Water Withdrawals
Indicator #7056

This indicator report was last updated in 2005.

Overall Assessment

Status:	**Mixed**
Trend:	**Unchanging**

Lake-by-Lake Assessment

Separate lake assessments were not included in the last update of this report.

Purpose
- To use the rate of water withdrawal to help evaluate the sustainability of human activity in the Great Lakes basin

Ecosystem Objective
The first objective is to protect the basin's water resources from long-term depletion. Although the volume of the Great Lakes is vast, less than one percent of their waters are renewed annually through precipitation, run-off and infiltration. Most water withdrawn is returned to the watershed, but water can be lost due to evapotranspiration, incorporation into manufactured goods, or diversion to other drainage basins. In this sense, the waters of the Great Lakes can be considered a non-renewable resource.

The second objective is to minimize the ecological impacts stemming from water withdrawals. The act of withdrawing water can shift the flow regime, which in turn can affect the health of aquatic ecosystems. Water that is returned to the basin after human use can also introduce contaminants, thermal pollution or invasive species into the watershed. The process of withdrawing, treating and transporting water also requires energy.

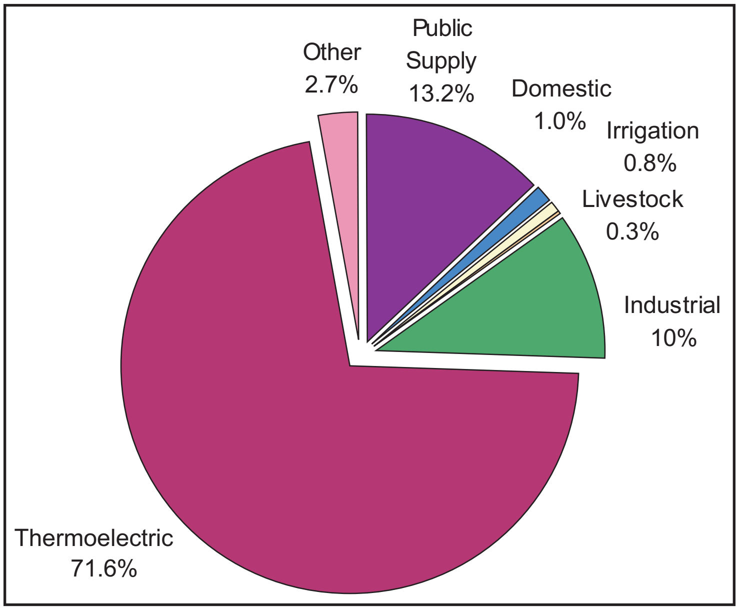

Figure 1. Water Withdrawals in the Great Lakes basin, by category as percentage of total, 2000.
Source: Great Lakes Commission (2004)

State of the Ecosystem
Water was withdrawn from the Great Lakes basin at a rate of 174 billion liters per day in 2000 (46,046 million gallons per day (MGD)), with almost two-thirds withdrawn in the U.S. side 117,260 million liters per day (MLD) (30,977 MGD) and the remaining one-third in Canada 57,046 MLD (15,070 MGD). Self-supplying thermoelectric and industrial users withdrew over 80% of the total. Public water systems, which are the municipal systems that supply households, commercial users and other facilities, comprised 13% of withdrawals. The rural sector, which includes both domestic and agricultural users, withdrew 2%, with the remaining 3% used for environmental, recreation, navigation and quality control purposes. Hydroelectric use, which is considered "in-stream use" because water is not actually removed from its source, accounted for additional withdrawals at a rate of 3,028 billion liters per day 799,987 MGD (Figure 1) (Great Lakes Commission (GLC) 2004).

Withdrawal rates in the late 1990s were below their historical peaks and do not appear to be increasing at present. On the U.S. side, withdrawals have dropped by more than 20% since 1980, following rapid increases from the 1950s onwards (USGS 1950-2000)[1]. Canadian withdrawals continued rising until the mid-1990s, but have decreased by roughly 30% since then (Harris and Tate 1999)[2]. In both countries, the recent declines have been caused by the shutdown of nuclear power facilities, advances in water efficiency in the industrial sector, and growing public awareness on resource conservation. Part of the decrease, however, may be attributed to improvements in data collection methods over time (USGS 1985). Refer to Figures 2, 3 and 4.

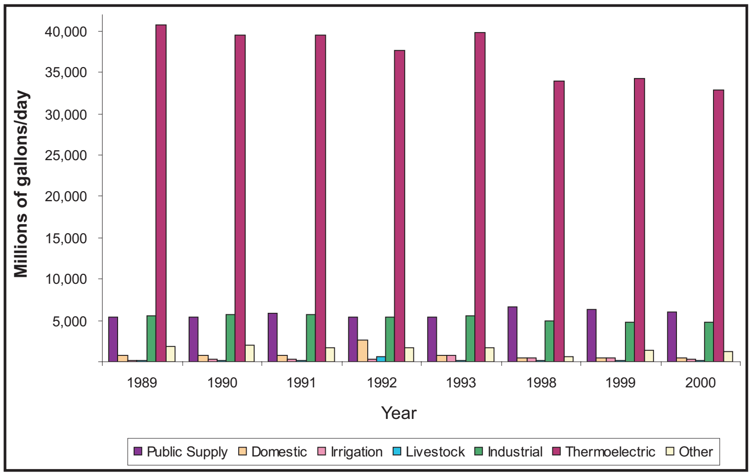

Figure 2. Great Lakes basin water withdrawals by category, 1989-1993 and 1998-2000.
Source: Great Lakes Commission, 1991-2004

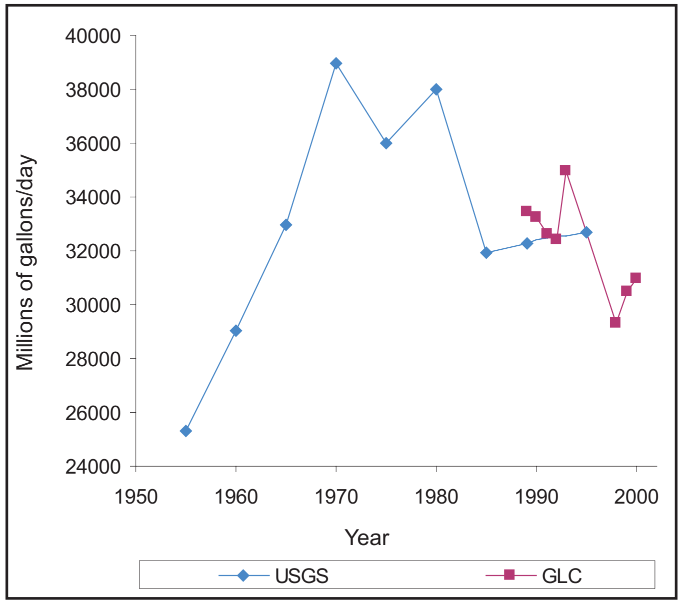

Figure 3. U.S. basin water withdrawals, 1950-2000.
Source: U.S. Geological Survey (1950-2000), Great Lakes Commission (GLC)

The majority of waters withdrawn are returned to the basin through run-off and discharge. Approximately 5% is made unavailable, however, through evapotranspiration or incorporation into manufactured products. This quantity, referred to as "consumptive use," represents the volume of water that is depleted due to human activity. It is argued that consumptive use, rather than total water withdrawals, provides a more suitable indicator on the sustainability of human water use in the region. Basin-wide consumptive use was estimated at 11,985 MLD (3,166 MGD) in 2000. Although there is no consensus on an optimal rate of consumptive use, a loss of this magnitude does not appear to be placing significant pressure on water resources. The long-term Net Basin Supply of water (sum of precipitation and run-off, minus natural evapotranspiration), which represents the maximum volume that can be consumed without permanently reducing the availability of water, and equals the volume of water discharged from Lake Ontario into the St. Lawrence River, is estimated to be 500,723 MLD (132,277 MGD) (estimate is for 1990-1999 period, Environment Canada 2004). It should be noted, however, that focusing on these basin-wide figures can obscure pressures at the local watershed level.

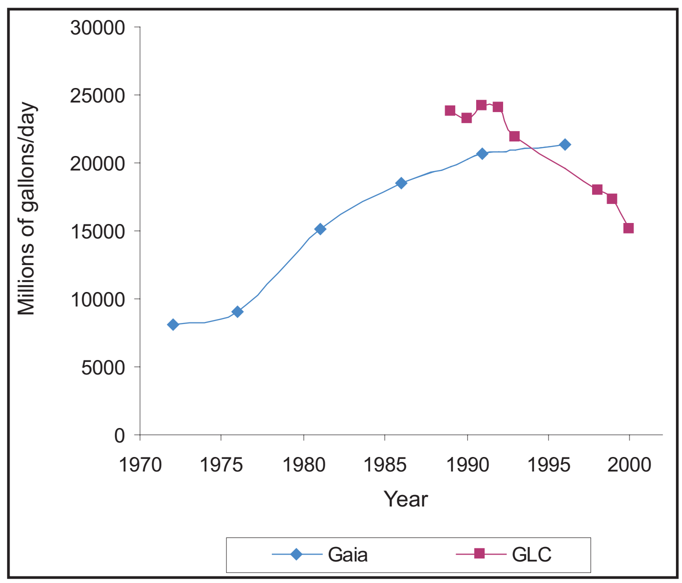

Figure 4. Canadian basin water withdrawals, 1972-2000.
Source: Gaia Economic Research Associates (1999) (based on data from Environment Canada and Statistics Canada), Great Lakes Commission (GLC)

Moreover, calculating consumptive use is a major challenge because of the difficulty in tracking the movement of water through the hydrologic cycle. Consumptive use is currently inferred by multiplying withdrawals against various coefficients, depending on use type. For instance, it is assumed that thermoelectric users consume as little as 1% of withdrawals, compared to a loss rate of 70-90% for irrigation (GLC 2003). There are inconsistencies in the coefficients used by the various states and provinces. Estimating techniques were even more rudimentary in the past, making it problematic to discuss historical consumptive use trends. Due to these data quality concerns, it may not yet be appropriate to consider consumptive use as a water use indicator.

Water removals from diversions, by contrast, are monitored more closely, a result of the political attention that prompted the region's governors and premiers to sign the Great Lakes Charter in 1985. The Charter and its Annexes require basin-wide notification and consultation for water exports, while advocating that new diversions be offset by a commensurate return of water to the basin. The two outbound diversions approved since 1985 have accommodated this goal by diverting water in from external basins. The outbound diversions already in operation by 1985, most notably the Chicago diversion, were not directly affected by the Charter, but these losses are more than offset by inbound diversions located in northwestern Ontario. Thus, there is currently no net loss of water due to diversions.

There is growing concern over the depletion of groundwater resources, which cannot be replenished following withdrawal with the same ease as surface water bodies. Groundwater was withdrawn at a rate of 5,833 MLD (1,541 MGD) in 2000, making up 3% of total water withdrawals (GLC 2004). This rate may not have a major effect on the basin as a whole, but high-volume withdrawals have outstripped natural recharge rates in some locations. Rapid groundwater withdrawals in the Chicago-Milwaukee region during the late 1970s produced cones of depression in that local aquifer (Visocky 1997). However, the difficulty in mapping the boundaries of groundwater supplies makes unclear whether the current groundwater withdrawal rate is sustainable.

Pressures

The Great Lakes Charter, and its domestic legal corollaries in the U.S. and Canada, was instituted in response to concerns over large-scale water exports to markets such as the arid southwestern U.S. There does not appear to be significant momentum for such long distance shipments due to legal and regulatory barriers, as well as technical difficulties and prohibitive costs. In the immediate future, the greatest pressure will come from communities bordering the basin, where existing water supplies are scarce or of poor quality. These localities might look to the Great Lakes as a source of water. Two border-basin diversions have been approved under the Charter and have not resulted in net losses of water to the basin. This outcome, however, was achieved through negotiation and was not proscribed by treaty or law.

As for withdrawals within the basin, there is no clear trend in forecasting regional water use. Reducing withdrawals, or at least mitigating further increases, will be the key to lessening consumptive use. Public water systems currently account for the bulk of consumptive use, comprising one-third of the total, and withdrawals in this category have been increasing in recent years despite the decline in total withdrawals. Higher water prices have been widely advocated in order to reduce water demand. Observers have noted that European per-capita water use is only half the North American level, while prices in the former are twice as high. However, economists have found that both residential and industrial water demand in the U.S. and Canada are relatively insensitive to price changes (Renzetti 1999, Burke *et al.* 2001)[3]. The over-consumption of water in North America may be more a product of lifestyle and lax attitudes. Higher prices may still be crucial for providing public water systems with capital for repairs; this can prevent water losses by fixing system leaks, for example. But reducing the underlying demand may require other strategies in addition to price increases, such as public education on resource conservation and promotion of water-saving technologies.

Assessing the availability of water in the basin will be complicated by factors outside local or human control. Variations in climate and precipitation have produced long-term fluctuations in surface water levels in the past. Global climate change could cause similar impacts; research suggests that water levels may be permanently lower in the future as a result. Differential movement of the Earth's crust, a phenomenon known as isostatic rebound, may exacerbate these effects at a local level. The crust is rising at a faster rate in the northern and eastern portions of the basin, shifting water to the south and west. These crustal movements will not change the total volume of water in the basin, but may affect the availability of water in certain areas.

Comments from the author(s)

Water withdrawal data is already being compiled on a systemic basis. However, improvements can be made in collecting more accurate numbers. Reporting agencies in many jurisdictions do not have, or do not exercise, the statutory authority to collect data directly from water users, relying instead on voluntary reporting, estimates, and models. Progress is also necessary in establishing uniform and defensible measures of consumptive use, which is the component of water withdrawals that most clearly signals the sustainability of current water demand. Mapping the point sources of water withdrawals could help identify local watersheds that may be facing significant pressures. In many jurisdictions, water permit or registration programs can provide suitable geographic data. However, only in a few states (Minnesota, Illinois, Indiana and Ohio) are withdrawal data available per registered facility. Permit or registration data, moreover, has limited utility in locating users that are not required to register or obtain permits, such as the rural sector, or facilities with a withdrawal capacity below the statutory threshold (100,000 gallons per day in most jurisdictions.) Refer to Figures 5 and 6.

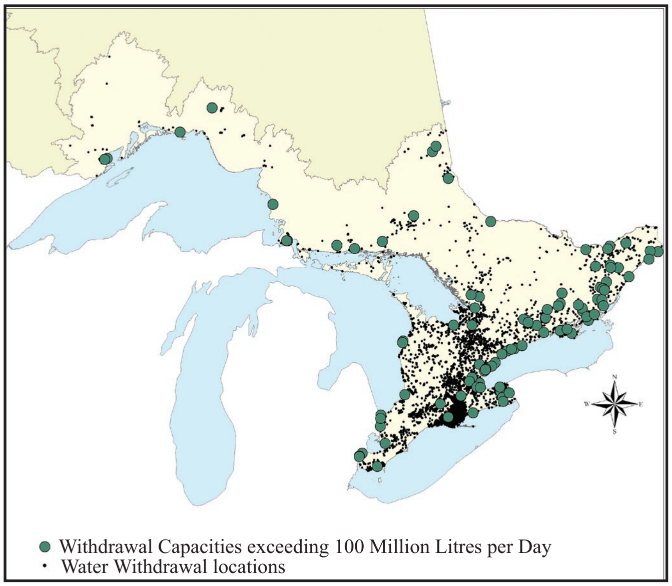

Figure 5. Permitted water withdrawal capacities in the Ontario portion of the Great Lakes basin.
Source: Ontario Ministry of Natural Resources

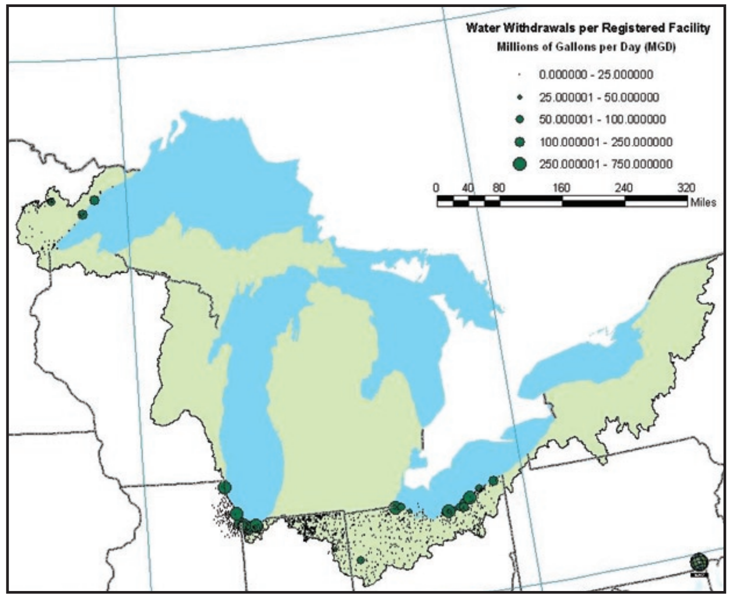

Figure 6. Map of Reported Water Withdrawals at Permitted or Registered Locations in Minnesota, Illinois, Indiana and Ohio.
Source: IL Department of Natural Resources, MN Department of Natural Resources, OH Department of Natural Resources, IN Department of Natural Resources

Further research into the ecological impact of water withdrawals should also be a priority. There is evidence that discharge from industrial and thermoelectric plants, while returning water to the basin, alters the thermal and chemical integrity of the lakes. The release of water at a higher than normal temperature has been cited as facilitating the establishment of non-native species (Mills *et al*. 1993). The changes to the flow regime of water, through hydroelectric dams, internal diversions and canals, and other withdrawal mechanisms, may be impairing the health of aquatic ecosystems. Reductions in groundwater discharge, meanwhile, may have negative impacts on Great Lakes surface water quality. Energy is also required for the process of withdrawing, treating and transporting water. These preliminary findings oblige a better understanding of how the very act of withdrawing water, regardless of whether the water is ultimately returned to the basin, can affect the larger ecosystem.

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Site-specific water withdrawal data courtesy of James Casey (Illinois Department of Natural Resources), Sean Hunt (Minnesota Department of Natural Resources), Paul Spahr (Ohio Department of Natural Resources) and Ralph Spaeth (Indiana Department of Natural Resources). Ontario water permit map courtesy of Danielle Dumoulin (Ontario Ministry of Natural Resources).

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Endnotes

[1] USGS estimates show water withdrawals in the U.S. Great Lakes watershed increasing from 95,691 MLD (25,279 MGD) in 1955 to a peak in the 136-148,000 MLD (36-39,000 MGD) range during the 1970 to 80 period, but dropping to the 117-121,000 MLD (31-32,000 MGD) range from 1985 to 1995. GLC reported U.S. water withdrawals in the 121-129,000 MLD (32-34,000 MGD) range for 1989 to 1993, and around 114,000 MLD (30,000 MGD) since 1998, with 117,261 MLD (30,977 MGD) in 2000.

[2] Historical Canadian data from Gaia Economic Research Associates (GERA) report, and are based on data from Statistics Canada and Environment Canada. GERA reported that Canadian water withdrawals increased from 30,798 MLD (8,136 MGD) in 1972 to 80,690 MLD (21,316 MGD) in 1996. GLC reported Canadian withdrawals of 79-91,000 MLD (21-24,000 MGD) in 1989 to 1993, around 64,000 MLD (17,000 MGD) for 1998 and 1999, and 57,046 MLD (15,070 MGD) in 2000.

[3] Econometric studies of both residential and industrial water demand consistently display relatively small price elasticities. Literature review on water pricing economics can be found in Renzetti (1999). However, the relationship between water demand and price structure is complex. The introduction of volumetric pricing (metering), as opposed to flat block pricing (unlimited use), is indeed associated with lower water use, perhaps because households become more aware of their water withdrawal rate (Burke *et al.* 2001).

Last Updated
State of the Great Lakes 2005