Annual Reports were issued to provide an overview of accomplishments and challenges facing each lake. The 2015 LAMP Annual Reports, which are pictured in Figure 6, and the previous LAMP Annual Reports dating back to 2012 are available at www.binational.net (https://binational.net/category/a2-2/lamps-paaps/).

Figure 6 – 2015 LAMP Annual Reports.

CHEMICALS OF MUTUAL CONCERN ANNEX

OVERVIEW

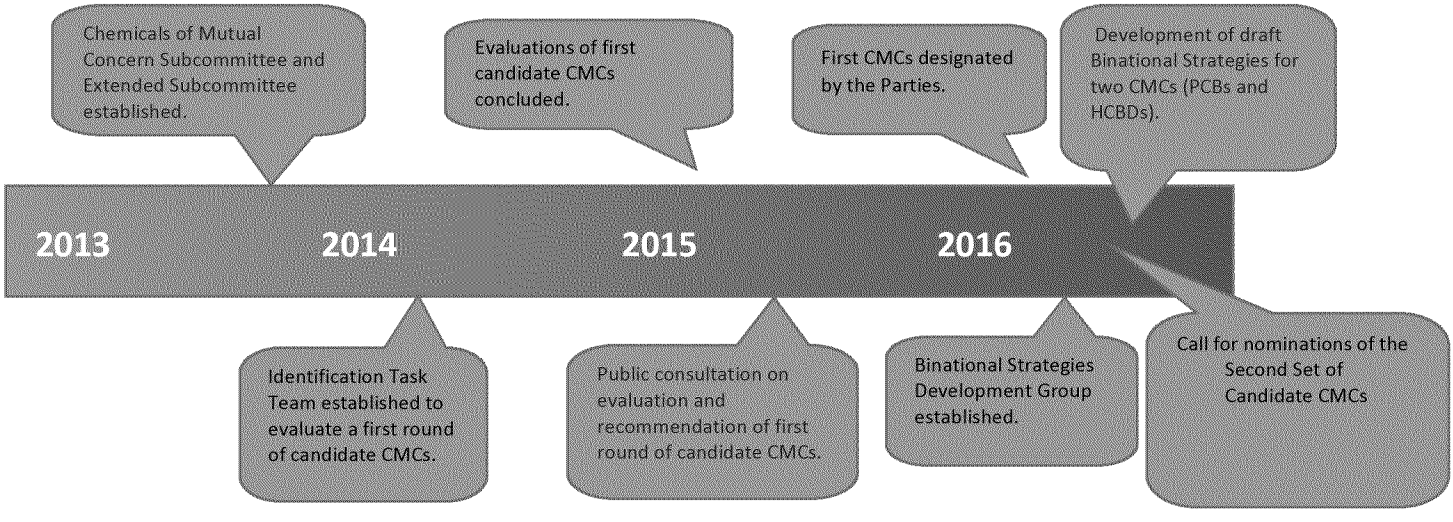
Due to the high population density and concentration of industrial activity in the Great Lakes region, as well as long-range atmospheric transport and deposition from out-of-basin sources and the long residence times of certain chemicals in the environment, chemical pollution has long been a serious concern in the Great Lakes. Certain chemicals can harm aquatic ecosystems and negatively impact habitats and biodiversity throughout the Great Lakes. Some chemicals are persistent and can bioaccumulate in the food web, exposing humans to potentially harmful chemicals through fish consumption. As such, addressing the threats posed to the Great Lakes by chemicals in the environment has been a priority of Canada and the United States since the late 1970's.

The purpose of the Chemicals of Mutual Concern Annex is to contribute to the achievement of the Great Lakes Water Quality Agreement (GLWQA) by protecting human health and the environment through cooperative and coordinated measures to reduce anthropogenic inputs of chemicals of mutual concern (CMCs) into the waters of the Great Lakes, and to ensure that such anthropogenic chemical inputs have adequate research, monitoring and surveillance support.

Under the CMC Annex, the Parties have committed to:

- Identify CMCs and potential Candidates on an ongoing basis
- Take specific actions for identified CMCs, including the development of binational strategies, which may include pollution prevention, control and reduction actions as well as research, monitoring and/or surveillance activities, and
- Ensure that research, science, and monitoring and surveillance programs are responsive to CMC identification and management needs.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



The implementation of this Annex is supported by the Chemicals of Mutual Concern Annex

Subcommittee (C3), which is co-led by Environment and Climate Change Canada and the United State Environmental Protection Agency and includes State, Provincial and Tribal governments. The C3 is supported by an Extended Subcommittee (EC3) with representation from non-government organizations (NGOs) and industry.

Organizations on the C3 during this Triennial included: the Ontario Ministry of Environment and Climate Change (OMOECC), the Indiana Department of Environmental Management (IDEM), the Minnesota Department of Health (MDH), Wisconsin Department of Natural Resources (WDNR) and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) [logos to be inserted]. Organizations on the EC3 included the Canadian Environmental Law Association (CE:A), the National Wildlife Federation (NFW), the Great Lakes Green Chemistry Network, the Council of Great Lakes Industries (CGLI), the Chemical Industry Association of Canada (CIAC) and Pollution Probe [logos to be inserted].

BINATIONAL ACTIONS TAKEN

Pollution prevention and control of chemicals in Canada and the United States occurs through a number of programs and under different legislation at the federal, provincial, state and local levels. Recognizing this, the 2012 GLWQA focuses attention on those chemicals present in the Great Lakes, for which additional effort are warranted and can be advanced through binational coordination and cooperation.

Identifying chemicals of mutual concern that originate from anthropogenic sources, which are potentially harmful to human health or the environment.

- *Developing Criteria for Evaluation CMCs.* A series of criteria, the *Binational Considerations*, were developed to evaluate candidate CMCs. Using these criteria, a first round of candidate CMCs were evaluated, with detailed reports for eight candidate CMCs posted to binational.net for public input (http://binational.net/2015/05/13/cmc-cand-pcspm/ – the *Binational Considerations* can be found in Appendix A of each of these eight reports for candidate CMCs).
- *Ensuring Participation in the CMC Evaluation Process*. To ensure that the best science could be included within each CMC evaluation, the Parties developed Identification Task Teams for Candidate CMCs to provide for enhanced stakeholder engagement and involvement of the review of potential CMCs.
- Taking into consideration the information in the reports and input provided by the Chemicals of Mutual Concern Subcommittee, Extended Subcommittee, the Great Lakes Executive Committee and the public, on May 31, 2016, Canada and the United States designated the following eight chemicals as the first set of CMCs through the auspices of the 2012 GLWQA:

    1. Mercury;
    2. Polychlorinated biphenyls (PCBs);
    3. Perfluorooctanoic acid (PFOA),
    4. Perfluorooctane sulfonate (PFOS),
    5. Long-chain perfluorinated carboxylic acids (LC-PFCAs);
    6. Polybrominated diphenyl ethers (PBDEs)
    7. Hexabromocyclododecane (HBCD); and,
    8. Short-chain chlorinated paraffins (SCCPs)

- *Seeking Additional CMC Candidate Substances.* To foster enhanced stakeholder engagement, the Parties created a process by which stakeholders, including non-government organizations, industry, academia and the public, can propose specific chemicals for consideration as potential candidate CMCs. A support document for the external nominations process is available on binational.net (https://binational.net/2015/05/13/cmc-pro-pcspm/), which describes the information to be submitted by stakeholders in support of a nomination.

Targeting these identified Chemicals of Mutual Concern for action.

- Draft *Binational Strategies*, which may include research, monitoring, surveillance and pollution prevention and control actions, are being developed for all of the CMCs nominated through the first round. Polychlorinated Biphenyls (PCBs) and Hexabromocyclododecane (HBCD) will be disseminated to stakeholders, including the public, first, and the remaining strategies will be provided shortly thereafter. These reviews will contribute to the development binational strategies via specific input and review opportunities.

- The development of *Binational Strategies* for the remaining CMCs will take into account lessons-learned while developing the first two *Binational Strategies*.

- Existing relevant Canadian and United States environmental quality guidelines (including federal and provincial or state guidelines and other relevant criteria) for CMCs are being compiled and will be made available on binational.net, as *Binational Strategies* are finalized and published. These guidelines can be considered in conjunction with other information (e.g., from state of the environment reporting) to evaluate progress towards the implementation of *Binational Strategies* for CMCs.

Coordinating science priorities, research, surveillance and monitoring activities, as appropriate related to CMCs.

- Through mechanisms such as the Cooperative Science and Monitoring Initiative under the Science Annex (Annex 10), monitoring of CMCs in relevant environmental media of the Great Lakes is being pursued in a collaborative and coordinated manner, whenever possible.

- Monitoring of CMCs supports the commitments of the Chemicals of Mutual Concern Annex, and is also critical for the development of the triennial State of the Great Lakes Indicators report, in which levels of these chemicals in the Great Lakes are reported.

- Canada and the United States have comprehensive national monitoring and surveillance programs, as well as regional, Great Lakes-specific programs and activities, which evaluate a broad suite of chemicals, including more recent chemicals of potential concern (e.g., organic flame retardants and perfluorinated chemicals). National monitoring and surveillance programs incorporated chemicals identified through the Annex 3 process will be monitored as appropriate.

DOMESTIC ACTIONS TAKEN

CANADA

- The Government of Canada continues to assess and manage the risks posed by chemicals subject to the Chemicals of Mutual Concern Annex through its national Chemicals Management Plan. Under the Chemicals Management Plan, over 2,750 substances have been assessed, and 363 substances or groups of substances have been concluded to be toxic. For these toxic substances, 78 final risk management instruments have been established, and additional risk management instruments are being developed.

- All designated CMCs are listed under the Schedule 1 – List of Toxic Substances of the *Canadian Environmental Protection Act, 1999*. As such, all CMCs are subject to federal risk management in Canada, for example through the *Polychlorinated Biphenyl Regulations* and the *Prohibition of Certain Toxic Substance Regulations*. Additionally, Environment and Climate Change Canada has developed federal environmental quality guidelines and supported the development of federal-provincial guidelines, for many of the first CMCs.

- Canada is a Party to many Multilateral Environmental Agreements aimed at globally addressing environmental and human health impacts of chemicals. Examples of relevant Multilateral Environmental Agreements include the Minamata Convention on Mercury and the Stockholm Convention on Persistent Organic Pollutants.

- Environment and Climate Change Canada also delivers a number of foundational water quality monitoring and surveillance activities in the Great Lakes watershed, including the Great Lakes Surveillance Program, the Great Lakes Fish Contaminant and Sediment Monitoring and Surveillance Programs, Canada Chemicals Management Plan Monitoring and Surveillance Program in the Great Lakes Basin, and the Great Lakes Connecting Channels Program, through which CMCs are currently being monitored in the Great Lakes.

UNITED STATES

Monitoring & Surveillance

- The United States Environmental Protection Agency delivers a number of foundational water quality monitoring and surveillance activities in the Great Lakes watershed, including the Great Lakes Fish Monitoring and Surveillance Program and the International Atmospheric Deposition Network.

Science & Research

- The United States also has funded, and continues to fund, research on the presence, effects, and trends of emerging chemicals, including CMCs, in a variety of media through the Great Lakes Restoration Initiative and its partners. As a result of the identification of hexabromocyclododecane (HBCD) as a CMC, it has been added to the routine monitoring program of the Agency's Great Lakes Fish Monitoring and Surveillance Program. These activities provide data and information to regulatory offices within the Environmental Protection Agency for consideration and incorporation into decision making processes.

National Chemical Management

In the United States, CMCs are regulated under a combination of multiple federal, state and local statutes and regulations, depending on the source, use and release of the respective CMC. Such work will be detailed in the forthcoming *Binational Strategies* for each CMC. The Environmental Protection Agencyaddresses CMCs generally through the Toxic Substances Control Act (TSCA), which seeks to address the human health and environmental impacts of chemicals in industrial use through a combination of voluntary and regulatory risk management activities. With the passage of The Frank R. Lautenberg Chemical Safety for the 21wst Century Act on June 22, 2016, which amends TSCA, will enable the United States to better link national chemical management enhancements to those it undertakes within the Great Lakes Basin.

Coordination of Inter-Agency and Federal Chemical Management Activities

- As implementation of the Chemicals of Mutual Concern Annex proceeds toward the development of Binational Strategies and ensuing actions, the United States will seek to more closely align its actions at the federal levels with those at state and local levels to better support CMC-oriented actions that are specific to the Great Lakes basin, as appropriate, through the Binational Strategies process, which will identify such coordination opportunities.

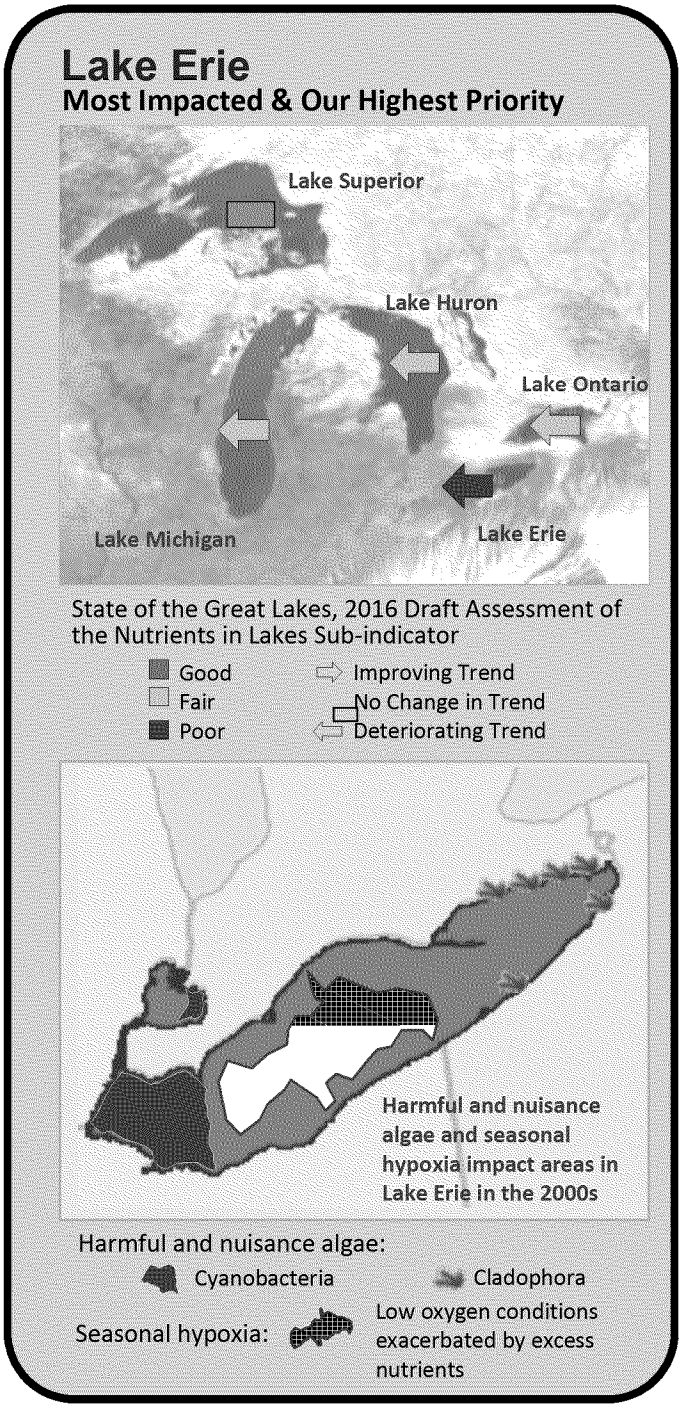
NUTRIENTS ANNEX

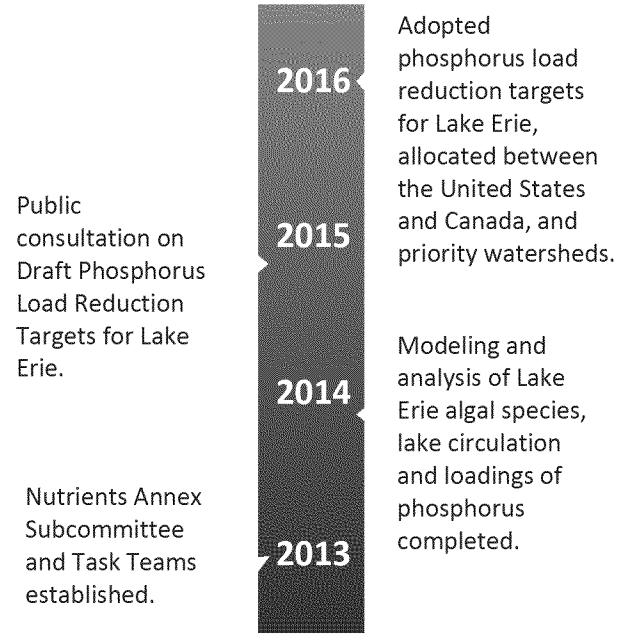
OVERVIEW

In some areas of the Great Lakes, excess phosphorus loadings threaten water quality and ecosystem health by contributing to harmful and nuisance algal blooms that can cause drinking water impairments, exacerbate low oxygen conditions, and drive beach closures that result in loss of recreational opportunities. Recognizing the magnitude of the threat to Lake Erie in particular (Figure 7), the 2012 Agreement requires that Canada and the United States establish phosphorus loading targets for the nearshore and open waters of Lake Erie, allocated by country, by 2016, and that Domestic Action Plans to achieve the Lake Erie targets be in place by 2018.

On February 22, 2016, following a robust binational science-based process and an extensive public consultation, the United States and Canada adopted new phosphorus reduction targets for the western and central basins of Lake Erie. The Parties and multiple partner agencies are now working to develop Domestic Action Plans to meet the 2018 deadline.

Figure 7 – Excess phosphorus loadings threaten Great Lakes water quality and ecosystem health.


Lake Erie
Most Impacted & Our Highest Priority
Lake Superior
Lake Huron
Lake Ontario
Lake Michigan
Lake Erie
State of the Great Lakes, 2016 Draft Assessment of the Nutrients in Lakes Sub-indicator
Good
Fair
Poor
Improving Trend
No Change in Trend
Deteriorating Trend
Harmful and nuisance algae and seasonal hypoxia impact areas in Lake Erie in the 2000s
Harmful and nuisance algae:
Cyanobacteria
Cladophora
Seasonal hypoxia:
Low oxygen conditions exacerbated by excess nutrients



This Annex's implementation is supported by the Nutrients Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include:

BINATIONAL ACTIONS TAKEN

By 2016, develop binational substance objectives for phosphorus concentrations, loading targets, and loading allocations for Lake Erie.

- The Parties led an extensive binational effort to increase understanding of the Lake Erie algae problem in relation to the three main basins of the Lake – the Western Basin, the Central Basin and the Eastern Basin. Information on algal patterns and species, lake circulation, and sources and loadings of phosphorus were studied. Modeling experts from Canada and the United States used nine different computer simulation models to correlate changes in phosphorus levels with levels of algal growth. By comparing and contrasting the results of these models, draft phosphorus load reduction targets to achieve the Lake Ecosystem Objectives for Lake Erie were developed.

- The Parties then led extensive consultations of the draft targets. Information about the draft targets

was made available online, for approximately 60 days up to August 31, 2015, through www.binational.net, and Environment and Climate Change Canada and United States Environmental Protection Agency websites. The Parties also reached out through a number of binational and domestic face-to-face meetings with interested stakeholders and partners including agricultural commodity groups, municipalities, Conservation Authorities, First Nations, non-government organizations, and others. Feedback received included both technical comments on the targets as well as ideas for action.

- Following this robust science-based process and public consultation, Canada and the United States adopted the following phosphorus reduction targets for Lake Erie (based on a 2008 baseline year):

  - **To minimize the extent of hypoxic zones in the waters of the central basin of Lake Erie:** a 40 percent reduction in total phosphorus entering the western and central basins of Lake Erie—from the United States and from Canada—to achieve an annual load of 6,000 metric tons to the central basin. This amounts to a reduction from the United States and Canada of 3,316 metric tons and 212 metric tons, respectively.

  - **To maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the western and central basins of Lake Erie:** a 40 percent reduction in spring total and soluble reactive phosphorus loads from the following watersheds where algae is a localized problem: in Canada, Thames River and Leamington tributaries; and in the United States, Maumee River, River Raisin, Portage River, Toussaint Creek, Sandusky River and Huron River (Ohio).

  - **To maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the western basin of Lake Erie:** a 40 percent reduction in spring total and soluble reactive phosphorus loads from the Maumee River in the United States.

- While the above targets for the western and central basins of Lake Erie are expected to reduce nuisance benthic algae growth in the eastern basin, further science and analysis is underway to determine if further reductions will be necessary to address the issue in the eastern basin as well.

By 2018, develop binational phosphorus reduction strategies and domestic action plans to meet the objectives for phosphorus concentrations and loading targets in Lake Erie.

- The United States and Canada are working with multiple partner agencies, tribes, First Nations, Métis, and stakeholders to develop a binational phosphorous reduction strategy and Domestic Action Plans. These plans will identify the actions required to meet the agreed to load reduction targets. Stakeholders are being engaged during the development process, and the draft plans will be available for further consultation in 2017.

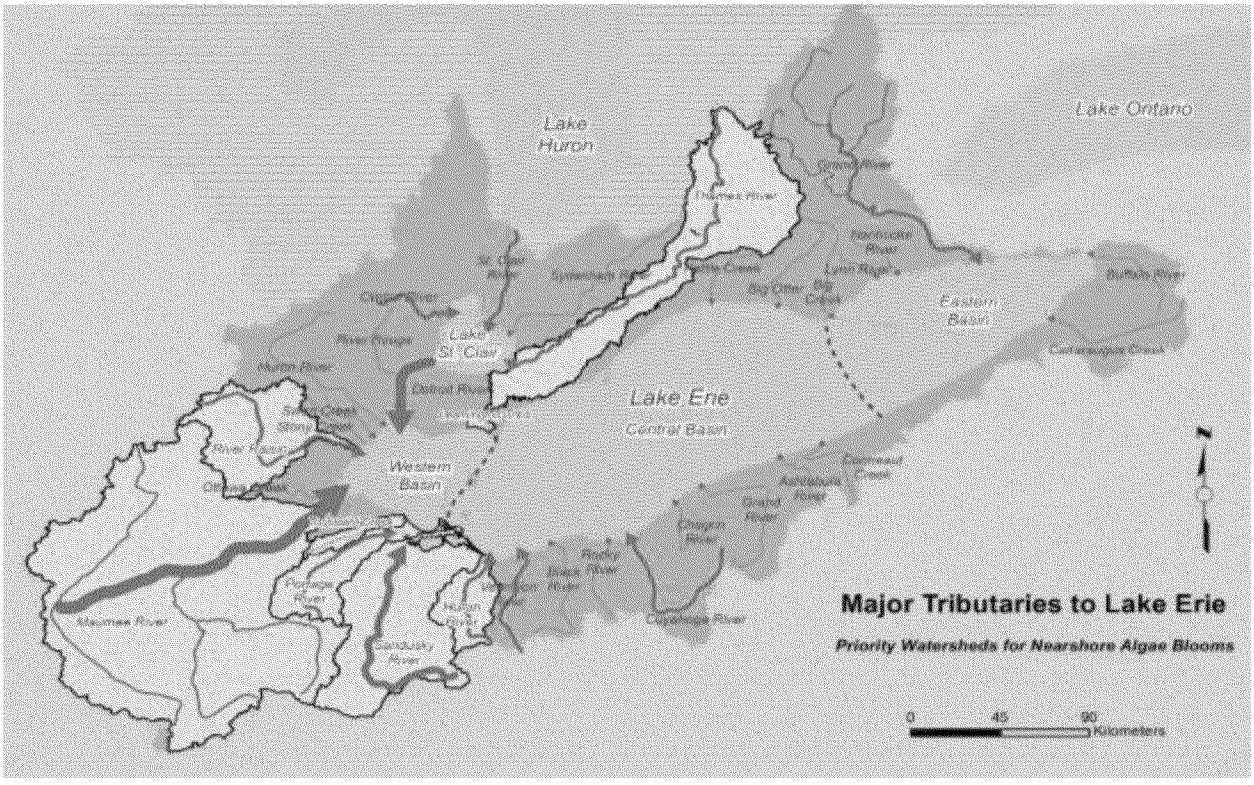
Assessing, developing, and implementing programs to reduce phosphorus loadings from urban, rural, industrial and agricultural sources.

- Work is underway to evaluate existing programs in Canada and the United States, identify opportunities to maximize current phosphorus reduction efforts, and propose new programs and approaches to manage phosphorus loadings from municipal and agricultural point and non-point sources. Ongoing efforts to limit excess phosphorus loading to the Great Lakes – through detergent bans, optimizing sewage treatment, and implementing best management practices on agricultural lands – continue to be enhanced with better targeting and adoption. For example, the new Western Lake Erie Basin Initiative, which was designed and is being delivered by the U.S. Department of Agriculture, Natural Resources Conservation Service, is based on a comprehensive assessment of conservation effects and remaining treatment needs on croplands in the Western Basin. The WLEB Initiative is designed to complement existing programs on agricultural lands in the region such as the Great Lakes Restoration Initiative, Regional Conservation Partnership Program, and general Farm Bill efforts. Similarly, the governments of Ontario and Canada recently launched the Great Lakes Agricultural Stewardship Initiative to provide targeted support for farmers in the Lake Erie and Lake St. Clair watersheds.
- For information on actions being taken in Canada and the US to reduce phosphorus, see the Domestic Actions section

Identifying priority watersheds that contribute significantly to local algae development, and implementing management plans to achieve phosphorus load reduction targets and controls for these areas.

- ~~While phosphorus reductions are required from all watersheds entering Lake Erie,~~ the United States and Canada identified eight priority watersheds (as seen in Figure 8) – two in Canada and six in the United States – where phosphorus control is required in order to address algal blooms occurring in the nearshore waters of Lake Erie.

Figure 8 – Major tributaries to Lake Erie and the priority watersheds for nearshore blooms. Tributary size indicates magnitude of phosphorus loading to the Lake in 2008.

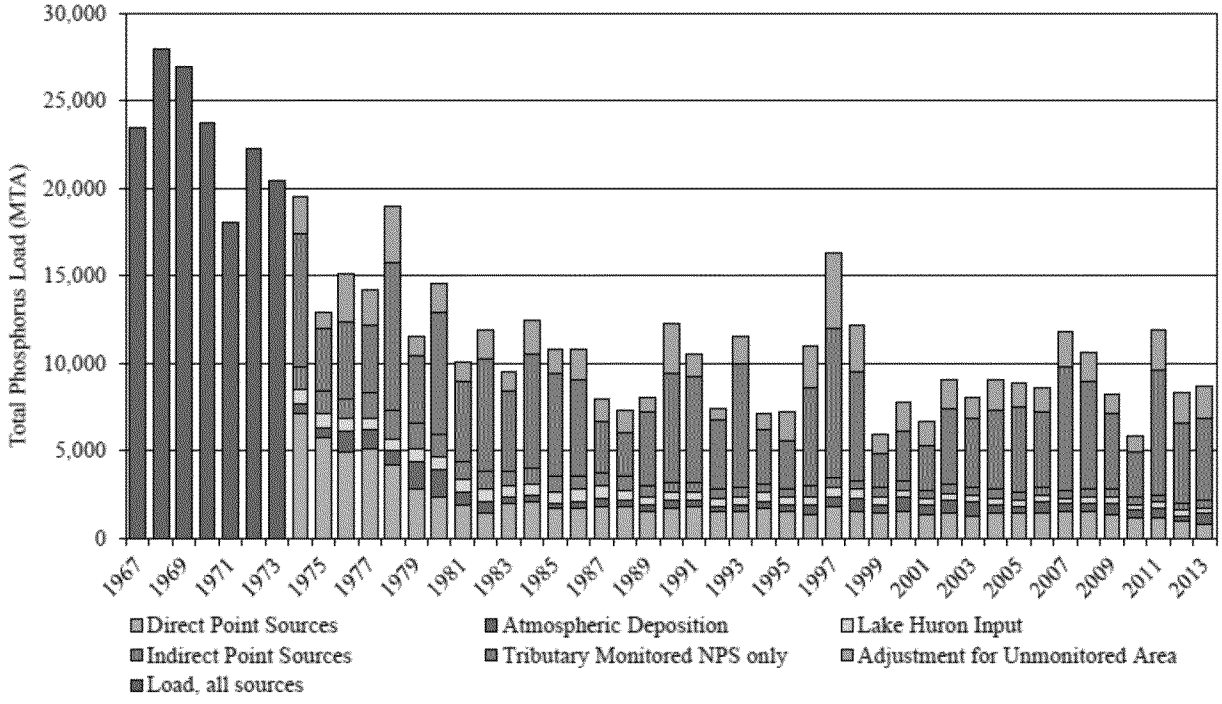


Undertake and share research, monitoring and modeling necessary to establish, report on and assess the management of phosphorus and other nutrients and improve the understanding of relevant issues associated with nutrients and excessive algal blooms.

- Canada and the United States engaged many scientific experts in the development of the new phosphorus loading targets for Lake Erie, and are currently developing an approach to monitor and track progress towards the new targets. The following priorities for research, monitoring and modeling have been identified:
    - Monitoring of total phosphorus and dissolved reactive phosphorus loads and harmful algal blooms and hypoxia extent and duration to evaluate effectiveness of load reduction efforts and the lake's response over time;
    - Research on factors that contribute to toxin production by harmful algal blooms;
    - Better understanding of internal lake phosphorus loads, including factors controlling the growth of the nuisance algae, *Cladophora,* and improvement of ecosystem models to assist in understanding the relationship between external and internal phosphorus loads and the occurrence of algal blooms.

- Figure 9 shows phosphorus loadings data collected in support of the previous targets. Canada and the United States tracked phosphorus loads and sources on a whole-lake basis. The new targets for Lake Erie are refined to specific locations, forms of phosphorus, and time of year. Going forward, tracking and assessments related to these new targets will need refinement and appropriate data collection will be critical to the evaluation of implementation efforts and the Lake's response over time.

Figure 9 – Total phosphorus loads to Lake Erie by source type, 1967 - 2013.



DOMESTIC ACTIONS TAKEN

In the United States, hundreds of millions of dollars are being allocated for a wide array of projects that will reduce the loading of nutrients to the Great Lakes. The U.S. Environmental Protection Agency (EPA) is the coordinating agency for the Great Lakes Restoration Initiative (GLRI) - the largest investment in the Great Lakes in two decades -which is implemented by a task force of 16 federal agencies and many of the region's governors. Federal agencies and their State partners are leveraging GLRI, the Farm Bill, and many other funding resources to enhance existing programs and develop new programs aimed at reducing nutrient loads into the Great Lakes. Some examples of this are highlighted below, with a focus on Lake Erie.

More than 680 projects and $60 million of GLRI funds were invested in the Lake

Erie Basin from 2010 through 2015 to reduce nutrient pollution and to support related science and monitoring work.

While not a comprehensive list, the following summary is intended to convey the scope and variety of nutrient management efforts by federal and state agencies since the 2012 GLWQA was signed in 2013. Major progress is being made to accelerate nutrient reductions on the ground, enhance monitoring and research efforts to better understand the effectiveness of actions taken to reduce nutrient loadings and minimize health impacts associated with harmful algal blooms. Furthermore, many recently adopted strategies, policies and legislative actions in the Great Lakes Region will have lasting impact on protecting human health and the environment from excess nutrients.

Nutrient reductions "on the ground"

- During fiscal year 2015 alone, the GLRI funded nutrient and sediment reduction projects on over 100,000 acres in targeted agricultural watersheds in the Great Lakes Basin. These projects are projected to prevent over 160,000 pounds (72.5 metric tons) of phosphorus from entering the Great Lakes annually. Federal agencies and their partners also funded urban runoff projects that are anticipated to capture an average annual volume of more than 37 million gallons of untreated urban runoff per year. These projects reduce flooding, increase green space in urban areas, and return vacant properties to productive use.

- In 2015, United States Department of Agriculture (USDA) awarded $17.5 million to a Regional Conservation Partnership Program (RCPP) in the western basin of Lake Erie. The targeted approach focuses efforts on the 855,000 acres that have been identified as the most critical areas to treat within the larger 7 million acre watershed. The RCPP project expands access to public and private technical assistance, new and ongoing innovative conservation practices and expertise for modeling and evaluating outcomes to farmers in critical sub-watersheds. The five-year multi-state project includes more than 40 collaborating public and private sector organizations with representation from Ohio, Michigan and Indiana, state and local governments, as well as nonprofit entities, universities and private sector businesses, committing an additional $28 million to the project.

- In 2016, USDA Natural Resources Conservation Service (NRCS) launched a new funding initiative and strategy based on the findings of their special study evaluating the impacts of voluntary conservation in the WLEB and conservation treatment needs. The WLEB Initiative will help landowners reduce phosphorus runoff from farms by more than 640,000 pounds (290 metric tons) each year - 175,000 pounds that is in the form of soluble phosphorus - by effectively doubling the acres under conservation in the Western basin over the course of the three-year investment.

- GLRI funding of more than $1.7 million was provided by NRCS in 2015 to reduce phosphorus runoff and sediment pollution in priority watersheds in the Great Lakes basin through the Great Lakes Sediment and Nutrient Reduction Program. This federal/state partnership coordinated by the Great Lakes Commission was formerly known as the Great Lakes Basin Program for Soil Erosion and Sediment Control, but became the GLSNRP in 2015 to recognize the program's increased emphasis

on phosphorus reduction.

- The GLRI is also accelerating the implementation of conservation practices on Demonstration Farms in the Fox River basin and elsewhere in the region. The farms are open for annual tours where other farmers in the watershed can view the installed practices, hear farmers' opinions on the value that conservation farming practices can add to their farming operations, and ask questions. In 2016, Ohio NRCS and the Ohio Farm Bureau Federation entered into a 5-year agreement to create the Blanchard River Demonstration Farms Network. Three farms committed a total of 700 acres to the Network and will implement standard and innovative conservation systems to reduce the quantity of sediment and phosphorus entering the Western Basin of Lake Erie. Data collected by the USDA Agricultural Research Service (ARS) from edge-of-field water quality monitoring stations will be used to evaluate the effectiveness of these conservation systems. Farmer field days will be held for peer-to-peer education and technology transfer over the life of the project, which was funded in part by the Great Lakes Restoration Initiative.

- Ohio EPA is leading implementation of the Maumee River Sediment and Nutrient Reduction Initiative - a new $3.7M 5-year GLRI initiative comprised of a diverse coalition of 10 public and private entities using innovative agricultural sediment reduction practices and aggressive implementation.

- The Ohio Clean Lakes Initiative appropriated more than $3.55 million for the installation of best management practices (BMPs) to reduce nutrient runoff in the Western Lake Erie Basin. State and local partners worked with more than 350 farmers to implement BMPs on more than 40,000 acres.

- Since 2010, Ohio EPA has awarded more than $292 million in low-interest and interest-free loans from the Water Pollution Control Loan Fund for 138 projects in the Western Lake Erie watershed. These projects help local communities develop and implement long-term control plans to reduce overflows of nutrient-rich sewage into streams and lakes following heavy storms and snow melt.

- Michigan DEQ has been working with Detroit Water and Sewerage Department to proactively take measures to reduce loadings of Total Phosphorus from the Detroit plant, through lower permitted effluent limits and strategies to minimize untreated discharges from combined sewer systems. Optimization of the plant in 2013 has reduced the average annual loading of Total Phosphorus to Lake Erie by ~65 Metric Tons.

- Indiana is working with landowners to help improve the water quality of streams and inland rivers, and ultimately Lake Erie by partnering on several projects which will result in a significant measurable load reductions in nutrients and sediment. A summary of the progress being made in Indiana's portion of the Western Lake Erie Basin can be found at the Indiana State Department of Agriculture website (http://www.in.gov/isda/3261.htm).

- Pennsylvania is working with Lake Erie MS4 municipalities to plan for future stormwater infrastructure needs, and with grape farmers to improve environmental and economic sustainability of their agricultural operations through the Pennsylvania Vested in Environmental Sustainability (PA VinES) Program.

- The New York State Department of Environmental Conservation (DEC) is forming the Lake Erie

Watershed Protection Alliance, comprised of three counties and numerous municipalities within the Lake Erie watershed that will work cooperatively to monitor Lake Erie tributaries and work locally to further reduce sources of nutrients and pathogens. The DEC is also partnering with the State's Department of Agriculture and Markets (DAM) and the Genesee River Watershed Coalition of Conservation Districts to implement a strategy to promote and track the effectiveness of nutrient reduction best management practices among farms in the Genesee River basin (part of the Lake Ontario Watershed), a GLRI Priority Watershed for Nutrient Reduction.

Enhanced monitoring and forecasting tools

- GLRI-funded research led by the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory, in collaboration with partners from the University of Michigan's Cooperative Institute for Limnology and Ecosystems Research, is investigating impact of land use changes on algal bloom development in the western basin of Lake Erie and in Lake Huron's Saginaw Bay. The Great Lakes Environmental Research Laboratory combines remote sensing, monitoring, and modeling to produce weekly forecasts of *Microcystin* bloom concentration and transport in Lake Erie, which are distributed to regional stakeholders. National Oceanic and Atmospheric Administration researchers, with their partners at Heidelberg University, have also initiated early season projections of the seasonal harmful algal bloom severity in western Lake Erie.

- During fiscal year 2015, GLRI partners established a network of four real-time continuous observing buoys to track detailed water quality conditions to support modeling, forecasting, and public warnings of harmful algal bloom conditions throughout western Lake Erie. The observing buoys are capable of tracking water quality and bloom conditions and measuring dissolved phosphorus concentrations at hourly intervals. During the 2015 bloom season, these buoys collected over 7,000 in-lake nutrient and water quality measurements, providing unprecedented spatial and temporal details of internal lake dynamics and bloom development. In addition to providing real-time tracking of harmful algal bloom conditions for water intake managers and recreational users, the observing data will be used to improve ongoing forecasting efforts covering a range of spatial and temporal scales including seasonal harmful algal bloom forecasts, 5-day forecasts, and vertical distribution forecasts.

- After the "do not drink" advisory issued in Toledo, Ohio in August 2014, Ohio passed legislation in July 2015 to address harmful algal blooms and algal toxins at public water supplies. New rules were then finalized in 2016 that established a drinking water action level of microcystins, outlined monitoring requirements for microcystins and cyanobacteria screening, established public notification, reporting, treatment technique and laboratory certification requirements. The State agencies in Ohio also worked together to revise the State's Harmful Algal Bloom Response Strategy for Recreational Waters where HABs exist or are suspected. Ohio is one of the first states to establish formal rules for issuing advisories when algal toxins are present at or above threshold levels.

- In coordination with the Pennsylvania Lake Erie Harmful Algae Bloom (HAB) Task Force, Pennsylvania Department of Environmental Protection began a strategic partnership with the Regional Science Consortium at Presque Isle to complete comprehensive monitoring of Pennsylvania Lake Erie beaches and public areas for the presence of HAB conditions throughout the 2016 season.

- U.S. Geological Survey scientists collect water-flow and water-quality data from 24 tributaries to the Great Lakes to measure natural and human-caused sources of nutrients and sediment to the Lakes. The Great Lakes National Monitoring Network continues to be enhanced through the use of automated samplers and water quality multi sensor probes, to provide better baseline information on nutrient loads and demonstrate the ability to reduce monitoring costs through the use of real-time sensors.

- The National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) is leveraging GLRI funding to develop and implement runoff risk reduction tools aimed at enhancing short-term (next 10 days) nutrient application management. Incorporated into their daily routines, this tool will alert applicators of future unsuitable conditions, from rainfall or snowmelt that could result in undesired transport of recently applied manure and fertilizer from their fields into nearby water bodies.

- Federal agencies and partners are also working to expand edge of field (EOF) monitoring and research, which measures the amount of nutrients and sediment in water runoff from agricultural fields to compare the improvements under different conservation systems. This research is critical to evaluating the effectiveness of agricultural best management practices. The United States Geological Survey is leading a GLRI-funded effort with NRCS and other partners to conduct EOF monitoring on 22 farm sites in the Maumee River basin, the Fox River basin, the Saginaw River basin and the Genesee River basin. These watersheds were selected because of the high density of agricultural land use and their ecosystem impairments.

- Also in partnership with NRCS, the United States Department of Agriculture- Agricultural Research Services (ARS), has an extensive network of 42 EOF study sites in Ohio. The number, quality and spatial extent of this ARS managed effort is unprecedented and science from this work, particularly in conjunction with watershed assessment under NRCS's Conservation Assessment Effects Program, has already been key to assessing losses and informing conservation strategies in the WLEB.

New Nutrient Management Strategies, Policies and Legislative Actions

- In June 2015 Governor Rick Snyder of Michigan, Premier Kathleen Wynne of Ontario and Lieutenant Governor Mary Taylor of Ohio signed the Western Basin of Lake Erie Collaborative Agreement which establishes a collaborative initiative that will use adaptive management to achieve a recommended 40 percent total load reduction in the amount of total and dissolved reactive phosphorus entering the WLEB by the year 2025 with an aspirational interim goal of a 20 percent reduction by 2020. Each state and province committed to developing, with stakeholder involvement, a plan outlining their proposed actions and time lines toward achieving the phosphorus reduction goal. Michigan and Ohio released draft implementation plans in response to this commitment in 2015 and 2016, respectively.

- In May 2014, Ohio Governor John R. Kasich signed into law Senate Bill 150. The bill requires fertilizer applicators to undergo education and certification by Ohio Department of Agriculture (ODA); encourages producers to adopt nutrient management plans; and allows ODA to better track the sales and distribution of fertilizer. In April 2015, the Governor signed Senate Bill 1, legislation to protect Lake Erie and Ohio's water quality. Highlights include: restrictions on fertilizer and manure

application on frozen, snow-covered or saturated ground in the Western Basin Lake Erie watershed; prohibition of open lake disposal of dredge material by 2020; and additional phosphorus monitoring at wastewater treatment facilities.

- Minnesota's landmark buffer law will establish new perennial vegetation buffers along rivers, streams, lakes, public ditches and some wetlands. Buffers protect water resources by helping filter out phosphorus, nitrogen and sediment. Gov. Mark Dayton championed the buffer initiative legislation in the 2015 and 2016 sessions. Studies by the Minnesota Pollution Control Agency (MPCA) show that buffers are critical to protecting and restoring water quality and aquatic habitat.

- In January 2010, New York's Phosphorous Runoff Act went into effect, designed to reduce water pollution caused by excess phosphorus running off lawns into New York waters by restricting sales of all non-agricultural fertilizer to concentrations less than 0.67% phosphate, with certain exceptions. Since 2014-2015, the State Attorney General has reached settlements on violations of the law by major retailers at 12 stores in the Lake Erie/Niagara River basin.

- In June 2014, Congress reauthorized the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) by passing the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 (HABHRCA 2014, P.L. 113-124). The reauthorization of HABHRCA acknowledged concerns related to HABs and hypoxia, extended the scope of the legislation to include freshwater HABs and hypoxia, and recognized the need for further coordinated action across the Federal sector to address these issues. Additionally, the legislation called for Federal agencies to provide integrated assessments on the causes and consequences of and approaches to reducing HABs and hypoxia nationally, with particular emphasis on the Great Lakes. Finally, the reauthorization included a specific focus on the needs of stakeholders, requiring that Federal agencies engage with stakeholders around the country.

- On August 7th, 2015, the President signed H.R. 212 (Drinking Water Protection Act) which directs EPA to develop and submit a strategic plan for assessing and managing risks associated with algal toxins in drinking water provided by public water systems. The resulting *Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water*, released in November 2015, includes steps and timelines to asses: algal toxins and their human health effects, health advisories, factors likely to cause HABs, treatment options, analytical methods, frequency of monitoring, treatment options, and source water protection practices.

- Currently there are no U.S. federal water quality criteria, or regulations for cyanobacteria or cyanotoxins in drinking water under the Safe Drinking Water Act (SDWA) or in ambient waters under the Clean Water Act (CWA). However, under the SDWA, EPA may publish Health Advisories for contaminants that are not subject to any national primary drinking water regulation. EPA developed Health Advisories for the cyanobacterial toxins microcystins and cylindrospermopsin in 2015, and is currently developing Ambient Water Quality Criteria for cyanotoxins for the protection of recreational activities in freshwater systems.

- Ohio EPA is developing Nutrient Water Quality Standards targeting phosphorus and nitrogen in response to U.S. EPA's national nutrient criteria recommendations and the Clean Water Act. In 2013, Ohio EPA asked for public comments from various stakeholder groups. A nutrient technical advisory group will advise Ohio EPA as it moves forward with the next steps in developing nutrient standards.

- As part of Indiana's Nutrient Reduction Strategy, in 2013, the Indiana Conservation Partnership (ICP) began using a common Load Reduction model to track and report the impact of installed conservation practices on water quality. Nutrient and sediment load reductions are estimated from a variety of state and federally funded programs. Indiana is the only state in the country to adopt a common model among so many partners to estimate conservation impact on a statewide scale.

- Following an extensive engagement process, Michigan DEQ's Office of the Great Lakes recently finalized a new Water Strategy built around a 30-year vision for ensuring Michigan's water resources support healthy ecosystems, residents, communities and economies. A key recommendation in the strategy is to achieve a 40 percent reduction to phosphorus in the western Lake Erie basin.

- Canada and Ontario are taking action under the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, 2014, to reduce phosphorus loads to Lake Erie through urban, agricultural, rural and industrial or commercial point and non-point source initiatives including ongoing infrastructure and agricultural stewardship programs. To further improve the effectiveness of current and future phosphorus reduction actions in Lake Erie, Canada and Ontario, along with their partners and stakeholders are working to review and where necessary implement changes to the existing program, policy and legislative phosphorus management frameworks.

- Canada's Great Lakes Nutrient Initiative (2012-2016) enhanced Environment and Climate Canada funding to support the critical science and policy development needed to support the establishment of new phosphorus reduction targets for Lake Erie. Initiative activities included:
    - enhanced water quality monitoring at key locations in the Lake Erie basin – including the Thames River, the Sydenham River, the Detroit River and the Grand River – in order to measure phosphorus concentrations and loads from the Canadian portion of the Lake Erie basin;
    - new modeling and research to enhance understanding of the factors contributing to the reoccurrence of large scale outbreaks of toxic and nuisance algae in Lake Erie;
    - an assessment of current Canadian best practices and policy options for reducing loadings of phosphorus to Lake Erie in order to achieve targets;
    - an assessment of socio-economic costs of algal blooms in Lake Erie;
    - the development of inventories of phosphorus management programs;
    - cost-benefit modeling of phosphorus management in the Grand River basin; and,
    - an assessment of future trends and demographics in urban and agriculture landscapes in the Lake Erie basin.

- Canada's 2016 Federal Budget announced $3.1 million in 2016 to 2017, to Environment and Climate

Change Canada, to continue to improve nearshore water and ecosystem health, by reducing phosphorus and the resulting algae in Lake Erie. With these resources, and building on the work accomplished under the Great Lakes Nutrient Initiative, the focus will shift from setting phosphorus targets to achieving them, including developing a domestic action plan in collaboration with Ontario and other partners, and monitoring and reporting on progress.

- Canada's 2016 Federal Budget also announced a five-year, $5.0 billion investment in water, wastewater and green infrastructure projects across Canada. This includes the $2 billion Clean Water and Wastewater Fund (CWWF), of which $569,642,062 has been allocated for water and wastewater projects in the Province of Ontario. The CWWF, and existing programs such as the New Building Canada Fund – Provincial-Territorial Infrastructure Component (NBCF-PTIC), can address phosphorus loads from municipal wastewater, as well as other priorities. Provinces and territories, in consultation with municipalities, are responsible for identifying projects to be funded through the CWWF and the NBCF-PTIC. As such, it is up to the Province of Ontario to prioritize projects for reducing phosphorous loads in the Great Lakes under these programs.

- Canada continues to invest in research that improves our understanding of phosphorus uptake and movement, and develops best management practices and technologies to improve crop nutrient use efficiency and reduce phosphorus losses from agricultural production to the Great Lakes. Over the last three years, projects funded by Agriculture and Agri-Food Canada have investigated the nature of losses of phosphorus through subsurface tile drains, improved field and regional indicators of risk of phosphorus loss to water, developed tests to indicate availability of phosphorus from different manures and soils to crops and losses by water, and characterized the Canadian Basin of Lake Erie by agricultural production systems (i.e. cropping, livestock, horticulture). Research on Lake Erie is also a priority under the science sector strategy for *Agro-ecosystem Productivity and Health*, which is one of the sector strategies guiding future Agriculture and Agri-Food Canada investment in research.

- Canada has also launched discussions with provinces, towards renewing Canada's federal-provincial agricultural policy framework, called Growing Forward. Discussions on priorities for a renewed Growing Forward agreement will take into consideration agricultural contributions to phosphorus loadings.

- As part of the Growing Forward agreement, the governments of Ontario and Canada launched the Great Lakes Agricultural Stewardship Initiative (http://www.ontariosoilcrop.org/oscia-programs/glasi/), to provide $4 million annually, over 2015 to 2018, in targeted support for farmers in the Lake Erie and Lake St. Clair watersheds, and in Lake Huron's southeast shores watershed. Producers and their advisors will identify ways producers can improve soil health, reduce run-off, modify equipment to address risks related to manure application, create soil erosion control structures, grow cover crops, manage crop residue, and build buffer and shelter strips. As part of this initiative:
    - Sub-watersheds requiring focus and attention have been selected where a systems approach to best management practices will be demonstrated, verified, measured and modelled to determine their reduction of non-point phosphorous loading.
    - Education and outreach projects are underway to promote greater understanding of Great Lakes water quality and to promote the uptake of actions to improve it.
    - The Farmland Health Checkup, a proactive whole farm environmental evaluation was created. The Farmland Health Checkup identifies site specific actions to manage

phosphorus and soil health by teaming farmers with trained agronomic and water quality experts. Cost-share funding is available for implementing identified actions that reduce phosphorus loss and improve soil health.

- Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs funded the Water Resource Adaptation and Management Initiative (WRAMI) and the Water Adaption Management and Quality Initiative (WAMQI) for $3 Million. The WRAMI initiative in 2013 (17 projects) and the expanded WAMQI in 2014 (28 projects) included projects to help Ontario farmers better manage nutrients and minimize off-site impacts of nutrients on surface and ground water quality. Demonstration of technologies such as closed system water recycling, precision manure application, low erosion and cover crop planting were all part of this initiative.

- Ontario's Great Lakes Protection Act, 2015, which received Royal Assent on November 3, 2015, reflects the goals and principles of Ontario's Great Lakes Strategy and enshrines it in law, setting out detailed requirements for strategy contents, reporting and periodic review (https://www.ontario.ca/page/protecting-great-lakes). The Act is designed to help address the significant environmental challenges facing the Great Lakes and St. Lawrence River Basin, including the changing climate. One of the initial priorities identified under the Act for immediate action is reducing harmful algal blooms by committing to establishing at least one target within two years to support the reduction of algal blooms; and act will enable geographically-focused initiatives as a tool for developing and implementing policies to address priority issues, including reducing excessive algae, in a specific location.

- Ontario government researchers are adding to the understanding of harmful algal blooms and nuisance algae by monitoring nearshore water quality at 17 drinking water intake sites in the Great Lakes, including five locations in Lake Erie. The Government of Ontario also monitors 70 sites in nearshore areas of the Great Lakes to track long-term trends in Great Lakes water quality. These long-term data sets, together with special studies in the lakes and their tributaries, advance our understanding of nearshore responses to climate change and other stressors, including changes in nutrient loading.

- In 2013, the Government of Ontario launched the Multi-Watershed Nutrient Study. The seven-year study will examine the management of agricultural land and the extent of nutrient runoff in 11 agricultural watersheds in the basins of Lakes Erie, Ontario and Huron. This will be an ongoing study to determine the role agriculture can play in resolving a very complex issue. Comparative data from previous studies will be used to track changing climate conditions, to develop a "then-and-now" analysis and to model future scenarios.

- The Ministry of Environment and Climate Change together with the Ministry of Agriculture, Food and Rural Affairs ensure the requirements of the Nutrient Management Act and regulations are met by farmers through approval of nutrient management plans and strategies that detail the source, rate, time and placement of nutrients for crop growth. Ontario continues to provide training, examination and certification of professional nutrient management planners which work with farmers to apply environmentally responsible nutrient use. Resources detailing better management practices and regulatory requirements have been updated to be more interactive and easier to use.

- In 2016, the Government of Ontario increased targeted engagement with the agricultural community to encourage organizations and industry to take the lead in addressing the phosphorus

issue. A working group, composed of farmers, conservation authorities, agri-business and farm organizations, was convened to discuss and analyze key priorities to identify and implement additional actions to improve water quality. Topics included timing of application of nutrients and expanded use of cover crops. Workgroup members have initiated pilot projects to support further uptake of actions by farmers such as: in-field demonstrations; education workshops; best management practices toolkits; performance standards coaches for nutrient management; and research to support continuous improvement.

- The Government of Ontario worked with the Ontario Greenhouse Alliance on an overall strategy to reduce phosphorous discharges into to the Leamington tributaries – a priority watershed under the 2012 GLWQA due to the presence of nearshore algae blooms. In January 2015, as part of this strategy the Government of Ontario instituted new regulations, under the Nutrient Management Act, to provide an effective option whereby nutrients that can no longer be used in the greenhouse, may be applied to field crops. In the spring of 2016, growers were offered additional information and cost-share support to help them achieve compliance approval for surface water discharges by March 31, 2017.

- 4Rs Nutrient Stewardship is an internationally recognized approach based on core scientific principles of applying the right source of plant nutrition, at the right rate, at the right time, and in the right place to improve nutrient use efficiency to reduce any potential nutrient loss into the environment. As a result of the partnership of the Ontario Ministry of Agriculture, Food and Rural Affairs, Fertilizer Canada, and the Ontario Agri Business Association, Ontario is piloting 4R initiatives ahead of broader implementation across the Lake Erie basin and has successfully:
    - Implemented 20 4R Demonstration Farms;
    - Reached more than 115 Ontario growers through 4R Nutrient Stewardship Workshops;
    - Enrolled 21 agri-retailers in the Ontario Agri Business Association's voluntary 4R Designated Acres pilot program; and
    - Launched the Ontario Certified Crop Advisor 4R Nutrient Management Specialty Certification; 65 of Ontario's Certified Crop Advisors are registered to write the certification exam in August 2016.

- Between 2013 and 2016, Ontario Ministry of Agriculture, Food and Rural Affair's research programs, University of Guelph Partnership and New Directions, provided approximately $3.4 million in direct project operating funding to 25 research projects that targeted improvement of agri-food sector's water quality and nutrient management efficiency in the Great Lakes watershed. Another $1 million since 2013 in 21 applied field projects verified and demonstrated best management practices to support the reduction of phosphorus to Lake Erie. The objectives of these research projects include development and evaluation of wastewater treatment technologies/best management practices, improvement of nitrogen use efficiency in crops, understanding phosphorus dynamics and non-point sources in the field, groundwater quality and soil health. The major research collaborators/partners include primary producers, food processors, Ontario universities and colleges, conservation authorities and non-governmental organizations.

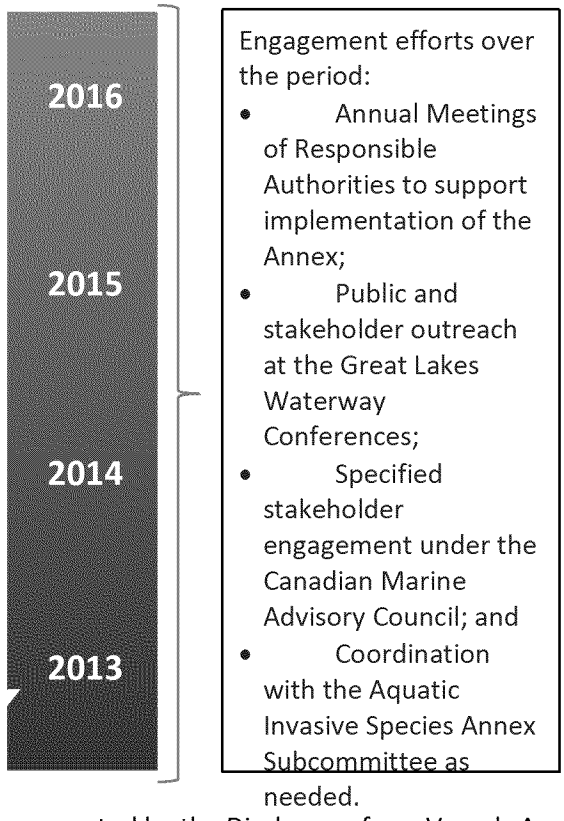
DISCHARGES FROM VESSELS ANNEX

OVERVIEW

The Great Lakes and St. Lawrence Seaway System is a binational trade route that supports tens of thousands of jobs on both sides of the border and serves as a critical transportation corridor for commodities such as iron ore, coal, minerals and grain. Canada and the United States recognize the environmental and economic importance of this system and ensuring it is safeguarded. The Discharges from Vessels Annex of the 2012 GLWQA commits the responsible authorities in Canada and the United States (Transport Canada, Fisheries and Oceans Canada, the Canadian Coast Guard, the United States Coast Guard, and the United States Environmental Protection Agency) to prevent and control vessel discharges that are harmful to the waters of the Great Lakes, including: Oil and hazardous Polluting Substances; Garbage; Wastewater and Sewage; Biofouling; Antifouling Systems; and Ballast Water.

Under the 1987 GLWQA, biennial reports to the International Joint Commission from the responsible Canadian and the United States agencies (last submitted in 2012) consistently indicated that potential discharges of oil and hazardous substances, garbage, wastewater, ballast water and sewage from vessels are well regulated and that sufficient reception facilities are available to receive discharges ashore. This continues to be the case as enforcement of Canadian and United States domestic regulatory regimes and applicable international conventions has reduced the risk of discharges of concern from vessels. Canada and the United States are committed to the continued prevention and reduction of threats to the waters of the Great Lakes from all vessel discharges.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex's implementation is supported by the Discharges from Vessels Annex Subcommittee, co-led by Transport Canada and the United States Coast Guard. Organizations on the subcommittee include: Transport Canada, Fisheries and Oceans Canada, Canadian Coast Guard, Ontario Ministry of Transportation, United States Coast Guard, United States Environmental Protection Agency, Wisconsin Department of Natural Resources, Indiana Department of Environmental Management, United States Maritime Administration, Lake Carriers Association, Shipping Federation of Canada, Canadian Ship Owners Association [logos to be inserted].

BINATIONAL ACTIONS TAKEN

Preventing the discharge of Oil and Hazardous Polluting Substances from vessels.

- Transport Canada and the United States Coast Guard have a compatible and effective port and flag state regulatory regime in place to prevent the discharge of oil or hazardous substances on the Great Lakes from vessels and maritime transportation-related facilities that transfer oil or hazardous substances in bulk. The countries' port state control initiatives are risk-based vessel examination programs focused on foreign-flag vessels (non-Party) that operate in their respective waters to ensure compliance with international conventions and the Parties' laws and regulations. The Parties' flag-state programs ensure comparable compliance by the Canadian or United States flag fleets.
- In response to the possibility of the maritime transportation of crude or other heavy oils on the Great Lakes, Canada and the United States created a working group on Maritime Transportation of Hydrocarbons and their by-products. This multi-agency group, chaired by the Transport Canada and the United States Coast Guard, serves as a binational forum to facilitate discussions regarding

maritime shipments of hydrocarbons and their by-products (defined initially as crude oil and associated bulk liquids) and address any concerns that may arise in a coherent and consistent manner. The initial focus of this work is on freshwater, including the Great Lakes and its tributaries, and the St. Lawrence River and Seaway. A phased workplan has been developed and will focus on areas of mutual interest in preparedness, response, liability, and compensation.

Addressing the discharge of Garbage from vessels.

- The illegal discharge of Garbage from commercial vessels in the Great Lakes continues to be a rare event. For the Great Lakes and the coasts, the majority of marine debris entering the water comes from shore side sources.

- No enforcement events for violations of the International Convention for the Prevention of Pollution from Ships Annex V (MARPOL V) or other garbage-related incidents were reported between 2013 and 2016.

Ensuring adequate reception facilities for Garbage from vessels.

- Both Parties indicate there are sufficient and adequate MARPOL V reception facilities on the Great Lakes. There has not been a validated report of an inadequate reception facility on the Great Lakes since 2006.

Addressing the discharge of Wastewater and Sewage from vessels.

- Several Great Lakes states have established "no discharge zones" of sewage in their respective waters in accordance with the United States Clean Water Act. Since Marine Sanitation Devices on most vessels are designed for continuous operations, it has been reported that some vessels with no or insufficient holding tanks have been forced to divert untreated sewage or treated effluent to ballast tanks to remain in compliance. Both Canada and the United States are in agreement that ballast tanks are not an appropriate place to store sewage – treated or untreated.

Preventing harm from vessels' Antifouling Systems.

- Both Canada and the United States have regulations or policies in place implementing the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (IAFS), which ensures anti-fouling paint applied to vessels is free of tributyltin. Anti-fouling paint containing tributyltin is not available for sale on either side of the border. Both countries issue IAFS certificates to their flag state vessels and incorporate the IAFS in their respective Port State Control enforcement programs.

Addressing the discharge of Aquatic Invasive Species in the Ballast Water from vessels.

- The risk of the introduction of aquatic invasive species (AIS) to the Great Lakes via ballast water discharges from vessels arriving from outside of Canada's Exclusive Economic Zones[1] has been substantially reduced. Because of compatible ballast water exchange regulations between Canada and the United States and stringent binational enforcement, no new AIS attributable to the ballast water of these ships has been reported in the Great Lakes since 2006. Since that date, the Ballast Water Working Group[2] has examined 100% of these vessels. During these ballast management exams, 100% of the vessels' ballast tanks are examined to ensure that tanks have been fully exchanged or sufficiently flushed with sea water. Vessels that had not exchanged their ballast water or flushed their ballast tanks were required to either retain the ballast water and residuals onboard, treat the ballast water in an environmentally sound and approved manner, or return to sea to conduct a ballast water exchange. Vessels that were unable to exchange their ballast water or residuals and that were required to retain them onboard received a verification exam during their outbound transit, prior to exiting the Seaway. The Ballast Water Working Group verification efforts indicated that there was no non-compliant ballast water discharged in the Great Lakes. The Ballast Water Working Group annual reports for the past three years can be accessed at:
    - http://www.greatlakes-seaway.com/en/pdf/2014_BW_Rpt_EN.pdf
    - http://www.greatlakes-seaway.com/en/pdf/2013_BW_Rpt_EN.pdf
    - http://www.greatlakes-seaway.com/en/pdf/2012_BW_Rpt_EN.pdf

- Significant work is underway to move the current exchange-based programs to binationally compatible technology-based regimes that will require treatment of all ballast water to a common discharge standard and address the risk of spreading organisms. As agreed in the 2012 GLWQA, both Parties are taking into account, as appropriate, the standards set forth in the International *Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (the "BWM Convention") and its associated guidance. Canada has acceded to the BWM Convention while the United States Environmental Protection Agency, the United States Coast Guard, and the American Great Lakes States have established requirements under the *National Invasive Species Act* and the *Clean Water Act.* While there are differences between these approaches, the United States and Canada continue to work closely together – including bilaterally through annual meetings of the responsible authorities outlined in the Discharges from Vessels Annex and at the International Maritime Organization – towards maintaining compatible, fair, practicable and environmentally protective ballast water requirements in both countries.

Preventing the discharge of Biofouling from vessels.

- Both Canada and the United States have participated in the development of the International Maritime Organization's *2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species*.

[1] In relation to the Great Lakes, the Exclusive Economic Zones stretches 200 nautical miles from Atlantic coast and includes the Gulf of St. Lawrence.

[2] The Ballast Water Working Group is comprised of representatives from the United States Coast Guard, the U.S. Saint Lawrence Seaway Development Corporation, Transport Canada, and the Canadian St. Lawrence Seaway Management Corporation. Created in 2006, the group's mandate is to develop, enhance, and coordinate binational compliance and enforcement efforts to reduce the introduction of aquatic invasive species by transoceanic ships via ballast water and residuals.

DOMESTIC ACTIONS TAKEN

Ballast Water

- Were the BWM Convention to enter into force now, technical and regional compatibility factors would pose challenges to ships operating primarily on the Great Lakes-St. Lawrence Seaway system. As this Convention has not yet entered into force, Canada will continue to monitor these challenges and is considering options in case these challenges persist upon the Convention's entry into force. Canada remains committed to the Convention and will continue to work with the United States and other stakeholders towards compatible, fair, practicable and environmentally protective Great Lakes requirements meeting Canada's international obligations.

- Canada also continues to actively conduct ballast water research applicable to the Great Lakes. Results of a recent national risk assessment indicate that the ballast water transported by Great Lakes ships poses a high risk for spreading aquatic invasive species between ports in Canada and the United States when compared with the ballast water transported by international vessels (which are subject to regulations in both countries focused on lowering the risk of introductions from foreign ports). The following ballast water research studies undertaken by Canada since 2012:
  - Combining ballast water exchange and treatment to maximize prevention of species introductions to freshwater ecosystems (http://pubs.acs.org/doi/abs/10.1021/acs.est.5b01795)
  - Are the Great Lakes at risk of new fish invasions from trans-Atlantic shipping? (http://www.sciencedirect.com/science/article/pii/S0380133015001422)
  - Relative Invasion Risk for Plankton across Marine and Freshwater Systems: Examining Efficacy of Proposed International Ballast Water Discharge Standards (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0118267)
  - National risk assessment for introduction of aquatic nonindigenous species to Canada by ballast water (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2013/2013_128-eng.html)
  - Evaluating efficacy of a ballast water filtration system for reducing spread of aquatic species in freshwater ecosystems (http://www.reabic.net/journals/mbi/2014/3/MBI_2014_Briski_etal.pdf)
  - Domestic ships as a potential pathway of nonindigenous species from the St. Lawrence River to the Great Lakes (http://link.springer.com/article/10.1007%2Fs10530-013-0537-5)
  - Physical dispersion and dilution of ballast water discharge in the St. Clair River: Implications for biological invasions (http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20201/abstract)
  - Taxon- and vector-specific variation in species richness and abundance during the transport stage of biological invasions (http://www.aslo.org/lo/toc/vol_58/issue_4/1361.html)
  - A multi-dimensional approach to invasive species prevention (http://pubs.acs.org/doi/abs/10.1021/es3029445)

- Role of domestic shipping in the introduction or secondary spread of nonindigenous species: biological invasions within the Laurentian Great Lakes (http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2012.02186.x/full)
- Efficacy of NaCl brine for treatment of ballast water against freshwater invasions (http://www.sciencedirect.com/science/article/pii/S0380133011002176)
- Risk assessment for ship-mediated introductions of aquatic nonindigenous species to the Great Lakes and freshwater St. Lawrence River (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2011/2011_104-eng.html)
- Transactions on Ballast Water Treatment Systems for the Great Lakes-St. Lawrence Seaway System (https://www.tc.gc.ca/media/documents/marinesafety/Transactions_for_BWTS_on_the_Great_Lakes_-_Transport_Canada.pdf)

Oil and Hazardous Substances

- On August 28, 2015, the marine archaeological group, Cleveland Underwater Explorers (CLUE), discovered the barge ARGO (which had sunk during a storm in 1937 while carrying approximately 200,000 gallons of petroleum product – believed to be benzol and/or a light petroleum variant) approximately nine miles east of Kelleys Island and two miles south of the international border with Canada in approximately 13 meters of water. On September 8, 2015, CLUE notified the United States Coast Guard of the discovery. The GLEC was notified of a suspected minor discharge of product from the barge in accordance with Article 6 (a) of the 2012 GLWQA, and soon after, a Unified Command consisting of the Ohio Environmental Protection Agency and the United States Coast Guard was established. Assistance was provided by the United States Environmental Protection Agency, Ohio Department of Natural Resources, National Oceanic and Atmospheric Administration, Ohio Emergency Management Agency, Canadian Coast Guard, and Environment and Climate Change Canada. Over the following six weeks, the Unified Command oversaw the survey of the tank barge, preparations for the safe removal of several thousand gallons of a benzene-type hazardous substance from two of the barge's tanks.

Ballast Water

- The United States Coast Guard continues to implement its rulemaking that established a performance standard for the allowable concentration of living organisms in ballast water discharged from ships in waters of the United States. Five independent laboratories are in the process of testing multiple systems for type approval[3]. Numerous additional vendors have filed a Letter of Intent to begin type approval testing.
- Additionally, the Coast Guard currently has issued 56 interim Alternative Management System

[3] Type Approval is the primary process for equipment and materials to receive United States Coast Guard approval. See http://www.uscg.mil/hq/cg5/cg5214/eqpt_approval.asp for further information.

determinations for ballast water treatment systems and the Coast Guard expects type approval applications from several of these manufacturers. These designations are intended as a bridging strategy to allow for the use of Ballast Water treatment systems that are type-approved by foreign administrations in accordance with the International Maritime Organization Ballast Water Management Convention of 2004.

- The first four ballast water management systems (BWMSs) type approval applications submitted to the Coast Guard proposed using an alternative test method of determining the efficacy of the ultraviolet BWMSs. A subsequent Coast Guard review concluded that the alternative test method was not equivalent because it does not measure the efficacy of the BWMSs to the required performance standard required by the regulations and the BWMSs were not approved.

- Through the Great Lakes Restoration Initiation, the United States supported the independent performance testing of ballast water systems for use in freshwater ecosystems. During 2013 to 2015, numerous ballast water systems were tested at the Great Ships Initiative facility in Superior, Wisconsin. The Great Ships Initiative (www.greatlakesinitiative.org) mission is to accelerate research, development and implementation of effective ballast water management systems (BWMSs) on board commercial vessels that visit the Great Lakes region from abroad.

- In addition, the following ballast water research studies undertaken by the United States:
  - Investigation Of Ballast Water Treatment's Effect On Corrosion (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA613423)
  - Ballast Water Treatment, U.S. Great Lakes Bulk Carrier Engineering and Cost Study, Volume 1: Present Conditions (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA589870)
  - Ballast Water Treatment, U.S. Great Lakes Bulk Carrier Engineering and Cost Study, Volume 2: Analysis of On-Board Treatment Methods, Alternative Ballast Water Management Practices, and Implementation Costs (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA589362)
  - Results of Shipboard Approval Tests of Ballast Water Treatment Systems in Freshwater (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA613767)
  - Efficacy of Ballast Water Treatment Systems: A Report by the EPA Science Advisory Board (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA550605).

Rather than do track changes, this new binational write-up from Annex 6 is simply cut and pasted in with one U.S. edit in track changes (see below):

AQUATIC INVASIVE SPECIES ANNEX

OVERVIEW

Aquatic invasive species (AIS) currently in the Great Lakes are undermining efforts to restore and protect ecosystem integrity and water quality. These organisms have re-engineered the Great Lakes, the way nutrients and chemical contaminants move within the ecosystem, affecting the productivity of the lakes and disrupting integrity of food webs. These ecological effects of AIS have resulted in significant socio-economic impacts on the Canadians and Americans whom depend on the Great Lakes.

New potential invaders, such as Asian carps, threaten to further disrupt the integrity of Great Lakes ecosystems.

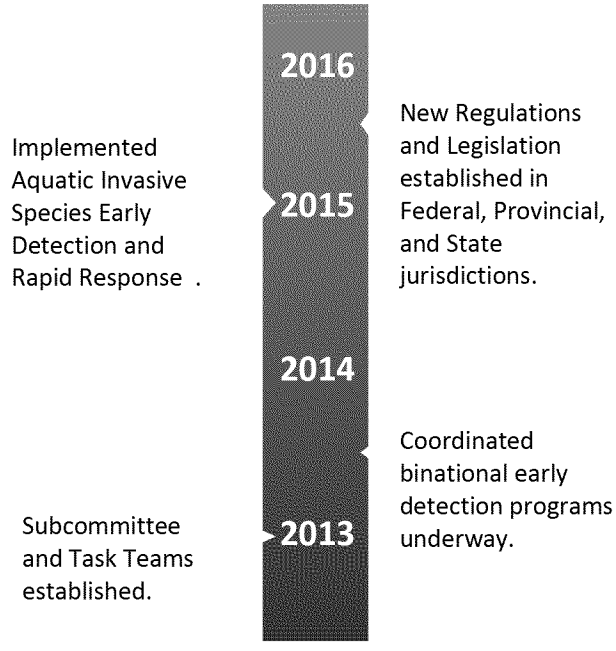
After invasive species become established in the Great Lakes, they are costly to control and nearly impossible to eradicate. Consequently, prevention is the most effective approach to dealing with these threats. The 2012 GLWQA commits the United States and Canada to: 1) preventing the introduction of AIS; 2) controlling or reducing the spread of existing AIS; and 3) eradicating, where feasible, existing AIS within the ecosystem.

The United States and Canada are working to identify and minimize the risk of Asian carps and other species invading the Great Lakes using a risk-assessment approach to better understand the risks posed by species and pathways and by implementing actions to manage those risks. Through efforts of federal, state, and provincial agencies, Canada and the United States have developed and implemented an early detection and rapid response initiative with the goal of finding new invaders and preventing them from establishing self-sustaining populations. This basin-wide effort resulted in several new detections of Grass Carp that triggered coordinated rapid responses by all involved agencies.

Coordinated actions have had significant success! As described, in the previous chapter about *Discharges from Vessels*, United States and Canadian regulations requiring ships to exchange their ballast water with salt water from the open ocean and a coordinated program of monitoring compliance of 100% of ships entering the St. Lawrence Seaway, no new invaders have been introduced by ships since 2006 (see Figure x).). The efforts undertaken since the inception of the 2012 GLWQA have contributed to the continuing success of no new AIS being known to have become established in the Great Lakes.

The threat of new AIS is ever present and, in spite of this success, continued and new actions are critical. For example, the recently detected evidence of Grass Carp reproduction in the Sandusky River, a tributary to Lake Erie in north-central Ohio in the United States, is of great concern. The United States and Canada are committed to further improving and strengthening the AIS actions and initiatives under the Aquatic Invasive Species Annex.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex is being implemented by the Aquatic Invasive Species (AIS) Annex Subcommittee, co-led by the United States Fish and Wildlife Service and Fisheries and Oceans Canada. The AIS Annex Subcommittee delivers its work in close cooperation with the Great Lakes Panel on Aquatic Nuisance Species, which is supported by the Great Lakes Commission and is partially funded by the United States Fish and Wildlife Service. Organizations on the subcommittee include:

BINATIONAL ACTIONS TAKEN

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- The United States and Canada undertook a review of existing species risks assessments, in coordination with Great Lakes jurisdictions and their partners. Based on this analysis, a binational assessment of the ecological risks and impacts related to Grass Carp establishment was completed, and is being peer reviewed. A similar binational risk assessment is being completed for Black Carp, currently known to occur in the middle Mississippi River and the last of the four Asian carp species that potentially threatens the Great Lakes.

- In 2013, the Conference of Great Lakes and St. Lawrence Governors and Premiers established a list of 16 "least wanted" species for the Great Lakes, based on a review of risk assessments by their Aquatic Invasive Species Task Group.

- Members of the Aquatic Invasive Species Annex Subcommittee are supporting work of the Conference of Great Lakes and St. Lawrence Governors and Premiers Aquatic Invasive Species Task Group to harmonize approaches to address aquatic invasive species across the basin with a focus on species risk assessments.

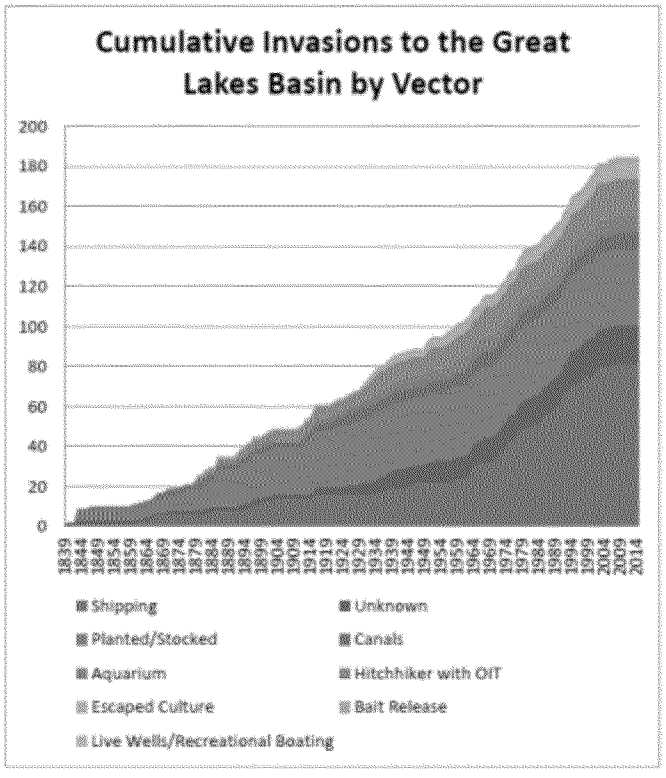
- A risk analysis of illegal trade and transport into Great Lakes jurisdictions was completed and a report of these findings was delivered to the Great Lakes Fishery Commission's binational Law Enforcement Committee. The report recommends risk management efforts to address the unacceptable risks documented for species regulated by state, provincial, and federal agencies in the internet, live bait, live food, aquaculture, private pond/lake stocking, water garden, aquarium/pet, and cultural release pathways. The AIS Subcommittee will continue to work with the Law Enforcement Committee to address risk management needs described in the risk analysis report.

- A new web-based tool called, *Great Lakes Detector of Invasive Aquatics in Trade*, has been developed by the Great Lakes Commission to better quantify the threat posed by the internet commerce pathway. The tool is available to managers in the United States and Canada to inform and help target risk assessment, monitoring and surveillance, and enforcement of aquatic invasive species available for purchase on the internet.

- In the United States, a government-industry partnership is working toward development of new United States recreational boat design standards for building new "AIS-Safe Boats," and development of United States standards for AIS removal from existing recreational boats.

- In Canada, a National Recreational Boating Risk Assessment, with focus on the potential movement of AIS within Canadian and United States waters of the Great Lakes, was carried out during 2015, and the products of this assessment will assist in identifying areas to focus on minimizing risk of recreational boaters spreading AIS.

Figure x - Joint United States and Canada ballast water exchange management success in preventing invaders

Historically, an average of one non-native species was found to be established in the Great Lakes about every 8 months. Most of those introductions resulted from ballast water discharge. No ballast-mediated introductions, and no additional introductions from other pathways, have resulted in establishment of a non-native species since 2008. The success of joint United States and Canada ballast water exchange management has been a major contributor, with no new introductions attributable to ships since 2006.	 *Source R. Sturtevant, GLANSIS-NOAA*

Undertaking outreach and engagement in support of meeting various annex commitments.

- While most outreach and engagement efforts are implemented domestically, experts from government agencies and non-government groups are working across jurisdictional lines to share resources and approaches that modify human behavior so as to minimize risk of people spreading AIS.

- To support this work, the binational Great Lakes Panel on Aquatic Nuisance Species' Information and Education Committee developed a synthesis of communication and education campaigns, programs, and products, which support prevention efforts for a variety of pathways, including recreational boating.

By 2015, develop and implement an Aquatic Invasive Species early detection and rapid response initiative.

- The United States and Canada developed an AIS early detection and rapid response initiative which included a number of strategies to prevent the introduction and spread of AIS. Early detection and rapid response provide a strong second line of defense to augment species prevention efforts by quickly finding AIS populations, including Asian carps, while they are still contained within relatively small areas and preventing them from becoming established. These efforts mark the first basin-wide early detection network in the history of the Great Lakes, an effort that will be strengthened

and enhanced in the future. A full account of the achievements to date under the initiative is available at www.binational.net (http://binational.net/2015/02/23/ais-early-detection/).

- Key components of the AIS early detection and rapid response initiative include:
  - An "AIS species watch list" of those species of the highest priority and likelihood of risk of invading the Great Lakes.
  - A list of priority locations to undertake surveillance for the potential introduction of species on the "AIS species watch list";
  - Protocols for systematically conducting monitoring and surveillance methodologies (such as sampling for environmental DNA (i.e. "free" DNA found in water) and sampling using gears that collect fishes and bottom-dwelling invertebrates) so that a potential invader is promptly observed and reported;
  - The sharing of relevant information amongst the responsible departments and agencies to ensure prompt detection of invaders and prompt coordinated actions to respond to them; and
  - The coordination of plans and preparations for any response actions necessary to prevent the establishment of newly detected AIS.

- The Conference of Great Lakes and St. Lawrence Governors and Premiers provided critical leadership with the establishment of a Mutual Aid Agreement to empower the states and provinces to work collaboratively and to share resources and expertise to deal with AIS that pose a regional threat.

Implementing early detection and rapid response.

- Binational early detection and rapid response for Asian carps have been a focus for Canada and the United States. The Asian carp actions include: establishing priority locations for potential invasion guided by risk assessments; sharing protocols for early detection monitoring; coordinated communication protocols; and coordinated response planning.

- Detections of Grass Carp in Canadian waters triggered fully coordinated implementation of response plans under the incident command system. Those successful responses provided real-world testing of the Canadian domestic response framework.

- On Lake Superior, a binational early detection program has been implemented by the United States federal, state, and tribal agencies and the province of Ontario. This coordinated effort has benefited from a performance evaluation of early detection monitoring surveillance programs which revealed new opportunities to substantially increase the speed and sensitivity of detecting newly-introduced species. By focusing efforts on areas within ports known to carry rare and invasive species, and by increasing the use of sampling equipment that captures a wide diversity of organisms, the effectiveness at detecting invasive species has nearly doubled. To continue improvement in the future, the United States Environmental Protection Agency, the United States Fish and Wildlife Service, and their partners, have implemented an adaptive management approach using a cycle of review and ongoing refinement of the surveillance program.

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

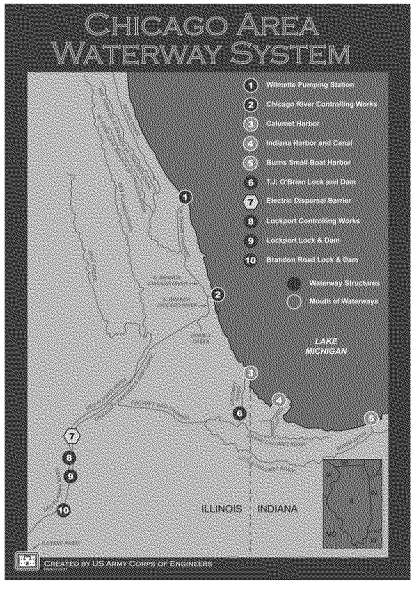
- The Asian Carp Regional Coordinating Committee provides a forum for coordination of new research about how to detect, control or contain Asian carps. The critical exchange of science ensures that research in the United States and in Canada is complementary and synergistic.

- The Great Lakes Fishery Commission, working with the UNITED STATES Geological Survey, United States Fish and Wildlfe Service, and Fisheries and Oceans Canada, delivers an ongoing binational research effort to find new ways to control Sea Lampreys and to improve the methods that are used today. An example of a new tool is the Sea Lamprey mating pheromone, 3kPZS, which was official registered in the United States and Canada as the first ever vertebrate pheromone biopesticide. Like an alluring perfume, the mating pheromone is a scent released by male Sea Lampreys to lure females onto nesting sites. The mating pheromone has been used as bait in traps that collect and remove adult Sea Lampreys before they have a chance to spawn. Research and development of the mating pheromone was funded by the Great Lakes Fishery Commission, with additional support from the Great Lakes Restoration Initiative, in collaboration with federal governments, university, and private industry partners.

Figure x – Battling Asian Carp Together

The Asian Carp Regional Coordinating Committee (ACRCC) was formed in 2009 to address the	

growing threat from established and expanding populations of Asian carps in the Mississippi River basin with the focus on Great Lakes protection. The ACRCC, co-chaired by the United States. Environmental Protection Agency and United States Fish and Wildlife Service, has grown to a bi-national partnership of 27 United States and Canadian federal, state, provincial, and local government agencies working in coordination to prevent the introduction, establishment, and spread of Bighead, Black, Grass, and Silver carp populations in the Great Lakes. The ACRCC has developed a comprehensive, multi-pronged approach, heavily focused on prevention and control opportunities in the Illinois Waterway and Chicago Area Waterway System as the primary potential pathway for dispersal toward the Great Lakes; basin-wide, bi-national surveillance and early detection for Asian carp; and assessment and closure of secondary pathways of potential introduction in Indiana and Ohio, as indicated in the Great Lakes and Mississippi River Interbasin Study (GLMRIS). The ACRCC approach, embodied in its annual strategy, the Asian Carp Action Plan (Action Plan) (http://www.asiancarp.us/documents/2016AsianCarpActionPlan.pdf), has evolved to include progressively more aggressive Asian carp management through targeted removal of Bighead and Silver carp in upstream locations in the Illinois Waterway; development of increasingly advanced genetics-based early detection technologies for use in basin-wide monitoring; use of risk assessment to inform the implementation of key management projects (e.g. to achieve GLMRIS pathway closures, and to guide Grass Carp surveillance in Canadian waters) and studies of additional possible pathways of introduction, including potential entrainment and transit of small fish in barges; the identification and development of new potential control tools and integrated pest management strategies; and comprehensive communications on Asian carp developments with policy makers, partners and stakeholders in the United States and Canada. While a key component in the strategy for Great Lakes defense remains the operation and expansion of the Corps of Engineers' electric dispersal barrier system near Chicago, the Action Plan has evolved to include a holistic portfolio of over 60 projects being implemented by member agencies, supported through federal, state and provincial agency base funds and the Great Lakes Restoration Initiative. The Action Plan is complemented by the partnership's annual Monitoring and Response Plan (http://www.asiancarp.us/documents/MRP2016.pdf), the tactical plan that prescribes the specific time, location, and duration of the many coordinated agency monitoring and control actions conducted throughout the year. The 2016 Monitoring and Response Plan includes new contingency for "emergency response" plans that provide specific recommendations of "shelf-ready" rapid-response control options currently available for use by the State and Federal response agencies in the event the upstream movement of any life stage of Asian carp is detected above a pre-determined threshold in key upstream navigation pools in the Illinois Waterway and the Chicago Area Waterway System. The primary focus of the contingency plans is on actions for defending navigation pools in the Illinois Waterway immediately downstream of the Brandon Road Lock and Dam. The ACRCC continues to strategically contain established populations of Asian carps below that lock and dam to prevent Asian carp population establishment in the Great Lakes. Additional information on the ACRCC partnership's bi-national efforts can be found at www.asiancarp.us and www.asiancarp.ca.



DOMESTIC ACTIONS TAKEN

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- Approximately 160 risk assessments were conducted by the United States on non-native species and published on www.fws.gov (http://www.fws.gov/fisheries/ANS/species_erss_reports.html) These risk assessments have identified high risk fish, crustaceans, and mollusks that thrive in climates similar to the Great Lakes Basin and could become established if they are introduced in large enough numbers.

    - The risk of barge shipping-related inadvertent entrainment and transport of small fishes within the Chicago Area Waterway System was evaluated, and the resulting report delivered to the Asian Carp Regional Coordinating Committee, industry, and the public. Results indicate that small free-swimming fish, including surrogate fish placed in and around barges by researchers and wild fish, can become trapped and remain between barges for substantial distances. In one trial, live fish were transported more than nine miles up the Illinois Waterway and Chicago Area Waterway System, travelling progressively upstream through the Brandon Road Pool, Lockport Lock, and, finally, the United States Army Corps of Engineers' electric dispersal barriers near Chicago. Further studies on the susceptibility of actual small (juvenile) Asian carps to becoming entrained and transported under realistic conditions, methods to clear all fish from these barge-to-barge junction spaces, and improvements in barge operation best management practices to minimize likelihood of entrainment are being pursued to reduce this risk.

Preventing introduction and spread of Aquatic Invasive Species through regulations.

- Based on risk assessments and supporting science, the state of Michigan amended its prohibited species list in regulation to include several new invasive species. Additional information can be found at: http://www.michigan.gov/invasives/0,5664,7-324-68071---,00.html.

- Similarly, the State of New York has recently amended their regulations, effective March 2015, to prohibit species to affect more control of the risk of new invaders. Additional information can be found at http://www.dec.ny.gov/animals/99141.html.

- The United States Fish and Wildlife Service has proposed adding 11 non-native freshwater species to the list of injurious species under the Lacey act. Ten fishes (Crucian Carp, Eurasian Minnow, Prussian Carp, Roach, Stone Moroko, Nile Perch, Amur Sleeper, European Perch, Zander, Wels Catfish) and one crayfish (common yabby) are included in the proposed rulemaking. A final rule is planned for release in 2016.

Implementing early detection and rapid response.

- Great Lakes states have been actively monitoring and responding to detections of invasive species, including recent response actions following detection of invasive Water lettuce, New Zealand Mudsnail, Parrot Feather, Red Swamp Crayfish, Water Hyacinth, Water Chestnut, European Frogbit, Starry Stonewort, Northern Snakehead, and small killifish (Mummichog).

- The invasive species Hydrilla was discovered in the Cayuga Lake Inlet and Erie Canal in central New York. Aggressive eradication projects started at both locations in response to concerns about the spread of this invasive plant species throughout the Great Lakes basin. Despite signs of a successful control, eradication may take several more years due to ability of root systems to lay dormant in the sediment. More information about Hydrilla can be found at http://stophydrillawny.org/.

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

- U.S. federal partners carried out development and testing to advance the use of near-real time environmental DNA (eDNA)-based analysis in the field to support law enforcement efforts for effectively detecting and interdicting illegal transport of Asian carp species into Great Lakes jurisdictions (eDNA is the "free" genetic material left behind by an organism and evident in water column).

- United States federal partners continue to evaluate the potential use of carbon dioxide as an environmentally sound approach to help contain or repel Asian carps in strategic confined locations (e.g. lock and dam approach channels, river/embayment confluences) to prevent additional introductions and limit further range expansion.

- Work was initiated in the United States on the development and testing of a system to deliver a piscicide (Antymicin) that can kill Bighead and Silver Carps while not harming other fishes. This technology could be used to reduce populations in the Chicago Area Waterway System and Illinois River, which would further reduce the risk of Asian carps becoming established in the Great Lakes.

- New molecular genetic techniques are being developed for detecting rare invasive species. Current research efforts funded by the Great Lakes Restoration Initiative (GLRI) have focused on: 1) expanding the use of environmental DNA; 2) genetic analyses of larval fish samples to detect the reproduction of invasive fishes; and 3) genetic analyses of lake sediments or benthos for detection of invasive species such as the Zebra Mussel, Quagga Mussel, and New Zealand Mudsnail. The current trend of advancing molecular genetic methods coupled with decreasing costs is highly promising.

- Based on extensive testing, the commercial product "Zequanox" was approved for open-water use to control invasive Zebra and Quagga mussels in lakes and rivers. United States agency and academic partners are exploring its strategic use in the Great lakes and inland lakes. Zequanox is composed of dead cells derived from a naturally occurring soil microbe, and it controls invasive

mussels in all life stages. Its active ingredient has low toxicity and presents little risk to non-target organisms.

- The United States is funding and supporting new methods to control the spread of invasive aquatic plant *Phragmities* including:
    - Research at Cornell University to identify insects that kill *Phragmites*. The researchers are evaluating the host-specificity of each insect species in preparation for wide-spread releases of insects that may help control *Phragmites* populations.
    - Work by the United States Geological Survey and its partners to identify the fungal microbes that help provide nutrients to nonnative *Phragmites*, and work to find ways to slow *Phragmites* growth by disrupting this symbiotic relationship.
    - Work by Wayne State University and United States Geological Survey scientists to silence important genes in *Phragmites* (e.g., those for flowering, seed set, and photosynthesis) in an effort to reduce its competitive advantage. Cooperating scientists are testing gene silencing of photosynthesis in *Phragmites*. The next step will be to test the technology in the field and develop an application method that will be feasible over a large scale.
    - More information about *Phragmities* can be found at http://greatlakesphragmites.net/research/control-options/.

Assessing the potential impacts of climate change on Aquatic Invasive Species.

- A climate change projection tool was developed that can project the AIS climate niche, within the Great Lakes basin, under several climate change scenarios published by the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/) for the years 2050 and 2070.

CANADA

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- During 2013, a national risk assessment of ballast water introductions of AIS species was completed with a focus on the Great Lakes and St. Lawrence River. That risk assessment identified the need to reduce risk by incorporating ballast water treatment into systems of ships that discharge ballast into the Great Lakes.

- During 2013, a peer review of available risk assessment tools was carried out, and science advice was published, about screening-level risk assessment protocols for nonindigenous freshwater organisms in trade in Canada that provides guidance to evaluating risks to support prevention

actions.

- Ontario Ministry of Natural Resources and Forestry has conducted 14 draft risk assessments for non-native fishes, aquatic invertebrates and plants. The risk assessments will be used in support of regulations under the new Invasive Species Act, 2015.

Preventing introduction and spread of Aquatic Invasive Species through regulations.

- With extensive public and government consultation, Canada established new aquatic invasive species regulations under the Fisheries Act in June 2015 creating new prohibitions for species based on risk and enabling new measures for prevention and control of AIS in Canada and at its borders.

- In November 2014, the Province of Ontario reintroduced the proposed Invasive Species Act, to support the prevention, early detection, rapid response and eradication of invasive species in the province. The Ontario Invasive Species Act, 2015, received Royal Assent on November 3, 2015 and comes into force on November 3, 2016. A risk assessment process will be used to classify species for regulation that pose a threat to Ontario's natural environment, including the Great Lakes.

Implementing early detection and rapid response.

- Canada, working closely with Ontario and United States jurisdictions, has delivered its Asian Carp Program based on four pillars: prevention, early warning, response, and management. The program includes extensive early detection surveillance activities in close conjunction with environmental DNA monitoring carried out by Ontario. More information can be found at http://asiancarp.ca/.

- Canada, in coordination with the Ontario Federation of Anglers and Hunters, the Invasive Species Centre, and Royal Ontario Museum carried out a large-scale outreach campaign specific to raise awareness and public understanding of best practices to prevent the transport and spread of Asian carps.

- The Ontario Federation of Anglers and Hunters, in partnership with Ontario engage the public in citizen science to detect invasive species through the Ontario Invasive Species Awareness Program, reporting hotline, and new tools like the Early Detection and Distribution Mapping System (EDDMaps Ontario) smartphone app.

- Findings of Grass Carp in lakes Erie and Ontario between 2013 and 2015 have triggered successful coordinated response efforts under the incident command system testing the domestic response framework established for Asian carps.

- Extensive efforts continue to respond to the establishment Water Soldier, an invasive aquatic plant, first discovered in 2008 in the Trent Severn Waterway in Ontario. Ontario, Parks Canada, the Ontario Federation of Anglers and Hunters, the Conservation Authority, and other partners

are collaborating to prevent further spread, to detect any expansion of the plants range and respond to new findings, and to eradicate the established population through chemical and mechanical control measures.

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

- Research has been completed about the capacity for invasive fish species, including Asian carps, to move through the Welland Canal and the St. Mary's River canals to help better understand the risk of spread and opportunities for control.

- Research on repulsion devices, including sound, light, and electricity, to potentially contain and control fish species, including Asian carps, has been carried out using surrogate species in a large-scale mesocosm located in Hamilton Harbour, Lake Ontario.

- Canada continues to actively research monitoring and treatment technologies to advance efforts to prevent AIS movement in the ballast water of ships including evaluation of the current binational ballast water exchange monitoring program, testing of ballast water treatment technologies, and evaluation of sampling methods to support new International Maritime Organization ballast water standards.

- Ontario and Canada are carrying out research to advance the application of environmental DNA for the detection of AIS for Asian carps, Water Soldier, Zebra Mussels, and other species, with refinement to quality control procedures, with refinement of detection sensitivities, and with establishment of new markers.

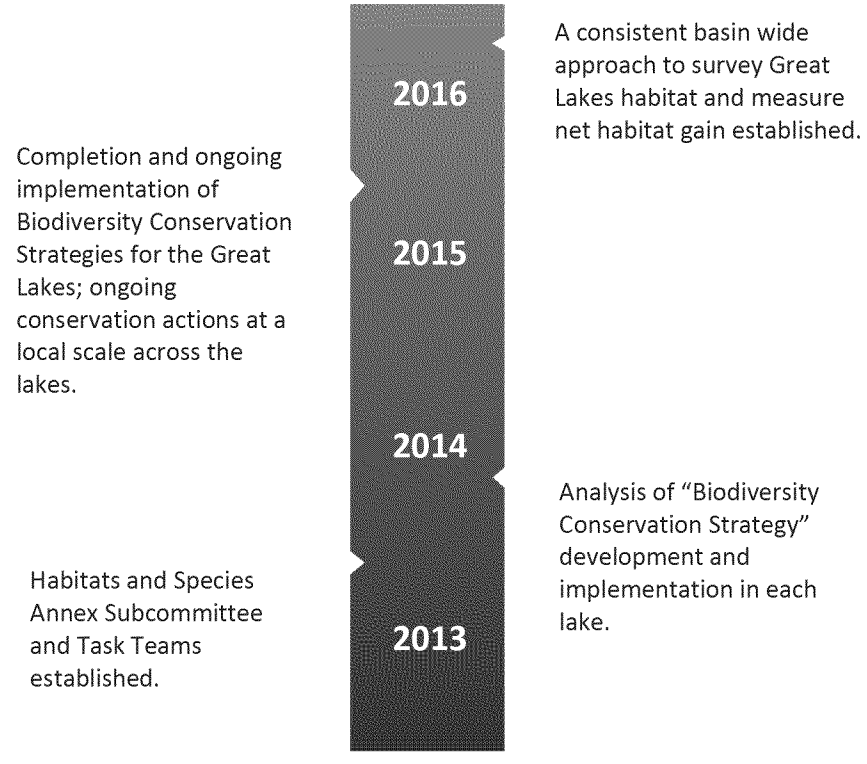
HABITAT AND SPECIES ANNEX

OVERVIEW

The Great Lakes basin is a vast freshwater system consisting of a wide range of habitats from sand dunes and rocky shorelines to wetlands and shoals. These habitats are home to great wealth of biodiversity including many globally rare species. This ecological diversity is an important resource to the region providing valuable ecosystem services (such as clean drinking water and harvestable fish) that contribute to the well-being of Great Lakes basin residents. Protection of the habitats, and the species that rely on these habitats, is an important component of managing the Great Lakes.

The 2012 GLWQA commits Canada and the United States to conserve, protect, maintain, restore and enhance the resilience of native species and their habitats, as well as supporting essential ecosystem services in the basin. Actions taken by the Parties are contributing to the recovery of populations of species at risk and the restoration of degraded native habitat and species.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



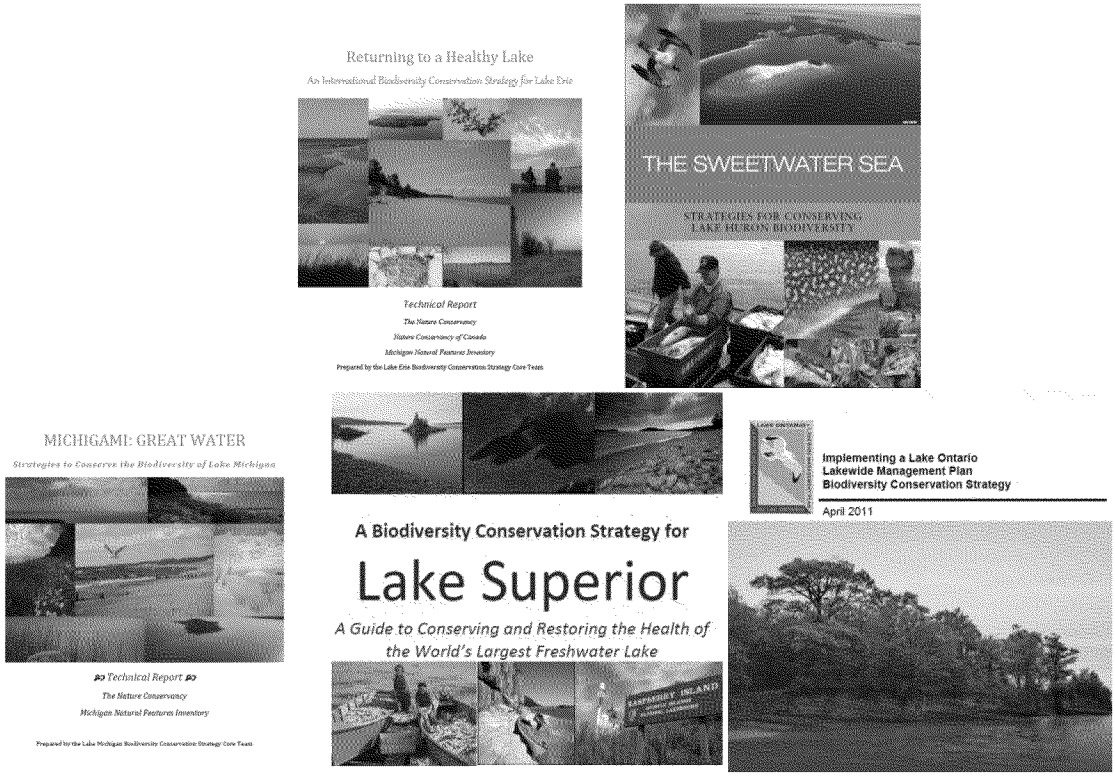
This Annex's implementation is supported by the Habitat and Species Annex Subcommittee, co-led by Environment and Climate Change Canada and the United States Fish and Wildlife Service. Organizations on the subcommittee include: Environment and Climate Change Canada; United States Fish and Wildlife Service; United States Environmental Protection Agency; United States National Oceanic and Atmospheric Administration; United States Geological Survey; Parks Canada; Ontario Federation of Anglers and Hunters; New York State Department of Environmental Conservation; Ontario Ministry of Natural Resources and Forestry; Michigan Department of Natural Resources; United States National Park Service; Indiana Department of Environmental Management; Wisconsin Department of Natural

Resources; United States Army Corps of Engineers; Great Lakes Fishery Commission; Fisheries and Oceans Canada.

BINATIONAL ACTIONS TAKEN

By 2015, develop Biodiversity Conservation Strategies for all of the lakes, including connecting channels, and begin implementing priority actions identified in the Strategies through existing programs and agreements.

Figure 10 – Lakewide Habitat and Species Protection and Restoration Conservation Strategies.



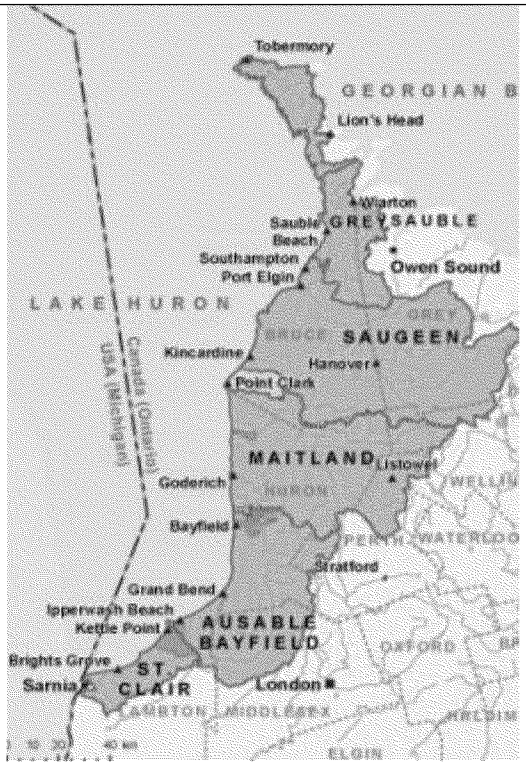
- Lakewide habitat and species protection and restoration conservation strategies, also called Biodiversity Conservation Strategies (Strategies), were developed for all five of the Great Lakes as of February 12, 2015. The Strategies assess the status and threats to lakewide biodiversity and recommend conservation priorities for native species and their habitats. The Executive Summaries (the covers of which are shown in Figure 10) are available on binational.net (www.binational.net/2015/02/23/habitat-and-species-strategies).

- Each Strategy is a product of extensive lakewide collaboration among regional and local stakeholders. They serve as tools to foster and guide shared implementation of priority conservation actions among federal, state, provincial, tribal, academic, municipal and watershed management agencies. Adaptive management is applied to the planning, application and implementation of the Strategies across the lakes.

- The Lake Superior Partnership is currently preparing watershed-level plans to further guide and support implementation of the 2015 Biodiversity Conservation Strategy at a local level. The Lake Ontario Partnership used the broader Lake Ontario Biodiversity Strategy to produce an implementation plan to focus effort on priority actions. Other Lake Partnerships are promoting implementation by identifying regional scale and watershed based biodiversity objectives and outlining the specific actions required to address habitat and species issues on a sub-basin scale.

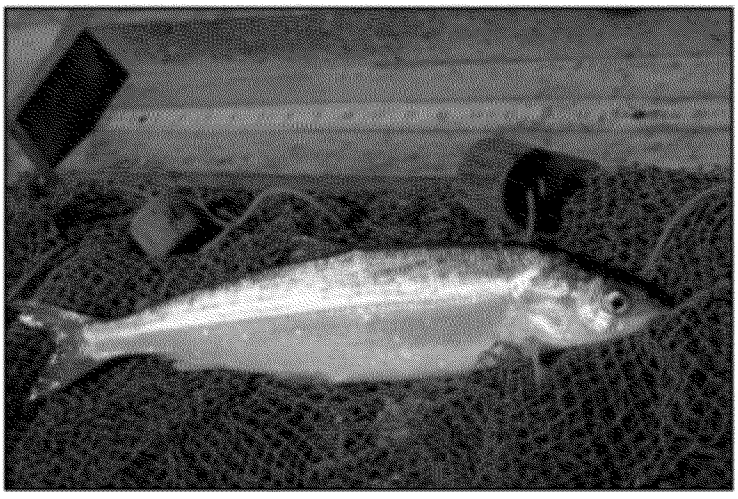
- Table 5 illustrates several examples of how the Strategies are being used in each lake basin to inform and implement priority conservation actions.

Table 5 – Examples of how Biodiversity Conservation Strategies are being used in each lake basin to inform and implement priority conservation actions.

Lake Huron: Healthy Lake Huron Healthy Lake Huron is a team of dedicated Canadian environmental professionals who coordinate actions aimed at improving overall water quality along the southeast shores of Lake Huron. Healthy Lake Huron is taking actions to address the issue of non-point source pollution, which has been identified as a critical threat in their Biodiversity Conservation Strategy.	 Membership of the Healthy Lake Huron group (www.healthylakehuron.ca)
Lake Superior: Superior Streams The Lake Superior Biodiversity Conservation Strategy classified dams and barriers as a high threat to meeting biodiversity targets. Dams and barriers are also critical in prevention of spread of aquatic invasive species. For example,	

the pictured dam on the Black Sturgeon River is identified as limiting Lake Sturgeon and Walleye spawning habitat but is also critical preventing significant Sea Lamprey infestation. Critical work on understanding these trade-offs is underway by Lakehead University and by the Aquatic Habitat Connectivity Collaboration supported by the Great Lakes Fishery Commission. Decisions about maintaining or removing dams require engagement with all stakeholders and Indigenous peoples to help ensure that all views and objectives are considered.	The Camp 43 Dam on the Black Sturgeon River, Ontario (Photo Credit: Ontario Ministry of Natural Resources and Forestry)
Lake Ontario: Bloater Fish Stocking In Lake Ontario, the Binational Lake Partnership identified the restoration of native preyfish species as a priority for the implementation of the Biodiversity Conservation Strategy. Canadian and United States agencies have initiated a program to reintroduce bloater to the lake in 2012. The program is ongoing, and nearly 62,000 bloaters were released in November, 2015.	Dale Hanson from the Green Bay Fish and Wildlife Conservation Office assists with bloater egg collection (Photo Credit: United States Fish and Wildlife Service)
Lake Michigan: Lake Herring Restoration Restoration of the native Lake Herring is a priority identified	

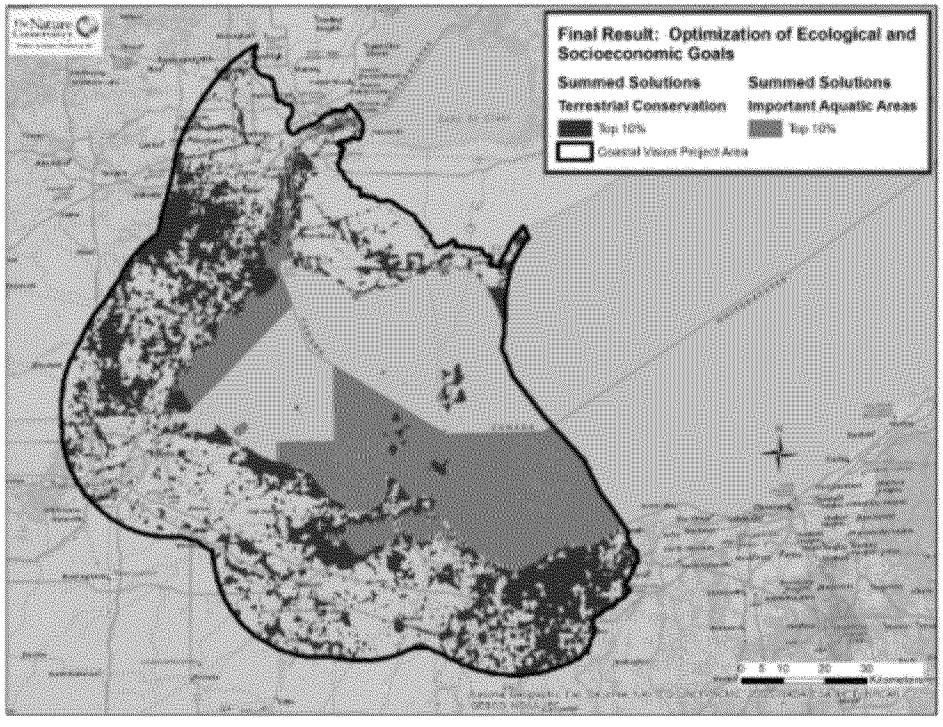
in the Lake Michigan Biodiversity Conservation Strategy. To help restore the species to its historical status as a primary prey fish in Lake Michigan, the Little Traverse Bay Bands of Odawa Indians released nearly 50,000 summer fingerling and 8,000 fall fingerling into Little Traverse Bay, Michigan, in 2014. The Little Traverse Bay Bands of Odawa Indians is currently evaluating the success of the fingerling releases.



Lake Herring (Photo Credit: United States Environmental Protection Agency)

Lake Erie: Western Basin Conservation Vision

Targets and goals from the Lake Erie Biodiversity Conservation Strategy were used in the development of a regional implementation plan called the Western Basin Conservation Vision. This plan identifies and maps areas to focus local conservation investments to meet regional conservation goals.



Final Results of the Optimization of Ecological and Socioeconomic Goals (https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/coasts/wle/Pages/default.aspx)

Conducting a baseline survey of the existing habitat against which to establish a Great Lakes Basin Ecosystem target of net habitat gain and measure future progress

- The Parties released a draft report entitled *Conducting A Baseline Survey of Great Lakes Habitat: Assessing and Measuring Progress toward a Great Lakes Ecosystem Target of Net Habitat Gain,* in May, 2016, identifying an approach to measure baseline conditions of habitat and monitor change over time. The report was developed with support from experts and partners around the lakes through a series of binational workshops, meetings and webinars.

- The Baseline Survey approach is built upon existing Great Lakes monitoring programs and emphasizes the use of remotely sensed information for maximum data coverage. The physical characteristics of the lakes will be used to map different habitat types and the condition of the habitats will then be assessed. The baseline survey will be conducted on a reoccurring basis to track changes in the ecosystem over time and to monitor progress.

DOMESTIC ACTIONS TAKEN

CANADA

- Canada and Ontario have multiple programs that contribute to the ongoing goals of the Habitats and Species Annex. In addition, there are many non-governmental partners making significant contributions to habitat and species conservation, including the Nature Conservancy of Canada, Conservation Ontario and the many individual Conservation Authorities in the province, the Ontario Federation of Anglers and Hunters, Ducks Unlimited Canada, and Stewardship Councils.

    - Environment and Climate Change Canada's National Wetland Conservation Fund, which was launched in 2014, is a $50 million funding program intended to support on-the-ground activities that will restore drained, degraded or lost wetlands across the country. Funding support has been provided to 39 projects in the Great Lakes basin, supporting actions that restore, protect, and conserve habitats for waterfowl, waterbirds and shorebirds. In the 2014 to 2015 fiscal year, 135 hectares of wetland habitat were restored and 6,440 hectares of wetland habitat were enhanced.
    - The Lake Superior National Marine Conservation Area Legislation received Royal Assent in 2015, representing a significant step in establishing one of the world's largest fresh water marine protected areas. The Lake Superior National Marine Conservation Area encompasses a 10,800 square kilometer area of the biologically diverse lake and includes lakebed, islands, and shore lands. This project contributes to Canada's commitment to conserve the countries' land and waters and meet Aichi 2020 biodiversity targets to protect 17% of land and inland waters. The Lake Superior National Marine Conservation Area Interim Management Plan was released in January 2016 (http://www.pc.gc.ca/eng/amnc-nmca/on/super/plan/interim-provisoire.aspx).

- Through strategic partnerships and collaboration, the Ontario Ministry of Natural Resources and Forestry coordinates the Ontario Eastern Habitat Joint Venture (OEHJV), a program focused on conserving migratory bird habitats, particularly wetlands and their associated habitats. Environment and Climate Change Canada and the Ontario Ministry of Natural Resources and Forestry support OEHJV partners in the implementation of priority conservation programs, with a particular focus on wetlands and associated habitats identified within OEHJV Priority Habitat Conservation Areas. From April 2012 to March 2015, this venture has secured 5,550 hectares through 10-30 year conservation agreements, and enhanced 605 hectares of previously secured lands within the Great Lakes basin.
- Environment and Climate Change Canada completed biodiversity and aquatic habitat monitoring at more than 40 Great Lakes coastal wetlands each year, including surveys on fish, marsh birds, aquatic invertebrates, vegetation, and water quality. Additionally, Environment and Climate Change Canada developed GIS mapping products to support reporting of Great Lakes Basin biodiversity.
- The Government of Canada's Ecological Gifts program provides a way for Canadians with ecologically sensitive land to protect nature through donations of land, or a partial interest of land, for conservation in exchange for significant tax benefits. In the 2015 to 2016 year alone 26 Ecological Gifts were completed in the Great Lakes Basin for total of 1,247.48 hectares valued at $8,853,800.
- The Province of Ontario is implementing a Land Stewardship and Habitat Restoration Program. Since its 2013 launch, the program's $300,000 annual fund has helped improve, restore or create more than 4,662 acres of habitat including plantings of over 105,000 trees and shrubs, supporting the hiring of 182 people and leveraging over $2.3 million in project-partner funding.
- Fisheries and Oceans Canada supports habitat restoration and enhancement through its Recreational Fisheries Conservation Partnerships Program. The program was established in June 2013 to support multi-partner projects at the local level aimed at restoring recreational fisheries habitat in order to enhance the sustainability and productivity of Canada's recreational fisheries.
- In May 2015, the Ontario Biodiversity Council released The State of Ontario's Biodiversity Report 2015. The report includes indicators that summarize data from monitoring programs to evaluate progress in achieving each of the 15 Targets and status and trends in three biodiversity theme areas: pressures on biodiversity; state of ecosystem, species and genetic diversity; and, conservation and sustainable use. Several provincial ministries played a role in the development of the report.
- *Wetlands in Ontario: A Discussion Paper* was released by the Ontario Ministry of Natural Resources and Forestry for public consultation from July to October 2015. The purpose of the paper was to provide an overview of Ontario's current wetland conservation framework; to increase awareness about the main issues and concerns related to wetlands in Ontario; to provide stakeholders and the public with some ideas and priorities for wetland conservation in Ontario; and to solicit feedback from diverse array of stakeholders and the public on the development of a Wetland Conservation Strategy for Ontario. A section on Wetlands in the Great Lakes Bain included a summary of inter-jurisdictional initiatives, including the GLWQA, that recognize the important role of wetlands in the Great Lakes, and seek to implement actions to protect and restore wetlands across the Great Lakes basin.

- In the United States, multiple federal and state agencies, as well as local and regional conservation entities, non-governmental organizations, and myriad conservation partners conduct a wide range of activities related to fish, wildlife and habitat. Many of these activities support goals and priorities of the Habitats and Species Annex. In addition to base-funded activities conducted by federal agencies, the Great Lakes Restoration Initiative (GLRI) has boosted funding in recent years to supplement agency budgets to allow them to pursue high priority conservation and restoration needs throughout the Great Lakes Basin, including fish and wildlife habitat.

- In 2015, GLRI agencies and their partners implemented 57 habitat and species projects resulting in more than 875 habitat and species projects underway or completed since the 2010 inception of the GLRI. Ten 2015 GLRI projects were directed towards protecting, restoring, and enhancing Piping Plover habitats. Over 40 projects have improved conditions for numerous federally and non-federally listed species in the Great Lakes such as Lake Sturgeon.

- GLRI funding implemented protection, restoration and enhancement projects that have reopened over 3,800 miles of Great Lakes tributaries, and increased aquatic connectivity for numerous fish species. Additionally, more than 36,000 acres of habitat in targeted watersheds were protected, restored and enhanced in order to sustain Great Lakes habitats and species populations. 300 miles of Great Lakes shoreline and riparian corridors, and 7,000 acres of Great Lakes coastal wetlands were protected, restored, and enhanced in 2015 alone.

- GLRI partners have completed the removal of the Cass River Dam during 2015. The dam at Frankenmuth, Michigan initially blocked the passage of fish to more than 1,700 miles of upstream spawning habitat on the Cass River and connecting tributaries since it was built in the 1850s. It is now placed with a rock ramp with a series of rock weirs to allow passage of fish species, such as walleye and lake sturgeon. Fourteen separate weirs and adjacent "resting pools" have been constructed over a span of approximately 350 feet to provide a roughly 3% grade for non-jumping targeted species.

- In 2015, GLRI partners reconnected the previously isolated Ottawa National Wildlife Refuge wetlands to Crane Creek and Lake Erie in Ohio. For the first time since the 1940s, the reconnected wetlands now function as a productive spawning ground and nursery area. Less than one week after re-establishing connectivity, Longnose Gar were found spawning in one of the pools. Thirteen species of fish not previously found entered through the structure and actively use the reconnected wetlands.

- The Fond du Lac Band of Lake Superior Chippewa developed better ways to control water levels and protect sustainable wild rice populations with GLRI funds. Projects included water control structures, beaver dam removals and channel obstruction removal that resulted in the protection of 855 acres of ecologically and culturally important wild rice habitat on the Fond du Lac Reservation in northeastern Minnesota. Federal partners and local Chippewa removed 97 acres of competing

aquatic plan species from Big Rice Lake and 59 acres of aggressive perennial vegetation from Perch Lake. In the St. Louis River Estuary partners reseeded 121 acres with wild rice. During the 2015 GLRI fiscal year, federal agencies and their partners restored and protected a total of 1,132 acres of wild rice habitat in Fond du Lac waters.

GROUNDWATER ANNEX

OVERVIEW

Understanding the extent of the impact that groundwater has on the chemical, physical and biological integrity of the Great Lakes is important for the long-term protection of the Great Lakes. Clean groundwater can enhance surface water quality and provide a protective treatment or storage zone; however, contaminated groundwater can act as a long-term source of pollutants and can adversely affect surface water quality. For the first time, the 2012 GLWQA recognizes the interconnection between groundwater and the waters of the Great lakes.

The 2012 GLWQA, commits the United States and Canada to coordinate scientific assessments of groundwater, in order to better understand how groundwater affects surface water quality and quantity, to coordinate groundwater management actions, and to protect and manage groundwater-related stresses affecting the waters of the Great Lakes.

As a first step in this process, the United States and Canada released a report on the relevant and available groundwater science in June, 2016.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS

Release of the "Groundwater science relevant to the Great Lakes Water Quality Agreement: A status report".

2016

A range of Great Lakes groundwater issues examined to support the development of the Groundwater Science Report, including: groundwater-surface water interaction; contaminants and nutrients in groundwater; the role of groundwater in aquatic habitats; urban development and climate change impacts on groundwater.

Groundwater Annex Subcommittee established.

2013

The implementation of this Annex is supported by the Groundwater Annex Subcommittee, co-led by the United States Geological Survey and Environment and Climate Canada. Organizations on the subcommittee include:

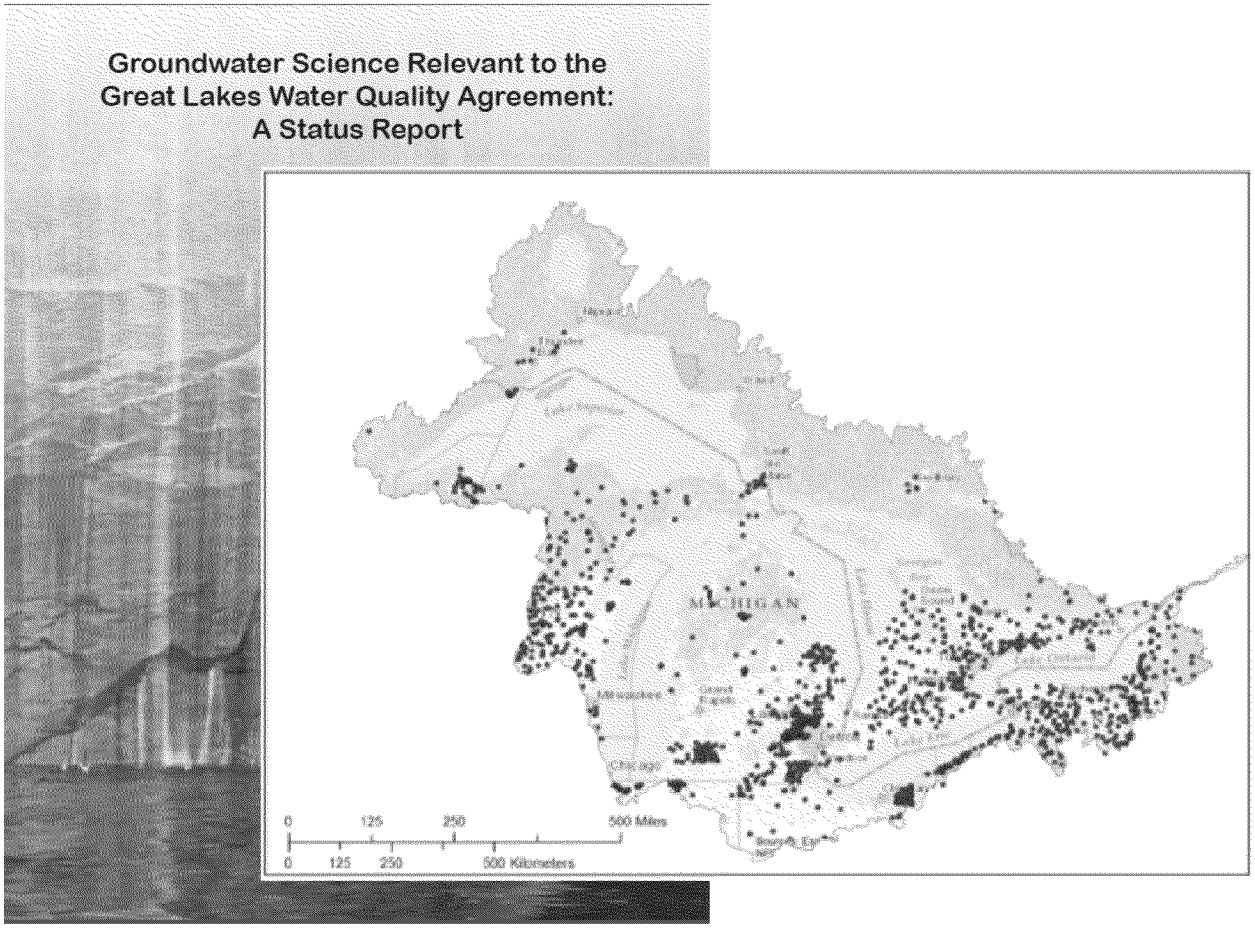
BINATIONAL ACTIONS TAKEN

By 2015, publish a report on the relevant and available groundwater science

- The Parties led the development of a report entitled *Groundwater Science Relevant to the Great Lakes Water Quality Agreement: A status report*. The report was finalized and made available on http://binational.net/2015/12/03/groundwater-science/ in June, 2016 (Figure 11 depicts the cover, and a map from the report showing the locations of monitoring wells in the Great Lakes Basin with publicly available water quality analyses). This report on the relevant and available Great Lakes groundwater science was developed through extensive collaboration among experts in a variety of subject areas from Canadian and United States federal departments, the Province of Ontario, state agencies (Michigan Office of the Great Lakes, Ohio Environmental Protection Agency, Wisconsin Department of Natural Resources), Conservation Authorities, universities, and others. The report takes into account public comments received from December, 2015 to the end of January, 2016.

- The report provides the current state of science on groundwater and its relation to Great Lakes water quality by examining various issues including: 1) the importance of groundwater-surface water interaction and interconnection; 2) contaminants and excessive nutrients in groundwater; 3) the influence of groundwater in providing aquatic habitats with a focus on Great Lakes nearshore areas, streams, and wetlands; and 4) the influence of urban development and climate change on groundwater quantity and quality. The Report also summarizes priorities for future groundwater science. This report provides a better basis and understanding of the issue of groundwater in the Great Lakes and its influence on the quality of the Waters of the Great Lakes; helps assess whether groundwater improves or adversely impacts Great Lakes water quality; and, supports future groundwater science and management actions.

Figure 11 – Locations of monitoring wells in the Great Lakes basin with publicly available water quality analyses.



Identifying priorities for science activities and actions for groundwater management, protection, and remediation; and

Coordinating binational groundwater activities under the GLWQA with domestic groundwater programs to assess, protect and manage groundwater impacting the Waters of the Great Lakes.

- Information from the Groundwater Science Report will be used to draft the 2017-2019 Binational Groundwater Priorities for Science and Action, which will be presented for public input at the Great Lakes Public Forum in October, 2016.

- Consultations with other GLWQA Annex Subcommittees is underway to inform these 2017-2019 Binational Priorities; to determine if there needs to be a focus on coordinating specific binational groundwater activities; and, to determine the need for surveillance of groundwater quality for priority areas.

- The United States and Canada, supported by a binational group of groundwater scientists, have initiated the development of a State of the Great Lakes Groundwater Indicator.

Currently, nitrate and chloride data from groundwater monitoring networks in the Great Lakes basin are being examined to assess the overall environmental status of groundwater quality and help measure progress towards the 2012 GLWQA's Article 3, General Objective (viii), "be free from the harmful impact of contaminated groundwater."

DOMESTIC ACTIONS TAKEN

Identifying groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes.

- The United States Geological Survey is continuing studies of selected areas of the Great Lakes Basin to evaluate the effects of land use and flow path on groundwater quality which, in turn, impact the Waters of the Great Lakes as groundwater interacts with surface water.

- The State of Michigan has developed a water withdrawal assessment tool that evaluates the effect of large water withdrawals, including groundwater, on fish habitat in streams. The assessment tool has been used in Michigan for several years and is being evaluated by a few other Great Lakes states for possible implementation. Understanding the effects of groundwater withdrawal on stream habitat is an important consideration under the 2012 GLWQA.

- Researchers at Ohio State University have recently begun a project entitled *Quantifying the effects of surface water-groundwater interaction on dissolved phosphorus loads to Lake Erie*. The results of this research should help clarify the potential for groundwater discharge to streams and lakes adding to already identified surface water sources of phosphorus.

Assessing information gaps and science needs related to groundwater to protect the quality of Waters of the Great Lakes.

- In March 2015, the Ontario Geological Survey and Geological Survey of Canada hosted a Groundwater Geoscience Knowledge GAP Analysis session for southern Ontario clients to seek input at the planning phase of several large Ontario Geological Survey and Geological Survey of Canada

collaborative mapping initiatives, and to discuss the future of provincial government data management. Session participants identified 30 individual groundwater geoscience knowledge gaps, which fell into seven categories including: i) communications, ii) standards and protocols, iii) water quality and geochemistry, iv) surface and groundwater interaction, v) geology and hydrogeology, vi) climate change and vii) data management and dissemination. The Ontario Geological Survey has taken significant steps to address many of the knowledge gaps brought forward at the session some of which are described at http://geoscan.nrcan.gc.ca (http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=297736).

Identifying groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes.

- The Ontario Geological Survey continues to improve understanding of the data and information needed to assess the impacts of groundwater on the waters of the Great Lakes. A water quality database, created through the Ontario Geological Survey's ambient groundwater geochemistry project, is being evaluated for potential use in the development of a groundwater indicator under the guidance of the Science Annex Subcommittee.

- Through the Lake Simcoe / Southeastern Georgian Bay Clean-up Fund, Environment and Climate Change Canada is currently assessing the role of groundwater as a source of nutrients (phosphorus and reactive nitrogen) to surface waters of Southeastern Georgian Bay and the Nottawasaga River.

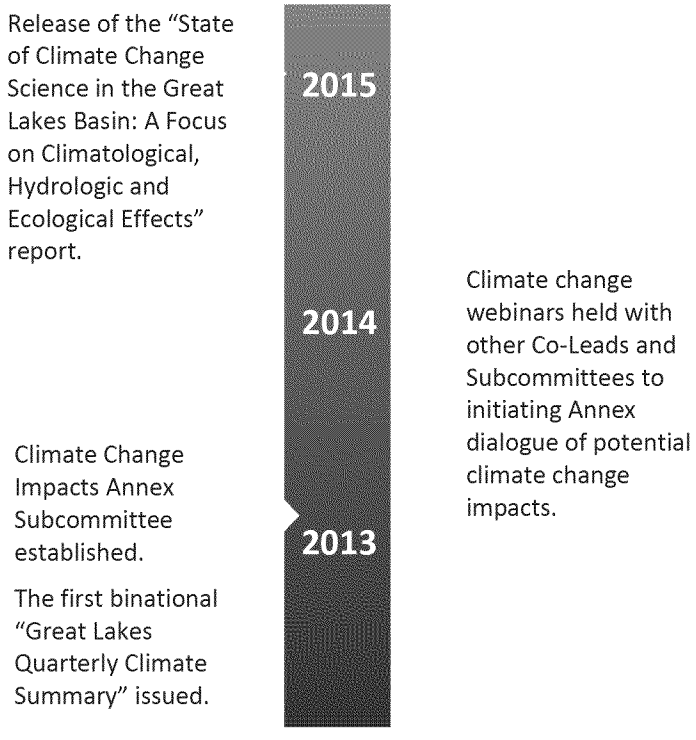
CLIMATE CHANGE IMPACTS ANNEX

OVERVIEW

Climate change impacts such as warming temperatures, changing precipitation patterns, decreased ice coverage, and alterations to water levels are being observed across the Great Lakes basin. Climate change impacts physical, chemical and biological processes such as runoff and erosion patterns, nutrient cycling, and wetland development in the Great Lakes. Understanding how climate change affects these processes now and in the future is important to making informed management decisions for the Great Lakes.

Recognizing that climate change has an impact on the quality of waters of the Great Lakes, Canada and the United States incorporated a new Annex in the 2012 GLWQA to address this issue, through which both governments commit to coordinate efforts to identify, quantify, understand, and predict the climate change impacts on the water quality of the Great Lakes and to share information broadly with Great Lakes resource managers to proactively address these impacts.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex's implementation is supported by the Climate Change Impacts Annex Subcommittee, co-led by Environment and Climate Change Canada and the National Oceanic and Atmospheric Administration. Organizations on the subcommittee include: Environment and Climate Change Canada, Ontario Ministry

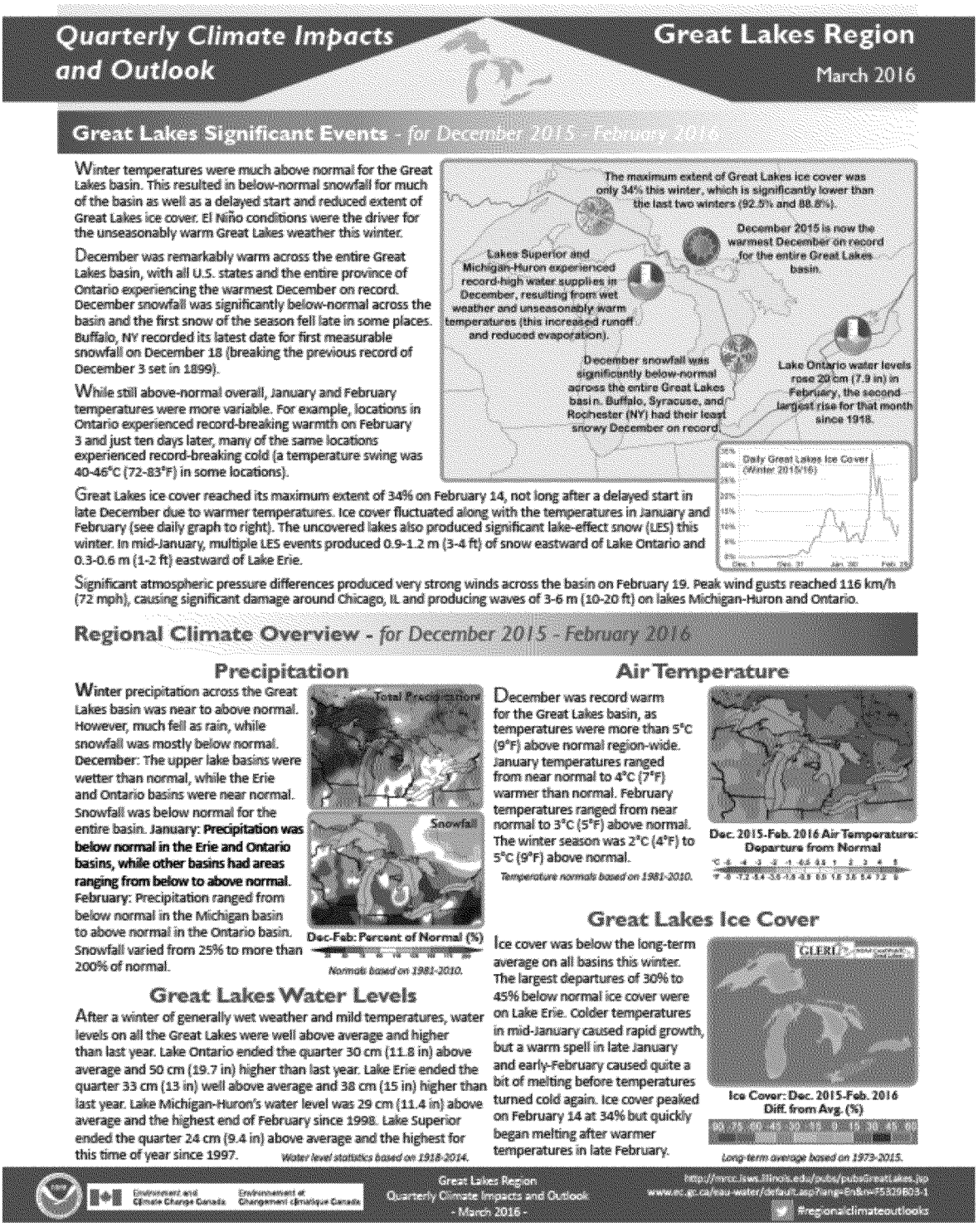
of Environment and Climate Change, Ontario Ministry of Natural Resources and Forestry, Conservation Ontario, United States National Oceanic and Atmospheric Administration, United States Environmental Protection Agency, United States Geological Survey, Oneida Tribe of Indians of Wisconsin, United States National Park Service, United States Fish and Wildlife Service, United States Army Corps of Engineers

BINATIONAL ACTIONS TAKEN

Coordinating binational climate change science activities to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts on Great Lakes water quality.

- In June 2013, Canada and the United States issued the first binational quarterly newsletter focusing on climate impacts and outlooks for the Great Lakes region. The Great Lakes Climate Quarterly newsletters provide a quick and easy-to-understand overview of the latest season's weather and water level conditions, weather and water level-related impacts, and an outlook for the upcoming quarter. These newsletters are produced by Canadian and United States experts for use by managers and practitioners at federal, state, provincial, regional, and local scales as well as stakeholders and the general public. The March, 2016 edition of the Great Lakes Climate Quarterly (shown in Figure 12) along with the other editions of the Great Lakes Climate Quarterly newsletters are available at www.binational.net/category/a9/qcio-btsc.

Figure 12 – Great Lakes Climate Quarterly March 2016 Newsletter.



Quarterly Climate Impacts and Outlook

Great Lakes Region

March 2016

Great Lakes Significant Events - *for December 2015 - February 2016*

Winter temperatures were much above normal for the Great Lakes basin. This resulted in below-normal snowfall for much of the basin as well as a delayed start and reduced extent of Great Lakes ice cover. El Niño conditions were the driver for the unseasonably warm Great Lakes weather this winter.

December was remarkably warm across the entire Great Lakes basin, with all U.S. states and the entire province of Ontario experiencing the warmest December on record. December snowfall was significantly below-normal across the basin and the first snow of the season fell late in some places. Buffalo, NY recorded its latest date for first measurable snowfall on December 18 (breaking the previous record of December 3 set in 1899).

While still above-normal overall, January and February temperatures were more variable. For example, locations in Ontario experienced record-breaking warmth on February 3 and just ten days later, many of the same locations experienced record-breaking cold (a temperature swing was 40-46°C (72-83°F) in some locations).

Great Lakes ice cover reached its maximum extent of 34% on February 14, not long after a delayed start in late December due to warmer temperatures. Ice cover fluctuated along with the temperatures in January and February (see daily graph to right). The uncovered lakes also produced significant lake-effect snow (LES) this winter. In mid-January, multiple LES events produced 0.9-1.2 m (3-4 ft) of snow eastward of Lake Ontario and 0.3-0.6 m (1-2 ft) eastward of Lake Erie.

Significant atmospheric pressure differences produced very strong winds across the basin on February 19. Peak wind gusts reached 116 km/h (72 mph), causing significant damage around Chicago, IL and producing waves of 3-6 m (10-20 ft) on lakes Michigan-Huron and Ontario.

Regional Climate Overview - *for December 2015 - February 2016*

Precipitation

Winter precipitation across the Great Lakes basin was near to above normal. However, much fell as rain, while snowfall was mostly below normal. **December:** The upper lake basins were wetter than normal, while the Erie and Ontario basins were near normal. Snowfall was below normal for the entire basin. **January: Precipitation was below normal in the Erie and Ontario basins, while other basins had areas ranging from below to above normal.** **February:** Precipitation ranged from below normal in the Michigan basin to above normal in the Ontario basin. Snowfall varied from 25% to more than 200% of normal.

Air Temperature

December was record warm for the Great Lakes basin, as temperatures were more than 5°C (9°F) above normal region-wide. January temperatures ranged from near normal to 4°C (7°F) warmer than normal. February temperatures ranged from near normal to 3°C (5°F) above normal. The winter season was 2°C (4°F) to 5°C (9°F) above normal.

Temperature normals based on 1981-2010.

Great Lakes Water Levels

After a winter of generally wet weather and mild temperatures, water levels on all the Great Lakes were well above average and higher than last year. Lake Ontario ended the quarter 30 cm (11.8 in) above average and 50 cm (19.7 in) higher than last year. Lake Erie ended the quarter 33 cm (13 in) well above average and 38 cm (15 in) higher than last year. Lake Michigan-Huron's water level was 29 cm (11.4 in) above average and the highest end of February since 1998. Lake Superior ended the quarter 24 cm (9.4 in) above average and the highest for this time of year since 1997.

Water level statistics based on 1918-2014.

Great Lakes Ice Cover

Ice cover was below the long-term average on all basins this winter. The largest departures of 30% to 45% below normal ice cover were on Lake Erie. Colder temperatures in mid-January caused rapid growth, but a warm spell in late January and early-February caused quite a bit of melting before temperatures turned cold again. Ice cover peaked on February 14 at 34% but quickly began melting after warmer temperatures in late February.

Long-term average based on 1973-2015.

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Great Lakes Region Quarterly Climate Impacts and Outlook - March 2016 -

http://mrcc.isws.illinois.edu/climan/pubs/greatlakes.jsp
www.ec.gc.ca/eau-water/default.asp?lang=En&n=75309B03-1

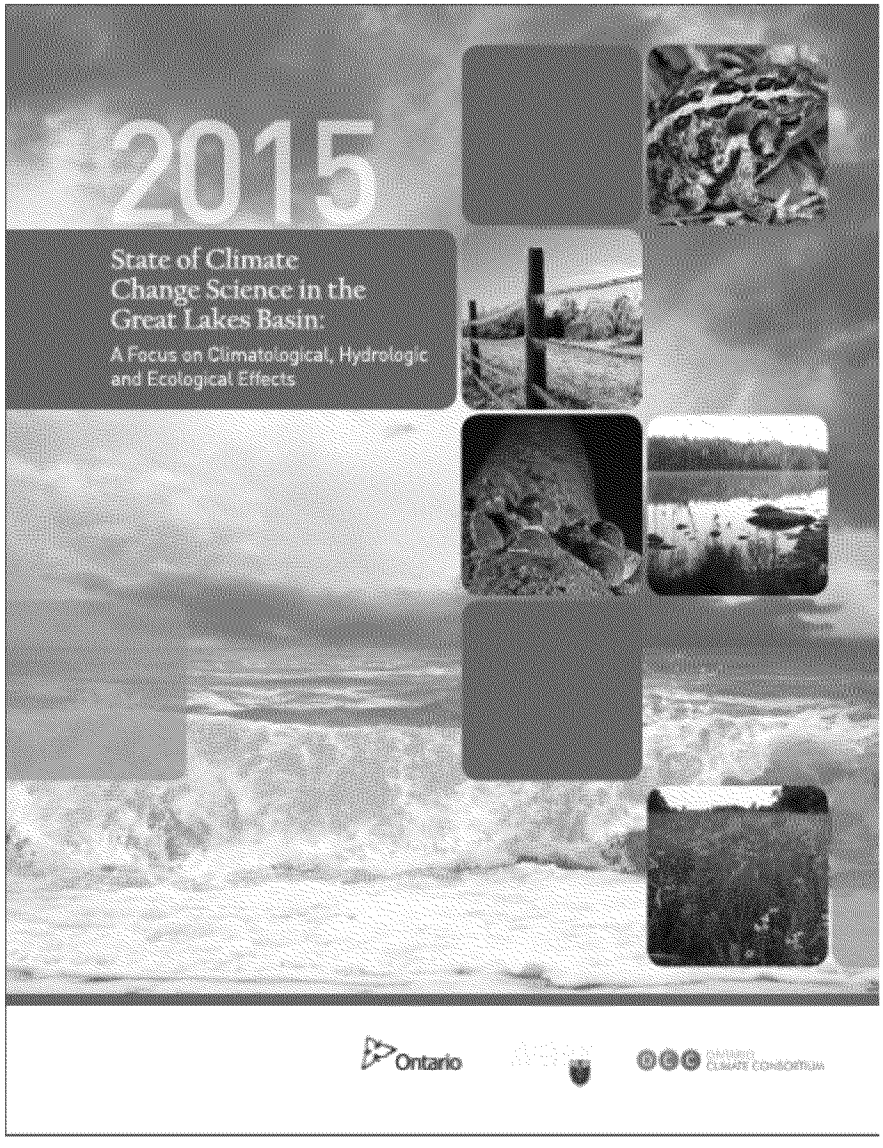
#regionalclimateoutlooks

- A series of webinars were conducted in 2014 to present information on the best available peer-reviewed climate change science in the Great Lakes to GLWQA Annex

Subcommittees, as well as other interested parties. Webinars were provided to: 1) enhance broad understanding of climate information; 2) to discuss the type of climate change information required by other Annex Subcommittees to support their activities; and 3) to help focus the work of the Climate Change Impacts Annex Subcommittee in providing tailored climate change information.

- In December 2015, a report entitled *State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic and Ecological Effects* was released, which synthesizes the state of climate change impacts in the Great Lakes basin and identifies key knowledge gaps (Figure 13 depicts the cover page of the Report). The Executive Summary and further information about the report is available at www.binational.net (https://binational.net/2016/05/16/sccs-escc/). The report, along with a companion database of all the literature reviewed for the report, were developed by the Ontario Climate Consortium, the Ontario Ministry of Natural Resources and Forestry, and McMaster University, with support from Fisheries and Oceans Canada and Environment and Climate Change Canada, and in consultation with the Climate Change Impacts Annex Subcommittee.

Figure 13 – Cover page of the State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic and Ecological Effects.



Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- A growing ensemble of in situ measurements – including offshore eddy flux towers, buoy-based sensors, and vessel-based platforms – are being deployed through an ongoing binational collaboration known as the Great Lakes Evaporation Network. The Network is helping to reduce uncertainties in the Great Lakes water balance, providing a more robust basis for short- and long-term projections of variations in climate and lake levels, and filling a significant gap in measurements, including evaporation and water temperatures, and related meteorological data. The Network is supported through a consortium of researchers from Environment and Climate Change Canada and the National Oceanic and Atmospheric Administration, the University of

Michigan, Northern Michigan University, the University of Colorado, Limno-Tech and the Great Lakes Observing System.

Developing and improving analytical tools to understand and predict climate change impacts.

- Environment and Climate Change Canada, the United States Geological Survey, and the National Oceanic and Atmospheric Administration's National Weather Service and Great Lakes Environmental Research Laboratory, have formed a binational collaboration to assess alternative methods for simulating runoff across large lake basins. The Great Lakes Runoff Inter-comparison Project is a binational collaboration aimed at assessing a variety of models currently used (or that could readily be adapted) to simulate basin-scale runoff to the Great Lakes. The first phase of the Great Lakes Runoff Inter-Comparison Project focused on Lake Michigan and involved the comparison between several very different hydrologic models in their ability to simulate the lake's tributary flows. The second phase of the Great Lakes Runoff Inter-Comparison Project focused on Lake Ontario and compared different hydrologic models in their ability to estimate Lake Ontario's direct incoming runoff. This work has improved the understanding of the differences in various models in simulating total runoff to the lakes and can help lead to improved climate change impact analyses.

DOMESTIC ACTIONS TAKEN

The Government of Canada is committed to addressing climate change by moving toward a pan-Canadian framework for clean growth and climate change, a concrete plan that will allow Canada to meet its international commitments and transition the country into a more resilient, low-carbon economy. Canada is committed to supporting climate change mitigation and adaptation by reducing carbon pollution; putting a price on carbon; and investing in green infrastructure, public transit infrastructure, and energy efficient social infrastructure. Canada will also build on actions already taken by the provinces and territories such as the Province of Ontario's recently released Five-Year Climate Change Action Plan 2016-2020, which includes measures to reduce greenhouse gas emissions in Ontario.

Developing and improving regional scale climate models to predict climate change in the Great Lakes Basin Ecosystem at appropriate temporal and spatial scales.

Linking projected climate change outputs from regional models to chemical, physical, biological models that are specific to the Great Lakes to better understand and predict climate change impacts.

- Environment and Climate Change Canada is supporting the development of coupled

atmospheric-land-ocean models for the Great Lakes-St. Lawrence River system that can be integrated with Regional Climate models to evaluate the hydrometeorological impacts of climate change.

- The Ontario Government continues to support the development of high resolution regional climate projections in support of climate impact assessments on various sectors in Ontario and the Great Lakes basin. In 2015, these regional climate projections were updated with the latest Coupled Model Intercomparison Project Phase 5 data and distributed through the following public climate data portals: http://OntarioCCDP.ca and http://occp.lamps.yorku.ca/.

- A coordinated evaluation of the impacts of climate change on the levels and flows of the St. Lawrence River between 2041-2070 and 1971-1999 is being undertaken through a collaborative of agencies including Fisheries and Oceans Canada, Hydro-Quebec, Direction de l'expertise hydrique of Quebec, OURANOS and Environment and Climate Change Canada. A major focus of this project is improving the analyses of the routing of Ottawa River flows so that Great Lakes and St. Lawrence River models can be linked, resulting in improved climate change impact projections over the entire system.

Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- Environment and Climate Change Canada collects data from a network of approximately 1300 surface weather and climate observing sites across the country. These sites include weather stations owned by Environment and Climate Change Canada, NAV CANADA, National Defence, along with volunteer climate stations. The majority of these sites are automated observing platforms which report year round, 7 days a week, 24 hours a day. Environment and Climate Change Canada in partnership with the Province of Ontario operates 440 active hydrometric gauges in the Canadian portion of the Great Lakes-St. Lawrence River Basin. Environment and Climate Change Canada also supports the operation of three evaporation stations at Stannard Rock on Lake Superior, Long Point on Lake Erie and Simcoe Island on Lake Ontario as part of the Great Lakes Evaporation Network. The information provided through these networks is critical to monitoring and predicting the impacts of climate change on the Great Lakes.

Developing and improving analytical tools to understand and predict climate change impacts.

- Environment and Climate Change Canada's Canadian Precipitation Analysis is an operational near real-time product, available since April 2011 for North America, which leverages a variety of observation and modelling information sources to estimate precipitation accumulation every six hours across Canada. The Canadian Precipitation Analysis is highly regarded due to its unique capability of capturing some of the precipitation features that are specific to the Great Lakes-St. Lawrence River region (including the effects that the lakes have on the precipitation patterns, something that is very difficult to discern with the existing precipitation gauging network). A project was initiated in 2015 to provide the foundation for extending the Canadian Precipitation Analysis back to 1983. This project will help improve hydrological forecasting and land surface estimates (including soil moisture, soil temperature and snow on the ground), leading to improved ecological

prediction.

Sharing information that Great Lakes resource managers need to address climate change impacts.

- Ontario is working to establish a climate change modeling collaborative for climate data that will establish a one-window source for climate data, for the purpose of ensuring open access to standardized and wide-ranging Ontario climate information. The modeling collaborative will help both public and private sectors make informed and evidence-based decisions regarding adapting to climate change and increasing resilience.

Developing and improving regional scale climate models to predict climate change in the Great Lakes Basin Ecosystem.

Linking the projected climate change outputs from the regional models to Great Lakes-specific chemical, physical, biological models.

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab brought together several different modeling and observational approaches to study climate change in the Great Lakes basin. The modeling activity consisted of further development and application of three atmosphere-lake-land regional climate models: 1) the Coupled Hydrosphere-Atmosphere Research Model (CHARM); 2) the Regional Climate Model version 4 (RegCM4) at the University of Wisconsin; and 3) the Weather Research and Forecasting Model (WRF) at the University of Maryland, as well as the development and testing of a simulation of ice and lower trophic level ecology in the form of a nutrient-phytoplankton-zooplankton-detritus model component.

Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- In 2013, the Lake Superior National Estuarine Research Reserve established a new Sentinel Site located in Pokegama Bay, Lake Superior. With funding support from the National Oceanic and Atmospheric Administration, this Sentinel Site included weather/meteorological station, water quality sonde, surface elevation tables, permanent vegetation transects, geodetic vertical referencing benchmarks, and an acoustic doppler current profiler installation. This site is now recording monthly water quality sampling for nutrients and chlorophyll. The primary goal is to understand sediment movement and how sediment transfer is impacting nearshore marsh environments with increased frequency and intensity of storm events.

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab has been exploring the relationships between ice cover, lake thermal structure, and regional climate for over 30 years through development, maintenance, and analysis of historical model simulations and observations of ice cover, surface water temperature, and other variables. Weekly ice cover imaging products produced by the Canadian Ice Service started in 1973. Beginning in 1989, the United States National Ice Center produced Great Lakes ice cover charts that combined both Canadian and United States agency satellite imagery. These products are available at the Great Lakes Environmental Research Lab through the Coastwatch program (www.coastwatch.glerl.noaa.gov), a nationwide National Oceanic and Atmospheric Administration program within which the Great Lakes Environmental Research Lab functions as the Great Lakes regional node.

- Currently, there is year-round monitoring infrastructure dedicated to understanding off-shore processes that impact Great Lakes ecosystem health. Beginning in Fiscal Year 2015, the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab (with funding support from the National Oceanic and Atmospheric Administration's Coastal Storms Program) is seeking to fill known data gaps (i.e., over-water evaporation and transpiration rates and how those rates effect the overall water budget) through a two-phased approach. First, the team will deploy and manage data from vessel- and buoy-based sensors to improve understanding of over-water meteorology, evaporation, and water temperature in the Great Lakes. Second, the project will also focus on data analysis, system validation, and model assimilation to improve access to and understanding of the acquired data.

Developing and improving analytical tools to understand and predict climate change impacts.

- The National Oceanic and Atmospheric Administration's Office for Coastal Management developed and released the Lake Level Viewer (www.coast.noaa.gov/llv) for the United States portion of the Great Lakes basin in 2014. This tool helps users visualize lake level changes that range from six feet above to six feet below historical long-term average water levels in the Great Lakes, along with potential shoreline and coastal impacts. Communities can use this information to determine what preparations make the most sense in planning for water level change scenarios. Preparations might include zoning restrictions, infrastructure improvements, and habitat conservation. As a result of this work and product delivery, Digital Elevation Models for each lake basin and the associated topographic and bathymetric data are now available on The National Oceanic and Atmospheric Administration's Digital Coast (https://coast.noaa.gov/digitalcoast/).

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab developed and released a basin wide Water Level Dashboard in 2014 (www.glerl.noaa.gov/data/dashboard/GLHCD.html). The Dashboard is a dynamic graphical interface for visualizing projected, measured, and reconstructed surface water elevations on the earth's largest lakes. This interface also reflects relationships between hydrology, climate, and water level fluctuations in the Great Lakes.

Coordinating binational climate change science activities to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts.

- The National Oceanic and Atmospheric Administration's National Center for Environmental Information produces an annual "State of the Climate" report (www.ncdc.noaa.gov/sotc). This report provides a collection of monthly summaries recapping climate-related occurrences on both a global and national scale.

- The National Park Service released Climate Change Scenario Planning Workshop Summaries for two US national parks on Lake Superior. The Isle Royale National Park report (https://www.nps.gov/isro/learn/nature/upload/Using-Climate-Change-Scenarios-to-Explore-Management-at-ISRO.pdf) summarized a 2013 workshop and the Apostle Island National Lakeshore report (https://www.nps.gov/apis/learn/nature/upload/APIS-Scenario-Workshop-Report-20160104-FINAL.pdf) summarized a 2014 workshop, which built on the process and results of the earlier session. These two-day workshops were a collaboration between the National Park Service and the Great Lakes Integrated Sciences + Assessments team (http://glisa.umich.edu/) from the University of Michigan. The primary objectives of the sessions were to help National Park Service leadership at local and higher levels make management and planning decisions based on up - to - date climate science and assessments of future uncertainty. The sessions were also designed to (1) assess the effectiveness of using regional - level climate science to craft local scenarios; and (2) to provide opportunities for participants to better understand how climate scenarios can be used.

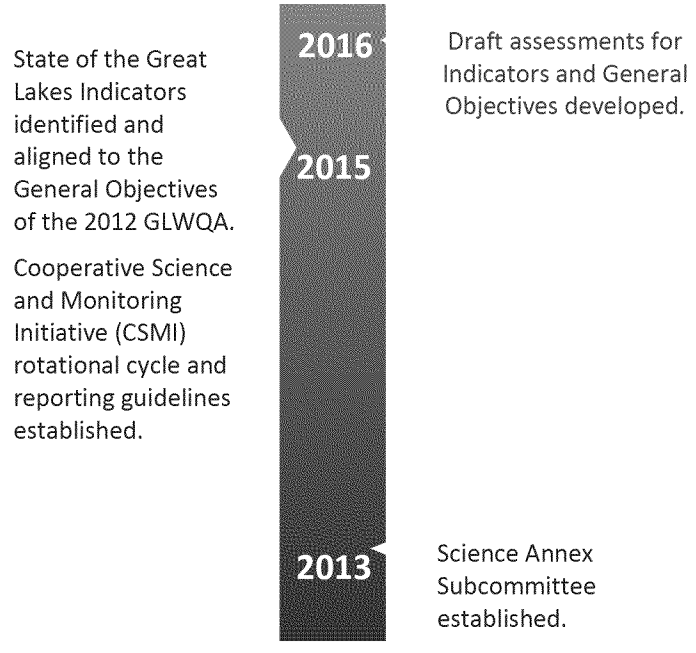
SCIENCE ANNEX

OVERVIEW

Science provides the foundation for management actions and policy decisions in support of meeting the objectives of the Agreement.

The 2012 GLWQA recognizes that the effective implementation of management decisions, policies and programs must be based on the best available science, research and knowledge. Throughout the 2012 GLWQA, specific science-based commitments are captured in relation to various Annexes. The Science Annex of the 2012 GLWQA commits the United States and Canada to enhancing the coordination, integration, synthesis, and assessment of science activities across all Annexes of the Agreement.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex's implementation is supported by the Science Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include: Environment and Climate Change Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Natural Resources Canada, Ontario Ministry of Environment and Climate Change, Ontario Ministry of Natural Resources and Forestry, Conservation Ontario, United States Environmental Protection Agency, United States National Oceanic and Atmospheric Administration, United States Army Corps of Engineers, United States Geological Survey, Wisconsin Department of Natural Resources

BINATIONAL ACTIONS TAKEN

Establishing and maintaining comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, to anticipate emerging threats, and to measure progress in relation to achievement of the Objectives of the Agreement.

In 2016, issue a State of the Great Lakes Report describing basin-wide environmental trends and lake-specific conditions using ecosystem indicators.

- In January of 2015, the United States and Canada confirmed the suite of indicators to be used to assess water quality and the ecosystem conditions of the Great Lakes under the 2012 GLWQA. This suite of indicators builds on the State of the Lakes Ecosystem Reporting by the Parties, which has been ongoing since 1994.

- The indicator suite includes nine indicators, one for each of the General Objectives of the 2012 GLWQA. The nine indicators are supported by 43 sub-indicators. Figure 14 depicts these indicators and sub-indicators.

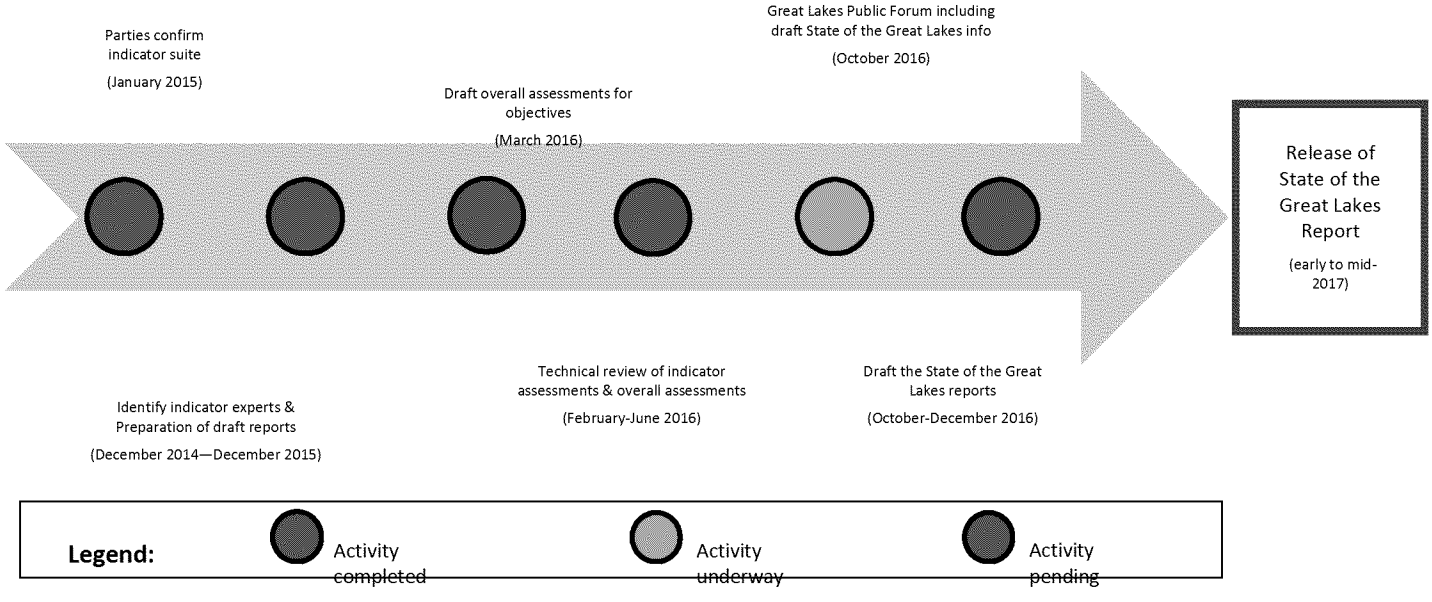
- Over 100 Great Lakes experts representing federal, provincial, state and local governments, as well as academia and non-governmental organizations, have engaged in assembling and assessing relevant data, and reporting against the indicator suite.

- In 2016, draft assessments for the indicators were developed and reviewed by subject matter experts. These draft assessment will be presented at the Great Lakes Public Forum in October, 2016 for public comment. A final State of the Great Lakes report, describing basin-wide and lake-specific environmental trends and conditions using the ecosystem indicators, is targeted for release in 2017 (as depicted in Figure 15).

Figure 14 - Indicators and Sub-Indicators for Assessing the State of the Great Lakes.

1. Drinking Water
2. Beaches
3. Fish Consumption
4. Toxic Chemicals
   - Toxic Chemical Concentrations (open water)
   - Toxic Chemicals In Great Lakes Whole Fish
   - Toxic Chemicals In Great Lakes Herring Gull Eggs
   - Toxic Chemicals in Sediment
   - Atmospheric Deposition of Toxic Chemicals
   - Water Quality in Tributaries
5. Habitat & Species
   - Coastal Wetland Invertebrates
   - Coastal Wetland Fish
   - Coastal Wetland Plants
   - Coastal Wetland Amphibians
   - Coastal Wetland Birds
   - Coastal Wetlands: Extent and Composition
   - Aquatic Habitat Connectivity
   - Fish Eating and Colonial Nesting Waterbirds
   - Phytoplankton (open water)
   - Zooplankton (open water)
   - Benthos (open water)
   - Diporeia (open water)
   - Preyfish (open water)
   - Lake Trout
   - Walleye
   - Lake Sturgeon
6. Nutrients & Algae
   - Nutrients in Lakes (open water)
   - Harmful Algal Blooms
   - Cladophora
7. Invasive Species
   - Aquatic Invasive Species
   - Sea Lamprey
   - Dreissenid Mussels
   - Terrestrial Invasive Species
8. Groundwater
9. Watershed & Climate Impacts
   - Water Levels
   - Surface Water Temperature
   - Ice Cover
   - Precipitation Events
   - Baseflow due to Groundwater
   - Watershed Stressors
   - Forest Cover
   - Land Cover
   - Tributary Flashiness
   - Hardened Shorelines
   - Human Populations

Figure 15 – State of the Great Lakes Report timeline.



Implementing a cooperative science and monitoring initiative for each of the Great Lakes on a five-year rotational basis.

- The Cooperative Science and Monitoring Initiative (CSMI) was developed under the 1987 GLWQA in order to binationally coordinate the research and monitoring activities being undertaken in the Great Lakes basin (such as coordinating the movement of research vessels like the Lake Guardian and Limnos pictured in Figure 16) and to ensure that the necessary science is efficiently provided to support Great Lakes decision-making and management actions. Each year, as part of the CSMI, U.S. and Canadian organizations assess one of the Great Lakes during that Lake's intensive CSMI field year. This emphasis on one Great Lake per year allows for enhanced coordination of research and monitoring activities, as well as the cooperation on specific science assessments, in that particular Great Lake during that year. This intensive CSMI field year follows a five year rotating cycle (as shown in Figure 17).
- The CSMI process includes the following steps leading up to and following the intensive field year: 1) identification of research and monitoring needs and other science priorities to assess threats to Great Lakes water quality and support management actions; 2) planning, which involves working with governmental and academic scientists to develop and coordinate specific research activities for the Great Lake in question; 3) undertaking the coordinated monitoring and cooperative science assessments (i.e. intensive field year); 4) laboratory analysis; 5) data analysis and reporting; and, 6) final report and communicating out.
- Some examples of lake-specific cooperative science include:
    - An assessment in Lake Ontario, in 2013, of the lower food web and the implementation of projects across federal and state agencies examining nutrient loadings and the nearshore-to-offshore movement of nutrients.
    - An assessment in Lake Erie, in 2014, of Dreissenid mussel populations, nutrient loadings from rivers and western basin sediments, and development of a phosphorus mass balance model for the western and central basin.
    - Addressing nutrient and contaminant loads to Lake Michigan, in 2015, to address contaminants in the lake, and to investigate the movement of nutrients and energy from nearshore to offshore waters.
    - An assessment in Lake Superior, in 2016, of chemical emission reduction actions and an evaluation of the health of the lower food web and important fish communities.

Figure 16 – Research efforts on the Great Lakes.

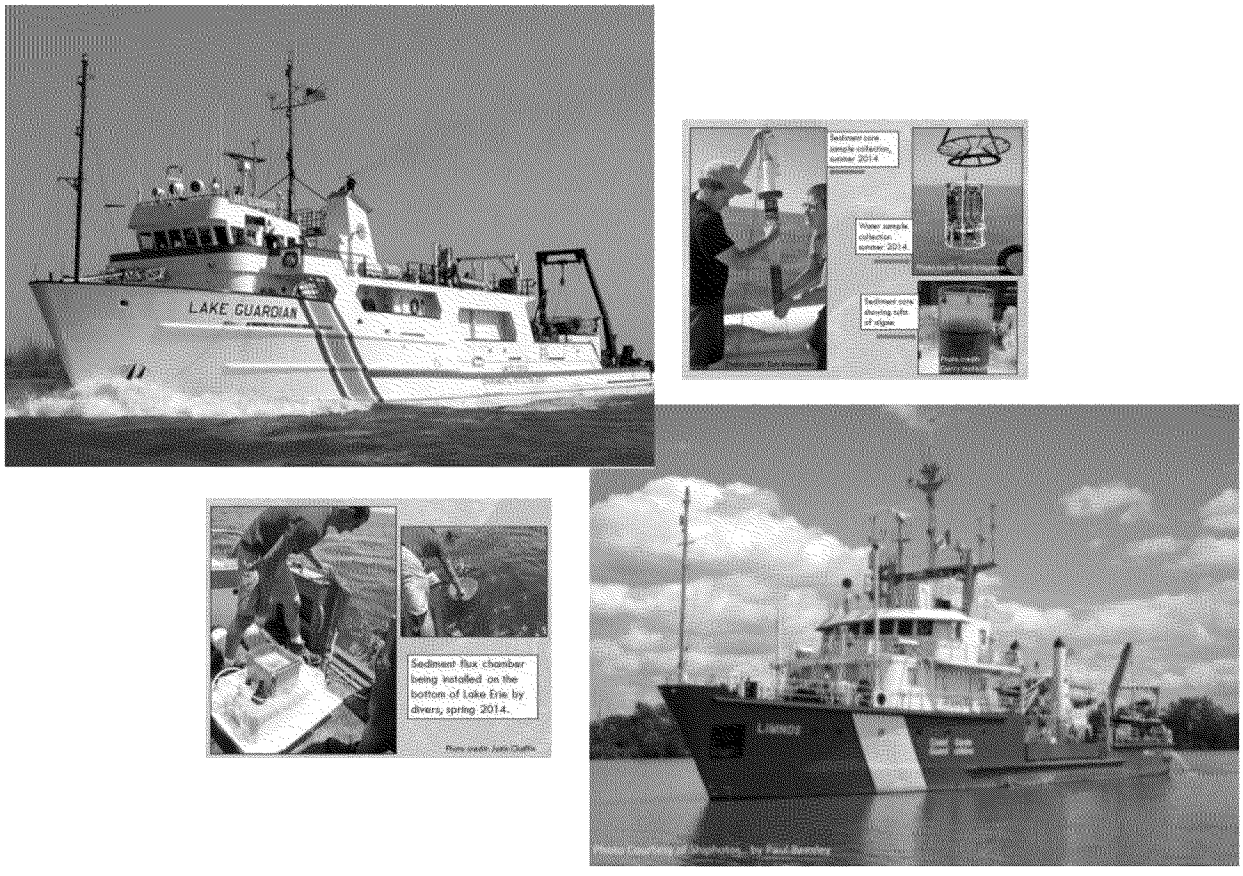
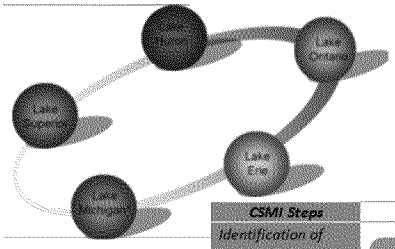


Figure 17 – The Cooperative Science and Monitoring Initiative rotational cycle.



CSMI Steps	2013	2014	2015	2016	2017	2018
Identification of research and monitoring needs and other science priorities	Lake Michigan *science needs*	Lake Superior *science needs*	Lake Huron *science needs*	Lake Ontario *science needs*	Lake Erie *science needs*	Lake Michigan *science needs*
Planning	Lake Erie *planning*	Lake Michigan *planning*	Lake Superior *planning*	Lake Huron *planning*	Lake Ontario *planning*	Lake Erie *planning*
Intensive field year	Lake Ontario *field year*	Lake Erie *field year*	Lake Michigan *field year*	Lake Superior *field year*	Lake Huron *field year*	Lake Ontario *field year*
Laboratory analysis	Lake Huron *lab analysis*	Lake Ontario *lab analysis*	Lake Erie *lab analysis*	Lake Michigan *lab analysis*	Lake Superior *lab analysis*	Lake Huron *lab analysis*
Data analysis and reporting	Lake Superior *data analysis*	Lake Huron *data analysis*	Lake Ontario *data analysis*	Lake Erie *data analysis*	Lake Michigan *data analysis*	Lake Superior *data analysis*
Reporting and communicating out	Lake Michigan *report/outreach*	Lake Superior *report/outreach*	Lake Huron *report/outreach*	Lake Ontario *report/outreach*	Lake Erie *report/outreach*	Lake Michigan *report/outreach*

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Facilitating information management and sharing to improve knowledge, accessibility and exchange of relevant Great Lakes information.

- Data and information management and sharing efforts to support implementation of relevant 2012 GLWQA commitments are being examined. An initial examination was undertaken to understand the data and information management and sharing needs across all of the Annexes of the GLWQA. Based on this information and discussions at the Great Lakes Executive Committee meetings, the Science Annex Subcommittee will be examining existing Great Lakes-related distributed data and information access systems and platforms and their application to a specific pilot project on a priority area such as the Lake Erie phosphorus and/or nearshore issue.

Identifying science priorities, taking into account recommendations of the International Joint Commission.

Undertaking a review of available scientific information to inform management actions and policy development.

- The Science Annex Subcommittee coordinated and assisted in the development of the 2014-2016 binational priorities for science amongst the other Annexes. As called for in Article 5 of the 2012 GLWQA, these priorities, along with the priorities for action, were posted on binational.net (www.binational.net/2014/03/20/psa-pasa-2014) in March 2014.

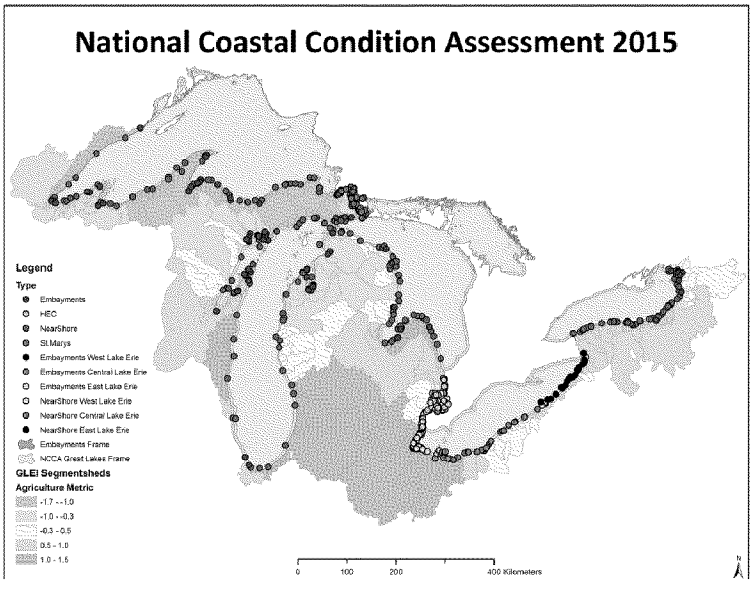
- In support of the development of nutrient objectives for controlling nuisance *Cladophora* in the Great Lakes, Canada and the United States held a binational workshop on January 28-26, 2016 to determine the state of knowledge of *Cladophora* from the perspectives of the entire Great Lakes basin, from that of individual lakes, and with respect to areas within each lake where *Cladophora* is perceived to be a significant local problem. The findings of the workshop will help guide a strategy for proposing nutrient reduction targets that will control *Cladophora*.

DOMESTIC ACTIONS TAKEN

- Between 2013 and 2016, the United States Environmental Protection Agency's Great Lakes National Program Office used Great Lakes Restoration Initiative (GLRI) funding to maintain and enhance its Long-Term Great Lakes Monitoring Programs. These programs include the Open Lake Water Quality Surveys, the Integrated Atmospheric and Deposition Network, the Great Lakes Fish Monitoring and Surveillance Program.

- Between 2013 and 2016, GLRI funding helped supplement the Environmental Protection Agency's implementation of its Great Lakes National Coastal Condition Assessment. The assessment is undertaken every five years to determine the condition of the nation's coastal waters as well as to evaluate the importance of key stressors such as nutrients and pathogens (as shown in Figure 18). The Great Lakes assessment included monitoring 100 sites per Great Lake, including the connecting channels (Huron-Erie Corridor and St. Marys River).

Figure 18 – United States Environmental Protection Agency's Great Lakes National Coastal Condition Assessment.



- In support of the Nutrient and Lakewide Management Annexes, and with the support of GLRI funding, the Environmental Protection Agency and the United States Geological Survey assessed and better understand the impacts of agriculture and agricultural practices, climate change, and land use change on the timing and magnitude of delivery of nutrients and sediments to the Great Lakes.

- In 2015, the United States National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory partnered with the University of Michigan's Cooperative Institute for Limnology and Ecosystems Research and used GLRI funding to sample eight sites throughout the western basin of Lake Erie and four sites in Lake Huron's Saginaw Bay. The sampling was done to assess the impact of land use on algal bloom development. Measurements of bloom toxicity have proven invaluable to regional stakeholders and the Nutrients Annex Task Team.

- In an effort to build broader research partnerships, the Environmental Protection Agency's Great Lakes National Program Office has made the 180-foot R/V Lake Guardian available to researchers to provide sampling access to the open waters of the Great Lakes.

- With the support of GLRI funding, an initial coastal wetland classification assessment

was completed that will be used by the Habitat and Species Annex Subcommittee to prioritize coastal wetland work.

CANADA

- The Government of Canada is committed to Open Science and Open Data, which includes performing science in a more open and collaborative manner, and maximizing accessibility to federal publications and data. Through the Action Plan on Open Government, Canada is pledging to expand its open government activities to broaden access to data and information, ensure transparency and accountability, and strengthen citizen engagement in the activities of government and in the democratic process. Data collected by Environment and Climate Change Canada in the Great Lakes to support the implementation of the 2012 GLWQA, is being prepared for release on the Government of Canada's Open Data Portal and datasets are being piloted through the process to validate and ensure future sustainability and openness of the approach.

- The Freshwater Quality Monitoring and Surveillance Program (FWQMS) of Environment and Climate Change Canada conducts water quality surveys of nutrients and contaminants in water, sediment and aquatic biota in the open lakes, tributaries, Areas of Concerns and in the connecting channels. This long-term monitoring program monitors legacy compounds (such as PCBs, PAHs and organochlorine pesticides), and more recently, also includes monitoring of emerging compounds (such as organosiloxanes, brominated and organophosphate flame retardants and Bisphenol A).

- The Environment and Climate Change Canada Chemicals Management Plan (CMP) Monitoring and Surveillance in the Great Lakes Basin (GLB) for air and precipitation monitors for both legacy and emerging compounds (CMP priority substances and others). Combining air (GLB), precipitation (GLB) and water (FWQMS) concentrations of these substances, atmospheric deposition can be estimated. CMP Monitoring and Surveillance also include monitoring of these substances in biota (fish and birds etc.), sediments and waste water treatment plants (biosolids, effluents, etc.). The CMP multi-media monitoring effort advances the understanding of Chemicals of Mutual Concern (CMC) input and pathways in the Great Lakes region. Also, this effort provides essential risk assessment information required for future identification of additional CMCs.

- In 2014, Environment and Climate Change Canada collaborated in a joint study with the Ontario Ministry of the Environment and Climate Change to measure changes in herbicide concentrations in Ontario urban streams (with five of the ten urban streams selected flowing into Lake Ontario) following a cosmetic pesticides ban in 2009. Findings indicate that concentrations in the majority of the study streams decreased significantly following the cosmetic pesticides ban, decreasing from 16% to 92%, depending on the stream and herbicide.

- As part of Great Lakes Nutrient Initiative, Environment and Climate Change Canada supported the development and implementation of binational phosphorous load targets in Lake Erie

by conducting intensive open lake, nearshore and tributary monitoring; and modelling and research on nuisance and harmful algal blooms.

- Environment and Climate Change Canada is also conducting nutrient loading research in Georgian Bay to identify adverse impacts such as the generation of harmful algal blooms and hypoxia in some nearshore regions.

- In March 2013, a Canadian workshop was organized to support identifying possible science priorities that Canada could put forward for first three years under the 2012 GLWQA, pursuant to the development of the binational priorities for science called for in Article 5 of the 2012 GLWQA.

- Within Environment and Climate Change Canada, two Great Lakes Science Days have been held in an effort to share information on priorities, progress and emerging issues, and also to encourage continued collaboration between Great Lakes scientists, researchers and program teams within the department.

SUMMARY AND CONCLUDING REMARKS

Under the 2012 Great Lakes Water Quality Agreement, Canada and the United States have been working together to *restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes.*

This report outlines the significant progress achieved over the first three years of the implementation of the Agreement's Articles and ten Annexes. The accomplishments demonstrate the Parties efforts to protect this vital treasure and fulfil their promises made under the Agreement.

As the first Progress Report of the Parties under the 2012 Great Lakes Water Quality Agreement, there is room for improvement and the Parties, using information from the forthcoming International Joint Commission's Assessment of Progress Report, will endeavour to further enhance the subsequent Progress Report of the Parties to be issued in 2019.

Canada and the United States look forward to continuing the vital work under the GLWQA, in a spirit of consultation and collaboration with state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, other local public agencies, and the general public.