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Ten Year Review of the International Joint Commission's Report on "Protection of the Waters of the Great Lakes"

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Executive Summary

When the International Joint Commission (IJC) submitted its report on Protection of the Great Lakes on February 22, 2000[1], the two federal governments authorized the Commission to review its recommendations after three years and at 10-year intervals thereafter. The Commission released its first review in 2004[2] and in 2014 agreed to undertake its first 10-year review. This report deals primarily with issues related to Great Lakes water uses and diversions since the year 2000 report.

What is described in this report is for the most part a good news story. The policy gaps identified by the IJC in 2000 have been largely filled. No new inter-basin or intra-basin diversions which would have significant negative impacts on the ecological integrity of the Great Lakes have been approved, the growth in consumptive use appears to have been at least temporarily arrested, and institutional arrangements, such as the Regional Body, are in place to continue those positive trends. But both ongoing management vigilance and additional scientific advances will be required to maintain that positive momentum. In this Executive Summary, a historical background is provided first; followed by summaries and recommendations related to policy, legal and decision-making considerations and then summaries and recommendations related to scientific and technical considerations.

1. A Brief Historical Perspective

The Great Lakes Basin, illustrated in Figure 1, is defined here as comprising the watersheds of the Great Lakes and the St. Lawrence River upstream from Trois-Rivières. To understand the current situation in the basin, one must go back at least 30 years. In January of 1985, the IJC released its first major report on Great Lakes Diversions and Consumptive Uses[3]. That report called for, among other things, improved information on consumptive use, and "a process of notice and consultation before additional new or changed diversions are approved." As that Reference was winding down, the eight Great Lakes States and two Canadian Provinces were already negotiating the Great Lakes Charter[4], which they signed on February 11, 1985.

The Great Lakes Charter provided that no state or province would approve or permit any major new or increased diversion or consumptive use of the waters of the Great Lakes Basin without notifying and consulting with all affected Great Lakes States and Provinces. In order to participate in the notice and consultation process, jurisdictions had to be in a position to provide accurate and comparable information on withdrawals, and have the authority to manage and regulate diversions and consumptive uses. The Charter also recorded commitments to develop

[1] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf
[2] International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004, www.ijc.org/files/publications/ID1560.pdf, accessed October 22, 2014.
[3] International Joint Commission, 1985. Great Lakes Diversions and Consumptive Uses (January, 1985)
[4] Council of Great Lakes Governors, 1985. The Great Lakes Charter Principles for the Management of Great Lakes Water Resources (February 11, 1985)

and maintain a common data base, the systematic exchange of data and information, and the creation of a Water Resources Management Committee.

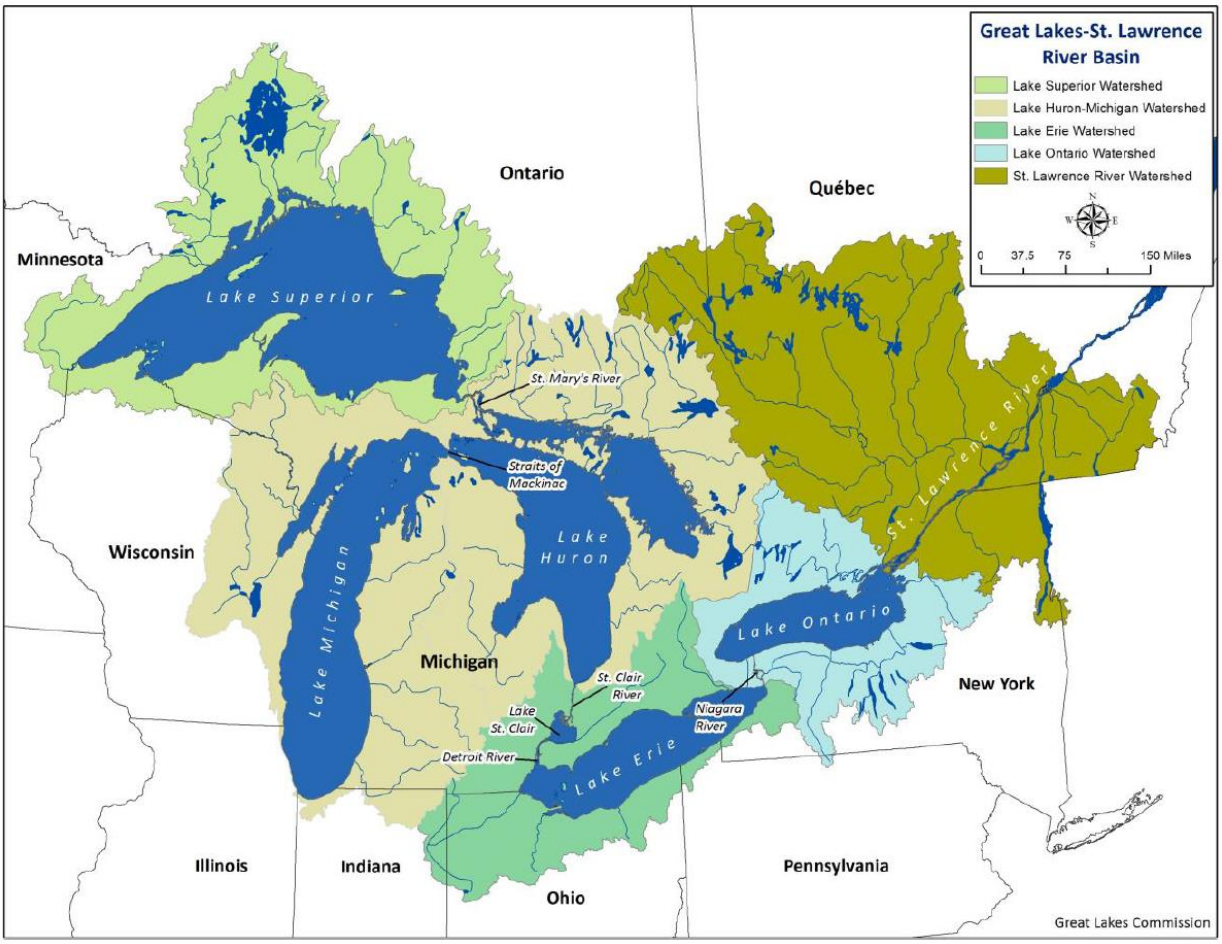


Figure 1. Map of Great Lakes basin. From Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010
http://www.glslcompactcouncil.org/Docs/Misc/2013%20Cumulative%20Impact%20Assessment%2012-6-13.pdf

The communities of Pleasant Prairie, Wisconsin in 1990 and Akron, Ohio in 1998 won the support of eight Great Lakes States for diversions outside the Basin on the condition that they would return an approximately equivalent amount of water; and were approved pursuant to the federal Water Resources Development Act of 1986, which required approval of any proposed diversion of Great Lakes waters by the governors of all Great Lakes states. The Governor of Michigan in 1992 disapproved a diversion sought by the town of Lowell, Indiana. At the same time, several other communities that straddle or are near the Basin divide, especially in Ohio, Indiana and Wisconsin were beginning to look to the Great Lakes for a secure source of future water supply.

In 1998, shock waves spread across the region when a Canadian entrepreneur proposed to ship Lake Superior water to Asia by marine tanker. Even though clearly impractical, that proposal, along with media speculation about possible large scale diversions to the U.S. southwest, raised

the specter of commercial trade in the resource, possibly even on a global scale, something quite different in nature from the regional or local development goal which had previously characterized diversion projects.

Governments at all levels acted quickly and decisively. The U.S. Government passed legislation which, among other things reconfirmed its 1986 prohibition on new diversions from the Great Lakes without the approval of each of the Great Lakes States and expanded the requirement to water exports. The Canadian Government initiated legislation to prohibit new removals from the Canadian boundary waters of the Great Lakes, with minor and well-defined exceptions. And the two national Governments issued a new Reference to the IJC, with instructions to report back with its findings and recommendations within a year.

On October 15, 1999, the Great Lakes Governors and Premiers issued a statement renewing their commitment to the principles contained in the Great Lakes Charter, and pledged to develop a new agreement that would bind the States and Provinces more closely to collectively planning, managing and making decisions regarding the protection of the Great Lakes. The Governors also pledged to develop a new common standard, based on the ecological integrity of the Great Lakes ecosystem, against which projects would be reviewed.

The IJC released its recommendations on February 22, 2000. The Council of Great Lakes Governors (in full partnership with the Premiers) proceeded with its negotiations until December 13, 2005, at which time the Governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, and the Premiers of Ontario and Québec signed the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement). Following ratification by the eight State legislatures and the U.S. Congress, the parallel Compact (Compact) was signed into law by President Bush on October 3, 2008 and came into force on December 8, 2008.

2. Findings and Recommendations

In its 2000 report, the IJC recommended that the governments of the Great Lakes States and Provinces should not permit any proposal for removal of water from the Great Lakes to proceed unless the proponent could demonstrate that the removal would not endanger the integrity of the ecosystem of the Great Lakes and that certain other conditions be met. The most critical of these conditions was that there be no greater than a 5% loss, and that the water is returned in a condition that protects the quality of and prevents the introduction of alien invasive species into the waters of the Great Lakes.

The Agreement and Compact include similarly stringent requirements. New or increased diversions outside the Basin are prohibited, with limited and conditional exceptions for municipal water supply to communities straddling the Basin divide, and for communities within straddling counties. Before they may be authorized, excepted diversions must meet strict requirements and comply with a specific Standard for Exceptions, including the obligation that the flow must be returned to the Great Lakes-St. Lawrence Basin. The Agreement requirement regarding actual return flow rather than the 5% recommended by the Commission is essentially the same with respect to average loss, but it is much more practical to implement. Intra-basin

diversions (from one Great Lakes watershed to another) are also subject to clearly defined Standards. It should be noted that Illinois is exempt from the Compact provisions governing both diversions and withdrawals, because virtually all withdrawals from the Lake Michigan Basin within Illinois continue to be governed by an earlier U.S. Supreme Court Decree[5].

In 2000, IJC recommendations regarding consumptive use suggested that major new or increased consumptive uses should only be permitted subject to full consideration of their cumulative impact, the implementation of effective conservation measures and the application of sound planning practices.

The provisions regarding withdrawals and consumptive use in the Agreement and Compact include both a prior notification requirement for any proposal leading to a water loss of 19,000 m^3/day or greater in any 90-day period, and a decision-making standard. The decision-making standard provides for the return of the withdrawn water to the same watershed, no significant individual and cumulative impact, the application of conservation measures, and reasonable use from a sustainable development perspective. The States and Provincesalso committed to conducting an assessment of the cumulative impact of water withdrawals at least every five years, taking climate change into account.

The Agreement and Compact provide a level of overall protection similar to that recommended by the International Joint Commission in 2000. The Agreement and Compact, if fully and rigorously implemented, will provide a solid foundation for managing Great Lakes diversions and consumptive uses into the foreseeable future.

Findings: The Agreement and Compact have been successful to date. There have been no new inter-basin or intra-basin diversions approved that would have significant negative impacts on then ecological integrity of the Great Lakes, the growth in consumptive use has slowed and institutional arrangements, such as the Regional Body, are in place.

2015 RECOMMENDATION 1: The existing Agreement and Compact should continue to be rigorously implemented to minimize loss of water from the Basin.

Diversions and Other Removals

Since the Agreement was signed in 2005, most of the basic legal framework necessary to support implementation of both the Agreement and the Compact has been put in place. In 2009, Québec enacted enabling legislation. In 2007, Ontario enacted the Safeguarding and Sustaining Ontario's Water Act for the same purpose. However, in the case of Ontario, the provisions only came into force on January 1, 2015 following adoption of regulations affecting new or increased transfers of water from one Great Lakes watershed to another. The new regulations fully comply with Agreement Standards. The Agreement came into force 60 days after the Premier of Ontario

[5] U.S. Supreme Court 1967/1980. Lake Michigan Diversion Supreme Court Consent Decree 388 U.S. 426 1967) Modified 449 U.S. 48 (1980)

notified the Regional Body that Ontario had completed the measures required to implement the Agreement. That formal notification took place on January 7, 2015.

In the United States, all eight state legislatures and their respective governors ratified the Compact, beginning with Minnesota on February 20, 2007, and ending with Michigan on July 9, 2008. The Compact was passed by the U.S. Senate on August 1, 2008, by the U.S. House of Representatives on September 23, 2008 and signed by the President on October 3, 2008. Since 2008, state legislatures and regulatory agencies have adopted numerous additional laws, regulations and guidelines in support of Agreement and Compact implementation, as have sub-state governments (e.g. municipalities).

The first successful request for a straddling community diversion exception was a proposal from the City of New Berlin, which was approved by the state of Wisconsin on May 21, 2009[6]. That approval enables New Berlin to receive additional Lake Michigan water from Milwaukee to supply parts of the City lying outside the Great Lakes Basin. Under the approval, the City will continue to return water to the Lake Michigan Basin via the Milwaukee Sewage District, resulting in no net loss of water to the Great Lakes Basin. The application was also deemed to have met all other Compact terms, including enhanced conservation efforts and strict monitoring and reporting requirements to ensure that the water withdrawal and return flow quality are closely tracked.

The first and only application to date under the straddling county provisions is one by the City of Waukesha, which is still pending[7][8]. The City of Waukesha, Wisconsin is located within the straddling county of Waukesha, but lies outside the Lake Michigan watershed. The application asserts that Waukesha needs a new source of water to address water quality (radium) and quantity concerns. The City currently obtains its public water supply primarily from groundwater wells in a deep aquifer.

Under the Compact process, the State must satisfy itself that the application is approvable before submitting it to the Regional Body made up of representatives of the Great Lakes States and Provinces. The Regional Body must then issue a declaration of finding, and the Compact Council (whose members are the Governors) must then approve the application before it can move forward. If approval under the Compact is obtained, the State would have the authority to complete the necessary permit reviews and issue a final decision. At the time of writing, consideration of the application was still pending in the State of Wisconsin, and no application had been forwarded for regional consideration.

There continue to be some longer-term public concerns about larger-scale diversions. The mega diversion era ended in the United States with the Central Arizona Project in the 1970s and in Canada with the La Grande Project in the early 1990s. But the possibility remains that climate change or other unforeseen circumstances could conceivably change that calculus. The Great Lakes Region needs to continue to be vigilant and precautionary in its approach to diversions.

[6] Milwaukee Journal Sentinel 2009. New Berlin's Request for Lake Water Approved, a First under the Great Lakes Compact, by Darryl Enriquez (May 21, 2009)
[7] Government of Wisconsin 2014. City of Waukesha Water Diversion Application. Current Status (June, 2014)
[8] Sarah Gardner, 2015, Waukesha Fights for a Share of Lake Michigan Water, Marketplace, February 4, 2015

Findings: To date, the precautionary approach adopted in the Agreement and Compact to deal with diversion proposals has been rigorously followed.

2015 RECOMMENDATION 2: The precautionary approach regarding diversions should continue to guide the States and Provinces in order to protect the Great Lakes from an ever-increasing number of larger-scale removals.

Water Use Data and Related Information

Box 1 summarizes recent (2012) information on water use in the Basin. The numbers indicate that basin-wide consumptive water use is small (0.4%) compared to basin-wide renewable supply.

Box 1. Great Lakes Basin Water Use Facts (2012) [9] [10]

- Total withdrawals as volume per time: 42,324 MLD [a] (11,200 MGD [b])
- Total withdrawals as fraction of basin-wide renewable supply [c]: 7%
- Total consumptive use as volume per time: 2,332 MLD (616 MGD)
- Total consumptive use as fraction of basin-wide renewable supply: 0.4%
- Average consumptive use coefficient: 6% [d]
- Consumptive use by water use sector as fraction of total consumptive use
  - public water supply: 34%
  - self-supplied irrigation and livestock: 17%
  - self-supplied industrial: 31%
  - self-supplied thermoelectric: 15%
  - self-supplied other: 3%

[a] millions of liters per day
[b] millions of US gallons per day
[c] basin-wide renewable supply equals long-term average St Lawrence River outflow
[d] consumptive use coefficient equals total consumptive use divided by total withdrawals

U.S. withdrawals in the Basin peaked in 2007, and decreased afterwards at a rate of 4% per year. For the U.S. as a whole, total withdrawals declined by 13% from 2005 to 2010. It is not possible to detect trends accurately in Canadian data because of data deficiencies and changing methodologies. Nevertheless, Environment Canada reports that in the public water supply sector, national per capita water use decreased by 14% from 2006 to 2009, but cautions that some of the decrease could have been due to climatic factors.

The Great Lakes Regional Water Use Database (GLRWUD) is the longest–running source of withdrawal and consumptive use data derived exclusively for the Great Lakes-St. Lawrence

[9] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/index.php
[10] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/data_about_cuc.php

River Basin. The database relies on measures and estimates provided by the States and Provinces, based on a combination of mandatory and voluntary reporting by individual users. Recent attempts have been made to standardize water use reporting basin-wide. In 2009, interim protocols for reporting water withdrawals were adopted by the Great Lakes Compact Council and Regional Body. The protocols aim for consistency in reporting for large water users, defined as having an average withdrawal of 378,000 liters per day (100,000 US gallons per day) or more on average on any 30 day period.

Significant gaps occur in historical Canadian data, attributed to a lack of assessment tools, staff and regulatory statutes. U.S. state agencies also reported that budgetary constraints have limited the quality and completeness of their databases. Discrepancies have been noted between water use estimates by the U.S. Geological Survey[11] and the GLRWUD for 2005. However, the magnitude of the discrepancies is not unusual, given typical levels of confidence in water use data. Protocols for reporting water withdrawals to the GLRWUD[12] adopted by the Great Lakes Compact Council and Regional Body in 2009 should improve the accuracy of water use data.

Most forecasts since the 1960s have substantially overestimated future withdrawals. Perhaps the most credible prediction at this time is one to the year 2090 based on a series of climate and socioeconomic scenarios.[13] Averaging over the climate scenarios, the forecasts suggest a decline in total withdrawals between 2005 and 2090 due to a wetter climate, a relatively constant population, and increases in water use efficiencies.

Findings: A complete understanding of consumptive use is critical to careful water management throughout the Basin, including evaluations of the impact of new diversions. Consumptive use in the Great Lakes Basin is small relative to renewable supply[14], and given recent trends is unlikely to increase substantially in the next few decades. Substantial improvements in water use data collection practices by the States, Provinces and Regional Body have occurred over the last five years. The reliability of water use reporting and consumptive use calculations remains questionable, given inconsistency in different sources of water withdrawal estimates, lack of consistent quality control procedures in water use reporting, and the use of consumptive use coefficients that have been criticized as inadequate.

2015 RECOMMENDATION 3: The Great Lakes States and Provinces, in collaboration with the two federal governments, should continue to investigate methodologies for improving the accuracy of water use and consumptive use estimates.

[11] Mills, P.C., and Sharpe, J.B. 2010. Estimated withdrawals and other elements of water use in the Great Lakes Basin of the United States in 2005: U.S. Geological Survey Scientific Investigations Report 2010–5031, 95 p.
[12] Resolution #9 - Adoption of Water Use Reporting Protocols Adopted by the Great Lakes-St. Lawrence River Basin Water Resources Council on December 8, 2009 (http://www.glslcompactcouncil.org/Docs/Resolutions/GLSLRBWRC_Resolution_9--Water_Use_Reporting_Protocols.pdf)
[13] Brown, T. C., R. Foti, and J. A. Ramirez (2013), Projected freshwater withdrawals in the United States under a changing climate, Water Resources Research, 49, 1259–1276, doi:10.1002/wrcr.20076
[14] Great Lakes Governors and Premiers 2013. Resolution: Water Monitoring (1 June, 2013).

Cumulative Impacts

The first mandatory cumulative impact assessment was released by the Regional Body and Council in December of 2013[15]. The primary theme running through that assessment is the uncertainty in water balance components, especially runoff, direct precipitation, direct evaporation, and consumptive use. It is clear that, unless the scale of new consumptive use or diversion proposals is substantially larger than the current totals, the impacts of these proposals on lake water balances, lake levels and ecological integrity on a lake-wide scale will be so small as to be impossible to estimate. There is also considerable uncertainty about how to gauge ecological or socio-economic impacts of lake level fluctuations.

The December 2013 cumulative impact assessment raises the question as to whether assessments only at the Great Lakes or Lake watershed scale are appropriate. It is possible that local consumptive uses at the sub-basin scale are large relative to local watershed outflows. For example, the Great Lakes Commission's "Value of the Great Lakes Initiative" report identified several watersheds in the U.S. portion of the Great Lakes Basin where consumptive uses exceed 20% of summer monthly flows.

Findings: The current magnitude of consumptive uses and diversions is smaller than the level of uncertainty in the water balance components. Unless proposed new proposals for consumptive uses and diversions are substantially larger than current levels or the science of lake hydrologic balances improves, the impacts of these proposals on lake water balances, levels and ecological integrity on a lake-wide scale will be too small to estimate. Continued work to reduce the uncertainty in water balance components is needed to support decision making.

2015 RECOMMENDATION 4: Further refinement of water balance components should continue to occur through federal agencies such the USGS, NOAA, US Army Corps of Engineers, and Environment Canada. Assuming that the science will continue to evolve rapidly, the Regional Body/Council should continuously review new knowledge regarding lake-wide hydrology and incorporate new advancement in decision-making processes.

Climate Change

The climate in the Great Lakes Basin is changing. Average air and surface water temperatures are rising, precipitation and evaporation are both increasing, and average annual ice cover is decreasing[16] [17] [18] [19] [20] [21]. For the Lake Michigan-Huron Basin, the increases in evaporation are

[15] Great Lakes Compact Council, 2013. Cumulative Impact Assessment of Withdrawals, Consumptive Use and Diversions 2006 – 2010

[16] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

[17] Kling, G.W., Hayhoe, K., Johnson, L.B., Magnuson, J.J., Polasky, S., Robinson, S.K., Shuter, B.J., Wander, M.M., Wuebbles, D.J., Zak, D.R. (Eds.), 2003. Confronting climate change in the Great Lakes region: impacts on our communities and ecosystems, 104 pp. UCS Publications, Cambridge, MA.

[18] Pryor, S. C., K. E. Kunkel, and J. T. Schoof, 2009a: Ch. 9: Did precipitation regimes change during the twentieth century? Understanding Climate Change: Climate Variability, Predictability and Change in the Midwestern United States, Indiana University Press, 100-112.

being mostly balanced by increases in local precipitation over the last 60 years.[22] [23] But, in the Lake Superior Basin, increased precipitation has not compensated for increased evaporation, explaining a trend towards declining water supplies in Lake Superior over the last 60 years.[24] [25] [26] While the trends may be weak with respect to the inter-annual climate variability and magnitude of uncertainty in the hydrologic components of the lake water balance, there has likely been a modest trend of declines in total Great Lakes supplies in recent decades, although recent (2013 and 2014) high runoff and precipitation levels have resulted in significant rebounds in Lakes Superior and Michigan Huron.

Findings: There is little agreement among studies of the impacts of future shifts in temperature and precipitation on water balances and lake levels. There does, nevertheless, seem to be a meta-trend in predictions, where earlier studies suggesting large declines are giving way to newer studies suggesting smaller declines. If the current trend of progress in the science of climate change and translation of climate change into hydrologic responses continues, it is expected that uncertainty will decrease.

2015 RECOMMENDATION 5: Considering the large uncertainties surrounding climate change and other human impacts on the hydrologic cycle, federal, provincial and state governments should continue to take an adaptive management approach in decision-making. Advancements in the state of science on climate change impacts in the Great Lakes should be encouraged by federal, state and provincial governments through further funding and a synthesis of the state of the science.

Groundwater

Although temporal trends in overall withdrawals appear to be flat or even declining, groundwater uses in the Basin increased by 3% between 1995 and 2005. In some areas, for example, in the Chicago-southeastern Wisconsin area in the U.S. and the Waterloo-Kitchener region in Canada, some experts suggest that the withdrawals may be so large as to be unsustainable. Excessive groundwater withdrawals can and in some areas actually do shift the groundwater divide in the aquifer system. This shift can negatively impact surface waters that are hydraulically connected to near-surface aquifers. Over-pumping of water supply aquifers can also result in degradation

[19] Austin, J. A., & Colman, S. M. (2007). Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback. Geophysical Research Letters, 34(6).
[20] Dobiesz, N. E., and N. P. Lester, 2009: Changes in mid-summer water temperature and clarity across the Great Lakes between 1968 and 2002. Journal of Great Lakes Research, 35, 371-384, doi:10.1016/j.jglr.2009.05.002.
[21] Lenters, J. D., 2004: Trends in the Lake Superior water budget since 1948: A weakening seasonal cycle, J. Great Lakes Res., 30, Supplement 1, 20-40.
[22] Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010 http://www.glslcompactcouncil.org/Docs/Misc/2013%20Cumulative%20Impact%20Assessment%2012-6-13.pdf
[23] NOAA Great Lakes Environmental Research Laboratory, Great Lakes Water Level Dashboard, http://www.glerl.noaa.gov/data/dashboard/data/, accessed December 9, 2014.
[24] Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010 http://www.glslcompactcouncil.org/Docs/Misc/2013%20Cumulative%20Impact%20Assessment%2012-6-13.pdf
[25] NOAA Great Lakes Environmental Research Laboratory, Great Lakes Water Level Dashboard, http://www.glerl.noaa.gov/data/dashboard/data/, accessed December 9, 2014.
[26] International Upper Great Lakes Study Board 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels, Final Report to the International Joint Commission.

of water quality and human health as naturally-occurring contaminants like radium and fluoride are drawn in from adjacent aquifers.

Many of these factors come into play in Agreement and Compact implementation. For example, in the case of the Waukesha, Wisconsin diversion application, aquifer drawdown has impacted negatively on water quality[27], and some have asserted that groundwater use outside the Basin is likely drawing water from aquifers in the Basin[28]. The Compact and Agreement recognize these issues by assuming the surface water and groundwater divides coincide, which is rarely the case, but at the same time requiring substantive consideration as to whether or not the existing water supply is derived from groundwater that is hydraulically connected to waters within the Basin.

Findings: Unsustainable groundwater use is continuing in some areas of the basin. While the focus on groundwater withdrawals usually considers impacts on groundwater supply availability, e.g. groundwater overdrafts, the impacts of groundwater withdrawals on groundwater quality are increasingly important, especially as these impacts relate to new requests for diversions.

2015 RECOMMENDATION 6: Great Lakes States and Provinces should fully factor the adverse ecological and water quality impacts of groundwater withdrawals into both water use permitting procedures and decisions regarding consumptive use. Federal, state and provincial research should focus on predicting where groundwater supplies may be degraded in the future and identify management methods for avoiding these problems.

Conservation

In 2000, the Commission recommended the development of a coordinated basin-wide water conservation initiative. In the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, the States and Provinces committed to the setting of regional goals and objectives, and the implementation of voluntary or mandatory programs for the conservation and efficient use of water. The chapter of this report on conservation provides a cursory jurisdiction-by-jurisdiction review of progress with respect to the establishment of baseline information, the development of goals, objectives and associated programs, the registration of withdrawals, and programs for regulating new or increased withdrawals and consumptive use. That cursory review points to many impressive accomplishments by the States and Provinces over the past decade.

Generally, water use in North America has levelled off and the Great Lakes Basin has made gains in water use efficiency since the signing of the Agreement. However, the region holds

[27] US Geological Survey, Ground water in the Great Lakes Basin: the case of southeastern Wisconsin, http://wi.water.usgs.gov/glpf/, accessed April 14, 2015.
[28] Feinstein, D.T., Eaton, T.T., Hart D.J., Krohelski, J.T., Bradbury, K.R. 2005, Regional aquifer model for southeastern Wisconsin – Report 2: Model results and interpretation, Technical Report 41, Southeastern Wisconsin Regional Planning Commission, http://www.sewrpc.org/SEWRPCFiles/Publications/TechRep/tr-041_aquifer_simulation_model.pdf, accessed April 14, 2015.

significant untapped potential to improve water efficiency performance in the areas of infrastructure maintenance.

The state of the region's deteriorating water infrastructure undercuts water conservation. Aging pipes commonly leak and waste significant amounts of water. The single largest need is repair, replacement and construction of transmission and distribution systems. Prudent leadership and investment by governments-at all levels-in maintaining and improving the delivery of drinking water can significantly enhance efficiency and may limit local impacts from drawdown on surface and groundwater, reduce energy required to treat and transport water, and preserve water to meet the needs of the multiple users and future generations.

Findings: The IJC commends the Great Lakes states and provinces for impressive strides in enacting water conservation measures but additional conservation potential exists.

2015 RECOMMENDATION 7: The IJC recommends broad-based collaboration among public and private sectors to fix leaking public water infrastructure, support innovation, and increase funding to close the region's water infrastructure deficit and unlock water conservation potential region wide.

Moving forward, it is important to remember that there really is no "surplus" water in the Great Lakes Basin. From an ecosystem perspective, it is all in use, even in periods of high supply. There continue to be large voids between our knowledge regarding levels and flows, and the impact they have on the ecosystem of the basin. Due to prevailing uncertainties such as those posed by climate change and the sheer threat of the unexpected, the precautionary principle needs to be continually applied by basin jurisdictions to ensure, to the extent possible, adequate supplies for all socio-economic and ecosystem uses for the long term.

Introduction

When the International Joint Commission (IJC) submitted its report on Protection of the Great Lakes on February 22, 2000[29], governments authorized the Commission to review its recommendations after three years and at 10-year intervals thereafter. The Commission released its first review in 2004[30] and in 2014 agreed to undertake its first 10-year review. This report deals primarily with developments related to Great Lakes water uses and diversions since the year 2000 report.

The product of the 10-year review will be a report to governments prepared by IJC staff and approved by IJC Commissioners. Two contractors, one American and one Canadian, were retained by the Commission to assist it by conducting a collaborative content review of the 2000 report and developments since its release. This draft represents the preliminary findings of the contractors. Following Commission review and revisions as necessary, it has become the basis for public consultations. The final Commission report is expected to be completed and submitted to governments in 2015.

The initial review has included two broad categories, the first being policy, legal and decision-making aspects, and the second being related technical matters. The first category focuses mainly on the negotiation and implementation of the Great Lakes – St. Lawrence Basin Sustainable Water Resources Agreement among the States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, and the Provinces of Ontario and Québec. It includes Chapters on Decision-Making Regarding Consumptive Uses and Removals, Legal and Policy Considerations, Diversions and other Removals, and Conservation.

The technical category begins with an examination and critique of current and probable future consumptive use estimates. It then goes on to examine cumulative effects, climate change, groundwater quantity and quality as they relate to Agreement implementation, and conservation. Aside from the complete analysis in the individual chapters, a short Executive Summary is provided and is intended to inform an interested but not necessarily technically-inclined audience. In that Executive Summary, in addition to providing an overview of the report, a brief historical perspective is provided and a number of conclusions flowing from the more detailed analysis are highlighted.

[29] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf

[30] International Joint Commission 2004. Protection of the Waters of the Great Lakes: Review of the Recommendations in the February 2000 Report (August, 2004)

Decision Making Regarding Consumptive Uses and Removals

1. Situation as of February 2000

The Commission's 2000 report[31] devoted considerable attention to the 1985 Great Lakes Charter[32], a non-binding arrangement among the Great Lakes States and Provinces that focused attention on a number of resource issues in an effort to promote cooperation. The report noted that:

> "The Charter provides that the planning and management of the water resources of the Great Lakes Basin should be founded upon the integrity of the natural resources and ecosystem of the Great Lakes Basin. Moreover, the Charter stipulates that the water resources of the Basin should be treated as a single hydrologic system that transcends political boundaries in the Basin. New or increased major diversions and consumptive use of the water resources of the Great Lakes are said to be matters of serious concern, and the Charter states that '[it] is the intent of the signatory states and provinces that diversions of Basin water resources will not be allowed if individually or cumulatively they would have any significant adverse impacts on lake levels, in-basin uses and the Great Lakes Ecosystem."

The Charter provided that no state or province will approve or permit any major new or increased diversion or consumptive use of the water resources of the Great Lakes Basin without notifying and consulting with and seeking the consent and concurrence of all affected Great Lakes States and Provinces. The trigger point for notification and for seeking the consent and concurrence of other Great Lakes States and Provinces was an average use of 5 million US gallons per day (MGD) or 19 millions of liters per day (MLD) in any 30-day period. In order to participate in this notice and consultation process, jurisdictions had to be in a position to provide accurate and comparable information on water withdrawals in excess of 378,000 liters (100,000 US gallons) per day in average in any 30-day period and have authority to manage and regulate water withdrawals involving a total diversion or consumptive use of Great Lakes Basin water resources in excess of 7.6 million liters (2 million US gallons) per day average in any 30-day period.

The Great Lakes Charter also recorded a commitment by the signatory States and Provinces to pursue the development and maintenance of a common base of data and information regarding the use and management of Basin water resources, the establishment of systematic arrangements for the exchange of water data and information, the creation of a Water Resources Management Committee, the development of a Great Lakes Basin Water Resources Management Program, and additional coordinated research efforts to provide improved information for future water planning and management decisions.

On October 15, 1999, the Great Lakes Governors issued a statement renewing their commitment to the principles contained in the Great Lakes Charter and pledged to develop a new agreement,

[31] International Joint Commission 2000. Protection of the Waters of the great Lakes, final Report to the Governments of Canada and the United States (February 22, 2000)

[32] Council of Great Lakes Governors 1985. The Great Lakes Charter, Principles for the Management of Great Lakes Water Resources (February 11, 1985)

based on those principles that would bind the States and Provinces more closely to collectively planning, managing, and making decisions regarding the protection of the waters of the Great Lakes. The governors also pledged to develop a new common standard, based on the protection of the integrity of the Great Lakes ecosystem, against which water projects would be reviewed.

The essence of Recommendation I (see Box 2) on removals was that the governments of the Great Lakes States and Provinces should not permit any proposal for removal of water from the Great Lakes to proceed unless the proponent can demonstrate that the removal would not endanger the integrity of the ecosystem of the Great Lakes and that certain other conditions be met. The most critical of these conditions was that there be no greater than a 5% loss, and that the water is returned in a condition that protects the quality of and prevents the introduction of alien invasive species into the waters of the Great Lakes.

Box 2: Recommendation I from 2000 Report. Removals

Without prejudice to the authority of the federal governments of the United States and Canada, the governments of the Great Lakes States and Ontario and Québec should not permit any proposal for removal of water from the Great Lakes Basin to proceed unless the proponent can demonstrate that the removal would not endanger the integrity of the ecosystem of the Great Lakes Basin and that:

a. there are no practical alternatives for obtaining the water,
b. full consideration has been given to the potential cumulative impacts of the proposed removal, taking into account the possibility of similar proposals in the foreseeable future,
c. effective conservation practices will be implemented in the place to which the water would be sent,
d. sound planning practices will be applied with respect to the proposed removal, and,
e. there is no net loss to the area from which the water is taken and, in any event, there is no greater than a 5 percent loss (the average loss of all consumptive uses within the Great Lakes Basin); and the water is returned in a condition that, using the best available technology, protects the quality of and prevents the introduction of alien invasive species into the waters of the Great Lakes.

In reviewing proposals for removals of water from the Great Lakes to near-Basin communities, consideration should be given to the possible interrelationships between aquifers and ecosystems in the requesting communities and aquifers and ecosystems in the Great Lakes Basin.
In implementing this recommendation, States and Provinces shall ensure that t the quality of all water returned meets the objectives of the Great Lakes Water Quality Agreement.

At this time, removal from the Basin of water that is used for ballast or that is in containers of 20 liters or less should be considered, prima facie, not to endanger the integrity of the ecosystem of the Great Lakes. However, caution should be taken to properly assess the possible significant local impacts of removals in containers.

Removal of water for short-term humanitarian purposes should be exempt from the above restrictions.

The governments of Canada and the United States and the governments of the Great Lakes states and Ontario and Québec should notify each other of any proposals for the removal of water from the Great Lakes Basin, except for removal of water that is used for ballast or that is in containers of 20 liters or less.

Consultations regarding proposed removals should continue in accordance with the procedures and processes that are evolving throughout the Great Lakes Basin and should be coupled with additional opportunities for public involvement.

Any transboundary disagreements concerning any of the above matters that the affected governments are not able to resolve may, as appropriate, be referred by the governments of Canada or the United States to the International Joint Commission pursuant to Article IX of the Boundary Waters Treaty.

Nothing in this recommendation alters rights or obligations under the Boundary Waters Treaty.

The Commission's Recommendation II (see Box 3) regarding consumptive use suggested that major new or increased consumptive uses should only be permitted subject to full consideration of their cumulative impact, the implementation of effective conservation measures and the application of sound planning practices. The Commission also recommended that state and provincial governments should not authorize or permit any new removals and should exercise caution with respect to major new or increased consumptive use until standards (see Recommendation IV regarding standards, Box 4) have been promulgated or until 24 months have passed, whichever comes first.

Box 3: Recommendation II from 2000 Report. Major New or Increased Consumptive Uses

To avoid endangering the integrity of the ecosystem of the Great Lakes Basin, and without prejudice to the authority of the federal governments of the United States and Canada, the governments of the Great Lakes States and Ontario and Québec should not permit any proposal for major new or increased consumptive use of water from the Great Lakes Basin to proceed unless:

a. full consideration has been given to the potential cumulative impacts of the proposed new or increased major consumptive use, taking into account the possibility of similar proposals in the foreseeable future,
b. effective conservation practices will be implemented in the requesting area, and,
c. sound planning practices will be applied with respect to the proposed consumptive use
.

In implementing this recommendation, States and Provinces shall ensure that the quality of all water returned meets the objectives of the Great Lakes Water Quality Agreement.
The governments of Canada and the United States and the governments of the Great Lakes States and Ontario and Québec should notify each other of any proposals for major new or increased consumptive uses of water from the Great Lakes Basin.

Consultations regarding proposed major new or increased consumptive uses should continue in accordance with the procedures and processes that are evolving throughout the Great Lakes Basin and should be coupled with additional opportunities for public involvement.

Any transboundary disagreements concerning the above that the affected governments are not able to resolve may, as appropriate, be referred by the governments of Canada or the United States to the International Joint Commission pursuant to Article IX of the Boundary Waters Treaty.

Nothing in this recommendation alters rights or obligations under the Boundary Waters Treaty.

Box 4: Recommendation IV from 2000 Report. Great Lakes Charter Standards

Without prejudice to the authority of the federal governments of the United States and Canada, the Great Lakes States and Ontario and Québec, in carrying out their responsibilities under the Great Lakes Charter, should develop, within 24 months, with full public involvement and in an open process, the standards and the procedures, including the standards and the procedures in Recommendations I and II, that would be used to make decisions concerning removals or major new or increased consumptive uses. Federal, state, and provincial governments should not authorize or permit any new removals and should exercise caution with respect to major new or increased consumptive use until such standards have been promulgated or until 24 months have passed, whichever comes first.

2. Recent Developments

Since the Commission issued its 2000 Report, there has been considerable and impressive progress, mostly under the aegis of the Great Lakes Governors' and Premiers' Regional Body. In 2001, the Great Lakes States and Ontario and Québec concluded an Annex to the 1985 Great Lakes Charter, a good-faith arrangement called Annex 2001[33] that committed them to establish a new decision-making standard and a decision-support system to manage withdrawals of water from the Great Lakes Basin.

Intense negotiations took place over the following three years, including the solicitation of advice from numerous external institutions and individuals, and proposed new arrangements to implement Annex 2001 were put out for public comment for 90 days beginning July 19, 2004. Following further intense negotiations, and a second round of public review and comment, on December 13, 2005, the Governors of the States of Illinois, Indiana, Michigan, Minnesota, New York Ohio and Wisconsin, the Commonwealth of Pennsylvania, and the Premiers of Ontario and Québec signed the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement; and following appropriate approvals within the United States, the parallel Great Lakes – St. Lawrence River Basin Water Resources Compact became effective on December 8, 2008.

The decision-making aspects of the Agreement and Compact, and progress in implementation, will be discussed in greater detail in subsequent chapters. However, the main features of the Agreement and Compact are described in Box 5.

Since the Agreement was signed in 2005[34], additional steps have been taken to

Box 5: Main features of the Agreement and Compact

Legal Status: The Agreement is a "good faith" arrangement under which the Parties undertake to render it binding by adopting appropriate domestic laws. In the United States, the Compact is a legally binding agreement as both State and Federal law.

Geographical scope: The waters in question include the Great Lakes, the St. Lawrence River, and all of the tributaries flowing into them within the jurisdiction of the Great Lakes States and Provinces. They also include all the groundwater located in the defined watershed. In Québec, the Basin ends at the limit of influence of tides which is at Trois-Rivières.

Objectives: The objectives of the Compact and Agreement are: to act together to protect, restore improve and manage the waters of the Great Lakes and St. Lawrence River Basin; to promote cooperation among the Parties; to create a cooperative arrangement for the management of proposals to withdraw water; to provide common and regional mechanisms to evaluate proposals to withdraw water, to retain State and provincial authority within the Basin, and to prevent significant adverse impacts of water withdrawals on the Basin ecosystem and its watersheds.

Diversions: New or increased diversions outside the Basin are prohibited, with limited and conditional exceptions for public water supply to straddling communities, communities within a straddling county and intra-basin diversions. Before they may be authorized, excepted diversions must meet strict requirements and comply with a specific Standard for Exceptions, including the obligation that the return flow must be returned to the Great Lakes - St. Lawrence Basin, as well as preventing the introduction of invasive species. Intra basin and Straddling County diversions (from one Great Lakes Watershed to another) are also subject to meeting additional clearly defined criteria. It should be noted that Illinois is not subject to the Compact provisions governing diversions and withdrawals more generally, because virtually all withdrawals from the Lake Michigan Basin within Illinois continue to be governed by an earlier U.S. Supreme Court decision.

[33] Council of Great Lakes Governors 2001. Annex 2001, an Addendum to the Great Lakes Charter of 1985
[34] Personal communications with Council of Great Lakes Governors staff (November, 2014)

facilitate implementation. These include, among other things: a memorandum of understanding between the Regional Body and Council of Great Lakes Governors regarding the Secretariat to the Regional Body; the creation of an Advisory Committee; the adoption of detailed interim procedures for dealing with specific proposals; protocols for state/provincial reporting to the regional water use database; a protocol regarding communications with First Nations and Federally-Recognized Tribes; a number of other guidelines on specific aspects of the Agreement; and most recently affirmation of Basin-wide conservation and efficiency objectives. Similar actions, including appointing the Council of Great Lakes Governors as their Secretariat, were undertaken by the Compact Council.

3. Remaining Issues

A comparison of the Commission's year 2000 recommendations regarding diversions with the provisions in the Compact and Agreement indicates only two significant differences. The first involves the return flow requirements for diversions, and the second involves the treatment of the Chicago Diversion.

For removals, the Commission recommended that there be "no net loss to the area from which the water is taken and, in any event, there is no greater than a 5 percent loss (the average loss of all consumptive uses within the Great Lakes Basin)) …." On the other hand, the Compact and Agreement require that the diversions be for public water supply purpose only, place geographical limits on the removals (communities straddling the Basin boundary or within straddling counties), and require that all return flow (withdrawal minus consumptive use) be returned to the source watershed. Although the effect of the two approaches is essentially the same in terms of average water loss, the approach adopted in the Agreement is more practical to actually implement.

Consumptive Use: The provisions regarding withdrawals and consumptive use include both a prior notification requirement for any proposal leading to a water loss of 19000m3/day or greater in any 90 day period, and a decision-making standard. The decision-making standard provides for the return of the withdrawn water to the same watershed, no significant individual and cumulative impact, the application of water conservation measures, and reasonable use from a sustainable development perspective. The Parties also committed to conducting an assessment of the cumulative impact of water withdrawals at least every five years, taking climate change into account.

Compact Council: The Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council) is created by the Great Lakes Compact. The Council reviews and approves or disapproves diversion proposals, identifies priorities and develops plans and policies relating to Basin water resources. It adopts and promotes uniform and coordinated policies for water resources conservation and management in the Basin.

Regional Body: The Parties agreed to establish the Great Lakes-St. Lawrence River Water Resources Regional Body comprised of the Governors and Premiers or their representatives. The duties of the Regional Body include reporting on Agreement implementation, performing regional analyses of projects submitted to it, issuing declarations on whether projects meet the Standards for Exception, facilitating the resolution of disputes, periodically assessing cumulative impacts, and reviewing and if appropriate revising Standards.

Regional Reviews: Rules regarding regional reviews of major withdrawal proposals are included, including those dealing with notification, public participation, technical reviews and Declarations of Findings. The Compact Council and the Party from which the application originates will consider the Declaration of Finding before deciding whether or not it approves the water withdrawal according to its own laws and regulations. A non-binding procedure for dispute resolution is also provided.

Final Provisions: These provisions reaffirm constitutional powers and responsibilities, the relationship between these arrangements and other international agreements or treaties, and understandings concerning the relationship with Tribes and First Nations. It also includes procedures regarding entry into force, the procedures for amendment, withdrawal and termination, and the languages used (English and French).

In 2000, the IJC did not anticipate the need for special treatment in the case of Illinois due to overriding legal constraints imposed by an existing Supreme Court Decree[35]. Agreement negotiators dealt with this dilemma by agreeing that "current, New or Increased Withdrawals, Consumptive Uses and Diversions of Basin water by the State of Illinois shall be governed by the terms of the United States Supreme Court decree in *Wisconsin et al v. Illinois et al*. and shall not be subject to the terms of this Agreement nor any rules or regulations promulgated pursuant to this Agreement."

As long as the decree stays in place and is fully complied with, it provides at least the same level of protection to the Great Lakes as the other provisions in the Agreement. In the summary of the December 6, 2013 meeting of the Great Lakes – St. Lawrence River Water Resources Regional Body, the Illinois representative reported that "Illinois continues to be in full compliance with the U.S. Supreme Court decree that limits diversions. Since 1994, Illinois has been below court limit every year and this will continue into the future. The state was well below the limit in both 2012 and 2013."

Regarding consumptive use, there has been considerable progress in establishing baseline volumes and registration programs, developing water conservation and efficiency goals, and implementing water conservation and efficiency programs. The approaches and level of success vary widely among jurisdictions, as would be expected with a mix of voluntary and mandatory programs, and very different starting points. These differences and relative successes are explored in more detail in the chapter on Conservation.

In summary, the Compact and Agreement provide a level of overall protection similar to that recommended by the IJC in 2000. The Compact and Agreement provide a solid foundation for managing Great Lakes diversions and consumptive uses into the foreseeable future, and no changes are required at this time.

As the IJC pointed out in 2000, for the 21st century, there is substantial uncertainty regarding factors such as future changes in consumptive use, and changes in water supply due to climate change. Although there are insufficient data and inadequate scientific understanding to precisely estimate the magnitude and timing of impacts associated with consumptive use and climate change, this does not mean that impacts couldn't be significant in the future. This – and the prospect of adverse cumulative impacts of new human interventions – suggests a need for great caution in dealing with factors that are within the control of Basin managers, such as adaptive management protocols, improved monitoring, and continual improvements in our knowledge of basin hydrology.

[35] U.S. Supreme Court 1967/1980. Lake Michigan Diversion Supreme Court Consent Decree 388 U.S. 426 (1967) Modified 449 U.S. 48 (1980)

Legal and Policy Considerations

1. Situation as of February 2000

In its 2000 Report, the Commission noted that the Great Lakes Basin was subject to a network of legal regimes, both domestic and international (see Recommendation V and Recommendation IX in Boxes 6 and 7, respectively). The report did not provide a detailed discussion of all the possible legal issues that could arise in the context of water management in the Basin; it did, however, identify those "aspects of the legal regime that bear most directly on the issues raised in [the] report." Specifically, the section in the report on legal and policy considerations focused on both the international legal context and the domestic legal context, with a separate short section on Aboriginal Peoples and Indian tribes.

Box 6: Recommendation V from 2000 Report. Existing Institutions and Mechanisms

To help ensure the effective, cooperative, and timely implementation of programs for the sustainable use of the water resources of the Great Lakes Basin, governments should use and build on existing institutions to implement the recommendations of this report. In this regard, the governments of the States and the Provinces should take action, with respect to the implementation of the Great Lakes Charter, to:

a. develop and implement, on an urgent basis, the Basin Water Resources Management Program,
b. develop a broader range of consultation procedures than is currently called for in the Charter to assure that significant effects of proposed uses of water resources in the Great Lakes Basin are assessed, and,
c. ensure that the notice and consultation process under the Charter is open and transparent and that there is adequate consultation with the public.

Box 7: Recommendation IX from 2000 Report. Trade Law

The governments of the United States and Canada should direct more effort to allaying the public's concern that international trade law obligations could prevent Canada and the United States from taking measures to protect waters in the boundary region, and they also need to direct more effort to bringing greater clarity and consensus to the issue.

1.2 International Legal Context

The discussion of the international legal context in the 2000 Report had three primary prongs: the legal regime created by the Boundary Waters Treaty of 1909, the arrangements instituted in the Great Lakes Charter of 1985, and international trade law.

Boundary Waters Treaty

The Commission noted the effectiveness of the Boundary Waters Treaty of 1909, for a period of over ninety years "in assisting Canada and the United States to avoid and resolve disputes over freshwater." It also observed, however, that the treaty regime does not treat all Basin waters in the same way. For example, while the treaty requires Commission approval in cases where the "use, diversion, or obstruction" of boundary waters will affect water levels or flows on the other side of the boundary (Article III), in the case of tributaries to boundary waters or of transboundary

rivers, each nation reserves "exclusive jurisdiction and control over [their] use and diversion". (Article II). The Commission also noted that groundwater was not referred to explicitly in the treaty.

Great Lakes Charter

The Commission's 2000 report noted the significance of the Great Lakes Charter of 1985 in the management of the waters of the Basin. Among other reasons, the Charter was initiated in reaction to proposals to divert Lake Superior water as a means of coping with the depletion of the Ogallala aquifer in the U.S. southwest. Although the Charter signatories include all the Great Lakes States and the two Canadian provinces, it was developed initially in the context of concerns originating in the United States, and the only litigation touching on the status of the Charter has been in U.S. courts.

Briefly, for those projects exceeding threshold levels, the Charter requires (Principle IV) that any signatory notify, consult and seek the consent of the other states or provinces for any new or increased diversion or consumptive use "of the water resources of the Great Lakes Basin." If the permitting state or province follows the Charter Consultation Procedures, it has the discretion to approve or disapprove a diversion. The Charter is a non- binding agreement and is at most "soft law". In the first litigation to consider it, a federal district court described it as "a kind of gentlemen's agreement between the Governors of the Great Lakes States and the Provinces of Ontario and Québec.[36]"

Shortly before the Commission issued its 2000 Report, the governors of the Great Lakes issued a statement that both re-committed them to the principles in the Charter and to the development of a new agreement to improve the collective management of the waters of the Great Lakes and the development of a common standard for reviewing water projects.

International Trade Law

The central conclusion of the Commission (Conclusion 23) with respect to international trade law obligations was that

> International trade law obligations ... do not prevent Canada and the United States from taking measures to protect their water resources and preserve the integrity of the Great Lakes Basin ecosystem. Such measures are not prohibited so long as there is no discrimination by decision makers against persons from other countries in their application, and so long as water management policies are clearly articulated and consistently implemented so that undue expectations are not created.

[36] Bowal, P. (2006). Canadian Water: Constitution, Policy, and Trade. Michigan State Law Review, 1141-1177.

1.3 Domestic Legal Context

Canada

In the case of the federal government, the Commission noted that it "exercises jurisdiction over water management primarily through its legislative [as opposed to proprietary] authority" and that "historically, the primary interest of the federal government has been focused on its constitutional responsibilities for fisheries…navigation…and international relations, although it has in recent years taken a role in water quality, particularly with respect to toxic substances."

The Commission noted that the federal government, in November 1999, had introduced into Parliament "proposed amendments to the International Boundary Waters Treaty Act that, if enacted, will impose a prohibition [for which there may be exceptions established by regulations] on removals of boundary waters from their water basins ... Moreover, the amendments will [subject to certain exceptions] require persons to obtain a license from the Minister of Foreign Affairs for the use, obstruction, or diversion of boundary waters in a manner that in any way affects, or is likely to affect, the natural level or flow of boundary waters on the other side of the international boundary."

All provinces have significant legislation governing the use of water. In the case of the two Basin provinces, Québec and Ontario, at the time of the Commission's 2000 report both these provinces had recently adopted new legal provisions with respect to water withdrawals. Ontario had adopted in 1999 a regulation[37] prohibiting (subject to certain exceptions) the transfer of water from the Great Lakes Basin. In the same year Québec adopted a *Water Resources Preservation Act*[38] prohibiting (subject to specified exceptions) the transfer of surface or ground water out of the province. Although this was adopted as an interim measure pending the completion of a then-ongoing provincial inquiry with respect to water management, the legislation was subsequently extended.

United States

In the case of the federal government, the Commission noted that "Congress has plenary power under the commerce clause of the U.S. Constitution to regulate interstate commerce. This federal authority includes the power to authorize and control the diversion of water from one navigable waterway to another and from one watershed to another, and it also includes the power to authorize the use of water for navigational purposes."

The key domestic developments in U.S. domestic law relating to water management in the Great Lakes Basin leading up to the release of the Commission's 2000 Report arose out of the Great Lakes Charter, discussed above. The Charter was implemented by the adoption of state laws that prohibited out of basin diversions. The Charter and related laws apply both to interstate and intrastate diversions.

[37] Government of Ontario 1999. O. Reg. 285/99 (filed April 30, 1999, gazetted May 15 1999)
[38] Government of Quebec 1999. Water Resources Preservation Act, S.Q. 199, c.63 (in force November 6, 1999)

Federally, Congress passed the *Omnibus Water Resources Development Act* of 1986 [WRDA][39] which prohibited all diversions from the Great Lakes or any United States tributary for use outside the Basin without the consent of all Governors. After its passage, WRDA was applied in several relatively small diversion proposals. These precedents may have influenced state thinking about the process and standards for diversions. Even small diversions could pose long-term risks because of their cumulative impacts.

1.4 Aboriginal Peoples and Indian Tribes

In its 2000 Report, the Commission noted that with respect to Canada the nature of Aboriginal Peoples' interests in water was not yet clearly settled, while in the United States, although "the right of Indian tribes to the use of the waters of the Great Lakes Basin has continued without significant challenge since the reservations were established (late 1700s to mid-1800s)", and although there has been some litigation as to tribal fishing rights in the Great Lakes, "there does not appear to have been any dispute over tribal use of water from the Great Lakes or its tributaries flowing through or adjacent to the reservations."

The situation in Canada was clarified somewhat in the mid-2014 Tsilhquot'in ruling in the Supreme Court of Canada[40]. The Court's decision affirmed aboriginal title to large swaths of frontier territory. It also confirmed that governments may not infringe on that title unless they can prove a "compelling and substantive" public need, and that they are fulfilling the Crown's fiduciary duty to the First Nation in question.

Whatever the ambiguities in the legal interests of Aboriginal Peoples and Indian tribes, the Commission found a consistent position in their "uniformly expressed opposition to exports or diversions from the Great Lakes Basin [in which they] strongly urged the need to ensure opportunities for the participation of Aboriginal Peoples and Indian tribes in decisions concerning the waters of the Great Lakes Basin ecosystem."

2. Recent Developments

2.1 Canada

In December 2002, the Canadian government proclaimed in force Bill C-6[41], which amended the *Canadian International Boundary Waters Treaty Act* and new International Boundary Waters regulations. These, among other things, prohibited new removals from the Canadian boundary waters of the Great Lakes – St. Lawrence Basin by means of diversions, and also prohibited removals by any other means of amounts over 50,000 liters per day (13,200 US gallons per day). There are limited and well-defined exceptions to these prohibitions.

[39] U.S. Government 1986. The Water Resources Development Act of 1986 (WRDA) and other "WRDAs" are omnibus water Bills which provide congressional authorizations for U.S. Corps of Engineer projects.
[40] Canadian Broadcasting Corporation 2014. Tsilhquot'in First Nations Granted B.C. Title Claim in Supreme Court Ruling (20 June, 2014)
[41] Government of Canada 2001. An Act to Amend the International Boundary Waters Treaty Act (Royal Assent 18 December 2001)

In 2013, the Canadian Parliament unanimously passed Bill C-383[42]. The key clause in that Bill is "No license may be issued for the construction, operation or maintenance of an international river improvement linking non-boundary or boundary waters to an international river the purpose or effect of which is to increase the annual flow of the international river". Even though this legislation is not directly applicable to boundary waters like the Great Lakes – St. Lawrence, it does solidify the strong and growing consensus within Canada that water should be kept within its natural drainage basins in the interest of preserving ecological integrity.

In 1999 Québec passed the *Water Resources Preservation Act* which prohibits, except in certain exceptional cases, the transfer of water outside its territory. On June 11, 2009, the National Assembly of Québec passed *An Act to Affirm the Collective Nature of Water Resources and Provide for Increased Water Resource Protection* in which are integrated the provisions of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement. In the years thereafter, the province of Québec adopted a *Regulation Respecting the Framework for Authorization of Certain Projects to Transfer Water Out of the St. Lawrence Basin*, another called the *Declaration of Surface or Groundwater Withdrawals*, and a third called the *Water Taking and Transfer Regulation*.

On June 4, 2007 Ontario enacted the *Safeguarding and Sustaining Ontario's Water Act* for the same purpose. On January 1, 2015, Ontario adopted regulations affecting new or increased transfers of water from one Great Lakes watershed to another. This matter will be discussed further under Remaining Issues.

2.2 United States

In the United States, Section 504 of the *Water Resources Development Act* of 2000 (WRDA 2000) amended the *Water Resources Development Act* of 1986 (WRDA 1986). Including this amendment, WRDA declares, among other things, that it is the purpose and policy of the Congress:

> "to take immediate action to protect the limited quantity of water available from the Great Lakes system for use by the Great Lakes States and in accordance with the Boundary Waters Treaty of 1909;
>
> "to encourage the Great Lakes States, in consultation with the Provinces of Ontario and Québec, to develop and implement a mechanism and provides a common conservation standard embodying the principles of water conservation and resource improvement for making decisions concerning the withdrawal and use of water from the Great Lakes Basin;
>
> "to prohibit any (new) diversion of Great Lakes water by any State, Federal agency, or private entity for use outside the Great Lakes Basin unless such diversion is approved by the Governor of each of the Great Lakes States; and

[42] Government of Canada 2013. An Act to Amend the International Boundary Waters Treaty Act and the International River Improvements Act (Royal Assent 19 June 2013)

> "to prohibit any Federal agency from undertaking any studies that would involve the transfer of Great Lakes water for any purpose for use outside the Great Lakes Basin."

Section 5904 (b) of the Act also expanded the prohibition to exports in response to the water export proposal in Canada: "Approval of Governors for Export of Water. Section 1109 (d) of the *Water Resources Development Act* of 1986 (42 U.S.C. 1962d – 20 (d) is amended by (1) inserting "or exported" after "diverted" and (2) inserting "or export" after "diversion."

As mentioned earlier, on December 13, 2005, the Governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, and the Premiers of Ontario and Québec signed the Great Lakes – St. Lawrence River Sustainable Water Resources Agreement. Before the parallel Compact could become a legal Interstate Compact in the United States, it had to be ratified by each of the eight State legislatures and be consented to by the U.S. Congress. According to information provided by Council of Great Lakes Governors staff, that happened as described in Box 8.

Box 8: Order of ratification of the Great Lakes – St. Lawrence River Sustainable Water Resources Agreement in the United States.

Illinois – Public Act 095-0238
Signed by Governor Rod Blagojevich on August 17, 2007

Indiana – Senate Enrolled Act 45
Signed by Governor Mitch Daniels on February 20, 2008

Michigan – Public Act 190 of 2008
Signed by Governor Jennifer M. Granholm on July 9, 2008

Minnesota – Minnesota Session Laws 2007--Chapter 2
Signed by Governor Tim Pawlenty on February 20, 2007

New York – Chapter 27
Signed by Governor Eliot Spitzer on March 4, 2008

Ohio – HB 416 of 2008
Signed by Governor Ted Strickland on June 27, 2008

Pennsylvania – Act No. 43 of 2008
Signed by Governor Ed Rendell on July 4, 2008

In addition, since 2008 States and Provinces have adopted a very large number of additional laws, regulations, rules and guidelines in support of Agreement and Compact implementation, as have sub-state and sub-provincial governments. The most important of these initiatives are reported on at regular meetings of the Great Lakes – St. Lawrence River Water Resources Regional Body. These meetings are open to the public, and the meeting summaries are available to interested publics on the internet. It is beyond the scope of this review to examine all of these initiatives in detail.

3. Remaining Issues and Recommendation

A Bulletin issued by the Great Lakes-St. Lawrence River Water Resources Regional Body[43] indicates that "in the United States, each of the eight State legislatures ratified the interstate Compact and Congress provided its consent. On December 8, 2008, the Compact became both state and federal law. Québec has enacted the Agreement and completed needed actions. Ontario has enacted the Agreement and it came into force on March 8, 2015. No federal legislation is required in Canada."

Box 8: Order of ratification of Great Lakes – St. Lawrence River Sustainable Water Resources Agreement. (continued)

Wisconsin – 2007 Wisconsin Act 227
Signed by Governor Jim Doyle on May 27, 2008

U.S. Congress – Public Law No: 110-342
Signed by President George W. Bush on October 3, 2008

Ontario's Environmental Registry dated April 24, 2014 confirms this understanding by noting that "The government is proposing draft regulatory amendments to support the implementation of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement. The regulatory amendments would enable proclamation of Ontario's legislation implementing the Agreement, and enable the Agreement itself to be brought into full force." The Registry goes on to note that "The proposal was posted for a 46-day public review and comment period starting April 24, 2014. Comments were to be received by June 9, 2014. All comments received during the comment period are being considered as part of the decision-making process by the Ministry of the Environment."

The further action that was required in Ontario to bring the Agreement's full entry into force was the adoption of regulations regarding new or increased transfers of water from one Great Lakes watershed to another (intra-basin transfers) based on the standards of the Agreement. The standards of the Agreement are clearly spelled out on pages 8 and 9 of the Agreement.

On January 1, 2015, the Province amended several Acts and Regulations including the *Water Taking Regulations* under the *Ontario Water Resources Act* and the *Classification of Proposals for Instruments Regulation* under the Environmental Bill of Rights. The provisions of the *Safeguarding and Sustaining Ontario's Water Act* 2007 that amend the *Ontario Water Resources Act and the Safe Drinking Water Act* 2002 were also proclaimed.

From time to time, State and Provincial legislators introduce new legislation either in support of the Compact and Agreement, or in some way related to them. A recent example is an Ohio bill[44] which would have established the presumption that any consumptive use less than one percent of the long-term annual runoff from the State's portion of the Lake Erie Basin will result in no significant individual or cumulative adverse impact on the quantity or quality of the water resources and water dependent natural resources of the Great Lakes Basin. The legislation was

[43] Great Lakes – St. Lawrence Regional Body, http://www.glslregionalbody.org/AgreementImplementationStatus.aspx (undated)
[44] Ohio Senate 2014. Section 1522.13 of HB 490 (The Bill died when the legislative session ended and was not re-introduced.)

not enacted, but this example demonstrates how important it is to avoid undermining inter-jurisdictional consistency with individual legislative initiatives.

An interesting trend over the past few decades in the U.S. States has been the adoption and application of public trust laws aimed at preserving the essence of water resources for the use and enjoyment of all, now and in the future. To the extent that this trend continues and moves into Canada as well, it will reinforce the objectives of the Agreement and Compact.

Findings: The Agreement and Compact have been successful to date. There have been no new inter-basin or intra-basin diversions approved which would have significant negative impacts on then ecological integrity of the Great Lakes, the growth in consumptive use has been at least temporarily arrested, and institutional arrangements, such as the Regional Body, are in place.

2015 RECOMMENDATION 1: The existing Agreement and Compact should continue to be rigorously implemented to minimize loss of water from the Basin.

Diversions and Other Removals

1. Situation as of February, 2000

In its 2000 report[45], the IJC defined a removal as water conveyed outside its basin of origin by any means. It went on to define bulk removal as including diversions or other means such as tanker ships or trucks which carry water in large volumes, but excluding water used as ballast water in ships or incorporated into products or otherwise bottled for retail sale. Intra-basin transfers, on the other hand, move water between individual basins without removing it from the Great Lakes Basin per se.

There was considerable debate during the 1999- 2000 IJC Reference and during Agreement negotiations regarding the relative impact of bulk removals and withdrawals for in-basin use. With bulk removals, unless return flow requirements are imposed, 100% of the amount transferred is lost to the Great Lakes ecosystem. By contrast, with withdrawals for in-basin use, only about 6% is lost[46] on average, with the rest automatically returned after use to support ecosystem and other in-basin uses. For that reason, both the IJC recommendations and the subsequent Compact and Agreement call for a virtual prohibition on removals, with minor and well-defined exceptions, but treat withdrawals in a somewhat more lenient way.

As of February 2000, there were at least eight intra-basin and six inter-basin diversions. However, only three inter-basin diversions (Long Lac, Ogoki, and Chicago); and two intra-basin diversions (Welland Canal and the New York State Barge Canal) were large enough to have a measurable impact on Great Lakes levels and outflows[47].

The Ogoki and Long Lake diversions are often considered together because both divert to Lake Superior waters that originally drained north through the Albany River to James Bay. These projects were developed in time to generate hydropower in support of Canada's defense industries during World War II, and in the case of Long Lac to subsequently transport pulpwood as well. The Ogoki diverts approximately 9,760 MLD (2,580 MGD) and Long Lac 3,900 MLD (1,000 MGD) on average[48]. At times, Ontario has reduced both diversions to help alleviate problems created by high Great Lakes levels.[49]

The Chicago diversion originated in 1848 as a small canal to link Lake Michigan to the Illinois-Mississippi River system. The actual diversion of water from Lake Michigan was small until 1900, when domestic water supply and sewage disposal needs led to reconstruction and rapid increases in diversions well above navigation needs, touching off disputes with various Great Lakes States and Canada. The U.S. Supreme Court gradually reduced the rate from as high as

[45] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf
[46] See chapter on Water Use Data and Related Information
[47] IJC Study Team 1999. Great Lakes Water Uses (consumption, diversions and removals), Study Team Contribution to the Interim Report, unpublished, June 1999
[48] IJC Study Team 1999. Great Lakes Water Uses (consumption, diversions and removals), Study Team Contribution to the Interim Report, unpublished, June 1999
[49] IJC Study Team 1999. Great Lakes Water Uses (consumption, diversions and removals), Study Team Contribution to the Interim Report, unpublished, June 1999

25,100 MLD (6,620 MGD) to 7,900 MLD (2,100 MGD), which was subsequently decreed by the Supreme Court.

The intra-basin Welland Canal diverts water from the north shore of Lake Erie to Lake Ontario, bypassing the rapids and falls of the Niagara River. The canal, originally built in 1829 and reconstructed several times since, is used primarily as a deep draft navigational waterway as part of the St. Lawrence Seaway and a source of water for hydropower generation at DeCew Falls. In the 1970s, the average diversion rate was raised to 23,200 MLD (6,140 MGD).

The New York State Barge Canal links the Niagara River near Buffalo to the Hudson River near Albany, New York. Almost all of the water diverted into the canal from the Niagara River is returned to Lake Ontario. Its predecessor, the Erie Canal was completed in 1825 as a navigation link between eastern U.S. ports and the western interior. The average diversion rate in 2000 was estimated at about 1,720 MLD (460 MGD).

The cumulative effects of these major existing diversions were estimated during the 2000 Reference (excluding the relatively minor New York State Barge Canal). The Ogoki, Long Lac and Chicago diversions had increased the mean outflow from Lake Superior by 13,800 MLD (3,650 MGD) and that of Lakes Michigan-Huron, Erie and Ontario by 5,900 MLD (1,600 MGD). However, the regulation plans in operation on Lakes Superior and Ontario had been designed to accommodate these diversions. The impact of these diversions, plus the Welland Canal on water levels were estimated at +2 cm (centimeters, +0.79 inches), -1 cm (-0.39 inches), -9 cm (-3.5 inches), and +4 cm (+1.6 inches) on Lakes Superior, Michigan-Huron, Erie and Ontario respectively.

Aside from these major diversions, there are several other very small examples which even considered together have little effect on Great Lakes levels and outflows. A few examples include the small Forrestport, New York and Portage, Wisconsin navigational canals (which ended in the 1990s), small diversions to meet municipal needs in London, Ontario and Detroit, and a small diversion to maintain summer flows in the Raisin River in Ontario. By 2000, the Communities of Pleasant Prairie, Wisconsin and Akron, Ohio obtained approval of other jurisdictions under the 1986 WRDA for diversion outside the Basin on the condition that they would return an equivalent amount of water.

By the turn of the century, several other communities that straddle or are near the Great Lakes Basin divide, especially in Ohio, Indiana and Wisconsin were beginning to look to the Great Lakes for a secure source of future water supply. And in 1998, shock waves spread across the Region when a Canadian entrepreneur proposed to ship Lake Superior water to Asia by marine tanker. Even though clearly impractical, this proposal raised the specter of commercial trade in the resource, possibly on a global scale, something quite different in nature from the regional or local development goals which had previously characterized diversion projects.

There are or could be other small-scale removals, including water in bottles, water in beverages, water in trucks, water in trains, and ballast water in ships. While significant on a very local scale, none of these have had a measurable impact on a basin-wide scale. Interestingly, the Commission found that there was much more bottled water imported into the Great Lakes Basin

than exported from it.[50] The subject of virtual water export, in other words water consumed during the production of goods subsequently exported from the Basin, also arises in discussions on this topic. Those uses have traditionally been dealt with under the rubric of consumptive use rather than as removals.

2. Recent Developments

As mentioned earlier, in December of 2005, the premiers of Ontario and Québec, and the Governors of the eight Great Lakes States signed the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement. On October 3, 2008, President Bush signed into law a parallel legally-binding intestate Compact. The Agreement and Compact commit the provinces and states that share the Great Lakes to implement measures to better protect, conserve and restore the waters of the Great Lakes-St. Lawrence River Basin.

At the heart of the Agreement and Compact is a prohibition on new inter-basin diversions or an increase in existing diversions, except for clearly articulated and strictly regulated exceptions. These exceptions have to do with communities either straddling the Basin divide or established in a county that straddles the Basin divide. This provision regarding diversions outside the Basin makes it impossible to divert water beyond these very strict geographical limits. Moreover, excepted inter-basin diversions may only be used for public water supply purposes.

Before they may be authorized, excepted inter-basin diversions must meet strict requirements and comply with a specific Standard for Exceptions, including the obligation to return water to the Great Lakes-St. Lawrence River Basin as well as preventing the introduction of invasive species. Intra-basin transfers of water (from one Great Lakes watershed to another) are similarly prohibited. However, the exceptions are of course not subject to the same geographical limitations as those for inter-basin transfers. Nevertheless, in both cases, any exception must meet the same seven criteria of the Standard for Exceptions:

- The need for water cannot reasonably be avoided through the efficient use and conservation of existing water supplies;
- The withdrawal is limited to quantities that are considered reasonable for the purpose for which it is proposed;
- All of the water withdrawn shall be returned to the Source Watershed (less an allowance for consumptive use). No water originating outside the Great Lakes-St. Lawrence River Basin may be used to meet this criteria except for certain technical reasons expressly mentioned in the Agreement;
- There is no significant adverse impact (individually or cumulatively);
- Environmentally sound and economically feasible water conservation measures will be applied to minimize the water withdrawal or the consumptive use;
- The proposal must comply with all applicable laws and treaties; and
- A proposal for an excepted diversion must also meet all additional conditions imposed.

[50] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf

Furthermore, a large part of the exceptions to the prohibition of diversions outside the Basin is subject to a regional review process.

The first successful request for a straddling community exception was a proposal from the City of New Berlin[51], which was approved by the state of Wisconsin on May 21, 2009. That approval enables New Berlin to receive additional Lake Michigan water from Milwaukee to supply parts of the City lying outside the Great Lakes Basin. Under the approval, New Berlin was authorized to withdraw an average of 8.11 MLD (2.142 MGD) to areas of the City outside the Great Lakes Basin. This volume essentially replaces the amount the City previously obtained from groundwater wells that produce water with radium levels exceeding state and federal health standards.

Under the approval, the City will continue to return water to the Lake Michigan Basin via the Milwaukee Sewage District, resulting in no net loss of water to the Great Lakes Basin. The application was also deemed to have met all other Compact terms, including enhanced conservation efforts and strict monitoring and reporting requirements to ensure that the water withdrawal and return flow quality are closely tracked.

3. Remaining Issues and Recommendation

3.1 Inter-basin Diversions- Waukesha Example

The City of Waukesha, Wisconsin is located within the straddling county of Waukesha, but lies outside the Lake Michigan watershed. This diversion proposal[52] may therefore be the first test case under the straddling county exception provisions of the Compact. The application asserts that Waukesha needs a new source of water to address water quality and quantity concerns. The City currently obtains its public water supply primarily from groundwater wells in a deep aquifer where water levels have been drawn down approximately 152 meters (500 feet), with lesser amounts drawn from a shallow aquifer.

The proposal is to divert an annual average of 38.2 MLD (10.1 MGD) of water with a maximum diversion of 63.2 MLD (16.7 MGD) by final build-out of the service area. The water is proposed to serve an area that includes all of the City of Waukesha, and may also serve portions of the City of Pewaukee and the Towns of Waukesha, Genesee and Delafield in the future. Treated Lake Michigan water would be piped to Waukesha. Return flow would be treated and piped to the Root River for return to Lake Michigan.

The City originally submitted a diversion application in May 2010. An updated application was submitted on October 14, 2013 which responded to the criticisms in the 2010 submission. At the time of the 2010 submission there were still non-governmental critics that claimed the proposal did not meet Compact Standards by failing to show that there are no reasonable water supply alternatives, and failing to show that strong conservation measures would be instituted.

[51] Milwaukee Journal Sentinel 2009). New Berlin's Request for Lake Water Approved, a First under Great Lakes Compact, by Darryl Enriquez, May 21, 2009

[52] Government of Wisconsin 2014. City of Waukesha Water Diversion Application, Current Status, June, 2014

Under the Compact process, the State must satisfy itself that the application is approvable before submitting it to the Regional Body made up of representatives of the Great Lakes States and Provinces. The Regional Body must then issue a declaration of findings, and the Compact Council (States) must approve the application before it can move forward. If approval under the Compact is obtained, the State would have the authority to conduct the necessary permit reviews and issue a final decision. At the time of writing, consideration of the application was still pending in the State of Wisconsin, and no application had been forwarded for regional consideration.

3.2 Intra-basin Diversions- Ontario

As mentioned earlier, until recently, the only remaining legal barrier to the State-Provincial Agreement coming into full force was regulations regarding intra-basin diversions in the Province of Ontario. The Agreement came into full force 60 days after the Premier of Ontario notifies the Regional Body that Ontario has completed the measures required to implement the Agreement. That formal notification took place on January 7, 2015. The regulatory changes that came into force on January 1, 2015 are complex, but in essence they:

- Require proposals for new or increased transfers of water between Great Lakes watersheds to meet specific criteria prior to a permit being issued (those specified in the Act mirror those in the Agreement Standards);
- Outline the terms and conditions that a Director (an official designated by the Minister) may include in a permit, including terms and conditions governing the transfer of water between Great Lakes watersheds;
- Authorize the Director to amend other Ministry of Environment approval documents to help regulate a transfer (e.g. a sewage works approval that regulates the return of transferred water as sewage);
- Add a requirement to ensure that, if a municipal drinking water system takes and transfers water between Great Lakes watersheds, that a Permit to Take Water authorizing the intra-basin transfer has been issued before a license for the system is issued or renewed under the *Safe Drinking Water Act*, 2002; and
- Authorize the Minister to be responsible for decisions on transfers of water between Great Lakes watersheds that are 19 MLD (5 MGD) consumptive use or more.

Because the criteria mirror those in the Agreement Standard, the changes appear to be entirely consistent with the intent of the Agreement negotiators.

The only small point of contention may be the fact that the watershed of a Lake is defined as including the watersheds of the channels connecting it to an adjacent lake. Provincial officials have pointed out that this approach is consistent with the approach adopted by Michigan and New York, the only other Parties whose jurisdiction includes the watersheds of connecting channels. It is also consistent with the binational Great Lakes Quality Agreement definition and approach for connecting channels. It should also be noted that, due to the geography of the Great Lakes watersheds relative to provincial and state boundaries, transfers of water between Great Lakes watersheds are not possible in Québec, Illinois, Minnesota, and Ohio, and are highly unlikely to occur in Pennsylvania and Wisconsin.

3.3 Longer-term Concerns

The mega diversion era ended in the United States with the Central Arizona Project in the 1970s, and in Canada with the LaGrande Project in the early 1990s. The break-up of the Soviet Union effectively ended construction of the Siberian north-south water diversion. More recently, the World Bank has imposed a moratorium on funding major dam construction anywhere pending the findings of an appointed commission of inquiry. The costs have become just too high and the adverse impacts too many.[53]

But there continue to be some exceptions such as major south-north inter-basin diversions in China. Climate change and other unforeseen circumstances could conceivably change the calculus in North America as well. The Great Lakes Region needs to continue to be vigilant and precautionary in its approach to diversions. The Agreement and Compact appear to have been carefully designed to avoid a "slippery slope" developing. It will be critically important that their rules continue to be strictly adhered to.

Findings: To date, the precautionary approach adopted in the Agreement and Compact to deal with diversion proposals has been rigorously followed.

2015 RECOMMENDATION 2: The precautionary approach regarding diversions should continue to be employed by the Great Lakes States and Provinces in order to protect the Great Lakes from an ever-increasing number of larger-scale removals.

[53] Frank Quinn & Jeff Edstrom (2000) Great Lakes Diversions and Other Removals, Canadian Water Resources Journal / Revue canadienne des ressources hydriques, 25:2, 125-151.

Water Use Data and Related Information

1. Situation as of 2004

Recommendation VI in the 2000 Report[54] (see Box 9) stressed the need for reporting of accurate water use information and encouraged collaboration among agencies involved in water use reporting efforts. The recommendation included provisions for allocating sufficient staff and funding for collection of water use data, consistency in water use reporting data collection and calculation efforts, and development of a water use database. The 2004 Review Report[55] concluded that basin-wide consumptive use was relatively small, representing 1% to 2% of the renewable supplies, and that consumptive use may have reached a constant level. However, the report acknowledged the difficulty in identifying trends in withdrawals or consumptive use, given that state and provincial reporting practices varied from year to year. The report recommended that "…states and provinces… must…intensify and…improve measurement, refine estimates, and validate consumption coefficients." The reliability of consumptive use coefficients was identified as particularly problematic; the report authors noted that the basis for the coefficients currently used by the States and Provinces was not well documented. The report also found that demand forecasting could have important implications but "will remain of limited use unless States and Provinces improve measurement and data collection, and begin to identify real trends in their historical data."

Box 9: Recommendation VI from 2000 Report. Data and Research

Federal, state, and provincial governments should move quickly to remedy water use data deficiencies by:

a. allocating sufficient staff and financial resources to upgrade the timeliness, precision, and accuracy of water use data,
b. working much closer together to ensure consistency in water use monitoring, estimation techniques, and reporting,
c. emphasizing and supporting the development and maintenance of a common base of data and information regarding the use and management of the water resources of the Great Lakes Basin, establishing systematic arrangements for the exchange of water data and information, and undertaking coordinated research efforts to provide improved information for future water planning and management decisions.

Furthermore, governments should immediately take steps to ensure that, on a binational basis, research is coordinated on individual and cumulative impacts of water withdrawals on the integrity of the Great Lakes Basin ecosystem. In support of their decision-making, governments should implement long-term monitoring programs capable of detecting threats (including cumulative threats) to ecosystem integrity. Such monitoring programs should be comprehensive, particularly in their approaches to detecting threats to ecosystem integrity at a spectrum of space and time scales.

As part of an anticipatory policy for identifying emerging issues, governments should, on a binational basis, undertake more active science and research and, in particular, should implement appropriate long-term monitoring programs for key indicators of ecosystem change.

[54] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf

[55] International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004, www.ijc.org/files/publications/ID1560.pdf, accessed October 22, 2014.

2. Recent Developments

2.1 Recent Data and Trends

The Great Lakes Regional Water Use Database[56] (GLRWUD) provides water use information on withdrawals and consumptive uses for the Great Lakes-St. Lawrence River Basin. This database is the longest-running source of withdrawal and consumptive use data derived exclusively for the Great Lakes-St. Lawrence River Basin. The database relies on water withdrawal reports from the Provinces and States. The Provinces' and States' estimates of water withdrawals have been based on a combination of mandatory and voluntary reporting by individual users and coefficient-based methods, where a coefficient is applied to a unit relevant to a particular sector. For the GLRWUD annual reports, most consumptive uses are calculated by multiplying withdrawals by consumptive coefficients that are constant for a given water use sector and given state and province[57].

In the following discussion, water used for hydroelectric power production, while a valuable use of water, has been excluded because it is assumed that there are no consumptive uses associated with this water use sector. For the most recent GLRWUD reporting year of 2012, total withdrawals were 42,324 MLD (11,200 MGD) and total consumptive use was 2,332 MLD (616 MGD). Given an estimate of average annual outflow of 603,000 MLD (159,000 MGD)[58], total withdrawals and total consumptive use represent 7% and 0.4% of annual renewable supply. Annual renewable supply is defined as the average annual outflow from the Great Lakes-St. Lawrence River Basin, which integrates Basin-wide inflows and outflows from natural and human sources.

Figure 2 shows the fraction of total water withdrawals and fraction of total consumptive use by major water use sector for 2012. As expected, thermoelectric power production is responsible for the majority of withdrawals, but when consumptive uses are calculated, this sector is not the primary user. Nevertheless, the magnitude of withdrawals for thermoelectric purposes suggests opportunities for conservation for the purpose of reducing ecological impacts of thermal discharges. Public water supplies and self-supplied industrial users are the leading consumptive use sectors (roughly one-third of the total, each), with self-supplied irrigation & livestock and self-supplied thermoelectric power users responsible for another third of the consumptive use totals, respectively.

Figure 3 shows the division of withdrawals by source. Great Lakes withdrawals occur directly from the Lakes, tributary surface water withdrawals occur from the rivers, streams, and lakes in the contributing watersheds and tributary groundwater refers to withdrawals from groundwater underlying the contributing watersheds. As expected, the Great Lakes are the source of most

[56] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/index.php, accessed November 1, 2014.
[57] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/data_about_cuc.php, accessed November 1, 2014.
[58] Neff, Brian P. and J. R. Nicholas, 2005, Uncertainty in the Great Lakes Water Balance, Date Posted: November 23, 2005: U.S. Geological Survey Scientific Investigations Report 2004-5100, 42 p. [http://pubs.water.usgs.gov/sir2004-5100/]

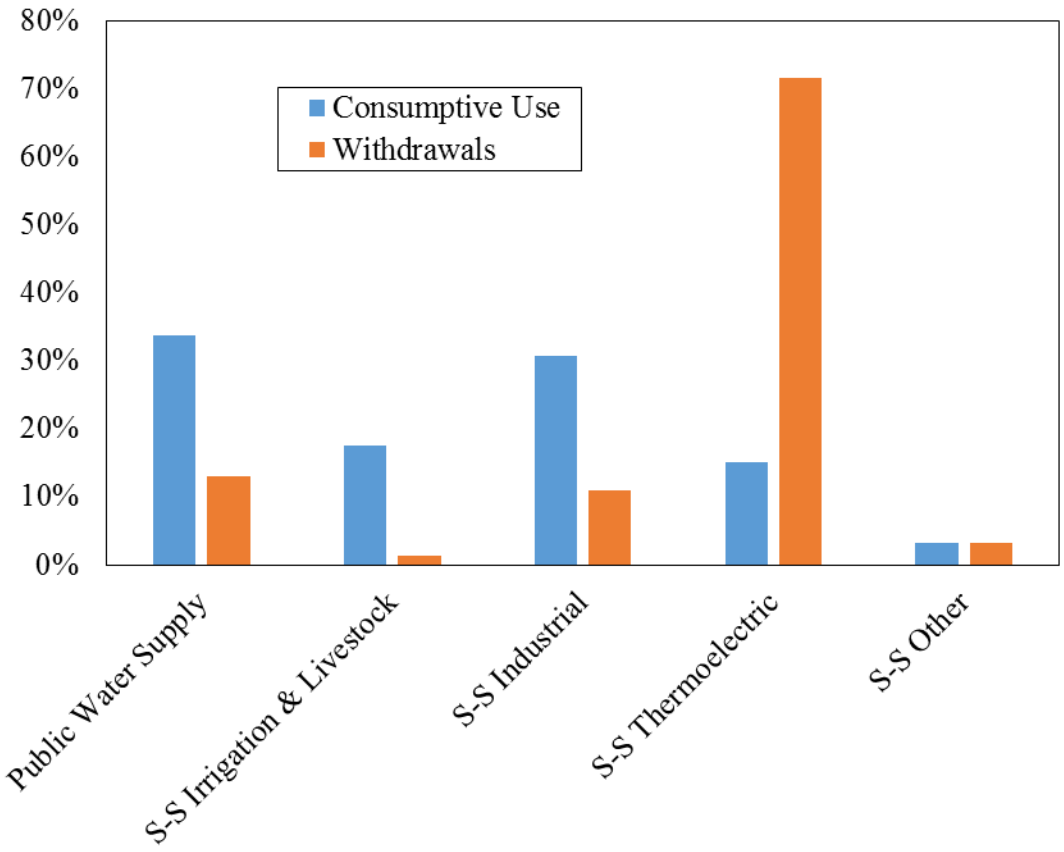


Figure 2. Fraction of total withdrawals by sector and fraction of total consumptive use by sector for the Great Lakes-St. Lawrence River Basin reported for 2012. Source: Great Lakes Regional Water Use Database. S-S = self-supplied. Some Great Lakes Regional Water Use Database water sectors have been combined: S-S irrigation and livestock; S-S Thermoelectric Power Production (Once-through cooling) and S-S Thermoelectric Power Production (Recirculated cooling); S-S Other and S-S Commercial & Institutional.

water withdrawals. The majority of withdrawals directly from the Great Lakes are for thermoelectric power production (78%). While the fraction of water withdrawals is relatively high for this sector, the consumptive use coefficient for thermoelectric power production over all sources in the Basin in 2012 was 1%. Further insights on water use for thermoelectric power production are revealed by noting the large difference between the consumptive use coefficients for once-through and recirculated cooling: 1% and 12%, respectively. Since the majority of thermoelectric power generators in the basin use once-through cooling, this cooling method dominates the overall consumptive use coefficient for thermoelectric power production.

Figure 4 shows the trends in withdrawals for both countries for the last decade of reported data. While US withdrawals peaked in 2007, withdrawals decreased afterwards at a rate of 4% per year. This decrease reflects trends reported for the previous decade for the US portion of the

Basin, where withdrawals decreased by 7% from 1995 to 2005,[59] and the US as a whole, where total withdrawals have decreased by 13% from 2005 to 2010[60]. It is not known how much of these decreases were associated with water use efficiency versus structural economic changes. Nevertheless, as discussed in section 2.3, Demand Forecasting (in this chapter), it is expected that water use per capita in the Basin will remain flat or even decline. Canadian withdrawals apparently increased substantially after new data on withdrawals was used in 2009 and increased slightly in 2012 after new withdrawal data was used; however, these changes are likely due to changes in water use reporting practices during these years[61].

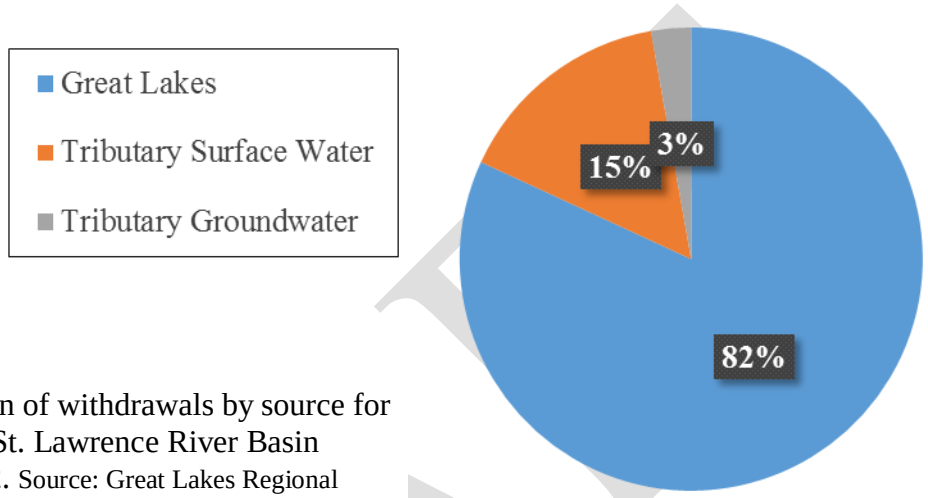


Figure 3. Fraction of withdrawals by source for the Great Lakes-St. Lawrence River Basin reported for 2012. Source: Great Lakes Regional Water Use Database.

Given the gaps in new data reporting, it is not possible to detect trends in water use for the Canadian portion of the Great Lakes Basin. Environment Canada reports that, for the public water supply sector, per capita water use across all of Canada decreased by 14% from 2006 to 2009, but cautions that some of the decrease could have been due to climatic factors[62]. Over the same period, populations in Ontario and Québec increased by 1% per year. Taken together, the rate of decrease in per capita use and rate of increase in population imply that, at least for the public water supply sector, withdrawals are likely to be flat or decreasing in Canadian portion of the Great Lakes Basin.

2.2 Water Use Reporting and Consumptive Use Estimates

As mentioned in Section 2.1, significant gaps occur in the Canadian data reported to the GLRWUD. These gaps were attributed to lack of assessment tools, staff, and regulatory statutes. US state agencies have also reported that budgetary constraints have limited the quality and

[59] Mills, P. C. and Sharpe, J. B. 2010. Estimated withdrawals and other elements of water use in the Great Lakes Basin of the United States in 2005. US Geological Survey.
[60] Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S. 2014. Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., *http://dx.doi.org/10.3133/cir1405*.
[61] From 2002 to 2008, 2000 and 1993 water withdrawal data was used for Ontario and Québec, respectively, in the GLRWUD. In 2010 and 2011, withdrawal data from 2009 was used for Ontario and Québec.
[62] Environment Canada, 2011. 2011 Municipal Water Use Report- Municipal Water Use 2009 Statistics. http://ec.gc.ca/Publications/992156D4-2599-4026-9B4C-47855D26CCB8%5C2011MunicipalWaterPricingReport2009Statistics.pdf

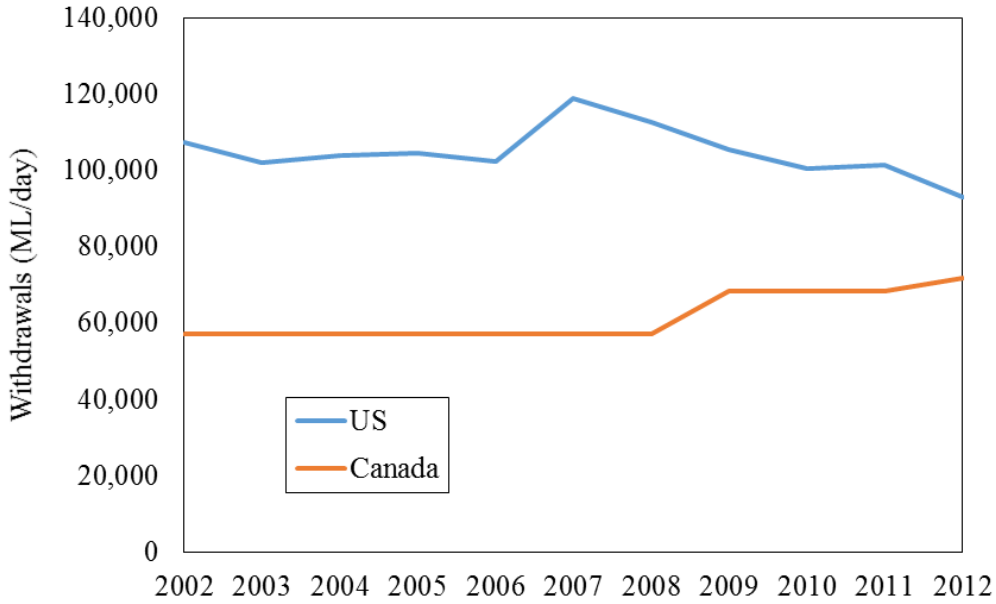


Figure 4. Total withdrawals for US and Canada in the Great Lakes-St. Lawrence River Basin reported for 2002-2012. Source: Great Lakes Regional Water Use Database.

completeness of the water withdrawal databases. Withdrawals have also been reported by the US Geological Survey (USGS) for the US portion of the Great Lakes Basin GLRWUD for 2005[63]. The GLRWUD estimates of total withdrawals for 2004 (these were the data available at the time of the USGS study) were 10% less than that of the USGS. According to the USGS report that contained the 2005 data, the GLRWUD and USGS withdrawals are based mostly on similar data collected by the Great Lakes States; however, the sources and methods of estimation for the GLRWUD and USGS do not completely overlap.

Attempts have been made to standardize water use reporting basin-wide, spurred by the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement and the Great Lakes-St. Lawrence River Basin Water Resources Compact. In 2009, interim protocols for reporting water withdrawals to the GLRWUD[64] were established and adopted by the Great Lakes Compact Council and Regional Body. The protocols provide for reporting withdrawals with consistent water sector categories, sources of watersheds, and Great Lake watershed terminology. The interim protocols require large water users (average withdrawals of 379,000 liters per day or greater over any 30-day period) to maintain records of monthly water withdrawals and consumptive use, with wide latitude for measuring withdrawals and calculating consumptive uses. The protocols were used first in the 2012 GLRWUD report. Details of the States' and

[63] Mills, P.C., and Sharpe, J.B. 2010. Estimated withdrawals and other elements of water use in the Great Lakes Basin of the United States in 2005: U.S. Geological Survey Scientific Investigations Report 2010–5031, 95 p.
[64] Resolution #9 - Adoption of Water Use Reporting Protocols Adopted by the Great Lakes-St. Lawrence River Basin Water Resources Council on December 8, 2009 (http://www.glslcompactcouncil.org/Docs/Resolutions/GLSLRBWRC_Resolution_9--Water_Use_Reporting_Protocols.pdf)

Provinces' reporting practices can be found in reports from the individual States and Provinces provided to the Regional Body in 2014[65]. In most cases registered or permitted large water users are required to report annually on water use. The water use data originates from several sources, including meters, manual methods, and other forms of voluntary reporting by users. In some cases, users report water withdrawals on an annual basis; others States and Provinces require monthly and peak day reporting. Some of the State or Provinces have established procedures for checking for errors or inconsistencies in the data, but there do not appear to be uniform quality assurance and control practices across the basin.

The new water use reporting protocols are apparently meant to provide more flexibility and accuracy in calculating consumptive use by allowing for users to estimate consumptive use by subtracting measured return flows from measured withdrawals. As mentioned in Section 1 of this chapter, the accuracy of consumptive use coefficients was questioned in the 2002, three-year Protection of the Waters of the Great Lakes review report. Thus, it makes sense for the States, Provinces and Regional Body to continue making progress on determining the best available approach for consumptive use calculations. USGS, which has been the basis for consumptive use coefficients to date, can be particularly helpful in this regard. The Council of Great Lakes Industries' Water Stewardship Project provides an example of the detailed tools and data-gathering studies required for estimating consumptive uses at an industry-by-industry level[66].

2.3 Demand Forecasting

Since a systematic water demand forecast for the Great Lakes States and Provinces has not been performed, demand projections for the region must rely on national- or international-scale studies. Brown et al.[67] have projected water withdrawals for the US to 2090, based in a series of climate and socioeconomic scenarios. Averaging over the climate scenarios indicates that, for the majority of the US portion of the Great Lake Basin, withdrawals will actually decrease between 2005 and 2090, due to a combination of projected wetter climate, relatively flat population, and increases in water use efficiency. Withdrawals in the northwestern portion of the lower peninsula of Michigan, however, are expected to increase between 0 and 10%, due to higher expected temperatures and smaller increases in precipitation in this area.

A 1998 international report on projected water demand[68] predicted 29% and 20% increases in withdrawal from 1990 to 2025 for Canada and the US, respectively. The report attributed the majority of the increase to growth in industrial and domestic withdrawals. However, large increases in these sectors are unlikely, given the flat or even decreased demand in these sectors over the last decade. One concern may be that water use associated with unconventional extraction of hydrocarbons (e.g. hydraulic fracturing) may require substantial increases in water use. Hydraulic fracturing is applied in areas with shale or oil gas formations. Substantial shale or

[65] Great Lakes-St. Lawrence River Water Resources Regional Body, 2014 State and Provincial Water Management Program Reports, http://www.glslregionalbody.org/Resolutions.aspx#ProgramReports, accessed March 11, 2015.
[66] Council of Great Lakes Industries, A Water Stewardship Tool for Great Lakes Industries, http://cgli.org/wp-content/uploads/2013/09/FinalCGLI-_WaterStewardshipPhIII_0917142.pdf, accessed December 26, 2014.
[67] Brown, T. C., Foti, R., & Ramirez, J. A. 2013. Projected freshwater withdrawals in the United States under a changing climate. Water Resources Research, 49(3), 1259-1276.
[68] Seckler, D. W. Amarisnhe, A., Molden, D., de Silva, R. and Barjer, R. 1998. World water demand and supply, 1990 to 2025: Scenarios and issues (Vol. 19). International Water Management Institute, Colombo, Sri Lanka.

oil gas formations are located in the lower peninsula of Michigan and southern Ontario[69]. In Michigan, companies that wish to extract water for oil and gas production must go through state-mandated procedures that evaluate the potential effects of the withdrawals[70].

3. Remaining Issues and Recommendation

Consumptive use in the Great Lakes Basin is small relative to inflows. Recent trends in withdrawals indicate that withdrawals are unlikely to increase substantially in the next few decades. However, the reliability of water use reporting and consumptive use calculations is still questionable. While the States and Provinces have made great strides in water use data collection procedures, it appears that quality assurance and quality control could be further improved. The Great Lakes States and Provinces should continue to investigate methodologies for improving the quality of water withdrawal and consumptive use estimates. A complete understanding of consumptive use is critical to careful water management in the Basin, including evaluations of the impact of proposed new diversions. The importance of reliable water use (and other water-related) information has been reaffirmed in a joint statement by the Governors and the Premiers in 2013[71].

Findings: Consumptive use in the Great Lakes Basin is small relative to renewable supply[72], and given recent trends is unlikely to increase substantially in the next few decades. Substantial improvements in water use data collection practices by the States, Provinces and Regional Body have occurred over the last five years. However, the reliability of water use reporting and consumptive use calculations remains questionable, given inconsistency in different sources of water withdrawal estimates, lack of consistent quality control procedures in water use reporting, and the use of consumptive use coefficients that have been criticized as inadequate. A complete understanding of consumptive use is critical to careful water management throughout the Basin, including evaluations of the impact of new diversions.

2015 RECOMMENDATION 3: The Great Lakes States and Provinces, in collaboration with the two federal governments, should continue to investigate methodologies for improving the accuracy of water use and consumptive use estimates.

[69] Ontario Ministry of Natural Resources, "Shale Gas Opportunities in Southern Ontario– an Update," Ontario Oil, Gas & Salt Resources Library, http://www.ogsrlibrary.com/downloads/Ontario_Shale_Gas_OPI_2009_Nov11.pdf., accessed January 8, 2015.
[70] Michigan Department of Environmental Quality, Hydraulic Fracturing in Michigan, http://www.michigan.gov/deq/0,4561,7-135-3311_4111_4231-262172--,00.html, accessed January 8, 2015.
[71] Resolution: Water Monitoring, Adopted by the Governors of the Great Lakes States and the Premiers of Ontario and Québec on this 1st day of June 2013 (http://www.cglg.org/media/1396/water-monitoring-resolution-6-1-13.pdf)
[72] Great Lakes Governors and Premiers 2013. Resolution: Water Monitoring (1 June, 2013).

Cumulative Impacts

1. Situation as of 2004

The 2000 Report[73]addressed the issue of cumulative impacts in Recommendation VI (see Box 10), stating that research on individual and cumulative impacts of water withdrawals on ecosystem integrity is needed and that long-term monitoring programs are needed to support decision-making with respect to cumulative impacts of withdrawals. With regard to indicators of ecosystem integrity, Recommendation VI further states that "As part of an anticipatory policy for identifying emerging issues, governments should, on a binational basis, undertake more active science and research and, in particular, should implement appropriate long-term monitoring programs for key indicators of ecosystem change." The 2004 Review Report[74] suggested that more progress was needed in quantifying ecological impacts related to water level or flow changes due to cumulative consumptive uses or diversions. The 2004 Review Report also observed that attempts to use cumulative impacts in a regulatory context would be especially difficult to implement.

Box 10: Recommendation VI from 2000 Report. Data and Research

Federal, state, and provincial governments should move quickly to remedy water use data deficiencies by:

a. allocating sufficient staff and financial resources to upgrade the timeliness, precision, and accuracy of water use data,
b. working much closer together to ensure consistency in water use monitoring, estimation techniques, and reporting,
c. emphasizing and supporting the development and maintenance of a common base of data and information regarding the use and management of the water resources of the Great Lakes Basin, establishing systematic arrangements for the exchange of water data and information, and undertaking coordinated research efforts to provide improved information for future water planning and management decisions.

Furthermore, governments should immediately take steps to ensure that, on a binational basis, research is coordinated on individual and cumulative impacts of water withdrawals on the integrity of the Great Lakes Basin ecosystem. In support of their decision-making, governments should implement long-term monitoring programs capable of detecting threats (including cumulative threats) to ecosystem integrity. Such monitoring programs should be comprehensive, particularly in their approaches to detecting threats to ecosystem integrity at a spectrum of space and time scales.

As part of an anticipatory policy for identifying emerging issues, governments should, on a binational basis, undertake more active science and research and, in particular, should implement appropriate long-term monitoring programs for key indicators of ecosystem change.

[73] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf
[74] International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004, www.ijc.org/files/publications/ID1560.pdf, accessed October 22, 2014.

2. Recent Developments

The 2005 Agreement/Compact defines cumulative impacts as "the impact on the Great Lakes-St. Lawrence River Basin Ecosystem that results from incremental effects of all aspects of a Withdrawal, Diversion or Consumptive Use in addition to other past, present, and reasonably foreseeable future Withdrawals, Diversions and Consumptive Uses regardless of who undertakes the other Withdrawals, Diversions and Consumptive Uses." The 2005 Agreement/Compact also mandated that cumulative impacts will be the basis for the review of potential new diversions.

The 2005 Agreement/Compact mandated that the Parties "….shall collectively conduct within the Basin, on a Great Lake and St. Lawrence River Basin basis, a periodic assessment of the Cumulative Impacts of Withdrawals, Diversions and Consumptive Uses from the Waters of the Basin." The timing of the cumulative impacts assessment was specified as the earlier of: (a) every five years; (b) each time the incremental losses to the Basin reach 190 MLD (50 MGD) average in any 90-day period in excess of the quantity at the time of the last assessment; or, (c) at the request of one or more of the Parties. Further, the Agreement/Compact specified that the assessment should

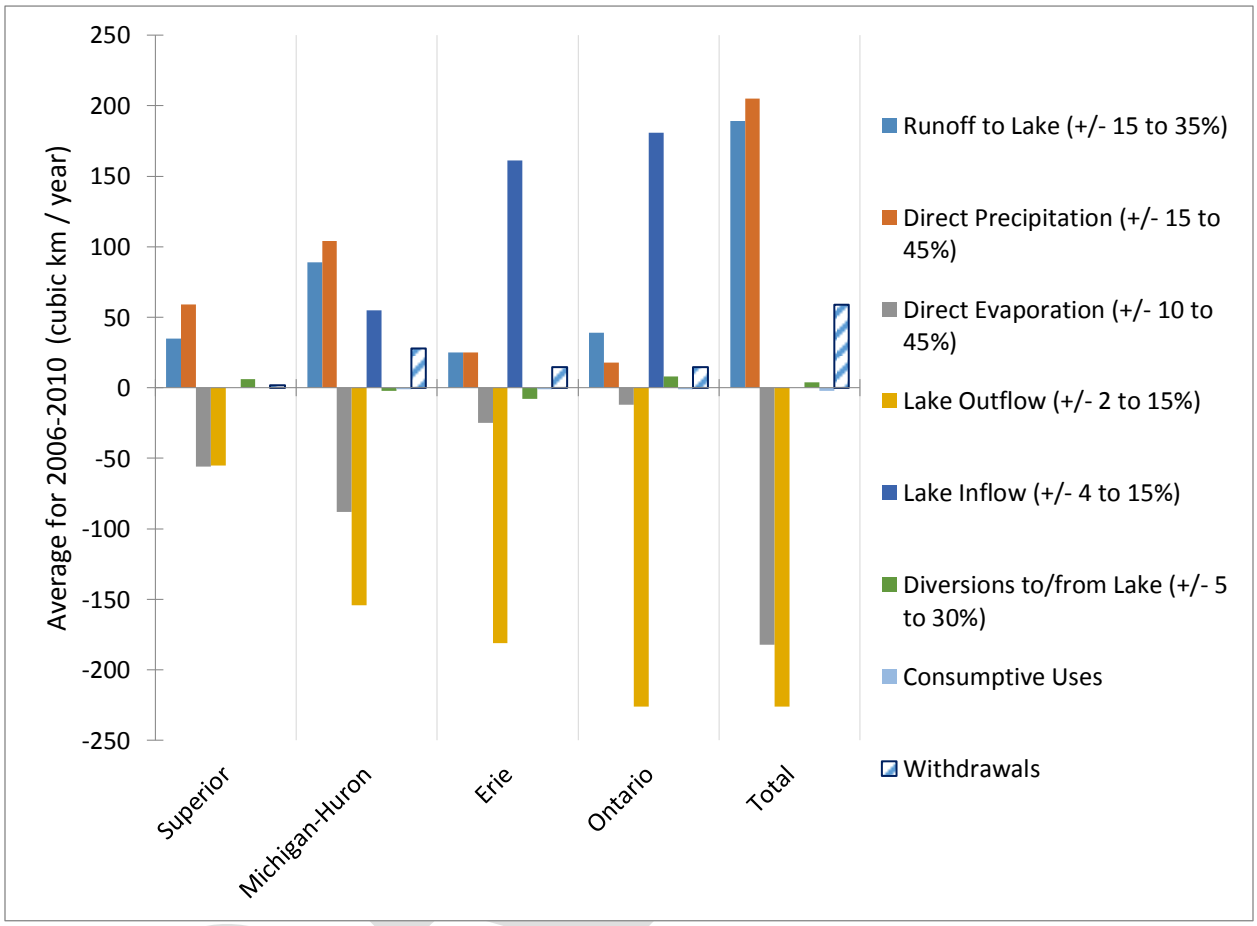
a. "Utilize the most current and appropriate guidelines for such a review…;
b. Give substantive consideration to climate change or other significant threats to Basin Waters and take into account the current state of scientific knowledge, or uncertainty, and appropriate Measures to exercise caution in cases of uncertainty, if serious damage may result;
c. Consider Adaptive Management principles and approaches recognizing, considering and providing adjustments for the uncertainties in, and evolution of, science concerning the Basin's water resources, watersheds and ecosystems including potential changes to Basin-wide processes, such as lake level cycles and climate."

In December 2013, the first cumulative impact assessment was released by the Regional Body/Council[75]. The assessment focused on the impacts of consumptive uses and diversions on water balances at the scale of each Great Lake watershed and the basin as a whole during the period 2006-2010. Figure 5 shows the hydrologic components for each lake and in total. Included are the hydrologic inputs to the Lakes (runoff, direct precipitation, and direct evaporation); inflows and outflows via the connecting channels; and diversions and consumptive uses. Withdrawals are also shown in Figure 5 to provide an additional perspective on water use in each of the Great Lakes' basins. The period 2006-2010 is relatively dry compared to long-term averages for some of the lakes,[76] but serves to demonstrate recent conditions for which component supply and consumptive use data are available. In addition, these numbers can demonstrate relative differences between the magnitude of water balance components and between the lakes.

[75] Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010 http://www.glslcompactcouncil.org/Docs/Misc/2013%20Cumulative%20Impact%20Assessment%2012-6-13.pdf

[76] International Lake Superior Board of Control provisional NBS dataset. NBS for Lake Superior: NBS 2006-2010 average = 1460 cms vs 2010 cms for 1900-2014 average. Michigan-Huron : 2006-2010 3240 cms vs 3200 cms for 1900-2014 average.

Figure 5. Average Water Balance Components by Lake (km^3/year) for the Period 2006-2010. Inflows and outflows are assigned as positive and negative quantities, respectively. Uncertainty listed for each component varies for different lakes.



Source of runoff, precipitation, evaporation, outflow, inflow, diversions and consumptive uses: Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010[77]. Source of withdrawals: Great Lakes Regional Water Use Database[78] Source of uncertainty estimates: Uncertainty in the Great Lakes Water Balance.[79] http://pubs.usgs.gov/sir/2004/5100/pdf/SIR2004-5100.pdf.

Consumptive uses and diversions for all of the Great Lakes are relatively small when compared to outflows. However, it is not clear how much of a role consumptive uses and diversions precisely play with respect to the overall balance, given the uncertainties in the water balance components. Figure 5 includes estimates of uncertainty in the water balance components reported in the U.S. Geological Survey report of 2004. Because runoff, direct precipitation, and direct evaporation estimates are based on sparse measurement points and/or empirical models, these components have a substantial amount of uncertainty.

[77] Cumulative Impact Assessment of Withdrawals, Consumptive Uses and Diversions 2006-2010 http://www.glslcompactcouncil.org/Docs/Misc/2013%20Cumulative%20Impact%20Assessment%2012-6-13.pdf
[78] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/index.php
[79] Neff, B.P., and Nicholas, J.R., 2005, Uncertainty in the Great Lakes water balance, U.S. Geological Survey Scientific Investigations Report 2004-5100, 42 p. http://pubs.usgs.gov/sir/2004/5100/pdf/SIR2004-5100.pdf

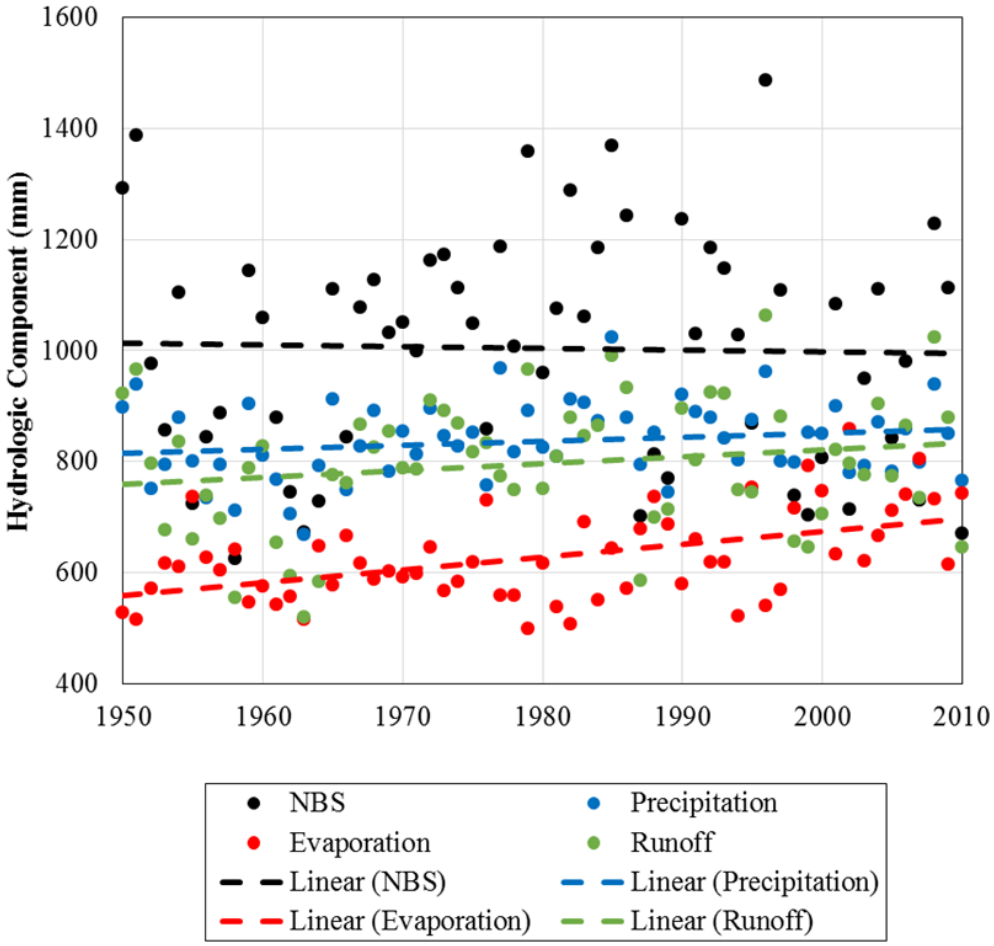


Figure 6. Net Basin Supply (NBS) and components (mm/year) for the Period 1950-2010. Note that this data set excludes the recent relatively wet years of 2013-2014. Source: NOAA Great Lakes Environmental Research Laboratory, Great Lakes Water Level Dashboard, http://www.glerl.noaa.gov/data/dashboard/data/, accessed December 9, 2014.

As discussed in the chapter on Water Use, consumptive use estimates also contain substantial uncertainties, due to questions regarding water use reporting and consumptive use calculations.

Trends in net basin supply (NBS) for all lakes combined and water levels for each Lake are shown in Figures 6 and 7, respectively. In Figure 6, linear trends are provided as a visual aid for interpreting the data and are not intended to provide a predictive capability. The 1950-2010 trends indicate that NBS has neither increased nor decreased significantly over the period. Increases in evaporation have been almost completely offset by increases in direct precipitation and runoff. Note that recent years (2013-14) high runoff and precipitation have resulted in increases in Lakes Superior and Michigan-Huron NBS.

In Figure 7, monthly water levels relative to the long-term average over the period 1918-2014 are provided. Water levels are reported for the combined Lakes Huron and Michigan since their water levels are in near-equilibrium, because these lakes are interconnected through the relatively large Straits of Mackinac. The figure demonstrates the recent period (prior to 2014) of lower water levels in Superior and Huron-Michigan and water levels in Erie and Ontario that are near historical average. As discussed in Chapter on Climate Change, the lower water levels in Superior are attributed to increases in evaporation rates that are not compensated by increases in direct precipitation and runoff.

Increases in conveyance in the St. Clair River, which connects Lake Huron to Lake Erie, due to gravel mining prior to 1925 and dredging to increase the size of the navigation channel up to the 1960s, have lowered Lake Michigan-Huron water levels.[80] The so-called 2005 "Baird Report[81]" attributed subsequent lowering of the levels of these lakes to erosion of the bed of the St. Clair River possibly caused by 1) changes to the upstream supply of sand and gravel through shore protection and harbor breakwater construction on the US and Canadian shores of Lake Huron leading up to the St. Clair outlet; 2) changes to the flow patterns at the outlet owing to the configuration of the outer navigation channel; and 3) removal of a protective gravel lag either through sand mining in the 1920's or through increased flow speeds related to point (2) above. A later detailed study commissioned by the IJC (International Upper Great Lakes Study report, Impacts on Upper Great Lakes Water Levels: St. Clair River[82]) determined that unexpected erosion in the channel after the last navigation channel enlargement project was completed in 1963 had caused an additional loss of water of 7-14 cm (2.8-5.5 inches), but that this erosion was not the primary reason for lower water levels on Lakes Huron and Michigan. The additional factors included differential changes in elevations of the lake beds from glacial isostatic adjustment and, primarily, shifts in supply to the lakes due to climate change or variability. The study also concluded that there has been no significant erosion of the channel in the upper reach of the St. Clair River since at least 2000.

The December 2013 cumulative impact assessment discussion of the effects of climate change on water levels centers on the combined uncertainty in future climate scenarios and the Basin water budget components. The cumulative impact assessment refers to the International Upper Great Lakes Study[83] (IUGLS) on Lake Superior regulation, where it is noted "how little the lake dynamics on inter-annual and decadal timescales are understood…lake levels remain almost entirely unpredictable more than a month ahead." Thus, although the Compact/Agreement mandates that the cumulative impact consider climate change, the state of climate science for the Great Lakes limits the ability to predict how climate change will interact with consumptive use and diversions.

[80] International Joint Commission's Advice to Governments on the Recommendations of the International Upper Great Lakes Study, http://ijc.org/iuglsreport/wp-content/uploads/2013/04/IUGLS-IJC-Report-Feb-12-2013-15-April-20132.pdf, accessed January 23, 2015.
[81] W.F. Baird and Associates Coastal Engineers Ltd. 2005 Regime Change (Man Made Intervention) and Ongoing Erosion in the St. Clair River and Impacts on Lake Michigan-Huron Lake Levels. Oakville, Ontario.
[82] International Joint Commission, Impacts on Upper Great Lakes Water Levels: St. Clair River. 2009. http://www.ijc.org/, accessed December 4, 2014.
[83] International Upper Great Lakes Study Board. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels.
http://www.iugls.org/files/tinymce/uploaded/content_pdfs/Lake_Superior_Regulation_Full_Report.pdf

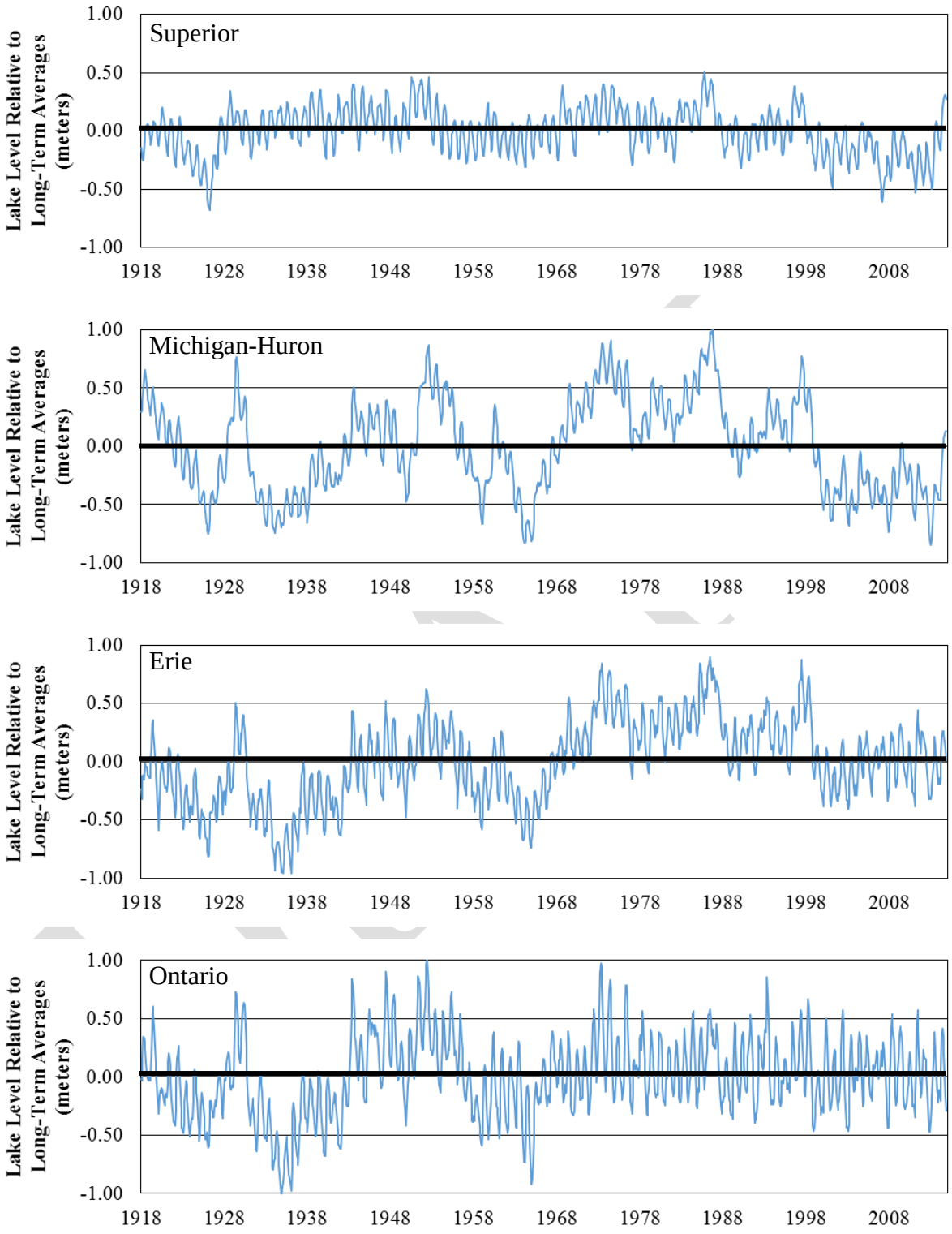


Figure 7. Monthly lake levels relative to long-term averages over the period 1918-2014. Long-term (1918-2014) average lake levels for Lakes Superior, Michigan-Huron, Erie, and Ontario are 183.40, 176.41, 174.14, and 74.75 meters, respectively, relative to the IGLD85 datum. Data source: Great Lakes Water Level Dashboard, Great Lakes Environmental Research Laboratory National Oceanic and Atmospheric Administration, http://www.glerl.noaa.gov/data/dashboard/data/levels/1860_1917, downloaded December 21, 2014.

In 2000, the IJC undertook a Lake Ontario-St. Lawrence River (LOSLR) study. The study recognized drawbacks of the current water regulation plan and described how system regulation might be improved. In 2008, the IJC proposed implementing a modified version of one of the water regulation plans recommended by the study; however, after hearing public concerns on the proposed plan, the IJC withdrew the proposal. The IJC then sought the advice of governments in the basin to find a new option for LOSLR regulation. After further public consultations, the IJC has recommended Plan 2014. The primary goal of the proposed plan is to restore more natural variability in the levels of Lake Ontario, and thereby reverse some of the harm to the ecosystem done by the existing plan, while balancing upstream and downstream uses and minimizing possible increased damage to shoreline protection structures. The plan is currently under consideration by the federal governments.

The Compact/Agreement also mandates consideration of adaptive management in cumulative impact assessments (Article 304 paragraph 3 of the Agreement and Section 4.2.3 of the Compact and Article 100 of the Agreement and Section 1.3.2h of the Compact). The December 2013 cumulative impact assessment stresses the importance of adaptive management, stating "as more is understood about the hydrologic effects of Diversions and Consumptive Uses, adaptive management will be an even more increasingly useful tool in addressing these effects." The report also emphasizes that data is critical for effective adaptive management efforts: "Adaptive management requires monitoring of the resource and benefits from modeling."

The December 2013 cumulative impact assessment specifies areas of improvement that are needed to produce more reliable estimates of the impact of diversions and consumptive uses on Lake water balances and levels including:

- improvement in estimates of consumptive use
- better understanding of the impacts of new or increased diversions and consumptive uses on flows and biophysical conditions
- better understanding of the impacts of water uses at range of scales, including local scales
- improvement in estimates of runoff, direct evaporation, direct precipitation, and connecting channel flows

In addition, the December 2013 cumulative impact assessment calls for better coordination between US and Canadian federal agencies to allow improved access to water balance data by decision makers and the public.

The December 2013 cumulative impact assessment did not attempt to relate ecological or socioeconomic impacts to water balance or lake level changes associated with consumptive uses or diversions. However, the absence of information about ecological impacts is probably related to the problem that the magnitudes of diversions and consumptive uses are smaller than the uncertainty in critical water balance components and overall Lake balances. In addition, the magnitude of year-to-year variations in climate-driven inputs to the Lakes (precipitation, evaporation, and runoff) is at least of the scale of diversions and consumptive uses.

The translation of water levels into measures of ecosystem integrity has proven to be less than straightforward and needs further development. The State of the Lakes Ecosystem Conference (SOLEC) identified an indicator, "Effect of Water Level Fluctuations" (Indicator #4861) that is

meant to capture effects of lake level fluctuation on coastal wetlands and has reported on the indicator most recently in 2007[84]and 2009[85]. These reports provide valuable information, but the material does not suggest that a systematic approach is available for measuring impacts on ecosystem integrity from lake level changes. While most attempts to describe water level impacts focus on the response of coastal wetlands to changes in lake levels, it has been suggested that other aspects of coastal ecosystems should be considered[86]. The LOSLR identified a number of ecosystem indicators associated with lake levels, such as diversity of plants in coastal wetlands and quality of habitat for bird nesting and breeding. [87]

The Regional Body/Compact Council have been supporting advancement in the understanding of basin hydrology through panel sessions at the International Association of Great Lakes Researchers conference since 2007.These sessions have provided a forum for presenting the latest scientific, peer reviewed research on topics directly related to the Science Objectives listed in the Agreement Section. Through the Regional Body/Compact Council's Technical Advisory Panel, specific studies have been funded and conducted, primarily by the U.S. Geological Survey, to assess groundwater, cumulative adverse impacts, basin and lake water balances, and to better understand the limitations of consumptive use coefficients. Some of these studies can be found in the IJC's Great Lakes-St. Lawrence Research Inventory.[88]

The International Upper Great Lakes Study recognized that reducing the uncertainty in the flows in the connecting channels and water balance components of the Great Lakes was needed to make more informed water-management decisions. With this objective, the study encouraged the installation of new acoustic velocity meters by the U.S. Geological Survey and Environment Canada to better measure flows in the St Marys, St. Clair, Detroit and Niagara rivers. The IUGLS also sponsored the first two installations of eddy-covariance instrumentation at offshore lighthouses to measure overlake evaporation in the Great Lakes. The resulting evaporation measurements been used to improve evaporation models NBS estimation for the Great Lakes [89] [90]. Since the IUGLS, researchers have added sets of similar instruments on other Great Lakes and have made advanced understanding of lake evaporation and the implications that climate

[84] State of the Lakes Ecosystem Conference, State of the Great Lakes 2007, Effect of Water Level Fluctuations Indicator #4861 http://www.epa.gov/solec/sogl2009/4861waterlevels.pdf,

[85]State of the Lakes Ecosystem Conference, State of the Great Lakes 2009, Effect of Water Level Fluctuations Indicator #4861 http://www.epa.gov/solec/sogl2009/4861waterlevels.pdf,

[86] Riseng, C.M. and Sparks- Jackson, B.L. Data Availability Assessment : IJC Apex Ecological Indicators for Evaluation of Progress toward Restoring the Great Lakes, International Joint Commission, http://ijc.org/files/publications/FinalReport_DataAssessment_Indicators_05032013.pdf, accessed December 19, 2014.

[87] International Lake Ontario-St. Lawrence River Study Board, 2006. Options for Managing Lake Ontario and St. Lawrence River Water Levels and Flows. http://www.losl.org/reports/finalreport-e.html

[88] International Joint Commission, Great Lakes-St. Lawrence Research Inventory, http://ri.ijc.org/, accessed March 19, 2015.

[89] Spence, C., P.D. Blanken, N. Hedstrom, V. Fortin and H. Wilson (2011). Evaporation from Lake Superior: 2. Spatial distribution and variability. *Journal of Great Lakes Research*, doi: 10.1016/j.jglr.2011.08.1013.

[90] Daniel Deacu, Vincent Fortin, Erika Klyszejko, Christopher Spence, and Peter D. Blanken, 2012: Predicting the Net Basin Supply to the Great Lakes with a Hydrometeorological Model. *J. Hydrometeor*, **13**, 1739–1759. doi: http://dx.doi.org/10.1175/JHM-D-11-0151.1

change may have on Great Lakes evaporation[91]. The Commission is supporting the creation of a database of these Great Lakes evaporation data to make these data accessible. The continued operation of these evaporation stations is uncertain.

The IJC, through its recently created Great Lakes – St. Lawrence River Adaptive Management Committee is supporting the Great Lakes Runoff Inter-comparison Project (GRIP), a collaboration between Environment Canada and the US National Oceanic and Atmospheric Administration scientists to compare and improve runoff modelling in Great Lakes watersheds. In a separate project, the IJC is supporting a join work by U.S. Geological Survey and Environment Canada scientists to assess the potential of state-space models, applied through Kalman filters, to estimate the magnitude and uncertainty of water budgets in the Great Lakes.

Significant progress has also been made in the estimation of areal precipitation in recent years. Moving beyond simple spatial weighted averaging of shore or inland precipitation observations[92], new methods[93] to estimate overlake precipitation for the Great Lakes now go, with systems that assimilate surface observations, radar based estimates and numerical weather model information.

3. Remaining Issues and Recommendation

The primary theme running through the December 2013 cumulative impact assessment is the uncertainty in water balance components, especially runoff, direct overlake precipitation, direct lake evaporation, and consumptive use. It is clear that, unless the scale of new consumptive use or diversion proposals is substantially larger than the current totals, it will be impossible to estimate the impacts of these proposals on Lake water balances and levels. An increase in observation points and research on the models used to calculate the problematic water balance components is needed. Further refinement of these water balance components should continue to occur through federal agencies such the USGS, NOAA, US Army Corps of Engineers, and Environment Canada. Assuming that the science will continue to evolve rapidly, the Regional Body/Council should continuously review new knowledge regarding lake-wide hydrology and incorporate new advancement in decision-making processes.

The December 2013 cumulative impact assessment raises the question as to whether assessment of impacts only at the Great Lake or basin scale is appropriate. It is possible that local consumptive uses at the sub-Great Lakes basin scale are large relative to watershed outflows.

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[91] Lenters, J. D., J. B. Anderton, P. Blanken, C. Spence, and A. E. Suyker, 2013: *Assessing the Impacts of Climate Variability and Change on Great Lakes Evaporation.* In: *2011 Project Reports*. D. Brown, D. Bidwell, and L. Briley, eds. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center: http://glisaclimate.org/media/GLISA_Lake_Evaporation.pdf

[92] Hunter, T., Clites, A., Campbell, K., Gronewold, A., Development and application of a North American Great Lakes hydrometeorological database — Part I: Precipitation, evaporation, runoff, and air temperature. *J. Great Lakes Res.* 41 (2015) 65–77 http://dx.doi.org/10.1016/j.jglr.2014.12.006

[93] Vincent Fortin, Guy Roy, Norman Donaldson, Assimilation of radar QPE in the Canadian Precipitation Analysis (CaPA). 2014 ASCE International Symposium on Weather Radar and Hydrology. http://collaboration.cmc.ec.gc.ca/science/rpn/publications/pdf/?C=M;O=D/radF907B_04_02_14_FINAL.pdf

For example, the Great Lakes Commission's "Value of Great Lakes Water Initiative" report[94] identified several watersheds in the US portion of the Great Lakes basin where consumptive uses exceeded 20% of summer month flows. Although the Compact/Agreement is not meant to address impacts in tributary watersheds, the criteria for the decision-making standard for management of new or increased withdrawals and consumptive uses states that "...the Withdrawal or Consumptive Use shall be implemented so as to ensure that the Proposal will result in no significant individual or cumulative adverse impacts to the quantity or quality of the Waters and Water Dependent Natural Resources *and the applicable Source Watershed*."

Finally, the December 2013 cumulative impact assessment avoids an analysis of the state of the art on the impacts of changes in water levels on ecological and socioeconomic systems. There is, however, a growing literature on these impacts (see for example, the IUGLS[95] and LOSLR[96]). An interesting aspect of the IUGLS is that, rather than depending on absolute predictions of water levels, the study focused on stakeholder definitions of lake levels that would make a particular socioeconomic sector, e.g. shipping, vulnerable. The following step is to analyze the likelihood that these lake levels would occur, given the range of climate, and hence, water level predictions. This process, referred to decision scaling[97], can be adopted for future cumulative impact assessments through interactions with Basin stakeholders.

Findings: The current magnitude of consumptive uses and diversions is smaller than the level of uncertainty in the water balance components. Unless proposed new proposals for consumptive uses and diversions are substantially larger than current levels or the science of lake hydrologic balances improves, the impacts of these proposals on lake water balances, levels and ecological integrity on a lake-wide scale will be too small to estimate. Continued work to reduce the uncertainty in water balance components is needed to support decision making.

2015 RECOMMENDATION 4: Further refinement of these water balance components should continue to occur through federal agencies such the USGS, NOAA, US Army Corps of Engineers, and Environment Canada. Assuming that the science will continue to evolve rapidly, the Regional Body/Council should continuously review new knowledge regarding lake-wide hydrology and incorporate new advancement in decision-making processes.

[94] Great Lakes Commission, Value of Great Lakes Water Initiative, Great Lakes Commission, Ann Arbor, Michigan, http://www.glc.org/wateruse/watervalue/

[95] International Upper Great Lakes Study Board. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels. http://www.iugls.org/files/tinymce/uploaded/content_pdfs/Lake_Superior_Regulation_Full_Report.pdf

[96] International Lake Ontario-St. Lawrence River Study Board, 2006. Options for Managing Lake Ontario and St. Lawrence River Water Levels and Flows. http://www.iugls.org/files/tinymce/uploaded/content_pdfs/Lake_Superior_Regulation_Full_Report.pdf

[97] Brown, C. 2011. Evaluation of Plausible Risk to Lake Superior regulation and the Upper Great Lakes amid Climate Variability and Change. Prepared for the International Upper Great Lakes Study.

Climate Change

1. Situation as of 2004

Recommendation VIII of the 2000 Report[98] (see Box 11) called on the governments of the US and Canada to reduce greenhouse emissions. The 2004 Review Report[99] focused on results from climate change models that had a bearing on water availability in the Great Lakes-St. Lawrence River Basin. The 2002 three-year review report found that model results were widely variable in terms for predictions of Great Lakes water levels, with the potential for "large decreases in water levels, small increases, or anything in between." The 2004 Review Report suggested that, given the level of uncertainty, caution should be exercised in water use and that adaptive and resilient approaches for water management in the Basin were sensible. For example, the report suggests that Lake regulation rules should be sufficiently robust to react to potential swings in Lake inflows.

Box 11: Recommendation VIII from 2000 Report. Climate Change

Recognizing that the Intergovernmental Panel on Climate Change has concluded that human activities are having a discernible effect on global climate, and despite the uncertainties associated with the modeling of future climate, the governments of Canada and the United States should fully implement their international commitments to reduce greenhouse gas emissions.

2. Recent Developments

2.1 Impacts of Recent Climate Change

The climate in the Great Lakes Basin is changing. The average air temperature in the majority of the region (at the least the US portion) has warmed by more than 0.8 °C (1.5°F) during the period from 1991-2012 when compared to the period from 1901-1960[100]. Precipitation has increased over the last decades, with much of the increase attributed to increase in heavy precipitation events[101]. For example, over a 50-year period (1958-2007), the greatest 1% rainfall events have increased by 31% in the US Midwest[102]. In the Great Lakes, the average annual maximum ice coverage during 2003-2012 was 40% compared to the previous 50-year period

[98] International Joint Commission 2000. Protection of the Waters of the Great Lakes, final Report to the Governments of Canada and the United States (February 22, 2000)

[99] International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004, www.ijc.org/files/publications/ID1560.pdf, accessed October 22, 2014.

[100] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

[101] Kling, G.W., Hayhoe, K., Johnson, L.B., Magnuson, J.J., Polasky, S., Robinson, S.K., Shuter, B.J., Wander, M.M., Wuebbles, D.J., Zak, D.R. (Eds.), 2003. Confronting climate change in the Great Lakes region: impacts on our communities and ecosystems, 104 pp. UCS Publications, Cambridge, MA.

[102] Pryor, S. C., K. E. Kunkel, and J. T. Schoof, 2009a: Ch. 9: Did precipitation regimes change during the twentieth century? Understanding Climate Change: Climate Variability, Predictability and Change in the Midwestern United States, Indiana University Press, 100-112.

average of 52%[103]. Lake Superior summer surface water temperatures have increased approximately 2.5°C (4.5°F) over the period 1979–2006[104]. The rate of increase in lake temperature is significantly greater than increases in regional air temperature; this discrepancy is attributed to declines in ice cover. Summer surface water temperature increased over the period 1968-2002 by 2.9°C (5.2°F) and 1.5°C (2.7°F) in Lakes Huron and Ontario, respectively; Lake Erie did not show a significant trend in surface temperature[105].

Natural climate variability at Lake and basin-wide scales on time scales of single to several years can be quite large. The variability generates inter-annual differences in hydrologic components (runoff, direct evaporation, and direct precipitation), making it difficult to detect long-term trends in Lake and basin-wide water balances and levels. Non-climatic factors such as glacial isostatic (i.e., glacial rebound) and unregulated inter-Lake flows (i.e. the St. Clair River channel) contribute even more to the uncertainty in historic analyses of lake water balance and level trends. While shifts in seasonal cycles for lake levels and water balances have been demonstrated in Lake Superior[106] and unprecedented shifts in seasonal cycles in Lake Erie have been observed recently (2011-2012)[107], most studies have not been able to demonstrate any overall trend in lake levels and water balances that might be connected with longer term climate change.[108]

The IJC commissioned the International Upper Great Lakes Study in 2007 (IUGLS)[109]. A major focus of the study was to improve understanding of climate-water balance-lake level relationships in the upper Great Lakes system (Superior, Michigan and Huron), including the possible impacts of climate variability and climate change on future water levels. The major findings regarding historical changes are that lake evaporation is increasing due to a combination of decreasing ice cover, increasing surface water temperatures, and increasing wind speeds. However, average annual precipitation has been documented as increasing. For the Lake Michigan-Huron basin, the increases in evaporation are being mostly balanced by increases in local precipitation. But, in the Lake Superior basin, increased precipitation has not compensated for increasing evaporation, explaining a trend of declining water supplies and levels in Lake Superior. [110]The recent, heavy precipitation and runoff in 2013 and 2014, however, have had the effect of restoring levels in Lake Superior above the historical average and underscore the role of climate variability in lake level fluctuations.

[103] Melillo et al. 2014.
[104] Austin, J. A., & Colman, S. M. (2007). Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback. Geophysical Research Letters, 34(6).
[105] Dobiesz, N. E., and N. P. Lester, 2009: Changes in mid-summer water temperature and clarity across the Great Lakes between 1968 and 2002. Journal of Great Lakes Research, 35, 371-384, doi:10.1016/j.jglr.2009.05.002.
[106] Lenters, J. D., 2004: Trends in the Lake Superior water budget since 1948: A weakening seasonal cycle, J. Great Lakes Res., 30, Supplement 1, 20-40.
[107] Gronewold, A. D., & Stow, C. A. (2014). Unprecedented seasonal water level dynamics on one of the earth's largest lakes. Bulletin of the American Meteorological Society, 95(1), 15-17.
[108] International Upper Great Lakes Study. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water levels. Final Report to the International Joint Commission. www.iugls.org.
[109] International Upper Great Lakes Study. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water levels. Final Report to the International Joint Commission. www.iugls.org.
[110] International Upper Great Lakes Study. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water levels. Final Report to the International Joint Commission. www.iugls.org.

2.2 Future Climate Change

Estimates of future temperature increases for the Great Lakes Basin depend on scenarios for the concentrations of greenhouse gases and the climate modeling methodology used to make a particular set of predictions. Projections for the middle of the 21st century (2041-2070) in the Great Lakes region suggest warming of 1.9-3.6°C (3.5-6.5°F), relative to 1970-2000, with the lower and upper ranges associated with lower and upper ranges of expected growth in global emissions of greenhouse gases[111]. Estimates of precipitation changes are, in general, less certain than those for temperatures[112], but, for example, with a higher greenhouse gas emissions scenario, most models project precipitation to increase 10% to 20% by later in the century (2071-2099), relative to 1970-2000[113]. Changes in the seasonal precipitation cycle are likely to be higher, with winter and spring rain increasing and summer rain decreasing by up to 50%[114]. Increases in the frequency and intensity of extreme precipitation are projected across the Great Lakes region.

There is little agreement among studies of the impacts of future shifts in temperature and precipitation on water balances and levels in the Great Lakes. The lack of agreement is caused by differences in (a) models or datasets used to predict climate, (b) models that translate climate into the hydrologic components that drive water balances and levels, i.e. runoff, direct precipitation, and direct evaporation, and (c) interpretations of the range of outputs that are generated in these studies by using numerous climate datasets or models. For example, there is disagreement on how to use temperature inputs in the formulation of runoff models, resulting in studies that, on the one hand, project general tendencies for water levels to be reduced substantially[115], and, on the other hand, projected water levels to drop, but by a lesser amount or to actually increase[116]. Differences in predicted water levels between these two studies for the Great Lakes were on the order of one meter. There does, however, seem to be a general trend in predictions where newer studies are predicting smaller declines in water levels, compared to earlier investigations[117].

Uncertainty in future predictions of lake levels and balances poses particular difficulty for developing regulation plans for the Lakes where outflows can be engineered, which was the focus of the IUGLS[118]. The IUGLS, among many other conclusions, stressed that, given the current uncertainty, adaptive management is critical, in order to provide a structured approach

[111] Melillo et al. 2014.
[112] Kunkel, K. E., L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S. D. Hilberg, M. S. Timlin, L. Stoecker, N. E. Westcott, and J. G. Dobson, 2013: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 3. Climate of the Midwest U.S. NOAA Technical Report NESDIS 142-3. 103 pp., National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.
[113] Melillo et al. 2014.
[114] Melillo et al. 2014.
[115] Angel, J. R., & Kunkel, K. E. (2010). The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan-Huron. Journal of Great Lakes Research, 36, 51-58.
[116] Lofgren, B. M., T. S. Hunter, and J. Wilbarger, 2011: Effects of using air temperature as a proxy for potential evapotranspiration in climate change scenarios of Great Lakes basin hydrology. J. Great Lakes Res., 37, doi: 10.1016/j.jglr.2011.09.006
[117] MacKay, M., & Seglenieks, F. (2013). On the simulation of Laurentian Great Lakes water levels under projections of global climate change. Climatic change, 117(1-2), 55-67.
[118] International Upper Great Lakes Study. 2012.

for adjusting decisions as new information becomes available or as conditions change. Adaptive management implies that decisions involving new infrastructure (e.g. docks, shore protection, marinas, water level control structures) or regulation plan release rules need to be developed so that they can adapt to new trends as they are detected.

The IUGLS also suggested that plans should be designed using risk-based approaches, where vulnerabilities to water level fluctuations specific to socio-economic or ecological systems are identified and the probability of occurrence for vulnerabilities are estimated for a given regulation plan[119]. "Stress tests" can be applied to these risk estimates where regulation plans are tested using more extreme scenarios for climate change and associated lake level changes. The IUGLS also revealed that there will be inherent trade-offs, no matter what plans are adopted. For example, maintenance of lake levels or water balances in Lake Superior may come at a cost to Lake Michigan-Huron. Since it is difficult to design a plan that will improve performance everywhere, adaptation to lower water levels may be necessary.[120]

The IJC is fostering emerging science to improve understanding of the relationship between climate change and Great Lakes hydrologic responses. The IULGS study led to IJC-supported new streamflow gauging in the connecting channels by USGS and WSC. The IUGLS also implemented the first ever overlake evaporation monitoring stations in the Great Lakes. The IJC encourages the ongoing operation and expansion of the overlake evaporation monitoring.

3. Remaining Issues and Recommendation

The overall themes in this chapter are coping with uncertainty and adaptive management. Decisions regarding new, proposed diversions and consumptive uses and new Lake regulation plans must incorporate an adaptive management approach, because it is unlikely that uncertainty in future hydro-climatic conditions will be reduced substantially in the next decade or even few decades. The Great Lakes-St Lawrence River Adaptive Management Task Team Report is an example of adaptive management approaches for Lake regulation[121].

However, adaptive management implies planning and operation that can not only respond to changes in trends but also are sufficiently robust to respond to surprises. Successful implementation adaptive measures will depend on several factors, including

a) sufficient financial capacity and funding to support and sustain initiatives;
b) institutional capacity including expertise in adaptation planning and implementation;
c) expanding hydro-climatic databases, monitoring infrastructures, and a hydro-climate research programs;
d) multi-sector coordination and information sharing across agencies; and
e) public concern or confidence in climate science.

[119] Brown, C., W. Werick, W. Leger, and D. Fay. 2011. A decision-analytic approach to managing climate risks: Application to the Upper Great Lakes. Journal of the American Water Resources Association 47:524-534.
[120] Moody, P., and Brown, C. (2013). Robustness indicators for evaluation under climate change: Application to the upper Great Lakes. Water Resources Research, 49(6), 3576-3588.
[121] International Joint Commission, Letter to Governments on Great Lakes Adaptive Management http://www.ijc.org/files/publications/IJC-ltr-to-govts-on-Great-Lakes-Adaptive-Management-Oct-29-2014.pdf, accessed January 7, 2015.

The first four of these factors are more or less under the control of national and state and provincial governments. But the last factor, public attitudes towards climate change, depends on complex political and cultural issues that have yet to be resolved in both countries.

Findings: There is little agreement among studies of the impacts of future shifts in temperature and precipitation on water balances and lake levels. There does, nevertheless seem to be a meta-trend in predictions, where earlier studies of large declines are giving way to newer studies of smaller declines. If the current trend of progress in the science of climate change and translation of climate change into hydrologic responses continues, it is expected that uncertainty will decrease. Reductions in uncertainty in future hydro-climatic conditions will greatly assist in assessing cumulative impacts of climate change on lake levels.

2015 RECOMMENDATION 5: Considering the large uncertainties surrounding climate change and other human impacts on the hydrologic cycle, federal, provincial and state governments should take an adaptive management approach in decision-making. Advancements in the state of science on climate change impacts in the Great Lakes should be encouraged by federal, state and provincial governments through further funding and a synthesis of the state of the science.

Groundwater

1. Situation as of 2004

Recommendation VII of the 2000 Report[122]considered that the state of knowledge considering groundwater resources needed improvement, as described in Box 12. The recommendation further recognized the importance of groundwater and surface water interactions and recommended that governments "apply the precautionary principle with respect to removals and consumptive use of groundwater in the Basin."

Box 12: Recommendation VII from 2000 Report. Groundwater

Governments should immediately take steps to enhance groundwater research in order to better understand the role of groundwater in the Great Lakes Basin. In particular, they should conduct research related to:

a. unified, consistent mapping of boundary and transboundary hydrogeological units,
b. a comprehensive description of the role of groundwater in supporting ecological systems,
c. improved estimates that reliably reflect the true level and extent of consumptive use,
d. simplified methods of identifying large groundwater withdrawals near boundaries of hydrologic basins,
e. effects of land-use changes and population growth on groundwater availability and quality,
f. groundwater discharge to surface water streams and to the Great Lakes, and systematic estimation of natural recharge areas, and,
g. systematic monitoring and tracking of the use of water-taking permits, especially for bottled water operations.

In recognition of the frequent and pervasive interaction between groundwater and surface water and the virtual impossibility of distinguishing between them in some instances, governments should apply the precautionary principle with respect to removals and consumptive use of groundwater in the Basin.

The 2004 Review Report[123] identified several issues related to groundwater resources. First, concern was expressed that mapping of groundwater aquifers was insufficient to quantify local and regional impacts of groundwater withdrawals and future groundwater availability. Second, the 2002 three-year review report suggested that a better understanding of how groundwater relates to the surface water system was needed and that tools were needed to estimate the effects of groundwater withdrawals on surface water flows. Third, the report underscored the role of groundwater in supporting surface water ecological systems and suggested that improvements were needed to assess the effects of groundwater withdrawals on hydraulically-connected surface water ecosystems.

2. Recent Developments

Although groundwater withdrawals are a small portion of total withdrawals in the basin (3% of the total in 2012[124]), groundwater is important as a source of water supply in the basin and is the

[122] International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000, http://www.ijc.org/files/publications/C129.pdf
[123] International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004, www.ijc.org/files/publications/ID1560.pdf, accessed October 22, 2014.
[124] Great Lakes Regional Water Use Database http://projects.glc.org/waterusedata/index.php

major source of supply for many large and rural communities. The USGS estimates that more than 8 million people in the US portion of the basin rely on groundwater withdrawals[125]. Although temporal trends in overall water withdrawals in the basin appear to be declining, groundwater use actually increased by 3% between 1995 and 2005, due to increases in withdrawals for irrigation and public water supply use[126]. In addition, groundwater contributes to surface water flows in the contributing tributaries and in the form of direct discharge to the Great Lakes. The Compact/Agreement recognizes the importance of groundwater in the basin and identified the special nature of groundwater as in the following.

a) In the assessment of "[p]roposal[s] to transfer Water to a Community within a Straddling County…substantive consideration will also be given to whether or not the Proposal can provide sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to Waters of the Basin.
b) "The Basin surface water divide shall be used for the purpose of managing and regulating New or Increased Diversions, Consumptive Uses or Withdrawals of surface water and groundwater."
c) "The [science] strategy shall guide the collection and application of scientific information to support…[i]mproved understanding of the role of groundwater in Basin Water resources management

The 2005-2010 USGS National Assessment of Water Availability and Use Great Lakes Basin Pilot[127,128], in particular, has resulted in tremendous gains in understanding groundwater in the basin The USGS estimated long-term average groundwater recharge to shallow aquifers across the entire basin[129]. The USGS conducted a study in 2006 to estimate groundwater availability in the US portion of the basin[130]. In addition to providing quantitative estimates of groundwater storage, the study noted the effects of intensive pumping in the Chicago-southeastern Wisconsin area. The pumping has caused large groundwater drawdowns, shifts of the regional ground-water divide in the aquifer system westward and away from the basin surface water divide, and flow of water from Lake Michigan into the coastal aquifer.[131] [132] A regional model of the Lake Michigan basin aquifer, one of the most important aquifers in the US portion of the basin, was developed in 2010 by the USGS. The model has provided an improved understanding of the response of the aquifer to pumping, including estimates of decreases in base flow to streams and

[125] Mills, P. C. and Sharpe, J. B. 2010. Estimated withdrawals and other elements of water use in the Great Lakes Basin of the United States in 2005. US Geological Survey.
[126] Mills, P. C. and Sharpe, J. B. 2010.
[127] USGS. 2011. National Assessment of Water Availability and Use Great Lakes Basin Pilot, http://water.usgs.gov/wateravailability/greatlakes/index.html, accessed November 12, 2014.
[128] Reeves, H.W., 2010, Water Availability and Use Pilot—A multiscale assessment in the U.S. Great Lakes Basin: U.S. Geological Survey Professional Paper 1778, 105 p.
[129] Neff, B.P., Piggott, A.R., and Sheets, R.A., 2005, Estimation of shallow ground-water recharge in the Great Lakes Basin: U.S. Geological Survey Scientific Investigations Report 2005-5284, 20 p.
[130] Coon, W.F., and Sheets, R.A., 2006, Estimate of ground water in storage in the Great Lakes Basin, United States, 2006: U.S. Geological Survey Scientific Investigations Report 2006–5180, 19 p.
[131] Grannemann,N.G., Hunt, R.J. , Nicholas, J.R., Reilly, T.E. and Winter, T.C. 200. The Importance of Ground Water in the Great Lakes Region. U.S. Geological Survey Water-Resources Investigations Report 00–4008 Lansing, Michigan.
[132] Cherkauer, D. S., & Carlson, D. A. (1997). Interaction of Lake Michigan with a layered aquifer stressed by drainage. Groundwater, 35(6), 981-989.

in direct discharges to Lake Michigan[133]. These studies and others suggest that groundwater withdrawals in the Chicago-southeastern Wisconsin area and the Waterloo-Kitchener area are unsustainable[134]. These areas and others that depend on groundwater supplies are under continued pressure from increasing populations.

A 2010 report authored by the Great Lakes Science Advisory Board for the IJC reviewed the state of groundwater resources in the basin in relation to Annex 16, Pollution from Contaminated Groundwater, of the Great Lakes Water Quality Agreement.[135] The report noted that gaps still exist in the hydrogeologic characterization of aquifers in the basin and that groundwater quality is threatened in many locations where groundwater supplies provide critical resources in the basin. The report made several recommendations, including expanding the scope of research on groundwater aquifer characterization and quality; expanding the monitoring groundwater use and quality; developing more comprehensive groundwater management plans and regulations pertaining to avoiding further contamination of groundwater resources.

Not only are there areas where groundwater supplies are diminishing from a drawdown or volumetric perspective, but groundwater quality has been and will also continue to be a concern in the basin. Degradation of groundwater quality has been attributed to anthropogenic contamination, but also has been linked to the inflow of poor quality water into water supply aquifers from adjoining aquifers, due to over-pumping of the water supply aquifer. In these cases, the poor water quality is attributed to naturally occurring contaminants, such as radium or fluoride. Groundwater supplies are threatened by loss of storage due to over-pumping or water quality in communities that are near or straddle the basin surface water boundary[136].

Circumstances in these communities meet one of the criteria necessary to be considered potential applicants for diversion (straddling communities or communities in straddling counties), including Waukesha, Wisconsin, which already has applied to divert from Lake Michigan. Declining groundwater levels and quality were the motivating factors behind the approval of the New Berlin, Wisconsin, diversion in 2009 by the state of Wisconsin.

There is growing recognition in the basin that groundwater withdrawals can negatively impact surface waters that are hydraulically connected to near surface aquifers. For example, Michigan's 2006 water law committed the state to develop a methodology to assess the potential for any proposed water withdrawal to produce adverse impacts, including groundwater withdrawals. In response, the Water Withdrawal Assessment Tool (WWAT[137]) was developed to determine the

[133] Feinstein, D.T., Hunt, R.J., and Reeves, H.W., 2010, Regional groundwater-flow model of the Lake Michigan Basin in support of Great Lakes Basin water availability and use studies: U.S. Geological Survey Scientific Investigations Report 2010–5109, 379 p.
[134] Frind, E. O., Russell, H. A., Rudolph, D. L., and Sharpe, D. R. 201). The Waterloo Moraine: Water, science and policy. Canadian Water Resources Journal, 39(2): 85-87.
[135] Great Lakes Science Advisory Board. 2010. Groundwater in the Great Lakes Basin, A Report of the Great Lakes Science Advisory Board to the International Joint Commission, Windsor, Ontario, Canada. http://www.ijc.org/en/reports/2010/groundwater-inthe-great-lakes-basin
[136] Alliance for the Great Lakes, 2013. On Track? Ensuring the Resilience of the Great Lakes Compact. http://www.greatlakes.org/document.doc?id=1410. accessed November 6, 2014.
[137] Michigan Department of Environmental Quality, Water Withdrawal Assessment Tool. http://www.deq.state.mi.us/wwat/, accessed November 22, 2014,

level of risk of adverse impact associated with proposed withdrawals. The ecological risk is associated with negative responses by vulnerable fish communities to decreases in streamflows. The potential impact relies on groundwater and surface water hydrologic models and fish response models. The system also accounts for cumulative impacts of withdrawals, so that, when the impact of a new, proposed withdrawal is assessed, prior withdrawals are counted against the water available before an ecological threshold is reached.

Direct contributions of groundwater emanating from the lakebed to the Great Lakes have always been poorly understood and are generally neglected in water balances in the Great Lakes. However, available data and hydrologic models indicate that direct groundwater inflows to the lakes are a relatively small fraction of Lake water balances[138] and there is general agreement the amount is less than the uncertainty associated with the major hydrologic inflows and outflows (runoff, direct precipitation and direct evaporation). On the other hand, the indirect contribution of groundwater to the Great Lakes, via discharge into tributary streams and rivers, is substantial[139]. For example, estimates of the average fraction of ground-water contribution to tributary streamflows range from 48% in Lake Erie to 79% for Lake Michigan[140].

The nations of Canada and the US recognized the importance of groundwater with the 2012 Great Lakes Water Quality Agreement (GLWQA)[141]. In Annex 8 (Groundwater), the GLWQA mandated that the Parties to the GLWQA shall:

- *within two years of entry into force of this Agreement, publish an initial report[142] on the relevant and available groundwater science, and update this report at least once every six years;*
- *identify priorities for science activities and actions for groundwater management, protection, and remediation, to achieve the General and Specific Objectives of this Agreement;*
- *coordinate binational activities under this Annex, together with domestic programs, to assess, protect, and manage the quality of groundwater, and to understand and manage groundwater-related stresses affecting the Waters of the Great Lakes;*
- *identify groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes;*
- *analyze contaminants, including nutrients in groundwater, derived from both point and non-point sources impacting the Waters of the Great Lakes;*
- *assess information gaps and science needs related to groundwater to protect the quality of the Waters of the Great Lakes;*

[138] Grannemann, N.G., and Weaver, T.L., 1999. An annotated bibliography of selected references on the estimated rates of direct ground-water discharge to the Great Lakes: U.S. Geological Survey Water-Resources Investigations Report 98-4039, 22 p.
[139] Grannemann, N.G.., Hunt, R.J., Nicholas, J.R., Reilly, T.E., and Winter, T.C. 2000. The Importance of Ground Water in the Great Lakes Region U.S. Geological Survey Water-Resources Investigations Report 00–4008, 14 p.
[140] Holtschlag, D.J., and Nicholas, J.R., 1998, Indirect ground-water discharge to the Great Lakes: U.S. Geological Survey, Open-File Report 98-579, 25 p.
[141] GLWQA. 2012. Great Lakes Water Quality Agreement Protocol Amending the Agreement Between Canada and the United States of America on Great Lakes Water Quality, 1978, as Amended on October 16, 1983, and on November 18, 1987; Signed September 7, 2012; Entered into force February 12, 2013, 1094_Canada-USA GLWQA _e.pdf , accessed December 21, 2014.
[142] The "initial report on the relevant and available groundwater science" is expected to be released in early 2015.

- *analyze other factors, such as climate change, that individually or cumulatively affect groundwater's impact on the quality of the Waters of the Great Lakes.*
- *report on progress toward implementation this Annex every three years through the Progress Report of the Parties.*

3. Remaining Issues and Recommendation

Whereas the understanding of groundwater systems has significantly improved since the 2002 three-year review report was released, significant portions of the basin, especially in Canada, have not been mapped sufficiently. Recharge estimates for deeper, major water supply aquifers are not well understood, including the impacts of land use (e.g. urbanization) or climate change on recharge rates. Continued groundwater withdrawals in portions of the basin, such as the Kitchener-Waterloo area, do not appear to be sustainable. Although tools such as the Michigan WWAT system represent significant advances in preventing adverse ecological impacts associated with groundwater withdrawals, it is not clear how the remaining States and Provinces are also factoring adverse ecological impacts into groundwater permitting procedures. Furthermore, the WWAT system accounts only for adverse impacts in streams and does not consider impacts on lakes or wetlands.

As groundwater development continues in the basin, the possibility of altering the quality of groundwater will increase. Groundwater quality can be degraded when lower groundwater levels induce water of lesser quality from an adjoining aquifer into a water supply aquifer, as has been the case for the New Berlin and Waukesha, Wisconsin diversion requests. While local studies of these problems have been conducted, regional-scale analyses of potential, future changes in groundwater quality are needed, since this issue has an indirect impact on water availability and potential requests for diversions from straddling counties.

Findings: Unsustainable groundwater use is continuing in some areas of the basin. While the focus on groundwater withdrawals usually considers impacts on groundwater supply availability, e.g. groundwater overdrafts, the impacts of groundwater withdrawals on water quality are increasingly important, especially as these impacts relate to new requests for diversions.

2015 RECOMMENDATION 6: Great Lakes States and Provinces should fully factor the adverse ecological and water quality impacts of groundwater withdrawals into both water use permitting procedures and decisions regarding consumptive use. Federal, state and provincial research should focus on predicting where groundwater supplies may be degraded in the future and identify management methods for avoiding these problems.

Conservation

1. Situation as of February 2000

In a brief section on conservation in its 2000 report, the Commission stated that "the first step in sound management of resources and the exercise of the precautionary principle is conservation." In the future, the Commission observed that the cumulative impacts of current and new uses, global warming, and a change in the patterns of consumptive use are likely to make conservation an even more important component of any overall sustainable use strategy. The Commission advised governments and citizens to "best prepare for future uncertainty and protect the overall health of the Great Lakes ecosystem by imbedding a robust ethic of conservation into education and into every level of planning and execution."

The Commission also included a statement on conservation in its conclusions: "Conservation measures can and should minimize the amount of water withdrawn and consumed in the Great Lakes Basin, and such measures must form part of any effort to preserve the integrity of the waters of the Great Lakes Basin and ensure the sustainability of those resources." The Commission also concluded that "the potential restraint (of the Dormant Commerce Clause Doctrine in the U.S.) is reduced considerably if the States can agree on common standards for the use and protection of the Great Lakes waters and can coordinate their water management programs with federal and binational efforts."

In Recommendation III of its 2000 report (see Box 13), the Commission suggested that the State and Provincial governments, in collaboration with local authorities, should develop and launch a coordinated basin-wide water conservation initiative, with quantified consumption reduction targets, specific target dates, and monitoring of the achievement of targets, to protect the integrity of the Great Lakes Basin ecosystem, and to take advantage of the other economic and environmental benefits that normally flow from such measures.

Box 13: Recommendation III from 2000 Report. Conservation

In order to avoid endangering the integrity of the ecosystem of the Great Lakes Basin, the governments of the Great Lakes States and Ontario and Québec should apply conservation measures to significantly improve efficiencies in the use of water in the Great Lakes Basin and should implement the conservation measures set out in this recommendation.

The governments of the Great Lakes States and Ontario and Québec, in collaboration with local authorities, should develop and launch a coordinated basin-wide water conservation initiative, with quantified consumption reduction targets, specific target dates, and monitoring of the achievement of targets, to protect the integrity of the Great Lakes Basin ecosystem, and to take advantage of the other economic and environmental benefits that normally flow from such measures.

In developing and implementing this initiative, the governments should, among other things, consider:

a. state-of-the-art conservation and pollution-control technologies and practices,
b. potential cumulative impacts,
c. the application of sound planning practices,
d. to the extent practicable, the setting of water prices at a level that will encourage conservation,
e. conditioning financial help from governments for water and wastewater infrastructure on the application of

Box 13: Recommendation III from 2000 Report. Conservation

sound conservation practices,

f. promotion of eco-efficient practices, especially in the industrial and agricultural sectors,
g. establishment of effective leak detection and repair programs for water infrastructure in all municipalities,
h. the inclusion of strong performance and environmental standards and financial incentives for water saving in contractual arrangements for delivery of water-related services, whether public or private,
i. the application of best practicable water-saving technologies in governmental facilities,
j. sharing experiences with respect to the planning and implementation of conservation policies and programs and the use of water-saving technologies, and,
k. joint preparation of promotional and educational materials and publication of success stories, including sponsoring conferences and workshops on water conservation, in partnership with others.

A technical review[143] of water conservation programs prior to the 2000 Commission report indicated that there was considerable room for improvement. The review indicated that Indiana, Michigan, Ohio, Québec and Wisconsin had either no formal conservation programs, or had limited programs. That review may, however, have painted too dark a picture, since, in all jurisdictions, programs exist at the local level, where much of the water management authority resides. The same review also noted that it will always be very difficult to collect data on and summarize conservation programs because of the very large number of local jurisdictions involved.

2. Recent Developments

Conservation is covered by Chapter 3 of the Compact and Agreement. More specifically:

"The Parties commit, two years after the implementation of the prohibition of Diversions outside the Basin, to implement a voluntary or mandatory program for the conservation and efficient use of water. This program must concern all water withdrawals, including existing withdrawals, in order to attain the goals and objectives that the Parties have set in relation to regional goals and objectives. The Parties agree to reduce the demand for water wherever feasible, to reduce losses and waste of water, or to apply incentive measures for water conservation.

The Parties will submit to the Regional Body a report on the water management, efficiency and conservation programs implemented to meet the commitments of the Agreement. This report will be reviewed by the Regional Body and a Declaration of Finding will be published. Every five years, the Parties will report to the Regional Body on the changes made to these programs."

Considerable progress has been made towards meeting these objectives. On August 21, 2007, a technical committee appointed by the Council of Great Lakes Governors submitted recommendations for basin-wide conservation and efficiency objectives, which were adopted on an interim basis by the Regional Body, and subsequently affirmed in 2014. The Compact Council adopted the same objectives at its first meeting in 2008 and similarly affirmed them in 2014. Annual Assessments have been submitted by each of the jurisdictions beginning in 2009,

[143] Great Lakes Water Uses Study Team, 1999, Great Lakes Water Uses: Consumption, Diversions and Other Removals, June, 1999.

and in 2014, each of the Parties submitted a report on their respective Water Conservation and Efficiency Programs[144].

In reviewing the status of individual state and provincial programs, there are three key questions that need to be answered. Have the jurisdictions established **baseline information** on withdrawals and consumptive use? Have water conservation and efficiency **goals and objectives** been developed, and associated **program**s been implemented? Are withdrawals being **registered**, and is there a water management program in place to **regulate** new or increased withdrawals and consumptive uses?

The following brief overviews by jurisdiction are based on two primary sources; a) the summary reports provided by each jurisdiction to the Regional Body in 2014[145] and b) a December 2014 progress report progress prepared by a consortium of non-governmental organizations[146]. The intent is merely to provide a broad overview of the general situation across the Basin from both governmental and non-governmental perspectives. It was beyond the scope of the consultant's review to conduct a comprehensive, independent analysis and critique of the conservation programs in all ten jurisdictions.

The reader should note that one thing common to all jurisdictions is that they all submitted their baseline data on schedule.

Illinois: The unique nature of Illinois' Lake Michigan water use and diversion as allowed under the U.S. Supreme Court Decree means that State is only required to comply with the conservation and registration requirements. Illinois already collects information on withdrawals under its existing Lake Michigan allocation program. Draft changes to the Lake Michigan Water Allocation Rules and Regulations to upgrade water conservation and efficiency requirements were released in February, 2013 and were expected to be finalized early in 2015. Groundwater withdrawals would not be covered.

The NGOs would like to see the updated rules finalized quickly and the state conservation and efficiency goals and objectives expanded to be more consistent with regional goals and objectives.

Indiana: Baseline data was submitted. Indiana originally implemented its obligations under the Compact under an emergency rule, which was subsequently finalized on September 1, 2014. As part of its final rule, the State created a voluntary water conservation program for existing withdrawals, including annual reporting. Subject to prescribed thresholds, the conservation program and reporting are mandatory for new permit applicants.

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[144] Council of Great Lakes Governors 2014. Personal communications with the staff of the Council of Great Lakes Governors in Chicago

[145] Great Lakes-St. Lawrence River Water Resources Regional Body, 2014 State and Provincial Water Conservation and Efficiency Program Reports, http://www.glslregionalbody.org/Resolutions.aspx#ProgramReports, accessed March 11, 2015.

[146] Alliance for the Great Lakes 2014. Progress on Implementation of the Great Lakes Compact and Agreement, updated December 5, 2014

The NGOs would like the rule a) revised to eliminate the apparent preferred treatment of existing users, and b) clarified to help users implement specific, cost-effective conservation strategies as well as to facilitate improved monitoring.

Michigan: Michigan submitted baseline data and adopted conservation goals and objectives identical to the regional ones in December, 2011. The foundation of Michigan's Water Conservation and Efficiency Program is the water withdrawal assessment required for all new or increased large quantity withdrawals (taking into account the cumulative impacts of all withdrawals). Proposed water uses are assessed relative to standards set for conserving and protecting the water resources of the Great Lakes Basin. A proposed withdrawal must meet the environmental and ecological standards of "no likely adverse impact" through the assessment process and be authorized before the withdrawal can occur.

The NGOs have suggested the need for an assessment process for lake withdrawals, and for a review of the self-certification conservation requirements in the permitting program. They note that the State has re-established an advisory council to assist with these tasks.

Minnesota: Minnesota's baseline data relied on information gathered through its appropriation permits. State goals and objectives have been posted. The Minnesota report describes a large number of both mandatory and voluntary conservation and efficiency programs that are currently in place and integrated with their water appropriation permit program. In addition, water supply plans for public water suppliers that address conservation, among other things, must be updated and approved every ten years. The state is currently developing new and improved water conservation, monitoring and management standards to incorporate into new public water supply plans that are due for updating over the next few years. Furthermore, water conservation rate structures for public water suppliers within the Basin must be implemented by 2015.

The NGO report suggests that Minnesota leads all Great Lakes States in conservation requirements and comprehensive water management, but the NGOs would still like to see goals and objectives, and decision-making criteria more consistent with those in the Compact.

New York: Based on an advisory committee report in 2010, New York has submitted baseline information from its registration program. Under a 2011 law, the Department of Environmental Conservation must develop a conservation program based on regional conservation and efficiency goals. Under that same law, all facilities with a threshold capacity greater than 100,000 US gallons per day will be required to obtain a permit. Existing non-municipal withdrawals have been grandfathered in with no additional conservation measures required for at least 3 – 10 years. It should be noted that, since 1988, New York has required the submittal of water conservation plans with each new application for a permit.

The NGOs suggest the need for a formal, stand-alone conservation program, finalization of a "best management practices" document, and better guidance regarding which conservation measures are required.

Ohio: Baseline information was submitted based on the advice of an advisory board. That same board recommended a voluntary conservation program in addition to stated efficiency goals.

Revised legislation was signed in June of 2012. An applicant for a water withdrawal and consumptive use permit is required to submit a facility water conservation plan. If that plan reasonably incorporates environmentally sound and economically feasible water conservation measures, it is considered to be in compliance with the Compact's requirements for water conservation and efficiency. All other elements of Ohio's water conservation and efficiency program are voluntary, except those that are authorized by pre-existing statutes, regulations, or programs.

The NGOs believe that Ohio must finalize the State goals, create an expanded conservation program, preferably using ideas from the advisory board, and create a water management program that complies with the Compact.

Ontario: Ontario has done preliminary work on its baseline data but has not yet submitted its list. The Province's 2013 report to the Regional Body notes that "in 2012, Ontario adopted water conservation and efficiency goals and objectives that are consistent with Basin-wide goals and objectives." It has had a water permitting program for withdrawals greater than 50,000 liters per day since the 1960s, which was amended in 2005 to strengthen factors considered in permitting and to require annual reporting. In 2007, the Province passed the Safeguarding and Sustaining Ontario's Waters Act to allow key elements of the Agreement to be implemented and the Agreement itself to be brought into full force. Regulations regarding intra-basin transfers were passed on January 1, 2015 which enabled proclamation of the implementing legislation, and enabled the Agreement to come into full force following appropriate procedural measures.

The NGOs point out that, once the Agreement comes into full force, Ontario is obliged to "submit its baseline data within one year; ensure compliance with the conservation requirements within two years; and ensure its existing water management program satisfies the Agreement within five years."

Pennsylvania: The Commonwealth of Pennsylvania's baseline data is based on permit limitations. Its Water Conservation and Efficiency Program is implemented through a mix of voluntary efforts and state-wide regulatory requirements. Public water supply agencies are required to obtain a water allocation permit for withdrawals from surface water sources. The Department of Environmental Protection administers a voluntary conservation program online to promote voluntary water conservation and provide technical assistance.

The NGOs suggests the online assistance centre is innovative, but incomplete and in need of updating. They also suggest the need for more work on conservation and efficiency goals and a further fleshing out of rules regarding permitting

Québec: In 2009, Québec adopted An Act to affirm the Collective Nature of Water Resources and Provide for Increased Water Resource Protection. The provisions of this law came into effect gradually with the adoption of a series of regulations. The last regulation permitting the complete implementation of the Agreement in Québec was adopted in July 2014. This regulation calls for compulsory permits for new or increased withdrawals above 75,000 liters per day. In 2011, Québec adopted its objectives of water conservation and efficient use in accordance to the

regional objectives. Québec submitted its program on water conservation and efficient use to the Regional Body in September 2013.

The NGOs agreed that Quebec has finalized implementing measures on diversions and has nearly completed its measures governing water withdrawals and consumptive uses.

Wisconsin: Wisconsin has enacted comprehensive legislation to set baselines and to implement the Compact, and was the first State to establish water conservation and efficiency goals. A statewide Water Conservation and Efficiency Program has been developed based on Wisconsin's adaptation of Regional Objectives. The program requires mandatory water conservation and efficiency measures for new or increased withdrawals in the Great Lakes Basin and for any new or increased diversions from the Great Lakes Basin; and voluntary water conservation and efficiency measures are encouraged for all existing water users throughout the state. A stringent permitting system is in place for new or increased withdrawals.

The NGOs recognize Wisconsin's leadership in establishing water conservation and efficiency goals, and in establishing mandatory conservation rules for new and increased withdrawals, but suggest the need to address existing users as well.

3. Remaining Issues and Recommendation

Surrounded by a seemingly inexhaustible supply of fresh water, citizens and institutions in the Basin may not perceive conservation of supply as an obvious high priority. The region developed using the abundantly available water to fuel industrial and urban growth. Given the uncertainties in future water supply resulting from climate change, water conservation in the region is important, but it requires a cultural shift and challenges citizens to envision how their water use and/or conservation can make a meaningful difference in water supply containing six quadrillion gallons (20 trillion cubic meters).

Other large natural water systems that seemed permanently vast have experienced significant reductions in size through human mismanagement, like the Aral Sea and Lake Chad. A true gift from the glaciers, less than one percent of the Great Lakes system is renewed annually through rainfall and snowmelt. Protecting the sheer volume of water in the system provides reliable drinking water, transportation, renewable energy, recreation, and natural, rural, suburban and urban habitats.

As noted, the conservation features of the Agreement and Great Lakes-St. Lawrence River Basin Water Resources Compact are being implemented by each jurisdiction in its own manner. For the first time, all Great Lakes state and provinces are integrating conservation into their water use programs. Examples of water conservation tools include the water withdrawal assessment required by Michigan for all new or increased large quantity withdrawals of 100,000 gallons per day or more (380 cubic meters per day). Proposed water uses are assessed relative to standards set for conserving and protecting the water resources of the Great Lakes Basin. Meanwhile, a 2014 Quebec regulation calls for permits for new or increased withdrawals over 75,000 liters per

day. These and other conservation measures undertaken by the states and provinces are commendable (20,000 gallons per day).

The jurisdiction by jurisdiction review in the previous section points to many impressive accomplishments over the past decade. Governments, the non-governmental community, industry and other stakeholders are all working together towards the common goal of protecting the Great Lakes ecosystem, and continuation of that collaboration should be encouraged.

The recent decline in water use in North America generally and in the Great Lakes Basin in particular is encouraging evidence that some gains are already being made in water use efficiency. Nevertheless, the potential for more gains remains high, and it continues to be important to capture that potential. Even though consumptive use is reported to be less than 1% of renewable supplies Basin-wide, as we pointed out on page 6, in many local areas, such as southwest Michigan or Kitchener-Waterloo Region in Ontario, water use conflicts are arising. In some areas, excessive withdrawals threaten to stress ecosystems, and the very substantial economic potential of conservation may be missed.

Organization for Economic Co-operation and Development (OECD) analyses point out that Canadian andU.S. residents are the greatest per capita water users in the industrialized world, and the prices of their water and wastewater services are lowest[147]. In the U.S. households typically pay less as percentage of income than those of any other developed country for water and wastewater services.[148] Recent legislation in Ontario requires local water prices to account for all operating, capital and source-protection costs that they incur and to recover these through appropriately designed prices. Other water use sectors, such as thermoelectric power producers, agriculture, and self-supplied industry, can also seek water conserving opportunities.

Some remaining conservation potential may very well lie in appropriate pricing of water and wastewater services. Putting an appropriate price on the private use of public water – at a minimum the full price of its future supply and security – could serve as a way to promote water conservation. It would discourage waste, and it could create incentives for large users to invest in process changes and other innovations that reduce water use. To the extent that Basin residents used less water, they would also save the vast amounts of energy that it takes to extract, store, treat, deliver, and heat water for its many end uses. A Basin-wide survey of water and wastewater prices and pricing policies might be conducted to identify lessons that might usefully be applied by individual jurisdictions to promote water conservation.

The state of the region's deteriorating water infrastructure undercuts water conservation. Aging pipes commonly leak and waste significant amounts of water. By one estimate, there are 240,000 water main breaks per year in the U.S[149]. The Chicago Metropolitan Agency for Planning has determined that the area's water supply systems are losing 22 billion gallons of

[147] OECD. 1999. The Price of water: Trends in OECD countries. Paris, France: Organisation for Economic Cooperation and Development, http://www.oecd.org/environment/resources/1934075.pdf, accessed March 19, 2015

[148] U.S. Environmental Protection Agency. Water and Wastewater Pricing: Introduction. http://water.epa.gov/infrastructure/sustain/Water-and-Wastewater-Pricing-Introduction.cfm, accessed March 19, 2015.

[149] American Society of Civil Engineers. 2013 Report Card for America's Infrastructure: Drinking Water. http://www.infrastructurereportcard.org/a/#p/drinking-water/overview, accessed March 19, 2015

water per year to leaky pipes, enough to supply a residential population of 700,000[150]. Up to one quarter of treated drinking water in Ontario annually – enough to supply over 2 million people -- never reaches a tap because of leaks, according to a 2009 study[151]. A 2013 assessment by U.S. EPA estimated a 20-year drinking water infrastructure need for the eight Great Lakes states of $102.3 billion, up from $96.1 billion in 2009, far in excess of available funds given current levels of investment[152]. The single largest need is repair, replacement and construction of transmission and distribution systems.

Prudent leadership and investment by governments-at all levels-in maintaining and improving the delivery of drinking water can significantly enhance efficiency and may limit local impacts from drawdown on surface and groundwater, reduce energy required to treat and transport water, and preserve water to meet the needs of the multiple users and future generations.

Funding the water infrastructure need is daunting. Water utility bills, municipal bonding and low to no interest loans are the primary sources of funding capital improvements of water infrastructure. With a multi-billion-dollar regional water infrastructure gap, the struggle to meet this need is more obvious than readily available funding solutions. Water services benefit the individual and society equally, demanding a truly collaborative approach to realize the region's long term water efficiency potential.

Findings: The IJC commends the Great Lakes states and provinces for impressive strides in enacting water conservation measures, but additional conservation potential exists.

2015 RECOMMENDATION 7: The IJC recommends broad-based collaboration among public and private sectors to fix leaking water infrastructure, support innovation, and increase funding to close the region's water infrastructure deficit and unlock water conservation potential region wide.

[150] Chicago Metropolitan Agency for Planning. An Assessment of Water Loss Among Lake Michigan Permittees in Illinois. July 2014. http://www.cmap.illinois.gov/documents/10180/296743/FY14-0071+IDNR+WATER+LOSS+REPORT/bfda6186-8c79-42b5-80b8-9d97c7c2300d, accessed March 19, 2015.

[151] Residential and Civil Construction Alliance of Ontario. "RCCAO study finds Ontario consumers paying $700 million a year for water that never reaches their taps." News Release, www.rccao.com/news/files/leakingPipes-NewsRelease.pdf, accessed March 19, 2015.

[152] U.S. Environmental Protection Agency. Drinking Water Infrastructure Needs Survey and Assessment, Fourth Report to Congress, February 2009. http://water.epa.gov/infrastructure/drinkingwater/dwns/,http://water.epa.gov/infrastructure/drinkingwater/dwns/ accessed March 19, 2015; Drinking Water Infrastructure Needs Survey and Assessment, Fifth Report to Congress, April 2013. http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf,, accessed March 19, 2015.

Conclusion

The Great Lakes basin is not only important to those who live in the region, but also of vital importance to both Canada and the United States. The basin is home to over 40 million citizens, and supports an industrial, agricultural and transportation structure responsible for a significant proportion of the gross domestic product of both countries. Basin jurisdictions are concerned about sustainability in terms of not foreclosing options to meet the needs of generations yet unborn. Accordingly, cooperative actions are being taken by the Great Lakes States and Provinces, with the full encouragement and support of the two federal governments, to ensure the goal of sustainability is factored into all decisions regarding diversions and consumptive uses.

Since publication of the Commission's year 2000 report, there has been considerable and impressive progress, mostly under the aegis of the Council of Great Lakes Governors in cooperation with the Premiers.

Following four years of intense negotiations, the eight Great Lakes States and two Great Lakes Provinces signed the Great-Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement in 2005. That Agreement is consistent with the intent of the Commission's year 2000 recommendations. Once the necessary approvals were in place in the United States, a parallel, legally-binding Compact came into force on December 8, 2008. This was and continues to be a very remarkable accomplishment. For as many as ten diverse jurisdictions to commit themselves to strong, common decision-making standards for managing their shared water resources may be without precedent anywhere in the world.

In essence, the Agreement and Compact call for a prohibition on bulk removals of water from the Basin, with minor and well-defined exceptions. For consumptive uses the Agreement and Compact call for prior notification for large proposed uses, and for uses subject to its decision making standards return of the withdrawn water to the same watershed, no significant individual or cumulative impact, the application of sound conservation measures, and reasonable use from a sustainable development perspective. From a global perspective, those measures have been mostly successful to date, in the sense that there have been no new inter-basin or intra-basin diversions approved which would have significant negative impacts on the ecological integrity of the Great Lakes, consumptive use has been declining, and institutional arrangements, such as the Regional Body, are in place to continue those positive trends.

All jurisdictions need to continue moving forward with their individual water conservation programs. And the first major test of the straddling county provisions regarding diversions is currently under consideration in the state of Wisconsin.

From a scientific and technical perspective, more work needs to be done to (a) verify water use and consumptive use estimates; (b) improve the science surrounding calculation of the various components of the water balance, especially in the light of climate change; (c) continue efforts for mapping and characterization of groundwater aquifers; and (d) improve the science of cumulative impact assessment associated with human activities on either a lake-wide or tributary scale. Furthermore, a regional study of pricing as a water conservation and financial tool would be desirable.

Moving forward, it is important to remember that there is no "surplus" water in the Great Lakes Basin. From an ecosystem perspective, it is all in use, even in periods of high supply. There continue to be large voids between our knowledge regarding levels and flows, and the impact they have on the ecosystem of the basin. Due to prevailing uncertainties such as those posed by climate change and the sheer threat of the unexpected, the precautionary principle needs to be continually applied by basin jurisdictions to ensure, to the extent possible, adequate supplies for all socio-economic and ecosystem uses for the long term.

2015 RECOMMENDATION 1: The existing Agreement and Compact should continue to be rigorously implemented to minimize loss of water from the Basin.

2015 RECOMMENDATION 2: The precautionary approach regarding diversions should continue to guide the States and Provinces in order to protect the Great Lakes from an ever-increasing number of larger-scale removals.

2015 RECOMMENDATION 3: The Great Lakes States and Provinces, in collaboration with the two federal governments, should continue to investigate methodologies for improving the accuracy of water use and consumptive use estimates.

2015 RECOMMENDATION 4: Further refinement of water balance components should continue to occur through federal agencies such the USGS, NOAA, US Army Corps of Engineers, and Environment Canada. Assuming that the science will continue to evolve rapidly, the Regional Body/Council should continuously review new knowledge regarding lake-wide hydrology and incorporate new advancement in decision-making processes.

2015 RECOMMENDATION 5: Considering the large uncertainties surrounding climate change and other human impacts on the hydrologic cycle, federal, provincial and state governments should continue to take an adaptive management approach in decision-making. Advancements in the state of science on climate change impacts in the Great Lakes should be encouraged by federal, state and provincial governments through further funding and a synthesis of the state of the science.

2015 RECOMMENDATION 6: Great Lakes States and Provinces should fully factor the adverse ecological and water quality impacts of groundwater withdrawals into both water use permitting procedures and decisions regarding consumptive use. Federal, state and provincial research should focus on predicting where groundwater supplies may be degraded in the future and identify management methods for avoiding these problems.

2015 RECOMMENDATION 7: The IJC recommends broad-based collaboration among public and private sectors to fix leaking water infrastructure, support innovation, and increase funding to close the region's water infrastructure deficit and unlock water conservation potential region wide.

Appendix A: Glossary

Agreement: The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement among the Great Lakes States and the Canadian provinces of Ontario and Québec defining bi-national water management for the basin,

Alien Invasive Species: Species that are not native to a specific geographical are, tend to spread quickly and overwhelm native specifies, and have been introduced due to human activity.

Anthropogenic Contamination: Chemical and biological contamination caused by the actions of humans.

Aquifer: An underground compartment of water-bearing permeable materials (e.g. fracture rock, gravel, sand, or silt) from which groundwater can be extracted for water supply wells.

Aquifer Drawdown: Local change in hydraulic head, manifested as changes in groundwater table elevations or pressures, and usually associated with groundwater pumping.

Compact: The Great Lakes-St. Lawrence River Basin Water Resources Compact, ratified in 2008, is a legally binding interstate compact among the U.S. States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin regarding water management in the basin.

Consumptive Use: That portion of water withdrawn which is evaporated, transpired from plants, incorporated into products or otherwise lost, and thus is not available for further use in the basin.

Consumptive Use Coefficients: A number between 0 and 1 (0% and 100%) that defines the fraction of a water withdrawal that is used consumptively.

Cumulative Impacts: Ecological and socio-economic impacts of withdrawals, consumptive uses and diversions of Water aggregated over the Great Lakes St. Lawrence River Basin; usually related to net basin supply or lake water levels.

Diversion: Water conveyed by canal, pipeline, modified channel or any similar means from its basin of origin for use in another drainage basin. This usually means interbasin diversion, e.g., Chicago diversion out of, or Ogoki diversion into, the Great Lakes Basin. There may also be diversions between sub-basins called intrabasin diversions, e.g., Welland Canal, diverting water from Lake Erie to Lake Ontario.

Ecosystem Integrity: Capacity of the ecosystem to maintain operations under normal conditions, to cope with external influences, and to continue the dynamic process of self-organization indefinitely.

Ecosystem Resilience: A measurement of the magnitude of disturbance that can be accommodated before the system alters its structure by changing the variables and processes that control system behavior.

Great Lakes Ecosystem: The interacting components of air, land, water and living organisms, including humans, within the Great Lakes Basin.

Hydrologic System: A conceptual model of the physical aspects of water system, including the inflows, outflows and storage components and the natural and human-derived factors that determine the flows and storage volumes.

Millions of US Gallons per Day (MGD): Unit expressing rate of discharge. One MGD is equivalent to one million gallons of water flowing past a particular point in one day. One MGD is equivalent to about four MLD. The flow over Niagara Falls in daylight hours in the tourist season is 64,000 MGD.

Millions of Liters per Day (MLD): Unit expressing rate of discharge. One MLD is equivalent to one million liters of water flowing past a particular point in one day. One MLD is equivalent to about one quarter of one MGD. The flow over Niagara Falls in daylight hours in the tourist season is 250,000 MLD.

Net Basin Supply: Net water supply in the Basin resulting from precipitation on the lakes' surfaces, runoff from their tributary drainage areas, groundwater flow into or out of the lakes, and evaporation.

Removal: Water conveyed outside its basin of origin by any means. Bulk removal includes diversions or other means such as tanker ships or trucks which carry water in larger volumes, but excludes water used as ballast in ships or incorporated into products or otherwise bottled for retail sale.

Return Flow (Non-Consumptive Use): The remaining portion of water withdrawn which returns to surface or underground sources after use, and thus becomes available for further use in the Basin.

Self-Supplied: Water users that maintain their own water supply and are not connected to a community or municipal water supply.

Straddling Community: A community or other geographic entity that lies on the Great Lakes basin surface water divide (or watershed boundary).

Sustainable Management: A set of objectives and activities consistent with the purpose of maintaining or improving the integrity of the ecosystem and contributing to the well-being of its living systems, now and in the future.

Transboundary Rivers: Rivers that cross a political border, either within a nation or an international boundary.

Withdrawal: Water taken from nature- surface or ground water- for uses such as agricultural, municipal and industrial uses.

Appendix B: International Joint Commission, Protection of the Waters of the Great Lakes Final Report to the Governments of Canada and the United States, February 22, 2000

http://www.ijc.org/files/publications/C129.pdf

Appendix C: International Joint Commission. 2004. Protection of the Waters of the Great Lakes Review of the Recommendations in the February 2000 Report, August 2004

www.ijc.org/files/publications/ID1560.pdf