Impacts of Food Production to Water Quantity in the Great Lakes Basin

Working Draft

January, 2001

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Executive Summary

The world's freshwater resources are becoming increasingly threatened. With an ever-growing population, water withdrawals from lakes, their tributaries or the groundwater feeding them have increased dramatically over the last century (World Water Council, 2001). At a recent international conference on the conservation and management of lakes held in Shiga, Japan, (November 11-16, 2001), a panel of experts found that more than half of the world's five million lakes and reservoirs, which hold nearly 90 percent of all surface freshwater, are facing massive ecological threats. One of the primary population-related phenomena causing declining water levels and degradation is overuse of lake water, especially from diversions for irrigation (Figure 1). Since 1900, estimated water withdrawals worldwide have increased over 500 percent (from 578 km^3 per year to 3,800 km^3 per year). Another study estimates a six-fold increase in water withdrawals from lakes and rivers between 1990 and 1995, a rate that is twice as fast as population growth (World Water Council, 2001).

The Great Lakes-St. Lawrence ecosystem currently holds 20% of the world's supply of fresh surface water. The vast surface areas of each of the Great Lakes account for storage of enormous quantities of water (Great Lakes Commission, 1995). It is one of the most intensively used freshwater systems in the world, serving multiple interests including navigation and transportation, hydropower, irrigation and livestock, municipal and industrial water supply, mining and recreation. Of these, the largest consumptive water use (water not returned and assumed lost from the system) is food production (Great Lakes Commission, 2000). Although long term trends show increasing freshwater use for irrigated land and livestock, and increasing exports of agricultural products by most of the Great Lakes States and Provinces, the relationship between water used for food production and Great Lakes water levels has not been well researched. Natural climatic factors are recognized as having more influence on lake levels than human activities, and recent low water levels, although below the historic mean, are averaging 1.5 feet (45 cm) higher than their record low water levels (Great Lakes Environmental Research Lab Website). Given the enormous natural variability in water levels, it is difficult to determine how much of an impact food production presently has on the water levels of this enormous ecosystem.

Despite its size, research is showing that the cumulative impact of increasing freshwater use in most sectors will lead to decreasing water quantity in the Great Lakes Basin (International Joint Commission, 2000; Canadian Environmental Law Association and Great Lakes United, 1997; Quinn, 1999). It is estimated that if water is consumed at currently projected growth rates, and if projected impacts of climate change occur, Great Lakes water levels will drop dramatically (Canadian Environmental Law Association and Great Lakes United, 1997). In less than forty years, the flow from the Great Lakes system into the St. Lawrence River will have been reduced to less than three-quarters of its current flow, without accounting for the compounding impact that diversions out of the Great Lakes Basin could have on the lake levels (Canadian Environmental Law Association and Great Lakes United, 1997). Growing water uses in the Great Lakes Basin, combined with potential future impacts from population growth, climate change,

land use and other changes, will lead to a combination of decreasing water availability and an ever-increasing value of freshwater due to competing interests.

This paper is written to provide general background on these issues, largely through literature review. It will focus on the relationship between food production and water quantity in the Great Lakes Basin and will analyze historical trends in water balance and fluctuations, ecological and ecosystem changes over time, policy, current water uses, water management and legislation, and potential future conditions resulting from various impacts to water quantity in the Great Lakes Basin. The paper will explore perceived gaps in knowledge, will begin to identify areas for further research, and finally will make general recommendations for improved water quantity management.

International Trends in Declining Lake Levels from Water Withdrawals and Overuse:

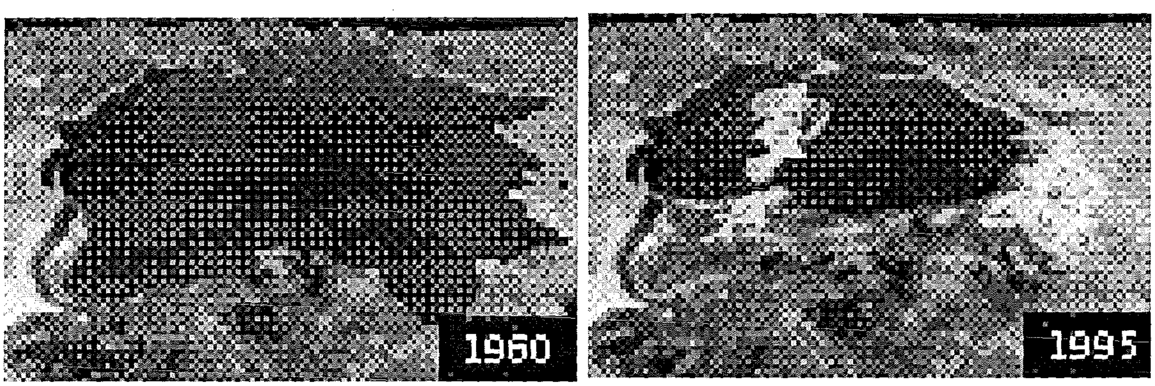
Although lakes are among the most vulnerable and difficult to restore of all natural ecological systems, they have been widely ignored even as they have deteriorated, according to Masahisa Nakamura, Director of the Lake Biwa Research Institute in Biwa, Japan (World Water Council, 2001). *See Box.*

- Between 1950 and 1980, 543 large and medium-sized lakes in China disappeared when their water was diverted for irrigation;
- The Arre Lake in Denmark has suffered severe water loss because of the rising use of water for growing populations;
- Many lakes and reservoirs in the Amazon Basin of Brazil have been drained for agriculture and other economic activities;
- Lake Chad, in Africa, has experienced a steep decline in its water levels;
- Lake Okeechobee in Florida, the second largest lake entirely within the U.S., has been severely depleted because of its use as a water source for growing populations, with the loss of the natural flow adversely affecting the Everglades;
- And perhaps the most dramatic example is that of the Aral Sea, located between Kazakhstan and Uzbekistan, which has lost more than 60% of its area and 80% of its volume since 1960 (Figure 1). The Aral Sea has dropped in size from the world's fourth largest lake to the eighth largest, predominantly from heavy withdrawals for irrigation

Source: World Water Council, 2001.

The cumulative climatic, ecological and economic consequences of these worldwide water losses are significant.

Figure 1: The Aral Sea, Disappearing Predominantly from Heavy Withdrawals for Irrigation, 1960-1995



Climatic consequences	Ecological / economic consequences
Mesoclimatic changes (increase of continentality)	Degeneration of the delta ecosystems
Increase of salt and dust storms	Total collapse of the fishing industry
Shortening of the vegetation period	Decrease of productivity of agricultural fields

Source: The Aral Sea Homepage

I. Physical Characteristics and Geography of the Great Lakes Basin

The Great Lakes-St. Lawrence River drainage basin is the largest body of fresh water in the world. The system extends from the Atlantic Ocean to nearly halfway across the North American continent (Great Lakes Commission, 1995). The Great Lakes Basin is bordered by eight U.S. States (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York) and two Canadian Provinces (Ontario and Quebec), (Figure 2). More than one tenth of the population of the U.S. and one quarter of the population of Canada inhabit this basin (U.S. Army Corps of Engineers and the Great Lakes Commission, 1999).

Figure 2: The Great Lakes Basin

Source: Institute for Agriculture and Trade Policy

The five Great Lakes- Superior, Huron, Michigan, Erie and Ontario- with their connecting channels and Lake St. Clair (Northwest of Lake Erie), have a total surface area of 94,900 square miles. The maximum dimensions of the basin are approximately 740 miles from north to south, and 940 miles from east to west. The total length of the shoreline, including islands, is 11,200 miles. Elevation ranges from 243 feet (Lake Ontario) to 600 feet (Lake Superior), and the average depth ranges from 62 feet (Lake Erie) to 483 feet (Lake Superior), (Table 1). Lake Michigan is completely within the United States, while the lower St. Lawrence River is wholly within Canada. The Canadian shoreline of the Great Lakes and the international section of the St. Lawrence River are entirely within the Province of Ontario (U.S. Environmental Protection Agency and the Government of Canada, 1995).

Table 1: Physical features of the Great Lakes

	Superior	Michigan*	Huron*	Erie	Ontario
Elevation (feet)	600	577	577	569	243
Length (miles)	350	307	206	241	193
Width (miles)	160	118	183	57	53
Average Depth (feet)	483	279	195	62	283
Maximum Depth (feet)	1,332	925	750	210	802
Volume	2,900	1,180	850	116	393
Land Drainage Area (sq. miles)	49,300	45,600	51,700	30,140	24,720
Miles of shoreline (cubic miles)	2,980	1,659	3,827	871	726

*Lakes Michigan and Huron are hydraulically considered as one lake.

Sources: Great Lakes Seaway Website; U.S. Environmental Protection Agency and the Government of Canada (1995).

Only 1 percent of the water of the Great Lakes is renewed each year through annual rainfall and river input (Canadian Environmental Law Association and Great Lakes United, 1997). The other 99 percent of the water is a result of glacial deposition (Michigan Environmental Council Website). This results in extremely long retention times. It takes an average of 191 years for water to travel through Lake Superior (O'Connor et al, 1970).

For more detailed information regarding Great Lakes physical characteristics, see U.S. Environmental Protection Agency and the Government of Canada (1995) and U.S. Army Corps of Engineers and the Great Lakes Commission (1999).

II. Historical Perspective: Water Balance and Lake Level Fluctuations

Natural variations in lake levels due to climate/meteorology

Lake levels are determined by the combined influences of precipitation (the primary source of natural water supply to the Great Lakes), upstream inflows, groundwater recharge, surface water runoff, evaporation, diversions into and out of the system, consumptive use, dredging, and water level regulation. Climatic conditions control precipitation (and thus groundwater recharge), runoff, and direct supply to the lakes, as well as the rate of evaporation. These are the primary driving factors in determining water levels. The lakes are generally at their lowest levels in the winter months when the air above the lakes is cold and dry, the lakes relatively warm, and evaporation is greatest. In the warmer months, as the snow melts, evaporation from the lakes is least in the spring and early summer when the air above the lakes is warm and moist and the lakes are cold. With more water entering the lakes than leaving, water levels rise (U.S. Army Corps of Engineers and the Great Lakes Commission, 1999).

The total area of the Great Lakes Basin, both land and water, is 298,500 square miles, of which about one third is lake surface (Quinn, in: Adams, 1999). This natural feature absorbs the large variations in the precipitation falling directly on each lake and the runoff from land draining into each lake. Consequently, the outflow of each lake is modulated so as to maintain a remarkably steady discharge into the next lower lake (Great Lakes Commission, 1995). Because of the relatively small range in lake levels, about 6 feet (1.8 meters), significant human uses have become dependent upon relatively constant water levels and outflows, resulting in system sensitivity to relatively small changes in climate variability and change (Quinn, in: Sellinger and Quinn, eds., 1999). *See Box.*

Fluctuations in Water Levels During the 20th Century on each of the Great Lakes:

Lake Superior:	**1.2 meters (4 feet)**
Lakes Michigan and Huron:	**1.9 meters (6.3 feet)**
Lake Erie:	**1.9 meters (6.3 feet)**
Lake Ontario:	**2.0 meters (6.7 feet)**

The full extent of these ranges is not seen during any one year. However in 1998, Lake Ontario saw a drop of 1.2 meters from April to December. Spring lake level rises due to heavy precipitation and snowmelt runoff can also be dramatic and when combined with severe spring windstorms are the subject of concern for many shoreline property owners.

Source: Environment Canada Website (1).

As shown in Figure 3, between 1918 and 1998, there were several periods of extremely high and extremely low water levels. Levels of some of the Great Lakes fell to their lowest recorded levels in the late 1920s, the mid-1930s, and the mid-1960s. Extremely high levels occurred in the early 1950s, the early 1970s, and the mid-1980s. High lake levels occurred between 1985 and 1987 when all of the lakes, except Lake Ontario, reached their highest levels recorded in the twentieth century. Over the following two years, lake levels dropped rapidly to their long-term averages. Much of the 1990s were characterized by persistently high water levels [Environment Canada Website (3)]. Extremely low water levels were experienced in the late 1990s leading up to today.

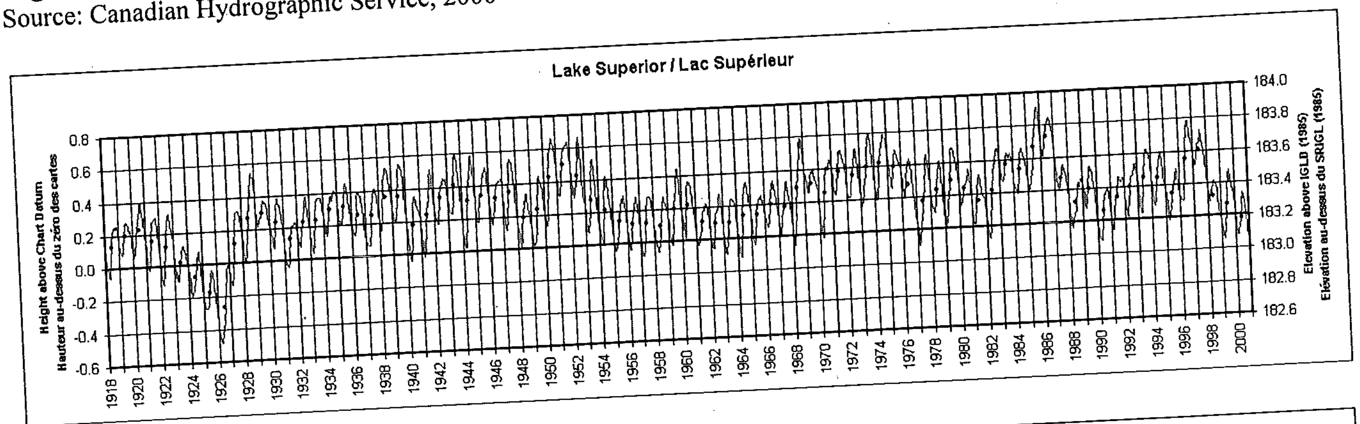
According to Frank Quinn of NOAA's Physical Sciences Division, precipitation in the Great Lakes Basin had shown a consistent upward trend over the 30 years prior to the 1990s (through 1997), and is essentially the result of a changed precipitation regime (Quinn, 1999). This phenomenon, more than any other, contributed to the higher lake levels. According to Doug Cuthbert, manager of Environment Canada's Water Issues

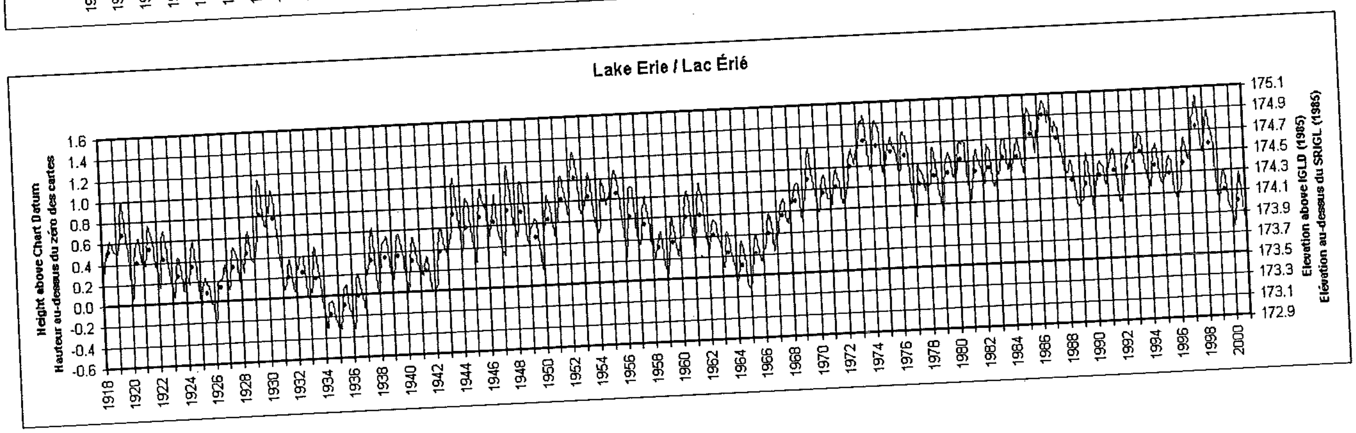
Division, although significantly higher than a half century ago, water levels on the lakes for most of the 1990s were still within the range of normal variability (Great Lakes Commission, Advisor, 1997).

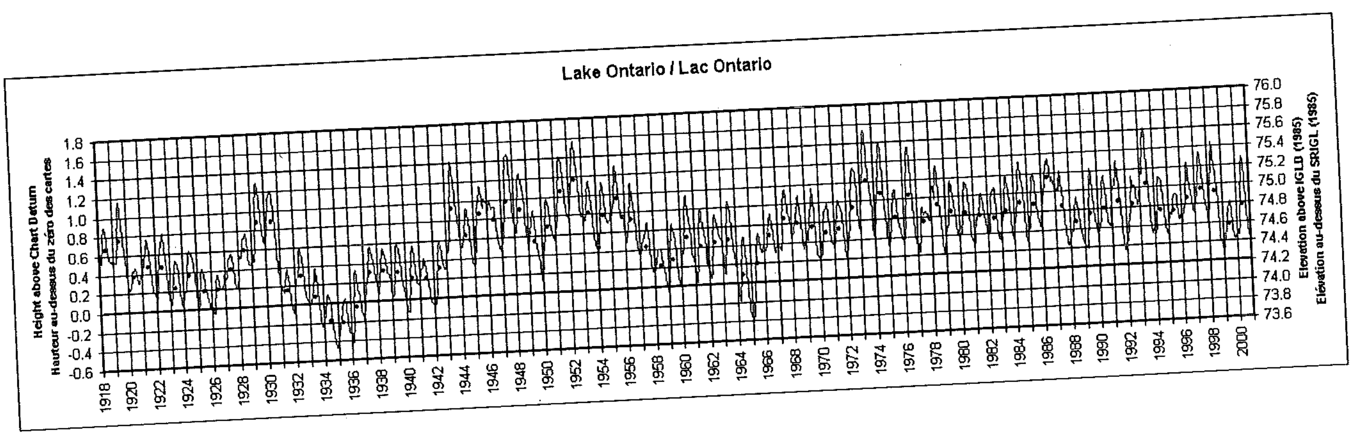
The recent decline of Great Lakes' water levels, now at lows not seen since the mid-1960s, is due mostly to evaporation during the above-average temperatures of the past three years, a series of mild winters, and below-average snowpack in the Lake Superior Basin. Although below the long-term average, studies of water level fluctuations have shown that the Great Lakes can respond relatively quickly to changes in precipitation, water supply, and temperature conditions (International Joint Commission, 2000). However, the factors that influence lake levels are still poorly understood (Great Lakes Environmental Research Lab Website).

Figure 3: Historic Annual Mean Lake Levels, 1918-2000

Source: Canadian Hydrographic Service, 2000







The following key findings are summarized by Sellinger (in: Sellinger and Quinn, eds., 1999) from workshop proceedings of research on the last 4,000 years of Great Lakes water levels:

- Lake levels are at the peak of the 150-year fluctuation and are headed back to a low period (Thompson, in: Sellinger and Quinn, eds., 1999);
- Fluctuations on Lake Superior for the last 2500 years are estimated to have ranged between 1 to 1.5 meters (Larsen, in: Sellinger and Quinn, eds., 1999);
- Lake Ontario's water levels fluctuated between 1 and 2 meters for about 1000 years within the last 4000 years (Lewis, in: Sellinger and Quinn, eds., 1999);
- Evidence indicates that the range in historical water levels has been exceeded over the last 3000 years for both Lake Superior and Lakes Michigan-Huron;
- Paleo lake levels for Lakes Ontario and Erie are much harder to quantify but have probably varied around the historical range;
- There may be a significant correlation between longer-term atmospheric circulation patterns and lake level fluctuations.

The natural range of lake level fluctuations is greater than any caused by anthropogenic influences in recent years [Environment Canada Website (3)].

Lake levels vary from year to year and can be expected to continue to do so (U.S. Environmental Protection Agency and the Government of Canada, 1995), with size and capacity being the fundamental characteristics governing the balance of water in the Great Lakes. According to the Great Lakes Commission (1995), although water availability from the Great Lakes appears unlimited for the foreseeable future, there are numerous societal matters in which water balance may play a role (Great Lakes Commission, Advisor, 1997).

Anthropogenic changes imposed due to diversions, irrigation, hydropower, and water level regulations must be considered in the overall water balance of the Great Lakes. Several human activities have affected levels and flows. For example, structures have been built to regulate the outflows of Lakes Superior and Ontario. Lake Superior has been regulated since 1921 as a result of hydroelectric and navigation developments in the St. Marys River. Lake Ontario has been regulated since 1960 after completion of the St. Lawrence Seaway and Power Project. Besides assisting navigation and allowing for dependable hydropower, these regulation structures have helped, to some extent, to stabilize the range of lake level fluctuations [Environment Canada Website (3)]. Still, because the major factors affecting the water supply to the lakes- precipitation, evaporation and runoff- cannot be controlled or accurately predicted for more than a few weeks into the future, our ability to effectively regulate lake levels is limited. Nature has a much greater influence through the effects of natural hydrologic cycles (Quinn, 1999; Great Lakes Net Website).

Hydrologic Cycles

Water level fluctuations affect most of the 40 million people who live within the Great Lakes watershed. High water levels are of serious concern to those who own and live on Great Lakes shoreline property as serious flood and erosion damages can occur during storm conditions. Low water levels, on the other hand, can have a huge economic impact on several industries, including shipping, recreational boating, hydroelectric power generation, and water suppliers. Fluctuating water levels also affect wetlands and fisheries [Environment Canada Website (1)].

Fluctuating water levels on the Great Lakes are essential for the well being of marine ecosystems. Various natural processes such as precipitation and evaporation can vary substantially with time. Water levels on the Great Lakes change seasonally and can vary dramatically over longer periods. There are three types of water level fluctuations on the Great Lakes: long-term (multi-year), seasonal (one-year) and short-term (from a less than an hour to several days). Short-term changes are generally of greater magnitude than monthly averages [Environment Canada Website (1)].

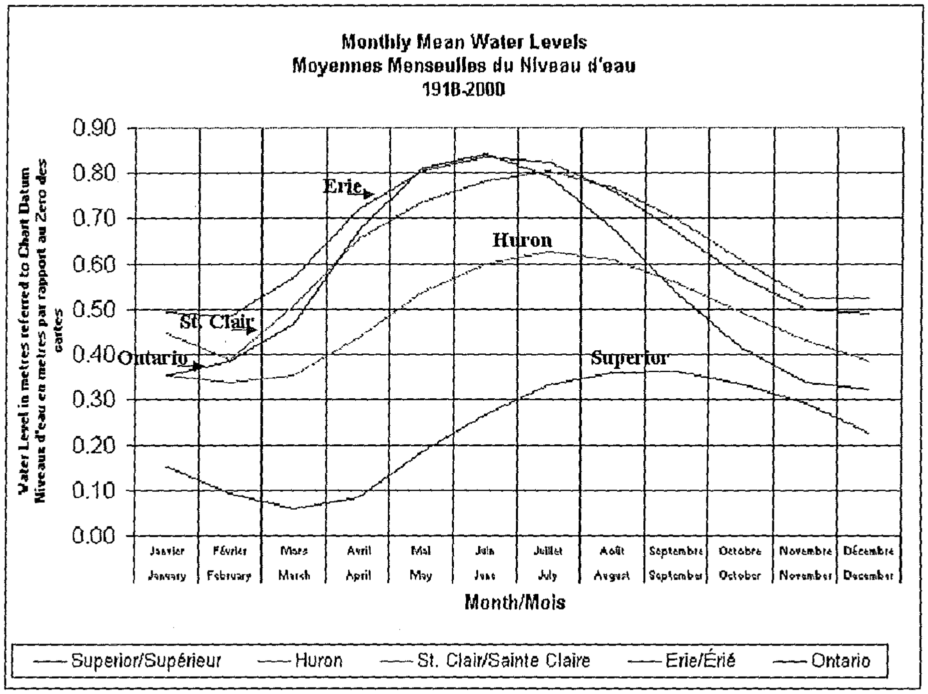
Long-term fluctuations: Long-term fluctuations occur over periods of consecutive years. More than a century of records in the Great Lakes Basin indicate no regular, predictable cycle. The intervals between periods of high and low levels and the length of such periods can vary widely and erratically over a number of years, and only some of the lakes may be affected (Canadian Hydrographic Service, 2000).

Seasonal fluctuations: These fluctuations of Great Lakes levels reflect the annual hydrologic cycle, characterized by higher net basin supplies during the spring and early summer and lower net basin supplies during the remainder of the year. With more water entering the lakes than leaving, water levels rise to their peak in the summer. Seasonal rises begin earlier on the more southern lakes that experience a slightly warmer climate. Lake Superior, the northernmost lake, is generally the last to peak, usually in August or September (Figure 4) (Canadian Hydrographic Service, 2000).

Short-term fluctuations: Some water level fluctuations are not a function of changes in the amount of water in the lakes, but are due to winds or changes in barometric pressure. These short-term fluctuations can last from a less than an hour to several days. One such phenomenon, known as wind set-up or storm surge, (seiche), occurs when sustained high winds from one direction push the water level up at one end of a lake, which reduces the volume by a corresponding amount at the opposite end. In deep lakes such as Lake Ontario, the surge of water level rarely exceeds 1.5 feet (0.5 meter), but in shallow Lake Erie, water-level differences from one end of the lake to the other of more than 16.5 feet (5 meters) have been observed. Although the range of fluctuations may be large, there are only minor changes in the volume of water in the lake (Canadian Hydrographic Service, 2000).

For a more detailed discussion regarding hydrologic cycles, see the Canadian Hydrographic Service (2000) and Quinn (2000).

Figure 4: Historic Monthly Mean Lake Levels, by Lake 1918-2000



Source: Canadian Hydrographic Service, 2000

Despite the predominant role played by climatic influence on Great Lakes water levels, in 1975, the International Joint Commission predicted that water consumption in the Great Lakes would increase three to seven times by 2035. The IJC estimates that such an increase will result in drops of about one foot (a third of a meter) in the water levels of Lakes Michigan, Huron and Erie (Canadian Environmental Law Association and Great Lakes United, 1997). Ecological impacts from human activities have already been extensive.

Ecological and Ecosystem Changes from Human Activities

The glacial history of the Great Lakes region and the vastness of the lakes create unique conditions that support a wealth of biological diversity, including more than 130 rare species and ecosystems with vast forests and wilderness areas, rich agricultural land, hundreds of tributaries and thousands of smaller lakes, and extensive mineral deposits (World Water Council, 2001). Each river basin contains many natural ecosystems including not only the aquatic habitats associated with water in the river channel, but all of the elements of the river catchment that contribute water, nutrients and other inputs to the river. These ecosystems include: the headwaters and the catchment landscapes; the channel from the headwaters to the sea; riparian areas; associated groundwater in the channel/banks and floodplains; wetlands; the estuary and any near shore environment that is dependent on freshwater inputs (Great Lakes Commission, 2001). These ecosystems perform functions such as flood control and storm protection, yield products such as wildlife, fisheries and forest resources, and are of aesthetic and cultural importance to millions of people (Great Lakes Commission, 2001).

Habitat within the basin has changed dramatically, both in terms of area and quality, since settlers arrived in the late 1600s (Maynard, in: Great Lakes Commission, 1996). Globally, fully 36 percent of species extinctions since 1600 that resulted from known causes are attributed to habitat destruction (U.S. Congress, Office of Technology Assessment, 1995). The Nature Conservancy has identified 100 species and 31 ecological communities at risk within the Great Lakes system, and notes that half do not exist anywhere else (Barlow, 1999). Since the early twentieth century, significant changes in land use in the Great Lakes Basin have resulted from deforestation, urban development and encroachment, agricultural practices such as land clearing and drainage, and the management of water levels (Maynard, in: Great Lakes Commission, 1996). One result of such activities is a staggering loss in two-thirds of the once extensive wetlands (Barlow, 1999), at a rate of 20,000 acres (8,000 hectares) per year (Canadian Environmental Law Association and Great Lakes United, 1997). Such land use changes have altered the runoff characteristics of the drainage basin. Although the extent to which these changes affect lake levels is difficult to define, research suggests that land use changes have increased water flows into the Great Lakes from some tributary streams [Environment Canada Website (3)].

In addition to loss in wetlands, another impact from human activities is an abundant loss in groundwater aquifers. Groundwater is important to the Great Lakes ecosystem because it provides a reservoir for storing water and for slowly replenishing the Great Lakes through base flow into the lakes and tributaries. Groundwater also serves as a source of water for many human communities, plants and other biota (International Joint Commission, 2000). However, groundwater supplies, like surface waters, are becoming increasingly depleted. According to Sandra Postel of the Worldwatch Institute (1999), because of accessibility and lower cost as compared to river/surface water irrigation, groundwater overpumping may be the single biggest threat to food production worldwide. Postel describes further that the vast majority of this overpumped groundwater is used to irrigate grain, the staple of the human diet. Since it takes about 1,000 tons of water to produce one ton of grain, some 180 million tons of grain—roughly 10 percent of the global harvest—is being produced by depleting water supplies (Worldwatch Institute, 1999). Although most freshwater used (all water use categories) in the Great Lakes Basin comes from surface water, about half of the water used for irrigation and livestock comes from groundwater sources (USGS, 1995).

According to Mills et al, (in: Great Lakes Research Review, 1998), since the early 1800s, the Great Lakes have been host to 141 non-indigenous species- nearly two-thirds of which arrived in the Great Lakes via two methods: unintentional releases (34 percent) and shipping activities (31 percent). Mills et al. assert that almost one-third of these exotic species have been introduced in the last thirty years, corresponding with the opening of the St. Lawrence Seaway. According to Barlow (1999), two hundred years ago, the five Great Lakes each had a flourishing aquatic community. However, over time, the native species in each of these aquatic communities is being outnumbered by exotic species, with devastating results to local species (Barlow, 1999).

Water Policy Timeline

Over the last century, there have been numerous policy initiatives regarding water quantity issues in the Great Lakes Basin- each stemming from limitations of the previous initiative to achieve its intended goal of controlling diversions: the 1909 Boundary Waters Treaty; the 1985 Great Lakes Charter; the 1986 Water Resources Development Act; and Annex 2001 to the Great Lakes Charter. *See Box.*

The 1909 Boundary Waters Treaty: The Boundary Waters Treaty was designed to address and resolve disputes and issues regarding the Great Lakes and other boundary waters. It created the International Joint Commission and gave it the power and responsibility to regulate the flow of waters along the boundary between Canada and the United States. Article III of the treaty provides that any diversion or obstruction that would "affect . . . the natural level or flow of boundary waters on the other side of the line" needs the approval of not only the Canadian and U.S. governments, but also of the IJC. However, what appears to provide the IJC with significant authority over levels, flows and diversions in the Great Lakes has not occurred. In 1985, the IJC expressed its frustration with the situation, concluding that: "the international requirements under the Boundary Waters Treaty with respect to both large and small diversions of boundary waters are not explicit, nor is any consistent practice followed" (Canadian Environmental Law Association and Great Lakes United, 1997). Throughout its history, the IJC has never denied a request for approval for a control works or diversion in the Great Lakes Basin (see: Canadian Environmental Law Association and Great Lakes United, 1997 for more detailed information).

The 1985 Great Lakes Charter: Recognizing the value and limited supply of water in the Great Lakes, the growing potential for new proposals to obtain water supplies from the region, and limitations of the existing legal framework for managing the Great Lakes waters, the Governors and Premiers from the States and Provinces bordering the Great Lakes developed a non-binding agreement known as the Great Lakes Charter of 1985 (New York State Department of Environmental Conservation Website). The stated purpose of the charter is to conserve the levels and flows of the Great Lakes and their tributary and connecting waters; to protect and conserve the environmental balance of the Great Lakes Basin ecosystem; to provide for cooperative programs and management of the water resources of the Great Lakes Basin by the signatory States and Provinces; to make secure and protect present developments within the region; and to provide a secure foundation for future investment and development within the region (Council of Great Lakes Governors Website). The Charter establishes a protocol for each State or Province to consult with the others in the region before approving any diversion of water greater than 5 million gallons per day average in any 30-day period. The charter had the potential to be a framework for sustainability by gathering data on use of the waters of the Great Lakes, by gauging future demands, by promoting cooperation, and by preventing diversions (Canadian Environmental Law Association and Great Lakes United, 1997). However, the Charter stopped short of establishing a comprehensive and enforceable standard by which a State or Province should deny certain projects. Therefore, each Great Lakes State and Province has no real enforcement authority or regionally consistent evaluation process under the Charter to prevent the removal of Great Lakes water from another State or Province (New York State Department of Environmental Conservation Website).

The Water Resources Development Act of 1986: The U.S. Water Resources Development Act of 1986 (WRDA) requires approval by the governor of each of the Great Lakes states for diversions out of the Great Lakes Basin. This legislation is more powerful than the Great Lakes Charter because it requires unanimous consent by the governors and because it has no minimum trigger level, meaning that the legislation applies to even the smallest diversion out of the basin. Unlike the Great Lakes Charter, WRDA does not apply to major consumptive uses within the basin. As discussed by Farid et al. (in: Canadian Environmental Law Association and Great Lakes United, 1997), this legislation has numerous weaknesses: it applies only to diversions that were established after 1986; it applies only to inter-basin diversions; there is ambiguity as to whether the terms of the legislation provide that each governor must actually consent to a diversion proposal, or whether it simply means that they have the right to veto a proposal for a diversion; the legislation applies only to the United States- Ontario and Québec are excluded from the provisions of the law despite the fact that water resources in both these jurisdictions would be detrimentally affected by a diversion out of the Great Lakes; confusion has arisen around whether the WRDA applies to groundwater diversions.

Annex 2001 to the Great Lakes Charter: Since the signing of the 1985 Great Lakes Charter, the state of scientific knowledge of how the ecosystem can be affected by changes in hydrology has greatly improved. It is now understood that the basin's ecological integrity is dependent upon how water moves through the ground, over land, through rivers and streams, and into the Great Lakes, in addition to the rates at which water leaves the system. The legal and policy context has also changed, for example, the States and Provinces have adopted various regulations governing the use of Great Lakes waters, as well as the U.S. and Canada entering into two significant international trade agreements (the North American Free Trade Agreement and the General Agreement on Tariffs and Trade, supplemented by agreements concerning the World Trade Organization), that affect decisions about the use and transfer of water (Great Lakes Protection Fund Website).

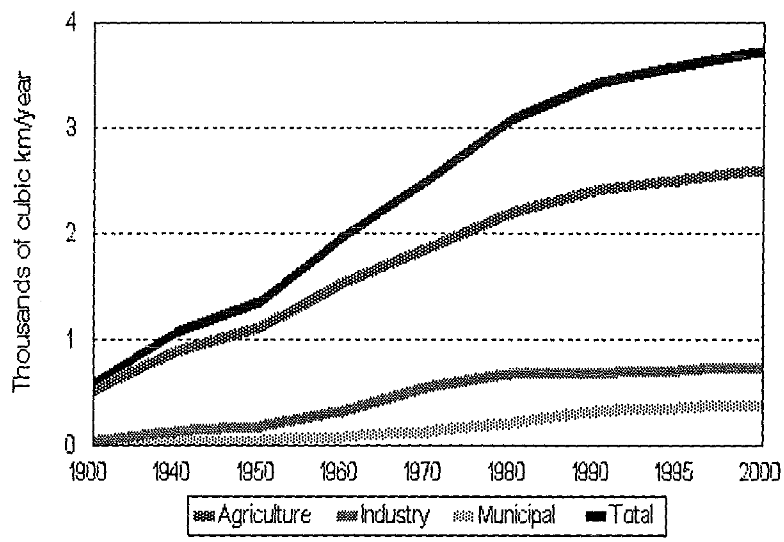
In December 2000, the Council of Great Lakes Governors, acting on behalf of the Great Lakes Governors and Premiers, released a draft amendment to the Great Lakes Charter of 1985 for public review and comment. The purpose of the amendment, referred to as Annex 2001, is to forge a new binding agreement to manage the Great Lakes waters, develop a new standard for new or increased water withdrawals, and make further commitments to continue to improve the Great Lakes water management system (New York State Department of Environmental Conservation Website). In the Annex, the Governors and Premiers reaffirm their commitment to the Charter principles and also "commit to develop and implement a new common, resource-based conservation standard and apply it to proposed new or added increased capacity withdrawals of Great Lakes water" (Great Lakes Protection Fund Website).

III. Current Conditions: Trends in Water Use

Global, U.S. and Canadian Water Use

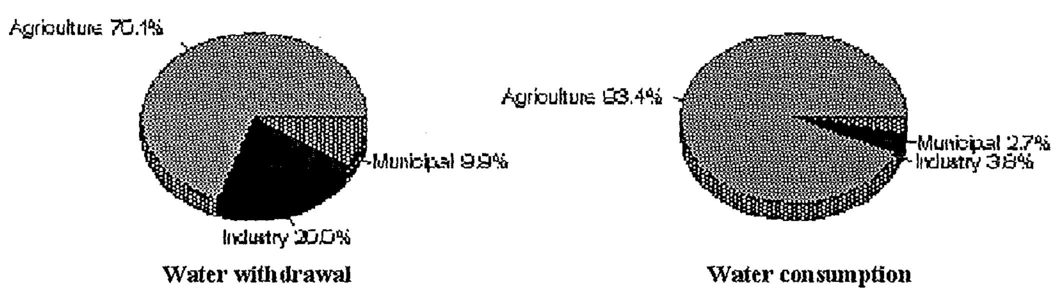
Global water usage has increased dramatically over the last century, with consumption of freshwater doubling every twenty years (The Western Producer, 2001). The predominant increase in water withdrawals (Figure 5) and water currently consumed (Figure 6), is devoted to agriculture (World Meteorological Institute, 1997). Irrigation accounts for 70 percent of the water taken from lakes, rivers, and underground sources (World Meteorological Institute, 1997).

Figure 5: Global Water Withdrawals by Sector, 1900-2000



Source: World Meteorological Organization, 1997

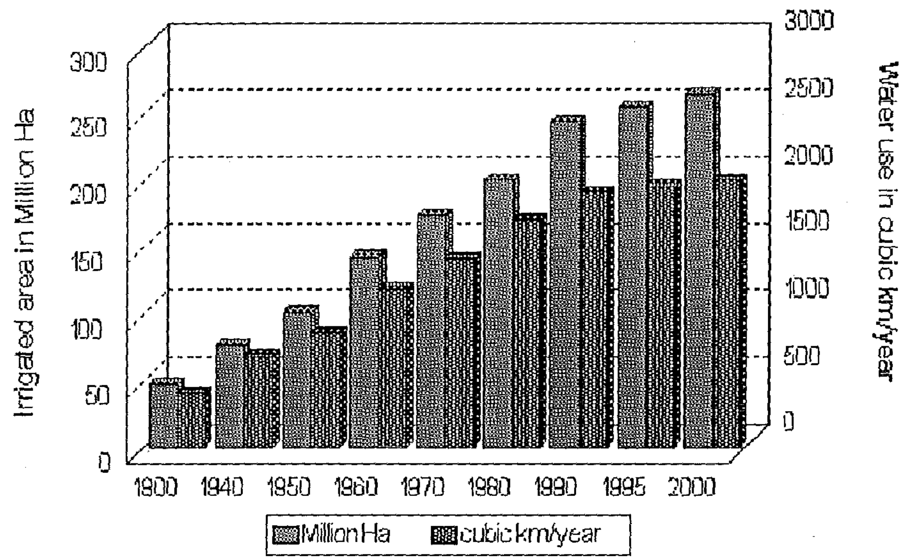
Figure 6: Current Water Withdrawal and Consumption by Sector, 1997



Source: World Meteorological Organization, 1997

The total amount of irrigated land and water consumed for irrigation worldwide has been increasing dramatically over the last century (Figure 7). Water withdrawals for irrigation have increased over 60 percent since 1960 (World Meteorological Organization, 1997).

Figure 7: Amount of Irrigated Land in the World, and Water Consumed for Irrigation, 1900-2000



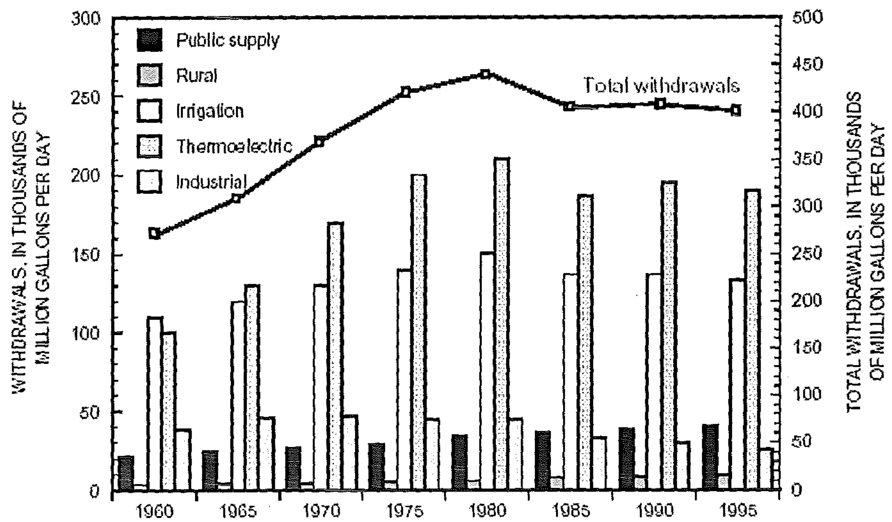
Darker colored bars depict amount of water consumption; lighter colored bars depict amount of land irrigated.

Source: World Meteorological Organization, 1997

In the U.S., total national water withdrawals increased from 1965 to 1980, and gradually declined from 1980 to 1995, as illustrated in Figure 8. Public supply and rural domestic and livestock categories are the only two categories that show continual increases from 1960 to 1995. The increase in public supply is largely due to population increases. The increase in rural domestic and livestock withdrawals is attributable to an increase in livestock withdrawals, especially animal specialties withdrawals. More water continues to be withdrawn for thermoelectric power generation than for any other category, peaking in 1980. Industrial withdrawals declined from 1980 to 1995 as a result of new industries and technologies that require less water, improved plant efficiencies, increased water recycling and conservation measures. Total irrigation withdrawals steadily increased from 1965 to 1980, and gradually decreased from 1980 to 1995. Irrigation application rates vary from year to year and depend on annual rainfall, surface water availability, energy costs, farm commodity prices, application technologies and conservation practices. In the 1980s, improved application techniques, increased competition for water, and a downturn in the farm economy reduced demands for irrigation water (USGS, 1995; USGS Website). However, according to the International Joint Commission (2000), irrigation use in the Great Lakes region increased fairly steadily from 1960 to

1995, and is expected to continue to grow.

Figure 8: National Trends in U.S. Water Withdrawals, by Sector, 1960-1995



Source: USGS, 1995

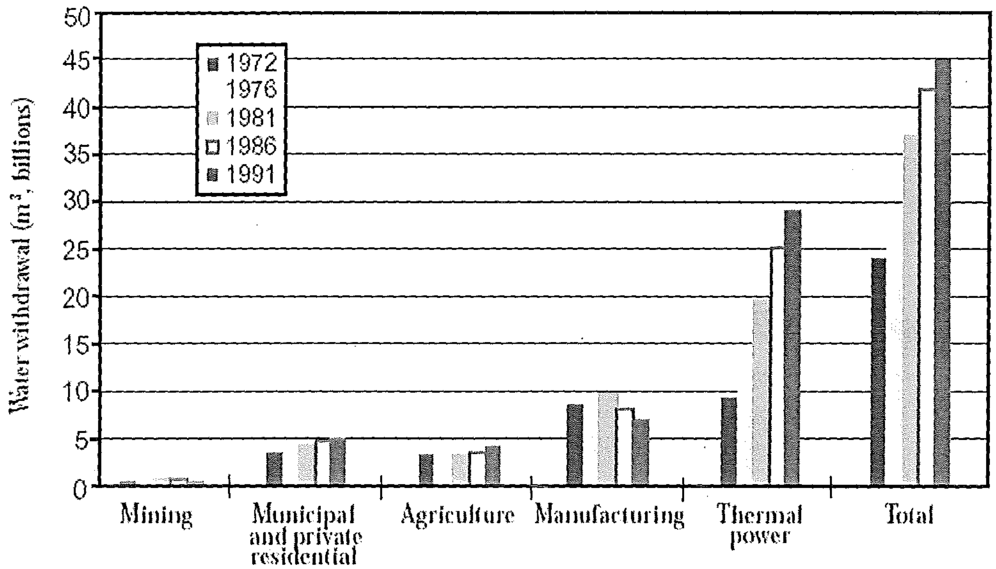
The two largest U.S. water use categories continue to be thermoelectric power and irrigation. In 1995, the most water (fresh and saline) was withdrawn for thermoelectric power cooling, whereas the most freshwater was withdrawn for irrigation (USGS, 1995).

As illustrated in Figure 9, in Canada, the trend in overall water usage is increasing (Agriculture and Agri-Food Canada, 2000). On a national level, agriculture withdraws a relatively small amount of water (9%) compared with thermal power generation (63%) and manufacturing (16%), however, unlike these industries, agriculture does not return a large portion of what it uses (Agriculture and Agri-Food Canada, 2000).

Estimates regarding the exact amount of water loss from irrigation vary. The World Meteorological Organization (1997) estimates about 40 percent of water used for irrigation is lost to the system; Agriculture and Agri-Food Canada (2000) estimate more than 70 percent loss; and USGS estimates 100 percent consumption from irrigation (Crane, in: Great Lakes Commission, 1996). Most states and provinces agree that consumption from irrigation is not 100 percent, however little research has been done to determine better consumption coefficients (Crane, in: Great Lakes Commission, 1996). The efficiency of irrigation systems also varies considerably depending on the type of irrigation and the crop grown.

In Canada, the demand for water is growing in all sectors, increasing the potential for competition and conflict among water users. Irrigation, the largest agricultural consumer of water, is often at the centre of such competition (Agriculture and Agri-Food Canada, 2000).

Figure 9: Total Water Withdrawals in Canada, by Sector, 1972-1991



Source: Agriculture and Agri-Food Canada, 2000

Consumptive Water Use in the Great Lakes Basin:
Freshwater use for food production

Water use in the Great Lakes Basin consists of consumptive and non-consumptive uses. Consumptive use is defined as that portion of water withdrawn or withheld from the Great Lakes and their connecting channels and assumed to be lost, or otherwise not returned to the system due to evaporation, incorporation into products or other processes (Great Lakes Commission, 2000). Consumptive uses include agriculture/livestock production, irrigation, domestic, industrial and municipal water uses, and diversions and dredging. Non-consumptive use refers to any water withdrawal or instream use in which virtually all of the water is returned to the system (U.S. Army Corps of Engineers and the Great Lakes Commission, 1999). Non-consumptive uses include hydropower, transportation, navigation and recreation.

Consumptive uses of Great Lakes water are generally not directly measured but are reported by water users under state or provincial water use permit programs, and are usually estimated from water withdrawals using consumptive use coefficients (Great Lakes Commission, 2000).

Water Uses in the Great Lakes Basin

- ***Thermoelectric Power Use.*** At thermoelectric power plants, water is used principally for condenser and reactor cooling. In the United States, thermoelectric withdrawals have remained relatively constant since 1985 and are expected to remain near their current levels for the next few decades. In Canada, modest increases are expected to continue along with population and economic growth.

- ***Agriculture.*** In the United States, water use for agriculture in the Great Lakes region increased fairly steadily from 1960 to 1995 and is expected to continue to grow. In Canada, the rate of increase was somewhat greater, so that combined projections indicate a significant increase by 2020. Climate change could increase even further the competitive advantage the basin has in agriculture as a result of its relative abundance of water.

- ***Industrial and Commercial Use.*** In the United States, industrial and commercial water use has declined in response to environmental pollution legislation, technological advances, and a change in the industrial mix from heavy metal production to more service-oriented sectors. A similar trend is evident in Ontario, so combined use is expected to gradually decline through 2020.

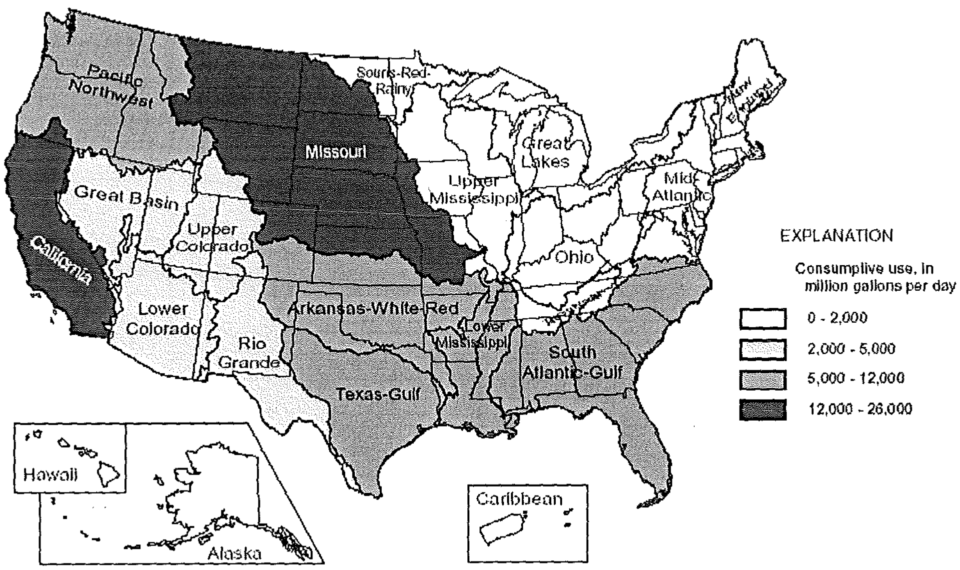
- ***Domestic and Public Use.*** In the United States, water use for domestic and public purposes in the Great Lakes Basin generally increased from 1960 to 1995 and is expected to climb gradually through 2020. In Ontario, however, the modest downward trend established in recent years because of water conservation efforts is expected to continue.

- ***Total Water Use.*** There is agreement that water withdrawal will increase in the future, although it is impossible to say with confidence just how much the increase will be. There is, however, no such agreement on consumptive use.

Source: International Joint Commission, 2000.

At a national scale (1995), freshwater consumptive use in the Great Lakes region is minimal, as compared to other parts of the U.S. (Figure 10). Total freshwater consumptive use in the East (water resource regions east of and including the Mississippi region) accounts for only 20 percent of the nation's consumptive use. By comparison, freshwater consumptive use in the West is about 47 percent of freshwater withdrawals nationally. The higher consumptive use in the West is attributable to the fact that irrigation accounts for the largest part of consumptive use (90 percent of the water withdrawn for irrigation occurs in the West) (USGS, 1995).

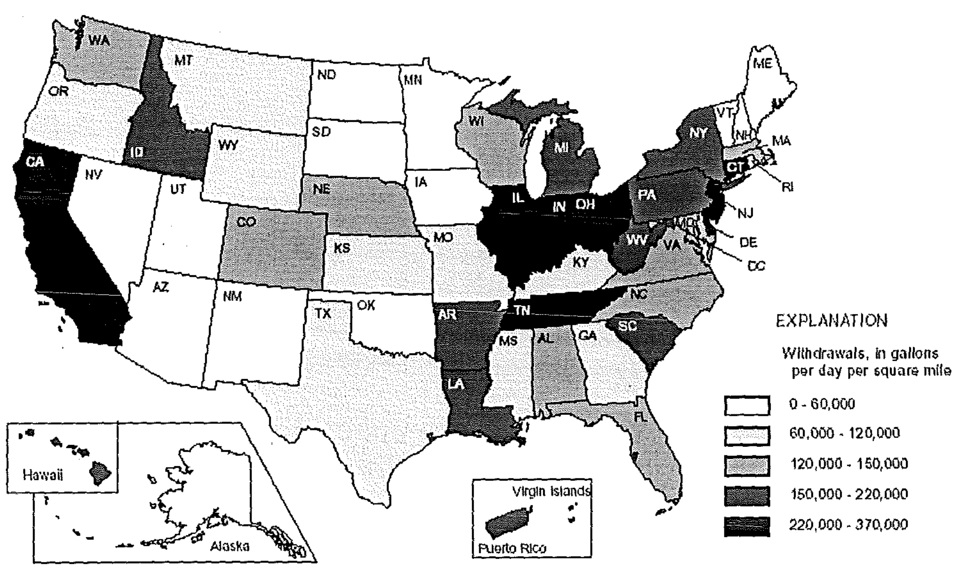
Figure 10: Freshwater Consumptive Use by Water-Resources Region, 1995



Source: USGS, 1995

However, in terms of intensity of freshwater usage per area, Great Lakes States withdraw more freshwater than other regions. Figure 11 shows the intensity of freshwater withdrawals by State in million gallons per day per square mile. The highly populated states in the Eastern U.S. show the most intense withdrawals by area (as well as California).

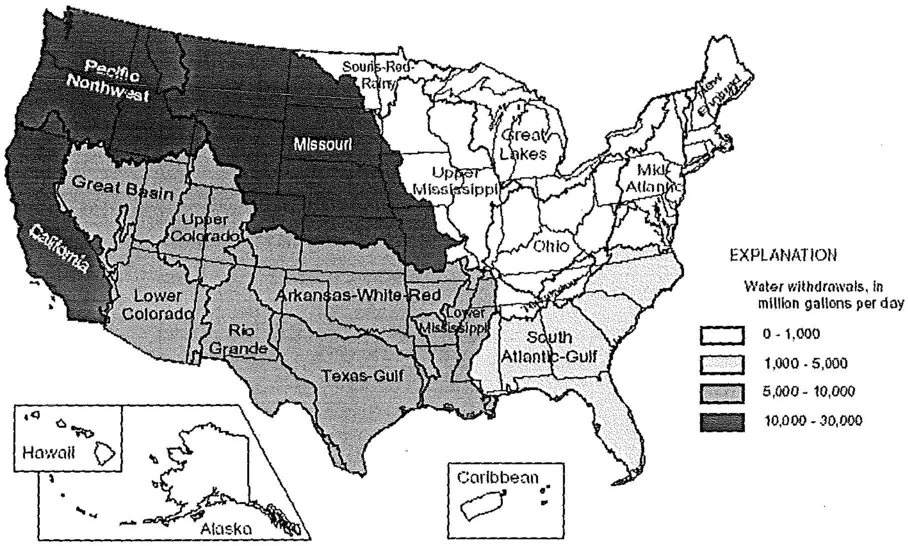
Figure 11: Intensity of Freshwater Withdrawals per Area, by State, 1995



Source: USGS, 1995

At a national level, the Great Lakes region, with modest rainfall and humidity as compared to the West, uses less freshwater for irrigation than other regions of the U.S. (Figure 12).

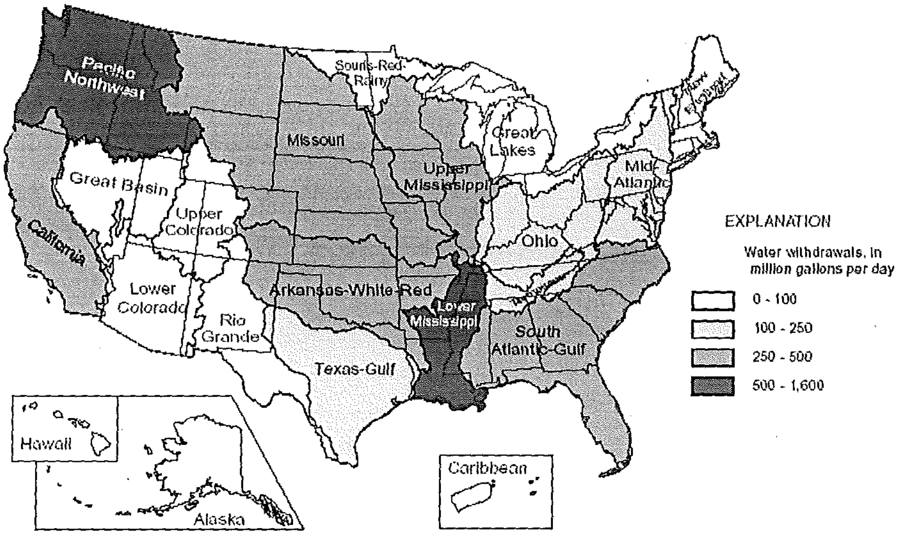
Figure 12: Irrigation Freshwater Withdrawals by Water-resources Region, 1995



Source: USGS, 1995

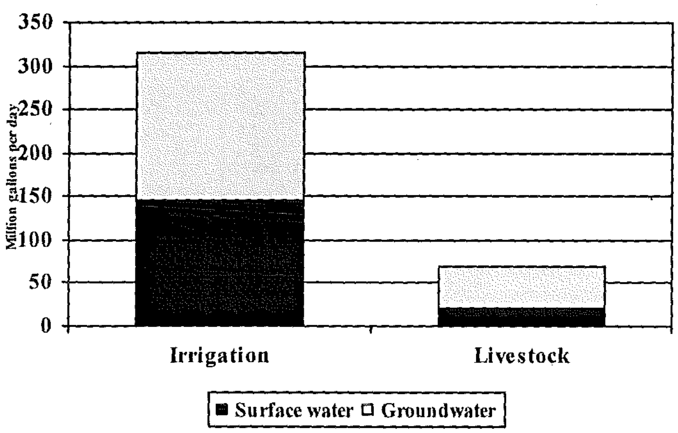
Similar to the trend in irrigation, the Great Lakes region uses comparatively little freshwater for livestock, as compared to other regions in the U.S. (Figure 13). However, of the freshwater used for irrigation and livestock in Great Lakes States, about half comes from groundwater sources (Figure 14). Over time, this will lead to an increasing pressure on groundwater aquifers.

Figure 13:
Total Livestock Freshwater Withdrawals by Water-resources Region, 1995



Source: USGS, 1995

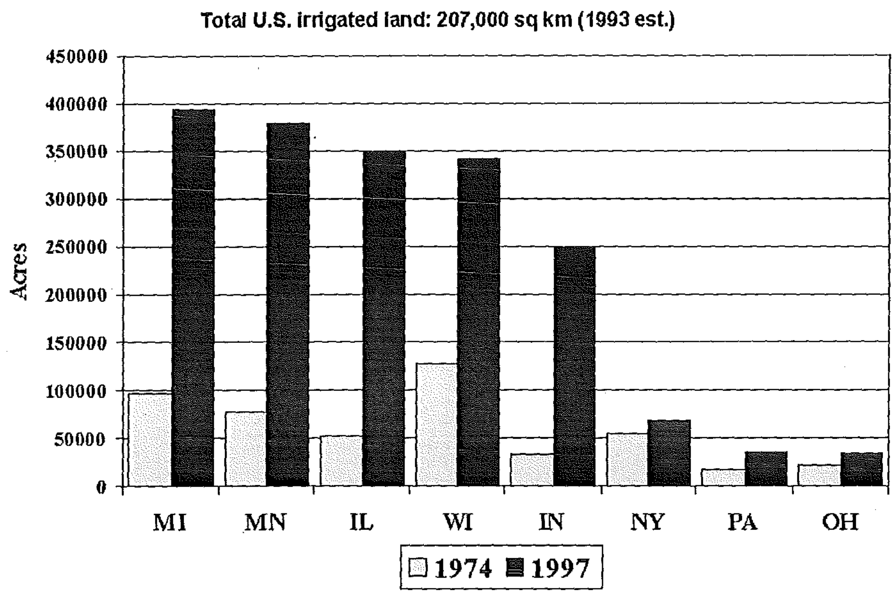
Figure 14: Surface and Groundwater Withdrawals for Irrigation and Livestock by Great Lakes States, 1995



Created by: Institute for Agriculture and Trade Policy
Data Source: USGS, 1995

Nearly 25 percent of total Canadian agricultural production and some 7 percent of U.S. production are located in the Great Lakes Basin (U.S. Environmental Protection Agency and the Government of Canada, 1995). In the Great Lakes States, between 1974 and 1997, although the total number of farms decreased, total acres of irrigated farms increased almost three-fold (Figure 15). Over time, the result is increasing water usage for food production.

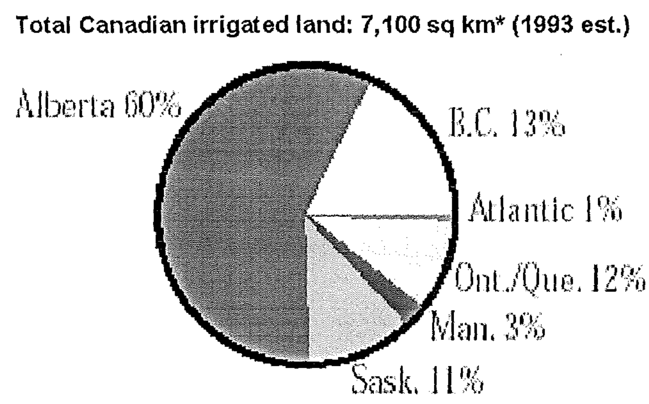
Figure 15: Acres of Irrigated Farms in Great Lakes States, 1974-1997



Created by: Institute for Agriculture and Trade Policy
Data Sources: U. S. Department of Agriculture, National Agricultural Statistics Service
USGS, 1995

In Canada, the Province of Alberta has the highest percentage of irrigated land nationally (60%), whereas the Great Lakes Provinces of Ontario and Quebec represent a combined total of just 12 percent of Canada's irrigated land (Figure 16). Availability of water is generally not a problem in Canada. Water supply issues are limited and generally apply to the semi-arid West (Harker, 1999). There, water quantity issues often revolve around considerations of whether there is enough water, how it will be apportioned, and security of supply. As discussed by Harker (1999), when it comes to irrigation, demand/pricing for irrigation water can significantly reduce the amount of water available for wildlife, recreation and other uses. He argues that irrigation development itself may be restricted due to a shortage of water, and that there may simply not be enough water available to irrigate substantially more lands. Over time, this may mean increasing pressure to divert Great Lakes water to more arid parts of the country.

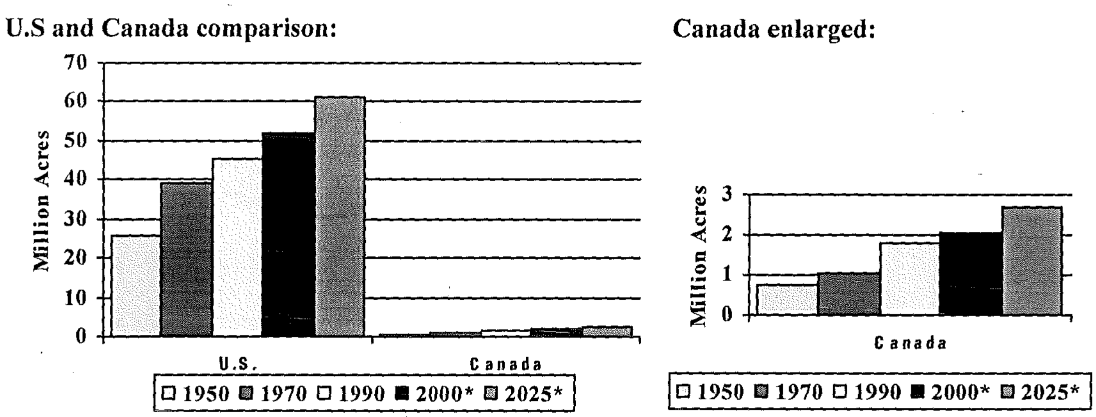
Figure 16: Distribution of Irrigated Land in Canada



Sources:
Agriculture and Agri-Food Canada, 2000
*International Commission on Irrigation and Drainage Website

Total area of irrigated land in the U.S. and Canada is projected to continue to grow (Figure 17). As irrigation in the Great Lakes Basin increases, reservoirs and groundwater levels may be reduced, potentially causing conflicts with other water uses (Crane, in: Great Lakes Commission, 1996).

Figure 17: Irrigation Area in the U.S. and Canada, 1950-2025

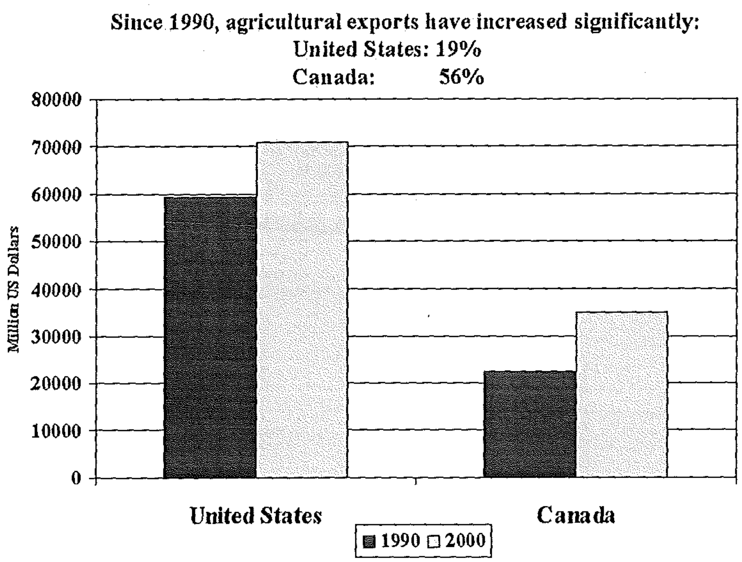


Created by: Institute for Agriculture and Trade Policy
Data Source: The Western Producer, 2001

Agricultural Exports

With an ever-growing increase in irrigated lands, it is not surprising that over the last decade, national exports of agricultural products by the U.S. and Canada have also increased (Figure 18).

Figure 18: Exports of Agricultural Products by the United States and Canada, 1990-2000



Created by: Institute for Agriculture and Trade Policy
Data Source: World Trade Organization Website, International Trade Statistics, 2001

Other Consumptive Water Uses

Domestic and Public Use: In the United States, water use for domestic and public purposes in the Great Lakes Basin generally increased from 1960 to 1995 and is expected to climb gradually through 2020. In Ontario, however, the modest downward trend established in recent years because of water conservation efforts is expected to continue (International Joint Commission, 2000). .

Industrial and Commercial Use: In the United States, industrial and commercial water use has declined in response to environmental pollution legislation, technological advances, and a change in the industrial mix from heavy metal production to more service-oriented sectors. A similar trend is evident in Ontario, so combined use is expected to gradually decline through 2020 (International Joint Commission, 2000).

Diversions: Two human activities, diversions and consumptive use, have the potential to impact lake levels. Diversion refers to the transfer of water from one watershed to another. As discussed earlier, consumptive use refers to water that is withdrawn for use and not returned. Such changes have resulted in either permanent alteration of water levels or a decreased range of levels (Quinn, 1999), resulting in significant environmental, social and economic harm (Canadian Environmental Law Association and Great Lakes United, 1997). For example, permanent alterations in levels result from diversions into, out of, or between the lakes, navigational dredging, and infrastructure placed in the connecting channels. A decreased range in levels results from the regulation of Lakes Superior and Ontario. At present, more water is diverted into the system than is taken out (International Joint Commission, 2000). However, as discussed by Quinn, (1999), "While individual impacts may or may not seem significant, cumulative impacts of even small changes may be important".

In 1982, the International Joint Commission reported on a study of the effects of existing diversions into and out of the Great Lakes system and on consumptive uses. Until this study, consumptive use had not been considered significant for the Great Lakes because the volume of water in the system is so large. The study concluded that climate and weather changes affect the levels of the lakes far more than existing human-made diversions. However, the report also concluded that if consumptive uses of water continue to increase at historical rates, outflows through the St. Lawrence River could be reduced by as much as 8 percent by around the year 2030 (U.S. Environmental Protection Agency and the Government of Canada, 1995). The diversion at Chicago, (the only major diversion out of the Great Lakes Basin), plus other diversion proposals have alerted the Council of Governors and Premiers to adopt a posture of opposition to any further out of basin diversions (Great Lakes Commission, 1995).

Dredging: Unlike other consumptive uses, dredging in the connecting channels has had a significant impact on lake levels, even in comparison to natural fluctuations. Connecting channels and canals that have been dredged to facilitate deep-draft shipping have permanently lowered Lakes Michigan and Huron by approximately 16 inches (40 cm) [International Joint Commission, 2000, Canadian Environmental Law Association and Great Lakes United, 1997, Environment Canada Website (3)]. Channel and shoreline modifications in connecting channels of the Great Lakes have affected lake levels and flows as well. For example, in the Niagara River, construction of bridges and infilling of shoreline areas have slightly reduced the flow carrying capacity of the river [Environment Canada Website (3)].

"While individual impacts may or may not seem significant, cumulative impacts of even small changes may be important" (Quinn, 1999).

Non-Consumptive Water Use in the Great Lakes Basin: Hydropower, transportation, navigation, recreation

Hydropower: Ninety-four percent of the water withdrawn from the Great Lakes for human use is taken by hydroelectric power plants. It does not figure in consumptive use estimates since almost all of it is returned to the lakes. However, the use of water for hydropower seriously disrupts the natural flows and levels of the rivers and lakes and thus affects downstream users- both people and wildlife (Canadian Environmental Law Association and Great Lakes United, 1997).

Water use for hydropower also poses potential conflicts in other ways than consumption, for example: higher water levels above the turbine increase shore erosion, and dams result in barriers to fish migration (Great Lakes Commission, 1995). As discussed by Linton (in: Barlow, 1999), "existing water diversions and hydroelectric projects in Canada are causing local climate change, reduced biodiversity, mercury poisoning, loss of forest, and the destruction of fisheries habitat and wetlands".

"The use of water for hydropower seriously disrupts the natural flows and levels of the rivers and lakes and thus affects downstream users-both people and wildlife" (Canadian Environmental Law Association and Great Lakes United, 1997).

Transportation/Navigation: The Great Lakes-St. Lawrence transportation system stretches more than 3,700 kilometers. Transportation was a pivotal factor in the development of the Great Lakes-St. Lawrence region. The combination of a natural water transport infrastructure and a strong resource base promoted settlement, agricultural development and a manufacturing economy (Great Lakes Commission, 1995).

Combined with the St. Lawrence Seaway, the Lakes are the mid-continent's trade link to world markets. Opened to navigation in 1959, total annual U.S. and Canadian tonnage for the 145 ports and terminals in the system has averaged around 200 million tons (181 million metric tons) in recent years. The St. Lawrence Seaway part of the system has moved more than 2.1 billion metric tons of cargo in 40 years, with an estimated value of $173 billion U.S. ($258 billion Canadian). Almost 50 percent of this cargo travels to and from overseas ports (Great Lakes-St. Lawrence Seaway Website).

Great Lakes and St. Lawrence River commodity movements are dominated by relatively low value bulk commodities. Grain flows have been quite variable as the world grain market adjusts to new supplies and demands (Great Lakes Commission, 1995). While there have been year-to-year fluctuations since the late 1970s, there has been a substantial negative trend in average Seaway tonnage (Great Lakes Commission, 1995).

Recent studies of the system's economic impact indicate that more than 60,000 U.S. and Canadian jobs are dependent on the cargo movements that generate more than $3 billion in business revenue and personal income. Maintaining levels of flow for shipping, maintenance dredging, and ice management, among other aspects of the transportation use of the Great Lakes, poses potential conflicts with other uses (Great Lakes Commission, 1995).

Recreation: The Great Lakes support a wealth of recreational opportunities. The Great

Lakes States are home to 4.2 million recreational boats, or about one-third of all registered recreational vessels in the United States (Great Lakes-St. Lawrence Seaway Website). Additionally, an estimated 1.2 million recreational boats are registered in the Canadian Province of Ontario. Recreational boating provides over 125,000 jobs and contributes approximately $9 billion (U.S.) annually to the regional economy (Great Lakes-St. Lawrence Seaway Website). Although recreational activities do not impact water levels, decreasing water levels would have negative consequences on this sector of the economy.

IV. Water Use Management

The Roles of the International Joint Commission and the Great Lakes Commission

The United States-Canadian border runs through four of the five Great Lakes and their interconnecting rivers, causing them to come under federal jurisdiction in both countries. Many policies related to U.S. and Canadian-provided services on the Great Lakes involve the work of two unique bi-national bodies, the International Joint Commission and the Great Lakes Commission.

The International Joint Commission (IJC): Canada and the United States are party to the 1909 Boundary Waters Treaty, which was designed to address and resolve disputes and issues regarding the Great Lakes and other boundary waters. This treaty established the International Joint Commission, a quasi-judicial body that has three responsibilities under the original treaty: 1) it may give or withhold approval for the use, obstruction, or diversion of boundary waters shared between Canada and the United States that would affect the natural level of flow on either side; 2) to conduct studies of specific problems; and 3) to arbitrate specific disputes between the two countries in relation to boundary waters. When requested, it investigates matters of concern to one or both governments (Environment Canada Website (3); U.S. Environmental Protection Agency and the Government of Canada, 1995).

The Great Lakes Commission (GLC): The Great Lakes Commission is an eight-state agency founded in state and federal law that represents the collective views of the Great Lakes States. An Associate Membership Program also provides for Canadian provincial involvement and a bi-national focus. The Commission is actively involved in research, analysis, policy development, and advocacy associated with issues of water quantity management. Among others, this has included serving as a participant in an Ontario hearing related to a proposal for the bulk export of Lake Superior water. The Commission is also a member of an IJC Study Team for an ongoing reference on the topic (Great Lakes Seaway Website).

Water Use Policy and International Trade Implications

Over the last few years, the diversion of water from the Great Lakes Basin has become a high profile issue, both nationally and internationally. The most notable story concerned a Canadian company's 1998 proposal to export Lake Superior water to markets overseas. Throughout the basin, concerns were voiced over the lack of consultation, the environmental implication of the withdrawal, and the legal precedent that such a withdrawal may set. The request was subsequently withdrawn. This situation brought diversion issues to the top of the Great Lakes agenda (U.S. Army Corps of Engineers et al, 2001).

In response to growing demands for limited water supplies, most Canadian provinces have developed water rights legislation to regulate the withdrawal of surface water and groundwater for beneficial uses. An exception to this occurs in Quebec and British Columbia, where the withdrawal of groundwater is not subject to licensing (*see Box*). Another issue is the export of water. Although this topic is undergoing considerable debate, it is generally believed that water becomes an export commodity only when it is bottled. It is still unclear whether bulk or flowing-water exports are permitted under existing legislation [Environment Canada Website (5)].

Water bottling in Quebec—A case of competition

The water-bottling industry is booming in Quebec, directly and indirectly employing 5,000 people and generating sales of $75 million each year. But the rapid expansion of this industry has some citizens concerned that there won't be enough water to go around. They worry that the lack of regulatory controls on groundwater use will allow the bottling industry to take more than its fair share, using up water also needed for domestic use, agriculture, and other activities.

In the Quebec municipality of Franklin, a citizens' committee has formed to oppose a new water-bottling project. They argue that a similar project near Mirabel has affected the quantity and quality of water used by 85% of the people living within 8 kilometers of the commercial well. Many Franklin farmers depend on groundwater to irrigate their fruit crops. The aquifer also serves the domestic needs of two municipalities, two agri-food industries, and two campsites receiving 10,000 visitors each summer. With good reason, Franklin's citizens are asking if their groundwater resource is going to last. The problem is that no one knows for sure how much groundwater is there, how it is renewed, or how extraction activities like water bottling affect the resource.

In the face of public and media pressure, the government of Quebec imposed a moratorium on the water-bottling industry in December 1997, freezing all new requests for permits until a new policy was created to define water rights and management in Quebec. Members of the industry protest this action, saying that they bottle only a fraction (half a million cubic meters) of the total amount of groundwater used in Quebec each year, while the aquaculture industry uses 40% (100 million cubic meters). They also decry the polluting effect of agriculture and are asking for exclusive and protected zones for their industry so the quality of their product can be protected.

Which water use should have priority? Who should have the power to decide this? All parties concerned agree that legislation is needed to provide precise and fair rules that will protect both the quantity and quality of the groundwater resource. *M.C. Nolin, Agriculture and Agri-Food Canada.*

Source: Environment Canada Website (5).

In March 2000, the IJC issued a report recommending that Canadian and United States federal, provincial, and state governments not permit the removal of water from the Great Lakes, citing the need to protect its ecological integrity (Anderson et al, in: Bennett, 2001). The only exception would be if the permit applicant can show that the removal will not have any adverse environmental effects. In addition, the applicant would have "to demonstrate that there are no practical alternatives to the removal, sound planning has been applied in the proposal, the cumulative impacts of the removal have been considered, and that conservation practices are in place in the region importing the water" (International Joint Commission, 2000). In December 2001, Canada reintroduced legislation to prohibit bulk water removals from the Great Lakes. Likewise, the eight Great Lakes States, acting through the Great Lakes Commission, have formed a united front to oppose the withdrawal of Great Lakes water for overseas export (Great Lakes Commission, 1998).

There has been some speculation, however, that these actions are resulting more as a result of public sentiment than to any real environmental threat that water exports pose to the Great Lakes (Anderson et al, in: Bennett, 2001). The IJC conducted an extensive analysis of the demand for bulk water exports from the Great Lakes and found that it is limited due to transportation costs. Regarding the bottled water industry, the IJC found that the Great Lakes region is a net importer of water (Anderson et al, in: Bennett, 2001).

Regarding international trade, as discussed by Farid et al. (in: Canadian Environmental Law Association and Great Lakes United, 1997), given the existing distribution of water on the continent, exports of water are most likely to come from the Great Lakes. The development of free trade in water has serious implications for attempts to prevent diversions from the Great Lakes and, as a result, for Great Lakes water levels. Under current trade agreements such as NAFTA (North American Free Trade Agreement between the U.S., Canada and Mexico), if water is traded as a commodity, the provisions of NAFTA apply. The primary guiding principle in this and other trade agreements (such as FTA/Free Trade Agreement between the U.S. and Canada) is that governments cannot act in ways that give economic advantage to their own people over people in other countries who wish to trade with them (Canadian Environmental Law Association and Great Lakes United, 1997).

A number of consequences flow from water being a "good". Barlow (1999) explains that there are three key provisions of NAFTA that place water at risk once it is traded. One is "National Treatment" whereby no country can "discriminate" in favor of its own private sector in the commercial use of water resources. Thus, if a Canadian company gained the right to export Canadian water, American trans-nationals would have the right to as much Canadian water as they wished.

The second provision is "Investor State" (Chapter 11), whereby a corporation of a NAFTA country can sue the government of another NAFTA country for compensation if the company is refused national treatment rights or if that country implements legislation that "expropriates" the company's future profit. Thus, if any NAFTA country, state or province tries to allow only domestic companies to export water, corporations in the other countries would have the right to compensation for "discrimination" (Barlow, 1999).

Third, the provision of "proportionality", under which the government of a NAFTA country cannot reduce or restrict the export of a resource to another NAFTA country once the export flow is established (Barlow, 1999). As further discussed by Farid et al, (in: Canadian Environmental Law Association and Great Lakes United, 1997), "Free trade has serious implications for attempts to prevent diversions from the Great Lakes. The ability of governments to act through the Great Lakes Charter, the imposition of special taxes on water use, the use of subsidies to help water users convert to conservation methods—all these are placed into serious doubt by free trade...The threat of a challenge under trade agreements may well be enough to discourage governments from even trying to proceed with such programs". Farid et al. conclude that it is essential to prevent the export of water from the Great Lakes Basin because, "under free trade, once we turn the tap on, we cannot turn it off". Only by specifically exempting water from NAFTA would the Canadian government be free to place a real ban on water exports. At this time, neither the U.S. nor the Mexican governments have even attempted to restrict water exports (Barlow, 1999).

Like NAFTA, the World Trade Organization (WTO) intends to render it more difficult for nations to place safeguards on exportable products, including natural resources (Barlow, 1999). Barlow explains that there is one provision of the WTO that particularly places water at risk. Article XI specifically prohibits the use of export controls for any purpose and eliminates quantitative restrictions on imports and exports. Thus, any quotas on water exports imposed for environmental purposes could be challenged. Further, the authority of the WTO includes water. Unlike any other global institution, the WTO has both legislative and judicial authority to challenge laws, policies and programs of member countries if they do not conform to WTO rules, and it can strike down these rules if they can be shown to be "trade restrictive". Barlow concludes that global trade in water will likely be seriously proposed in future, with the full support of the WTO, leaving water at grave risk.

V. Water Use Legislation

There is a substantial mixture of water management regimes within the Great Lakes Basin. According to Farid et al. (in: Canadian Environmental Law Association and Great Lakes United, 1997), while all jurisdictions measure water use, the categorizations of water use are different within each jurisdiction. In addition, not all states and provinces are in a position to regulate water, either because the legislation does not exist, or because the needed funds have not been allocated to this purpose. Finally, although most jurisdictions have attempted to conform to the provisions of the Great Lakes Charter, each state or province takes a different approach to doing so.

Great Lakes States Water Use Regulations

The current system for approving withdrawals, [as legislated in the Water Resources Development Acts (WRDA) of 1986 and 2000], prohibits any diversion or export of Great Lakes water outside of the basin without the consent of all 8 Great Lakes Governors [Northeast-Midwest Institute, (1)]. However, there is no standard regarding how the various states legislate and monitor water withdrawals. Several states (and provinces) have programs that require large water users to obtain water withdrawal permits. Others require large water users to register with the state (or provincial) regulatory agency but do not have to apply for a permit. Only Minnesota has a formal system that clearly defines water use priorities under the riparian system (Crane, in: Great Lakes Commission, 1996). *See Box.*

Indiana does not require a permit for any water withdrawals, either groundwater or surface water. State law does not allow water to be diverted from within the Great Lakes Basin for use outside of the basin, unless the diversion is approved by the Governors of each Great Lakes state; however, because the state does not require permits, it has difficulty identifying withdrawals that might be diverted out of the basin.

Illinois is legally limited in the amount of water that it can divert from the Great Lakes. Therefore, the state has developed a permitting process to allocate its share of Lake Michigan water, giving first priority to maintaining minimum flows in the Sanitary and Ship Canal and to certain residential, commercial or industrial users. The state considers the conservation practices of applicants when issuing permits.

Michigan does not regulate water withdrawals. However, the state requires community public water supply systems and certain large water users such as thermoelectric power plants and irrigated golf courses to submit water withdrawal reports.

Minnesota requires a water use permit from all users withdrawing more than 10,000 gallons per day (gpd) or 1 million gallons per year. Also, any inter-basin water diversion of more than 2 million gpd requires permission of the legislature and an environmental assessment. Furthermore, a diversion or consumptive use of more than 5 million gallons/day average from the Great Lakes Basin also requires approval from additional state agencies and the other Great Lakes States and Provinces.

New York requires registration of all withdrawals from the Great Lakes Basin that exceed 100,000 gpd averaged over a 30-day period. New York will consult with other Great Lakes States on any new withdrawal that will result in a 5 million gpd loss (30 day average) to the basin. Any inter-basin diversions from the Great Lakes require the approval of the governor and the legislature.

Pennsylvania does not have any system for permitting or notification of water withdrawals.

Ohio requires the owner of any facility with the capacity to withdraw more than 100,000 gpd to register that facility with the Ohio Department of Natural Resources. Also, the state may designate an area as a ground water stress area, establish a threshold withdrawal capacity for that area, and require registration for any withdrawals above this threshold.

Wisconsin requires reporting of any water withdrawal over 100,000 gpd (30 day average). A permit is required if the total water lost from the basin is greater than 2 million gpd (30 day average). A diversion or consumptive use of 5 million gpd or greater requires consultation with the other Great Lakes States.

Source: Northeast-Midwest Institute Website (1).

In 2000, WRDA amended the authority given to the Great Lakes Governors to manage Great Lakes water withdrawals so that a better framework for dealing with such withdrawals would be created. "Annex 2001" calls for the establishment of a standard that would be used in reviewing water withdrawals that involve both the exports outside the basin and withdrawals within the basin. This new standard would be created through a separate binding agreement among states and provinces. The principles of the Annex state that any Great Lakes water withdrawal proposal: (1) must implement reasonable water conservation measures; (2) will not cause significant adverse impacts; and (3) will result in an improvement to the resource. There will be an exception for withdrawals with de minimus impact. Once authorized by state and federal legislation, this new standard will apply to all new and expanded withdrawals within and outside of the Great Lakes Basin [Northeast-Midwest Institute Website (1)].

Regarding this requirement for governments to consider "reasonable water conservation measures" when considering withdrawal requests, Farid et al (in: Canadian Environmental Law Association and Great Lakes United, 1997), speculate that it is doubtful that this provision can be used under NAFTA. It is argued that the national treatment provisions will discourage efficient uses of water in the Great Lakes since no party can impose a tax or duty on another party that it does not impose on itself. The result will force domestic and export consumers to pay the same price for water. "Because Canadians and Americans do not pay the full cost of water, any trade from the Great Lakes Basin would subsidize the cost of water for the export consumer. Thus, until the full cost of water is charged to domestic consumers, the water will be a good deal for those who are importing it and will encourage wasteful usage. Given the important limitations on what types of regulations are permissible under free trade, government conservation programs will be more difficult to achieve. If a government were to subsidize industry in order to promote water conservation, this could be seen as an unfair trade advantage and could be challenged by foreign competitors". They continue: "If the residents of the Great Lakes Basin are to have any hope of protecting the waters of the Great Lakes under free trade, it is essential that they quickly develop and implement a powerful, effective water conservation program that is uniform throughout the Great Lakes. Only in this way could they hope to withstand a challenge under the free trade agreements if they try to impose restrictions on exports of water- even then it may be difficult" (Canadian Environmental Law Association and Great Lakes United, 1997).

Canadian Water Use Regulations

Provincial legislation or regulations generally list water uses in order of importance, with domestic and municipal needs in first and second place. Domestic uses are generally exempted from legislation or from licensing. Use of water for other purposes without a license or outside of license conditions carries penalties.

Besides meeting the requirements of water rights legislation, major water projects, such as irrigation and hydroelectric dams, must also comply with other federal and provincial statutory requirements. Among the major pieces of federal legislation that govern water development and use are the Fisheries Act, Navigable Waters Protection Act, Canadian Environmental Protection Act, and Canadian Environmental Assessment Act [Environment Canada Website (5)].

Outflow Regulations for Lakes Superior and Ontario

In 1914, the IJC approved a diversion for hydropower generation. The order specified certain conditions be met in the construction and operation of the facilities, which led to the regulation of outflows of Lake Superior (International Joint Commission, 2001). Although some control can be exerted over the levels and flows in the upper lakes, like the impacts of other human activities, outflow regulation is limited, and has a minimum effect on levels and flows as compared to natural variability (International Joint Commission, 2001).

Only limited controls of levels and flows are possible and currently, only for Lake Superior and Lake Ontario (International Joint Commission, 2001). The flows are controlled by locks and dams on the St. Marys and St. Lawrence Rivers, respectively. The current regulation attempts to balance the levels of Lake Superior and Michigan-Huron about their mean levels, with considerations for their natural fluctuations. Minimum allowable outflows designed to maintain minimum water levels in the lower St. Marys River are incorporated into the regulation. The plan also includes maximum winter allowable outflows to reduce risk of flooding from ice jams in the lower St. Marys (International Joint Commission, 2001).

Since the Upper Great Lakes Basin has been experiencing episodes of very high and very low water levels in recent years, concerns have been expressed about the ability of the current regulation plan to cope with these situations, as well as changes in future water supplies due to climate change and variability. In October 2001, the IJC developed a draft Plan of Study for review of the regulation of outflows from Lake Superior. The objective of the study is to review the current regulation criteria and regulation plan, to identify the needs of interest groups affected by water levels, potential climate changes that could affect water levels and flows of the Great Lakes system, and possible improvements to Lake Superior outflow regulation. This document describes the necessary tasks, schedules, and costs. It is expected that the first phase of the study would be completed in 2004 (International Joint Commission, 2001).

The IJC has also established a binational group to develop a Plan of Study to review the criteria in which Lake Ontario levels are regulated. The mission of the study is to consider, develop, evaluate and recommend updates and changes to the 1956 criteria for Lake Ontario-St. Lawrence River water levels and flow regulation, taking into account how water level fluctuations affect all interests and changing conditions in the system including climate change, all within the terms of the Boundary Waters Treaty (International Joint Commission Website).

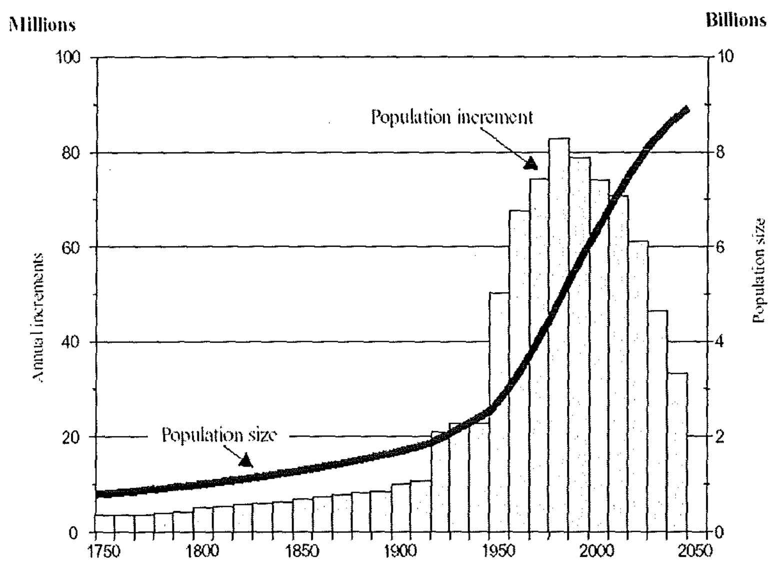
VI. Future Conditions

Other issues likely impacting Great Lakes water quantity and levels in the future include population growth, climate change, land use changes, bulk water removal/export, and water conservation practices.

Population Growth

Many of the risks to the world's lakes derive from a growing global demand for water, which will be increased as the world population rises by nearly 2 billion people by the year 2030 (Figure 19), (World Water Council, 2001). Postel (in: Worldwatch Institute, 1999) discusses the disparity between increasing population and water availability. Regarding the growing use of groundwater aquifers for irrigation, she raises a vital question: "if so much of irrigated agriculture is operating under water deficits now, where are farmers going to find the additional water that will be needed to feed the more than 2 billion people projected to join humanity's ranks by 2030?"

Figure 19: Long-term World Population Growth, 1750-2050

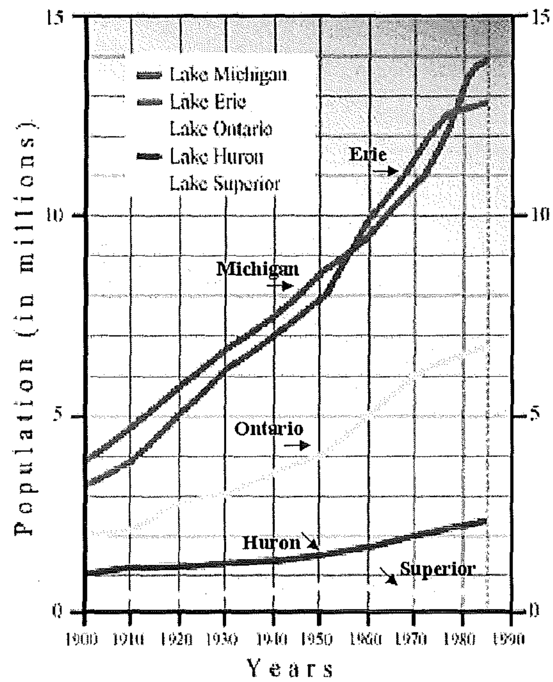


Source: United Nations Population Division, 1999

"Many of the risks to the world's lakes derive from a growing global demand for water, which will be increased as the world population rises by nearly 2 billion people by the year 2030" (World Water Council, 2001).

As shown in Figure 20, population in the Great Lakes Basin has also been growing over the last century, most significantly near Lakes Michigan and Erie.

Figure 20: Population Growth in the Great Lakes Basin, 1900-1990



Source: U.S. Environmental Protection Agency and the Government of Canada, 1995

As well, in-migration for both the U.S. and Canada has been increasing dramatically since 1970. In 1995, the U.S. and Canada were ranked first and fifth by the United Nations Population Division (1999) of the ten countries or areas with the greatest in-migration. In the next century, population growth in the U.S. and Canada is estimated to increase 26 and 37 percent, respectively, between 1999 and 2050 (United Nations Population Division, 1999). As the supply of freshwater becomes more limited, population growth is likely to be greatest in those regions of greatest supply.

Climate Change

Research is showing that the impacts of potential climate change could be dramatic [International Joint Commission, 2000; Quinn et al, 2000; Quinn, in: Adams, 1999; Canadian Environmental Law Association and Great Lakes United, 1997].

Experts from the U.S. National Oceanic and Atmospheric Administration (NOAA) and Environment Canada believe that climate change could result in a lowering of lake level regimes by up to three feet (one meter) or more by the middle of the 21st century, a development that would cause severe economic, environmental, and social impacts throughout the Great Lakes region. Experts associated with the U.S. National Assessment on the Potential Consequences of Climate Variability and Change indicate the possibility of both slightly increased and decreased lake levels as a result of their analysis of climate models. Given the large discrepancies in some results of the models, there continues to be a high degree of uncertainty associated with the magnitude of potential changes (International Joint Commission, 2000).

Despite the uncertainties, many experts agree that factors such as future consumptive use, small-scale water removals and climate change are likely to place downward pressures on water levels. Although there are insufficient data and inadequate scientific understanding to place precise estimates on the extent and timing of such impacts, the impacts could be significant. The International Joint Commission (2000) concludes that this, plus the prospect of adverse cumulative impact of new human interventions, suggests a need for great caution in dealing with those water use factors that are within the control of basin managers. Because population will increase, there is a greater probability of increasing water use in the future than there is of decreasing use (International Joint Commission, 2000).

As discussed by Farid et al, (in: Canadian Environmental Law Association and Great Lakes United, 1997), scientists forecast that if CO_2 concentrations double by the year 2100 as is now predicted, climate change will have the following impacts on the Great Lakes Basin:

- Average temperature increases of 15 degrees Fahrenheit (9.1 degrees centigrade);
- Lake level decreases basinwide by over three feet (one meter), and in Lake Michigan by 8 feet (2.5 meters);
- Loss of wetlands and the concomitant loss of essential habitat;
- Loss of forests, especially the boreal forests north of Lake Superior;
- Loss of cold water fish;
- Decreased water quality because of the resurfacing of buried contaminated sediments;
- Increased human health problems, including diseases now unknown in the Great Lakes region such as malaria;
- Increased crop damage;
- Decreased shipping because of low lake levels;
- Losses to industries such as breweries, the chemical industry and hydropower generators which are highly dependent on water.

Land-use Changes

There are very few areas in the Great Lakes Basin which have been unaffected by human activity. As discussed by Maynard (in: Great Lakes Commission, 1996), since the early twentieth century, changes in land use in the Great Lakes Basin have occurred resulting in significant habitat loss in the lower basin. According to Thorp (in: Great Lakes

Commission, 1996), one of the most significant land use changes is the continuing growth of major metropolitan into agricultural lands. Conversion of farmland to non-farm use, particularly around metropolitan areas, is increasing, resulting in dramatic impacts on the natural resources that sustain the regional economy. Land classified as farmland in the basin has declined by more than 4.5 million acres between 1981-82 and 1991-92. Thorp argues that efforts should be directed toward reversing this trend to improve long-term sustainability: "If significant conversion of farmland continues in the basin, the agricultural production base will decline and with it future farming opportunities. Also, because of the connection between farmland conversion and proximity to metropolitan areas, efforts to preserve farmland may also help to contain sprawling development patterns and improve community sustainability" (Thorp, in: Great Lakes Commission, 1996).

Bulk Water Removal/Export

Although the U.S. and Canada currently oppose bulk export of Great Lakes water, future conditions will likely lead to increasing pressure to do so. Issues such as water availability in regions outside the Great Lakes Basin where current and/or projected water demands far exceed sustainable supplies, as well as stresses from natural disasters, drought and other crisis situations in other parts of the world, will likely lead to ongoing consideration of bulk water export.

Water Conservation

Water conservation efforts in the Great Lakes region are currently limited by a widespread sentiment that there is an almost limitless supply of water. The predominant research and environmental focus has targeted water quality as opposed to water quantity issues. This, as well as low water pricing in both countries has resulted in minimum water conservation measures.

In those areas of Canada where water supply is limited, there is a growing emphasis on demand management rather than supply management, creating a climate favorable to research on technologies that use water more efficiently, such as improved irrigation systems. At the same time, public support of water metering and user-pay programs is increasing. In agricultural terms, demand management involves finding ways of using existing water more efficiently, learning to farm with less water, and facing the prospect of paying for water that traditionally has been a free or low-cost resource (Agriculture and Agri-Food Canada, 2000). In Ontario, there has been a modest downward trend in domestic, industrial and municipal water use in recent years because of water conservation practices (International Joint Commission, 2000).

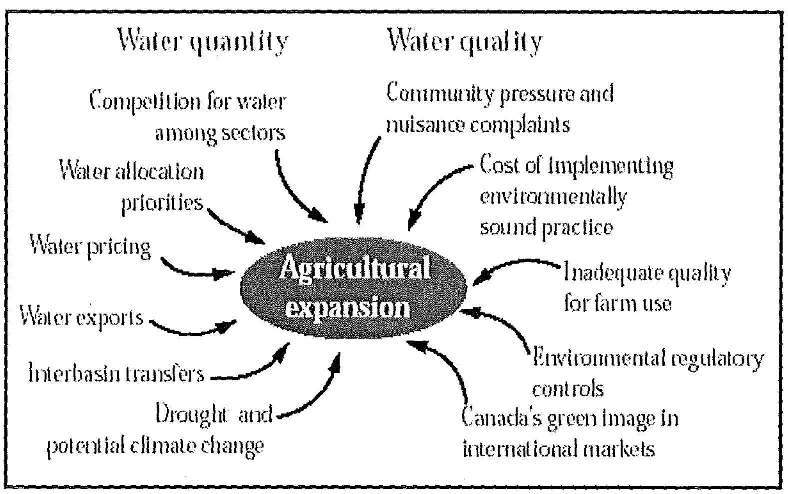
In the U.S., the degree of future water conservation will depend on numerous factors, but will likely not improve dramatically without changes to current water use policies, clear economic incentives, water valuation (World Meteorological Organization, 1997), and water pricing that encourages conservation practices.

VII. Cumulative Impacts of Reduced Water Levels

Long-term agricultural expansion in the Great Lakes Basin will likely be limited by water quantity issues such as increasing competition for water among sectors, water pricing, water exports, water allocation priorities and climate change, as well as water quality issues (Figure 21), (Agriculture and Agri-Food Canada, 2000). Increasing water usage and the potential for permanently lowered water levels will have significant ecological and economic impacts, not only to agricultural production. The synergy of such impacts will likely result in new water policies not previously considered.

As discussed by Farid et al, (in: Canadian Environmental Law Association and Great Lakes United, 1997): "As water sources throughout the North American continent are depleted, the grand schemes that have thus far been set aside may well become more viable and the need ever more compelling".

Figure 21: Constraints on Agricultural Expansion Related to Water



Source: Agriculture and Agri-Food Canada, 2000

"As water sources throughout the North American continent are depleted, the grand schemes that have thus far been set aside may well become more viable and the need ever more compelling" (Canadian Environmental Law Association and Great Lakes United, 1997).

Ecological Impacts

Human interventions (withdrawals, consumptive uses, regulation, dredging, land use, etc.) are inherently cumulative. Although the impact of localized, small-scale activities may be difficult to quantify on an individual basis, collectively, they can significantly alter the level and flow regime and associated ecological conditions. Even modest changes induced by individual, discrete actions have incremental and other cumulative impacts on both a localized and system-wide basis (International Joint Commission, 2000).

Although changes to lake levels and outflows are relatively easy to determine, the impact of these changes is subject to interpretation. The impacts of the changes in levels on the ecosystem as a whole, and especially on its lake and river subsystems, are not well understood. Research shows that decreasing water levels have many impacts to Great Lakes habitat, including changes to the hydroperiod, reductions to water flow variability and ecological niches, reduced biodiversity to coastal wetlands, and potential disruptions in breeding of fish populations. However, experts participating in a workshop on cumulative impacts concluded that it is difficult to quantify with any degree of precision the ecological impacts of most water withdrawals, consumptive uses, and removals (International Joint Commission, 2000).

Nestler & Long (1997), (in Great Lakes Commission, 2001), present a hydrological analysis of historic stream data collected on the Cache River at Patterson, Arkansas, as the basis for cumulative impact analysis of riverine wetlands. Subtle, long-term changes in hydroperiod (length of one wet and dry cycle), which could collectively have major effects on wetland function, are quantified. Various types of analyses show a steady decline in the magnitude and predictability of the baseflow during low flow periods. Complementary information suggests that hydroperiod alterations are associated with increased groundwater pumping. The changes in hydroperiod identified using these methods may have potential to explain changes in biotic communities or wetlands structure as part of comprehensive wetlands studies.

Adamus & Stockwell (1983), (in Great Lakes Commission, 2001), review wetland functions. Cumulative impacts and social factors affecting wetland significance are discussed, and effects of various factors on wetland function are documented, including: surface area, area of watershed and drainage area, land cover, soils, climate, wetland system, vegetation form, hydroperiod, water level fluctuations, tidal range, depth, vegetation density, flow pattern, human disturbance, temperature, and biotic diversity.

Naiman & Turner (2000), (in Great Lakes Commission, 2001), explore trends in alterations to freshwater ecosystems, discuss the ecological consequences of biophysical alterations expected to occur in the next 20-30 years, and identify some of the major scientific challenges and opportunities to effectively address the changes. Topics discussed include altered hydrological regimes, biogeochemical cycles, altered land use, riparian management, and relations between climate change and water resource management. They focus their discussion on processes at the watershed and landscape scales that require better understanding. They conclude a basic need is the incorporation of ecological principles into aquatic resource use and management decisions.

Regarding bulk water removal, another study concluded that in conjunction with other variables such as climate change and industrial, municipal and agricultural uses, bulk water removal projects could have direct or cumulative impacts on watersheds. Impacts could include the inter-basin transfer of non-native micro-organisms and exotic species, the alteration of natural ecosystems and changes in water flows and levels, and groundwater tables [Environment Canada Website (2)].

Economic Impacts

Should lower water levels continue in future, there are numerous economic impacts that could be significant to the regional economy including losses in hydroelectric power generation, higher shipping/transportation costs, commercial navigational impacts, and losses in tourism/recreation (International Joint Commission, 2000). *See Box.*

Economic Impacts to Lower Lake Levels

- **Hydroelectric Power Generation:** Even though they would not be nearly as severe as those projected in climate change scenarios, record low levels and flows in the 1960s caused hydropower losses of between 19 percent and 26 percent on the Niagara and St. Lawrence Rivers. A small proportion of these losses would be offset by lower heating costs, but this in turn would be offset by increases in air conditioning costs.
- **Transportation/Navigation:** For a typical 1,000 foot iron ore carrier the loss of one foot of water means 3,240 tons less cargo per trip. The ship would have to make 2.5 extra trips to make up the difference over a season, costing the shipping company an estimated $121,000 per ship, over the course of a season. Adaptation measures could include significant channel dredging.
- **Tourism, Recreational Boating and Sport Fishing:** There would likely be detrimental effects to tourism for example as a result of less attractive scenic views, and the need to modify water intakes and waste disposal outlets. Certain boat launches would no longer be viable and some boat slips that had been deep enough for docking may no longer be accessible.
- **Fish Populations:** Reductions in freshwater discharges into the St. Lawrence Estuary, Gulf, and beyond, would affect fish populations and other components of the St. Lawrence and Atlantic ecosystems, resulting in both ecological and economic impacts.

Sources: International Joint Commission, 2000; Michigan Environmental Council Website.

In the event of large-scale diversions of water from the Great Lakes, according to one study, significant costs on shipping and hydroelectric power production would result (David et al, 1988). This same study, however, did not attempt to quantify the economic impact of diversions on environmental attributes (such as wetlands, wildlife, and recreation), that would be affected by changes in lake levels. Neither did the study consider the cost of physically moving large amounts of water from the Great Lakes, considered to far exceed the estimated costs to shipping and hydroelectric power production. The authors thus believe that their findings significantly understate total potential costs of diverting water from the lakes (David et al, 1988).

Synergy of Effects:
As freshwater becomes less plentiful and more valuable, how might our thinking change regarding water quantity management in the Great Lakes?

As fresh water becomes more and more valuable, the need to revise certain aspects of water policy and management in the Great Lakes Basin will be necessary. In a future environment of growing population and decreasing water availability, policy options that may have seemed too costly or politically impossible to implement in the past may need to be reconsidered. This section will discuss pros and cons of some water management policies either not being considered under the current regime, or that could be expanded or improved upon under specific circumstances to better manage Great Lakes water resources for the future. Issues such as integrated watershed management, water markets/exports, inter-basin cap and trade, water transfers, green reporting, irrigation water conservation policies, and other voluntary initiatives are presented.

Integrated Watershed Management

Economic development is inherently linked to environmental health. A robust economy depends on an ecologically sound environment, and an environment under stress will not support a sustainable economy over the long term (Kerr et al, 1998). The watershed is the fundamental ecological unit in protecting and conserving water resources. In Canada, provinces, territories and the federal government are adopting a watershed approach as a key principle in water policy and legislation [Environment Canada Website (2)]. In the U.S., much research also discusses the need for a broad-based watershed management approach (U.S. Environmental Protection Agency and the Government of Canada, 1995; Regier/Baskerville, XXXX (ask Jim); Canadian Environmental Law Association and Great Lakes United, 1997, International Joint Commission, 2000). The watershed management approach recognizes the linkages of water systems and the need to manage water within drainage basins rather than on a river-by-river or lake-by-lake basis [Environment Canada Website (2)].

Although both countries are focusing more broadly on management of the Great Lakes Basin than they had in the past, no government agency currently has the ability to both legislate and manage Great Lakes water resources according to an integrated watershed approach. Current integrated watershed management efforts could be greatly improved through better coordination of management efforts between stakeholders, specifically governments. As discussed by Farid et al. (in: Canadian Environmental Law Association and Great Lakes United, 1997), sustainable watershed planning requires a basinwide management plan, making it necessary that the political system of each of the jurisdictions must adapt to the demands of the Great Lakes ecosystem. However, each government jurisdiction in the Great Lakes Basin has a different management system in place to address water quantity issues. Even more significantly, some jurisdictions have very few controls over the consumption and diversion of water.

Water Markets/Exports

Although the Great Lakes States and current Canadian government are committed to a ban on bulk water exports, some provinces are not in agreement, and could feasibly reverse this policy (Barlow, 1999). Since there are no guarantees that a ban on water exports will continue indefinitely, it is necessary to consider whether under certain policy alternatives, water markets/exports might be achieved sustainably, without causing significant environmental or economic harm to the Great Lakes Basin.

The total global value of ecosystem goods and services is estimated at $33 trillion (U.S.) per year, of which roughly 25 percent relates directly to freshwater ecosystems (Great Lakes Commission, 2001). With widespread and still growing recognition of these ecosystem values, it is necessary to determine how much water is required for the maintenance of ecosystems to provide environmental goods and services, and how much water is necessary to support agriculture, industry and domestic services (Great Lakes Commission, 2001). Understanding and accounting for these values in the Great Lakes is a key baseline for assessing bulk water exports from the basin.

In this context, successful Great Lakes water management would require extensive anthropogenic and ecological water needs research, such as the development of model estimates for future water needs in all sectors, improved understanding of water needs for current and expanded food production, and water valuation and necessary water requirements to maintain healthy ecosystems in the basin. If ecological needs and in-basin consumption demands can be adequately met, national water exports could play a role in supplying water to regions with limited alternative sources, alleviating the stresses of drought and providing a reliable source of drinking water.

According to Anderson et al, (in: Bennett, ed., 2001), interstate water markets offer a blueprint for how global water markets might work. With the increasing demands and growing value of water, proposals to develop water markets that cross political boundaries have increased. Anderson et al, explain that supply-side solutions that require government-subsidized dams and delivery systems to supply cheap water are becoming increasingly difficult to implement due to fiscal and environmental constraints. Water crises are becoming more common around the world, building pressure to change the institutions that govern water allocation.

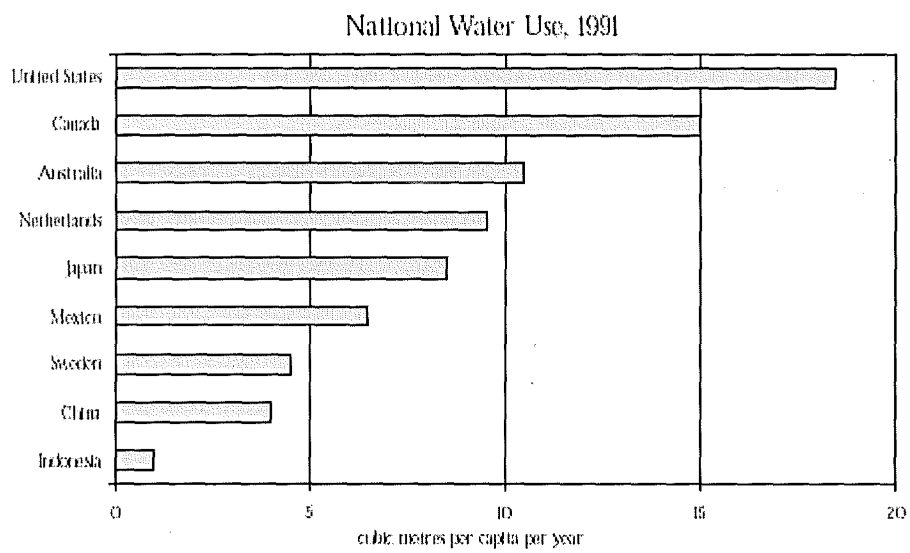
Anderson et al. further argue that water markets and water exports are improving the way water is managed and used. In the case of Australia, which has the longest and most extensive experience with interstate trading, water markets have created huge incentives to conserve water where none previously existed. The enormous financial potential of these markets encourages much needed new investment from the private sector. However, water markets face a number of challenges. The success and future of these growing markets ultimately hinge on legislative activities and the government's ability to establish water rights that both protect water resources and encourage active trading. This requires defining what water can be exported, how benefits and costs are allocated, and establishing clearly defined, secure, and tradable water rights. Such water rights ensure that owners bear the benefits and costs of their decision to keep or trade water (Anderson et al, in: Bennett, ed., 2001). Other issues, such as accounting for differing conservation practices, measurement, monitoring, currency, and transparency of trades must also be considered.

Inter-basin Cap and Trade

Another policy consideration might be to implement an inter-basin cap and trade program. Similar to emissions trading to reduce air pollution (U.S. Environmental Protection Agency, Clean Air Markets Division Website), water users in the basin could be allocated water use rights that they could either use now, bank for future use, or trade with other inter-basin users for profit, creating a clear market incentive to conserve water. After developing the necessary understanding of both current and future water needs, governments could prioritize water uses in such a way that it would be considered a "commodity" only after essential needs of the environment and people have been met. A policy of sensible water pricing should be implemented to promote conservation, with a heavier price burden placed on agribusiness and industry than on citizens (Barlow, 1999).

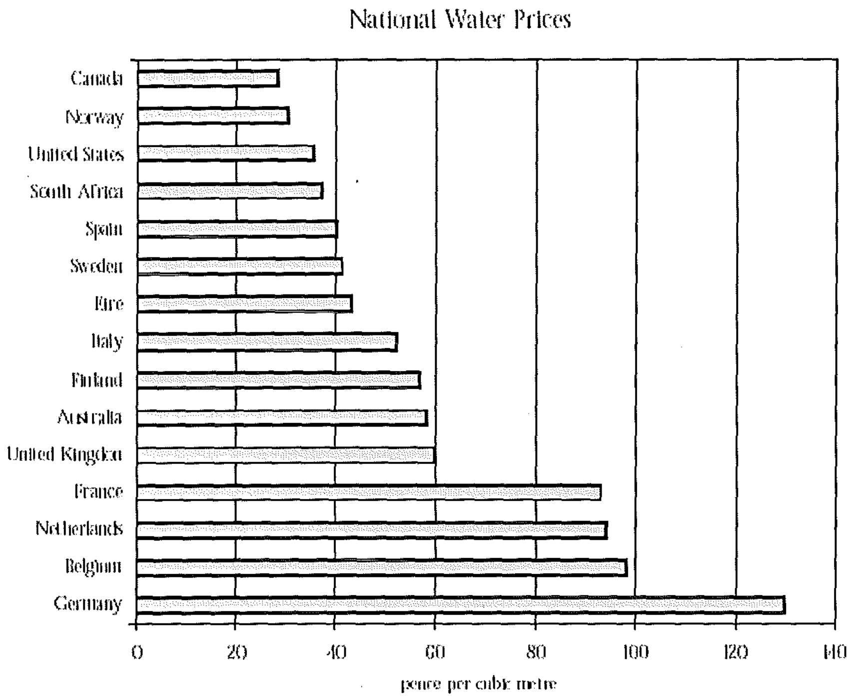
National water use and pricing statistics show that the U.S. and Canada lead the world in per capita water usage while at the same time maintaining some of the lowest water prices worldwide (Figures 22 and 23). With relatively low water prices, there is little conservation incentive and perceived profits are likely too low to stimulate expansion of these water markets.

Figure 22: National Water Use, 1991



Source: Canadian Environmental Law Association and Great Lakes United, 1997.

Figure 23: National Water Prices



Source: Canadian Environmental Law Association and Great Lakes United, 1997.

The key aspect of such a program would be to implement a cap, or limit, on the "surplus" water available to trade, in order to protect Great Lakes water resources. Although currently hindered by international trade agreements, the idea would be that necessary water levels and usage amounts could be maintained by capping the amount of surplus water that could potentially be withdrawn for other uses in any given year. Only this surplus amount of water would be allocated (or sold) to water users for potential trading. In order to maintain the necessary amount of water required for both environmental and economic sustainability, once this annual or seasonal limit is reached, no further water withdrawals would be allowed. Such an intricate program would require development of new water legislation, identification of all water users, complex allocation of water use rights, as well as government regulation and swift penalties in order to be successful. Necessary modifications to international trade agreements should also be considered.

Water Transfers

Market provisions for the sale of water rights or temporary lease of water could also encourage the conservation of agricultural water by providing farmers compensation for unused water entitlements. However, legal and institutional barriers have restricted widespread development of operational markets for water. For most federal water projects, changes in water deliveries are subject to administrative review, and water is generally not transferred beyond the project service area. Further, laws governing water use and transfer are vested with the individual state. In most states, irrigators do not retain rights to water conserved through improved irrigation efficiency. Thus, water "saved" is not available for transfer and is most often used on the farm for higher yields or irrigation expansion. Meanwhile, political concerns have focused on downstream impacts and secondary effects of reduced agricultural activity on local communities (U.S. Department of Agriculture, Economic Research Service, July, 1997).

In recent years, barriers to water marketing have been reduced in some locations. Statutory changes at the state level have increasingly recognized both the need to transfer water to meet new demands, and rights to water "salvaged" through conservation. Recent reform of water transfer policies may suggest a relaxing of constraints on transfers involving federal water supplies (U. S. Department of Agriculture, Economic Research Service, July, 1997).

Green Reporting

Green reporting refers to practices that increase consumers' awareness of the environmental benefits of a particular product. Environmental labels, the most widely used form of green reporting, benefit both the producer and consumer. "Green" companies may maintain or enhance their market share in environmentally conscious markets (Kerr et al, 1998), and consumers are given relevant information to make purchasing decisions accordingly. The interested public would thus have environmental information such as water usage and conservation initiatives to compare products. Again, there are numerous implementation issues associated with such measures such as monitoring, reporting standardization, comparability of alternative conservation initiatives, and in terms of trade, international recognition and acceptance of such standards (Kerr et al, 1998).

There are currently several companies who have demonstrated that superior environmental performance can be consistent with strong financial performance (Kerr et al, 1998). Within the context of international trade, Kerr et al. (1998) explain that the environment-competititveness relationship works in two broad ways. One, environmental concerns can be the basis for excluding a good or service from a country. This can happen via government mandate or regulation, including those adopted under multilateral environmental agreements, regulations aimed at protecting consumer health and safety, as well as consumer actions and boycotts on issues of environmental or social concerns. Two, environmental concerns can be the basis for a company expanding its share in foreign markets through improved products, eco-labels, or environmental improvements that yield economic benefits.

Irrigation Water Conservation Policies

Various research has examined the effects of irrigation water policy on water use and conservation. It was found that while limited water savings can often be achieved through lower-cost efficiency gains, more significant water savings generally requires reductions in consumptive use, with implications for producer profit (U. S. Department of

Agriculture, Economic Research Service, July, 1997). Significant water savings are more likely to be observed through changes in irrigated land base and acreage by crop, rather than through adjustments in per-acre water applications. In addition, substitutions among crops and inputs can result in significant regional water savings. One study found that improvements in on-farm water use efficiency increased the level of regional water savings attributable to crop substitution. A mix of conservation policies may help to distribute the costs of water conservation across water users and regions (U. S. Department of Agriculture, Economic Research Service, July, 1997).

Other Voluntary Initiatives

A shift in diets could also conserve large amounts of irrigation water. Postel (in: WorldWatch Institute, 1999) explains that the typical U.S. diet, with its high proportion of animal products, requires twice as much water to produce as the nutritious but less meat-intensive diets common in some Asian and European nations. Increased concern with the health impacts of high animal-fat diets, in combination with environmental considerations and the higher cost of animal products, could encourage some groups to reduce their intake of animal products and subsequently use less water.

VIII. Perceived Gaps in Knowledge

Although it is projected that future cumulative impacts of increasing water usage in the Great Lakes Basin will result in a dramatic reduction of Great lakes water levels, current research regarding the relationship between water used for food production and water quantity is limited. In the current literature, there are various research gaps regarding this issue:

- Research that differentiates between natural climatic variability, anthropogenic influences and the impacts of water management strategies to water levels.

- Research that quantifies the impacts of food production to water levels, including comparisons of irrigation techniques, impacts of specific agricultural crops and conservation strategies.

- Research that quantifies cumulative impacts.

- Research that links changes in levels and flows to specific changes in biota.

- An assessment of Great Lakes water diversions that result from the production and export of agricultural products outside of the basin.

- Research into the environmental impacts and societal costs that result from the maintenance of the St. Lawrence Seaway, and an investigation into alternative transportation practices.

- Improved methods to accurately measure consumptive uses, as well as development of better consumptive use coefficients.

- Better quantification of ecologic and economic impacts of water withdrawals, diversions and consumptive uses.

- Additional research in long-term lake level trends, long-term climatic patterns and lake level responses to climate change, as well as methods to accurately determine low lake levels.

- Additional research in demographic trends and land use, such as settlement patterns, agricultural land conversion and loss of natural habitat.

IX. Recommendations

- Integrated Basinwide Ecosystem Management. Improve management strategies for an integrated basinwide approach. Efforts should be directed toward improved coordination among stakeholders and to the extent possible, standardization of management systems in both nations regarding water quantity issues, such as legislation, regulatory controls and improved conservation initiatives. In this context, more focus should also be given to current international trade agreements and potential water quantity implications from future legal precedents.

- Research. Additional research is needed to bridge water quantity issues with both ecosystem effects and policy, specifically as related to cumulative impacts. In the literature, the primary concerns of reduced water levels are economic (shipping/navigation, reduced hydropower, recreation, etc.). Research on the relationship between water levels and measurable ecosystem impacts should be expanded. Additional research is also needed to better assess current and future water needs in all sectors, necessary water needs to maintain healthy ecosystems, as well as proper valuation of ecosystems.

- Data: Quality, Monitoring, Availability, and Presentation. While progress has been made in developing a uniform and consistent methodology for collecting and reporting water use data by States and Provinces, such a uniform methodology is lacking. Better estimation techniques are necessary to improve the quality of consumptive water use data and improve current coefficient estimates.

  Consideration should be given to integrating U.S. and Canadian water level monitoring efforts in terms of standardization of measurement and collection methods, equipment, data format (GIS), timescale, availability, etc. Such coordination would be beneficial both in terms of cost savings as well as reducing potentially duplicative efforts.

Expanded utilization of geographic information systems (GIS) would be useful both for improved policy analysis as well as a communication tool: to analyze current and future water policy in the Great Lakes; to improve analytical capabilities of impacts; to improve public understanding of the geography of Great Lakes environmental issues; and to make Great Lakes data available on the Web in GIS format for public use.

- Expand the role of the IJC. Effort should be directed toward granting legislation and enforcement capability to the IJC to ensure its recommendations are legally binding. Similar to the problems faced by the non-binding nature of the Great Lakes Charter, the role of the IJC is limited by its inability to legislate or enforce its recommendations.

  A uniform and consistent conservation initiative is also necessary for the Great Lakes. Although not one of its current responsibilities, the IJC would be the preferred bi-national organization to lead this effort.

- Public outreach, communication, education. Improve outreach and communication of Great Lakes water quantity and environmental concerns and highlight the importance of this enormous ecosystem to the public. Raising general awareness of the Great Lakes as an invaluable natural resource- regionally, nationally, and worldwide- would improve our ability to manage it effectively. The threat to the Great Lakes should be given national attention to raise public awareness, similarly to the threatened Florida Everglades. Educational materials should emphasize the ecological and economic importance of the ecosystem, include explanation of policy issues, ongoing strategies for improved water quantity management, conservation initiatives, and options for public involvement. Such materials should be directed not only to the general public, but also to the various stakeholders such as farmers/food producers, power producers, industry, policy makers, researchers and students.

- Product Development. Provide all Great Lakes water quantity data and information via one bi-national, centralized Website. Although not one of its current responsibilities, the IJC would be a sensible choice to lead this effort. Currently all Great Lakes environmental data is housed by multiple agencies and organizations in the U.S. and Canada. One bi-national coordinating body should act as a data clearinghouse/data repository for both U.S. and Canadian Great Lakes data and information. Technical data management of databases, if necessary could be assigned to a university, likely fueling additional research and interest in Great Lakes environmental issues. It would greatly benefit policy makers, researchers and the public if all/most of the ongoing studies and analyses, data, map products, and current/future management scenarios could be provided in one location.

In addition, based on current and future research, the creation of a geographically-based Great Lakes Water Atlas is necessary to better understand and balance water needs. Like the Water Resources Atlas of Florida (Florida State University, 1984), such a product would be an invaluable tool, providing a comprehensive assessment of the threats to Great Lakes water quantity, surface and groundwater use, water laws and policy, water management, human impacts to the system, conservation initiatives, future scenarios, and options for improved management using maps, tables, images, and written information.

- Policy. Make water quantity issues an agricultural policy priority. In recent years, policymakers have recognized some of the adverse environmental impacts that have resulted from agriculture such as phosphorus and sediment runoff. Because of increased awareness and changes in agricultural policy, some reductions in runoff have occurred. Water quantity issues need to be prioritized in a similar manner. Both market-based and regulatory approaches to managing irrigation and drainage should be explored.

Glossary of Terms

Agricultural water use: can be divided between irrigation and livestock. Irrigation includes all water applied to farm or horticultural crops; livestock incorporates water used for livestock, dairies, feedlots, fish farms, and other farm needs.

Boundary waters: shared waters with the Canada-U.S. border running through them. The principal boundary waters are the Great Lakes.

Bulk water removal: the removal and transfer of water out of its basin of origin by man-made diversions (e.g., canals), tanker ships or trucks, and pipelines. Such removals have the potential, directly or cumulatively, to harm the health of a drainage basin.

Consumptive use: that portion of water withdrawn or withheld from the Great Lakes basin and assumed to be lost or otherwise not returned to the basin due to evaporation, incorporation into products, or other processes.

Commercial water uses: those which take place in office buildings, hotels, restaurants, civilian and military institutions, public and private golf courses, and other non-industrial commercial facilities.

Diversion: a transfer of water from the Great Lakes Basin into another watershed, or from the watershed of one of the Great Lakes into that of another.

Domestic water use: includes everyday uses that take place in residential homes.

Dredging: the process of deepening a harbor, canal, river, etc. often to maintain or improve navigation.

Great Lakes Basin: the watershed of the Great Lakes and the St. Lawrence River, upstream from Trois Rivieres, Quebec.

Great Lakes Basin ecosystem: the interacting components of air, land, water and living organisms, including humankind, within the Great Lakes Basin.

Great Lakes Basin water resources: the Great Lakes and all streams, rivers, lakes, connecting channels, and other bodies of water, including tributary groundwater, within the Great Lakes Basin.

Great Lakes States and Provinces: the States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin, the Commonwealth of Pennsylvania, and the Provinces of Ontario and Quebec.

Great Lakes region: the geographic region comprised of the Great Lakes States and Provinces.

Hydrologic cycle: the natural cycle of water on earth, including precipitation as rain and snow, runoff from land, storage in lakes, streams, and oceans, and evaporation and transpiration (from plants) in the atmosphere.

Industrial water uses: include cooling in factories and washing and rinsing in manufacturing processes, estimated to be 8 percent of total freshwater use for all offstream categories. (Some of the major water-use industries include mining, steel, paper and associated products, and chemicals and associated products).

Instream water uses: those which do not require a diversion or withdrawal from the surface or ground water sources, such as:

- Water quality and habitat improvement
- Recreation
- Navigation
- Fish propagation
- Hydroelectric power production

Inter-basin diversion: a transfer of water from the Great Lakes Basin into another watershed.

Non-consumptive use: refers to any water withdrawal or instream use in which virtually all of the water is returned to the system.

Offstream water use: involves the withdrawal or diversion of water from a surface or ground water source for:

- Domestic and residential uses
- Industrial uses
- Agricultural uses
- Energy development uses

Removals: waters that are conveyed outside their basin of origin by any means, for example, diversion, other types of removals such as removal by marine tanker, bottled water, or ballast water.

Return Flow: the difference between the volume of water withdrawn and that consumed.

Riparian states/provinces: those states or provinces bordering a river.

Seiche: an oscillation in water level from one end of a lake to another due to rapid changes in winds and atmospheric pressure.

Watershed: a land area draining into a common watercourse or waterbody. Often called a catchment area, a drainage basin or a river basin. Examples of major watersheds in Canada include Atlantic (including the Great Lakes and St. Lawrence River), Hudson Bay, Pacific and Arctic. For example, the Great Lakes Drainage Basin is not restricted to the lakes themselves, but includes the many rivers and their tributaries that ultimately flow into the lakes.

Wind set-up: a local rise in water levels caused by winds pushing water to one side of a lake.

Withdrawal: water extracted from surface or groundwater sources.

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http://www.ec.gc.ca/water/en/info/pubs/primer/e_prim09.htm
4) *Water Use*: http://www.ec.gc.ca/water/en/manage/use/e_use.htm
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Dividing Up Report

Hydrogeology Vulnerability Sources	- RL - TAM
PUC	- RL - RN
Town	- RN
Health Unit	- TAM
Outbreak Detection	- TAM
Laboratory	- PM
MOE - Inspections	- RN
MOE - Budget	- PM
Contingency/ Emergency	- PM
Training	- PM
Enforcement / Voluntary Abatement	- RL
Rights to Know	- RN
Accountability	- PM