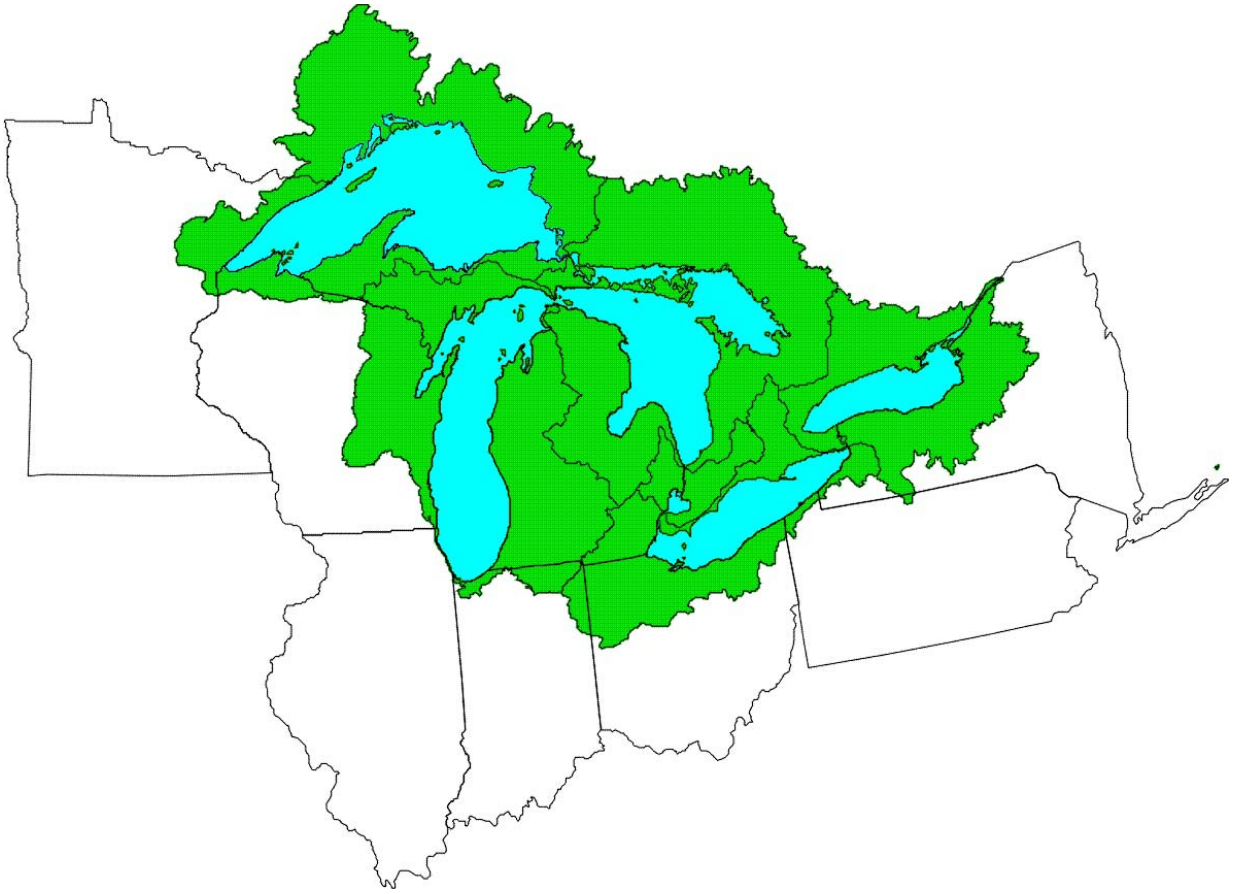
Improvements to the Great Lakes – St. Lawrence River Biohydrological Information Base

In response to Public Law 106-53, Water Resources Development Act of 1999, Section 455(b), John Glenn Great Lakes Basin Program, Great Lakes Biohydrological Information

Appendix F: Water Withdrawal and Use Data and Information



April 2005

US Army Corps of Engineers®

Measurement Converter Table

U.S. to Metric

Length
feet x 0.305 = meters
miles x 1.6 = kilometers

Volume
cubic feet x 0.03 = cubic meters
gallons x 3.8 = liters

Area
square miles x 2.6 = square kilometers

Mass
pounds x 0.45 = kilograms

Metric to U.S.

Length
meter x 3.28 = feet
kilometers x 0.6 = miles

Volume
cubic meters x 35.3 = cubic feet
liters x 0.26 = gallons

Area
square kilometers x 0.4 = square miles

Mass
kilograms x 2.2 = pounds

Appendix F: Table of Contents

APPENDIX F:

Water Withdrawal and Use Data and Information

Introduction

Traditionally, water management in the United States and Canada has focused on the manipulation of supplies of freshwater to meet the needs of a variety of users. The U.S. Geological Survey (USGS) is the primary federal agency involved in water use data collection and reporting, although the responsibility for water supply management has primarily rested with the states. As such, the individual jurisdictions of the Great Lakes-St. Lawrence River region have been involved with managing water resources for many decades.

In North America, many existing sources of water are being depleted and stressed by withdrawals from aquifers and diversions from lakes, rivers and reservoirs to meet the needs of cities, farms, homes and industries. While the water rich region of the Great Lakes-St. Lawrence has been mostly immune from serious water shortages and water supply problems, smaller watersheds are beginning to be stressed in some parts of the Great Lakes-St. Lawrence River basin. This may occur in areas where local surface water supplies are inadequate to meet needs and/or where groundwater supplies are unreliable or of poor quality. As other parts of the continent begin to experience water supply shortages, the Great Lakes may be viewed as a source of high quality freshwater to serve the needs of communities and industries located outside of the basin.

To report on how water resources are used in the United States, the USGS has compiled and disseminated estimates of water use at five-year intervals since 1950. In 1977, the U.S. Congress expanded USGS' water-use activities by establishing a National Water-Use Information Program (NWUIP), which, in cooperation with the states, is charged with the collection of reliable and uniform information on the sources, uses and management of water in the United States.

The Historic and Current Federal Role in Water Use Data Collection and Reporting

The NWUIP program began in 1978 with a $1 million appropriation to establish a national water use data activity. By 1981, 47 states were participating in the program (National Research Council, 2002). When the NWUIP was first established, the concern was with data quality control and data management. In 1980, the National Water-Use Data system (NWUDS) was organized to store water withdrawal and use data by county and basin. This was later updated and renamed the Aggregate Water-Use Data System (AWUDS) (National Research Council, 2002).

The NWUIP, coordinated by the USGS, was created to meet the evolving national water resources management needs and to establish high quality data for water use trend analysis, water demand forecasting and to help establish sound water supply management policies and reduce undesirable trends related to things like salt-water intrusion or groundwater aquifer overdraft, among others. Part of this program has included the publication of a national water use report which occurs every five years through the "Estimated Use of Water in the United States" series. The most recent report was published in 1995. In the first 15 years of NWUIP existence, steady progress occurred through the addition of data elements,

water use categories and improved QA/QC of data. Water use categories were added and expanded and other changes were made to the national water use reporting program such as submitting data by four digit HUCs and adding consumptive use estimates. Both of these changes occurred in 1990 (National Research Council, 2002). However, beginning in the mid to late 1990s, financial and institutional pressures forced the program to scale back. Beginning with the 2000 five-year report on water use, commercial water use, wastewater treatment, reservoir evaporation, hydroelectric power generation, reclaimed wastewater, return flows or deliveries from public suppliers and consumptive uses of water for all categories will no longer be reported as these parameters are no longer being tracked nationally. The loss of many of the water use categories and associated information has obvious implications for local and regional studies of water availability as well as for studies of how human use of water impacts the quantity, quality and sustainability of water resource systems (National Research Council, 2002).

It is clear from the authorizing language in the 1978 House appropriations bill, that the NWUIP was intended to be a cooperative program with the states. This relationship provided a relatively constant source of funding, but also created certain structural limitations (National Research Council, 2002). From fiscal year 1978 to 1985, federal funding for the program increased from $1 million to $5 million and these funds were matched at 100 % or more by the cooperating states. However, from 1983 until the present, funding has remained relatively flat. The NWUIP is no longer specified as a line item in the USGS's annual budget submission to Congress but the federal share of the NWUIP has been about $4.5 to $5 million annually for the last several years (National Research Council, 2002).

At current funding levels and without the plan recommended in this feasibility study, the NWUIP will continue to suffer from lack of financial support. This will result in inconsistent information on water withdrawals and uses due to differing levels of cooperation by states, both inside and outside the Great Lakes region. Incomplete, nonuniform and unreliable data and information will continue to be the norm compromising the region's ability to make science-based water resources management decisions needed to implement the Great Lake Charter Annex.

The water use data generated from the USGS National Water Use Information Program is inadequate to meet the needs for implementation of Great Lakes Charter Annex and needs to be strengthened.

In response to this, the following has been determined:

Task: The USGS needs to strengthen the National Water Use Information Program (NWUIP) and integrate this program with other related federal programs to support implementation of the Great Lakes Charter Annex.

While the Great Lakes states work closely with the USGS through its NWUIP, the concept of a region-specific binational water use data system to collect and maintain consistent and uniform data on withdrawals, diversions and consumptive uses of water has long been of interest to Great Lakes researchers and water resources program managers. This interest was heightened when, in 1983, the Great Lakes governors and premiers appointed a Task Force on Water Diversion and Great Lakes Institutions. This Task Force was established from ongoing concerns about future management of the Great Lakes-St. Lawrence River and the perceived significant economic and environmental consequences to the region from large-scale diversions of Great Lakes water. The report of the Task Force, submitted in January 1985, addressed three main areas: the need for regional action in the area of water management; the need to protect the water resources of the Great Lakes-St. Lawrence; and the institutional capabilities and needs in the Great Lakes region. Out of this report came the Great Lakes Charter of 1985, a series of principles for the management of Great Lakes water resources.

Throughout its deliberations the task force was troubled by the lack of consistent, reliable technical information related to water withdrawal and use for the Great Lakes. The task force found that "the kind of reliable, comparable water use data needed to accurately project future needs or to forecast 'significant impacts' are not available now." (Great Lakes Charter, 1985)

The Great Lakes Charter, signed by the Great Lakes governors and premiers in 1985, called for the establishment of a regional water use database that would provide a common base of data and information regarding the use and management of basin water resources and the establishment of systematic arrangements for exchanging and comparing water use data and information.

When working on the Charter, the states and provinces were also involved in some parallel studies to describe and document individual state and provincial water use data collection and reporting programs. These studies also provided guidance on how to establish a consistent approach to managing the water resources of the Great Lakes basin. For example:

- The Great Lakes Commission formed a Water Data Collection task force in early 1985 to evaluate regional data collection efforts. Through a survey process, the Commission's task force determined the extent of withdrawal, return flow and water consumption data in the Great Lakes states and provinces, along with the assessment, comparability and compatibility of the data. The results were published in an October 1985 report titled "Survey and Preliminary Evaluation of the Existing Water Use Data Collection Systems in the Great Lakes State and Provinces." (Great Lakes Commission, 1985)

- The USGS, in an extensive 1985-86 study undertaken with input from the Council of Great Lakes Governors' Water Resources Management Committee, examined and compared Great Lakes state and provincial data for nine water use categories. The December 1986 report titled "Water Use Data Collection Programs and Regional Data Base in the Great Lakes-St. Lawrence River Basin States and Provinces" (USGS Open File Report 86-546, December 1986) influenced the design of the Regional Water Use Database.

- After the signing of the Great Lakes Charter, a Water Resources Management Committee (WRMC) was established through the Council of Great Lakes Governors to work toward achieving the objectives of the Charter. Based upon recommendations of the WRMC in its February 1987 report to the governors and premiers titled "Managing the Waters of the Great Lakes Basin," the Great Lakes Commission was recommended to serve as the repository for the regional water use database. The function of the regional water use database is to store, aggregate, manipulate and display water withdrawal, diversion and consumptive use data (provided by the Great Lakes states and provinces) for multiple categories of use. The Regional Water Use Database has been operational since 1988, following a multi-year cooperative effort between the Great Lakes states and provinces and the USGS to design and develop the database system. The operation and use of this database system represents one of several ongoing activities on behalf of the Great Lakes states and provinces to fulfill obligations of the Great Lakes Charter of 1985.

Great Lakes Charter for Water Withdrawal and Use Data Collection and Reporting

The Charter describes, in general terms, the types of data and information to be collected and exchanged among jurisdictions and a compliance mechanism to ensure jurisdictional participation. Under the "Implementation of Principle" section, the Charter lays out three components to a common base of data.

- Each state and province will have the ability to collect and maintain, in comparable form, data regarding the location, type, and qualities of water use, diversion, and consumptive use, and information regarding projections of current and future needs for water withdrawals in excess of 100,000 gallons per day average in any 30-day period. Additionally, they must have the authority to manage and regulate water withdrawals involving a total diversion or consumptive use of Great Lakes Basin water resources in excess of 2,000,000 gallons per day average in any 30-day period.

- In order to provide accurate information as a basis for future water resources planning and management, each state and province will establish and maintain a system for the collection of data on major water uses, diversions, and consumptive uses in the Basin. The states and provinces, in cooperation with the federal Governments of Canada and the United States and the International Joint Commission, will seek appropriate vehicles and institutions to assure responsibility for coordinated collation, analysis, and dissemination of data and information.

- The Great Lakes states and provinces will exchange on a regular basis plans, data, and other information on water use, conservation, and development, and will consult with each other in the development of programs and plans to carry out these provisions.

Water use data collection and reporting programs provide a means of measuring current demands on Great Lakes water resources. Although many water resources management activities and programs in the Great Lakes-St. Lawrence River basin trace their origin to the 1985 Great Lakes Charter, the Great Lakes states and provinces have maintained a variety of independent water use data collection, storage and retrieval systems.

Reporting programs that existed before the Charter were adapted to meet its reporting requirements for withdrawals, uses, and diversions of more than 100,000 gallons per day average in any 30-day period.

The Charter intended that all the states and provinces be in compliance with the minimum data collection requirement of water withdrawals in excess of 100,000 gallons per day in order to participate in the prior notice and consultation process. However, in practice this requirement has not been emphasized, with the result that consistency among jurisdictions with regard to the principles of the Great Lakes Charter has been lacking, and gaps exist in state/provincial water use data collection and reporting programs.

Current Status of State/Provincial Water Use Data Collection and Reporting Programs

In 2002, the Great Lakes Commission initiated a survey of state/provincial water supply managers to evaluate how well each jurisdiction has met its commitments to two key Charter requirements: (1) ability to collect accurate and comparable information for withdrawals in excess of 100,000 gallons per day average in any 30-day period and (2) ability to report collected data for the agreed-to categories of use to the Regional Water Use Database Repository annually. [1]

The recipients of the survey rated their jurisdictions' fulfillment of the Charter commitments according to the legislative and/or regulator authority to cover water withdrawals within the water use category (legislative/regulatory fulfillment scale) and the implementation effort to provide the required water use data collection and reporting commitments for the water use category (implementation fulfillment scale). Ratings were based on a conventional five-point scale, from "0" meaning no legislative/regulatory authority or implementation effort to "4" meaning full legislative/regulatory authority or implementation effort. The information gleaned from this survey is qualitative and anecdotal but helpful to the discussion of water withdrawal and use data gaps and information needs at the state/provincial level.

Based on the survey, several conclusions may be drawn. About half of the jurisdictions discerned a high level of ability to fulfill the Charter commitments in both legislative/regulatory authority and implementation effort for almost all water use categories. The survey recipients from the other jurisdictions indicated an ability to partially fulfill Charter commitments either by legislative/regulatory authority or implementation effort. A common trend among respondents who believe their jurisdiction only partially fulfills its Charter commitments is that legislative/regulatory authority appeared to be strong while implementation efforts were weak. Inadequate resources to carry out the reporting programs authorized through legislation or regulations may be the reason for this trend. Among all jurisdictions, the weakest water use categories for data collection appear to be self-supply domestic, irrigation, and livestock.
Survey respondents expressed some difficulty in rating their state or province's performance for the hydroelectric power category due to several unique considerations. For major hydroelectric uses, especially along the St. Lawrence and Niagara Rivers where most of the quantity of hydroelectric water use occurs, high quality federal data exists which can be used

[1] This second requirement is not stated explicitly in the 1985 Great Lakes Charter. The Charter mandated the formation of a Water Resources Management Committee to develop and design a system for the collection and exchange of comparable water resources management data. The Water Resource Management Committee recommended in its 1987 report to the governors and premiers, that the jurisdictions provide collected data to the regional water use data base repository (i.e., the Great Lakes Commission) on an annual basis. In return, the repository would be responsible for preparing and distributing annual water use reports.

by the jurisdictions for reporting to the regional database. For smaller hydroelectric uses, high quality data are not available and the jurisdictions must rely on estimations or calculations to report these data. Indiana for instance uses electricity generation data collected from the U.S. Federal Energy Regulatory Commission to calculate water use for smaller hydroelectric facilities. However, New York, due to the larger number of small hydroelectric users in its jurisdictions, does not currently have the staff resources to calculate or estimate these water uses.

States and provinces also report differently on instream hydroelectric uses. Ohio does not report instream uses because it considers them to be incidental uses with no associated water rights, but other jurisdictions include these uses in their data reports. All states and provinces report non-run-of-the-river uses, which involve temporary storage of water so electricity can be generated to meet peak loads, but not many jurisdictions have these uses. Other water use categories also seem to have unique considerations that point to a general need for clarifying water use category definitions and determining whether categories should be reclassified.

While this preceding paragraph speaks to the need to continue making progress toward a uniform and consistent approach for water use data collection and reporting at state and provincial level, it also speaks to the inherent problems of data accuracy and reliability that have plagued the data collection and reporting efforts since the inception of the Great Lakes Regional Water Use Database in 1988 (see description below).

With regard to the states' reliance on the NWUIP to support their water use data collection and reporting efforts, the jurisdictions have expressed concern over the planned downsizing of the "Estimated Use of Water in the United States" series (USGS five-year reports) under the NWUIP. Jurisdictions with complex water management and accounting concerns, such as aquifer storage and recovery, artificial recharge, water reuse, total maximum daily load (TMDL) requirements and interbasin transfers of water will not find the present categories in the "Estimated Use of Water in the United States" series, sufficient to meet their needs. Many of the Great Lakes jurisdictions will continue to track trends and collect data for their own purposes but such data and information will not be available in a consistent and uniform manner at the regional or national scales.

Great Lakes Regional Water Use Database

With recent water shortages in arid regions of the United States and Canada as well as several documented localized water supply problems and shortages within the Great Lakes basin, the Great Lakes states and provinces have become increasingly aware of the need to protect and conserve Great Lakes-St. Lawrence River water resources.

The Great Lakes Charter of 1985 called for the establishment of a regional water use database to provide for a common base of data and information regarding the use and management of Great Lakes-St. Lawrence River water resources. Along with the establishment of the database, the Charter called for "the establishment of systematic arrangements for the exchange of water data and information" (The Great Lakes Charter, 1985).

The states and provinces in committing to the principles of the Charter recognized the importance of providing consistent and accurate water use information as a basis for future water resources planning and management. The Charter also recognized the importance of

coordinating this regional effort with federal governments of the United States and Canada and with the International Joint Commission and to assure a responsible and methodical approach for the collation, analysis and dissemination of annual water use data and information.

In signing the Great Lakes Charter Annex of 2001, the Great Lakes governors and premiers reaffirmed the commitment to the collect and disseminate consistent and accurate water use data and information and also committed the region "to improve the sources and information of scientific information regarding the waters of the Great Lakes basin and impacts of withdrawals from various locations and water sources on the ecosystem, and to better understand the role of groundwater in the Great Lakes basin by coordinating the data gathering and analysis efforts" (The Great Lakes Charter Annex, 2001).

It is clear from these statements that having a program to provide accurate, uniform and consistent water data on withdrawals, diversions and consumptive uses is critical to the region's ability manage and protect its water resources.

The Great Lakes Regional Water Use Database was established in 1988 to address these data collection and reporting needs. The database was founded by the Great Lakes states and provinces and housed by the Great Lakes Commission.

The Great Lakes Regional Water Use Database provides a common base of data and information on water use in the Great Lakes basin as called for in the 1985 Great Lakes Charter. As referred to in the previous sub-section the regional database was established to be a primary tool to support water withdrawal and use decisions in the Great Lakes-St. Lawrence River basin. (Great Lakes Commission, 2003).

The database uses standard relational database tools on most desktop personal computers. A customized program performs routine database operations and includes standard data entry, retrieval and report generation options. There are nine categories of use included in the Great Lakes Regional Water Use Database. These categories include public supply; self-supply-domestic; self-supply-irrigation; self-supply-livestock; self-supply-industrial; fossil fuel power; nuclear power; hydroelectric power; and other, which includes withdrawals for fish/wildlife purposes, low flow augmentation, navigation and recreation, among others. Each water-use category includes three types of withdrawal/discharge records: Great Lakes Surface Water (GLSW); Other Surface Water (OSW); and Groundwater (GW).

The system includes six drainage basins (Lake Superior; Lake Michigan; Lake Huron; Lake Erie; Lake Ontario; and the St. Lawrence River), which are numerically coded in the database. The connecting waterways and Lake St. Clair are grouped into the corresponding Lake basins listed above (see Figure F-1). All states and provinces submit water use data to the database repository by basin of withdrawal. There are 22 possible combinations of the six basins and ten jurisdictions. Each jurisdiction's set of sub-basin records is comprised of nine sets of water-use category records. Each set of water-use category records are comprised of three sets of withdrawal/discharge type records.

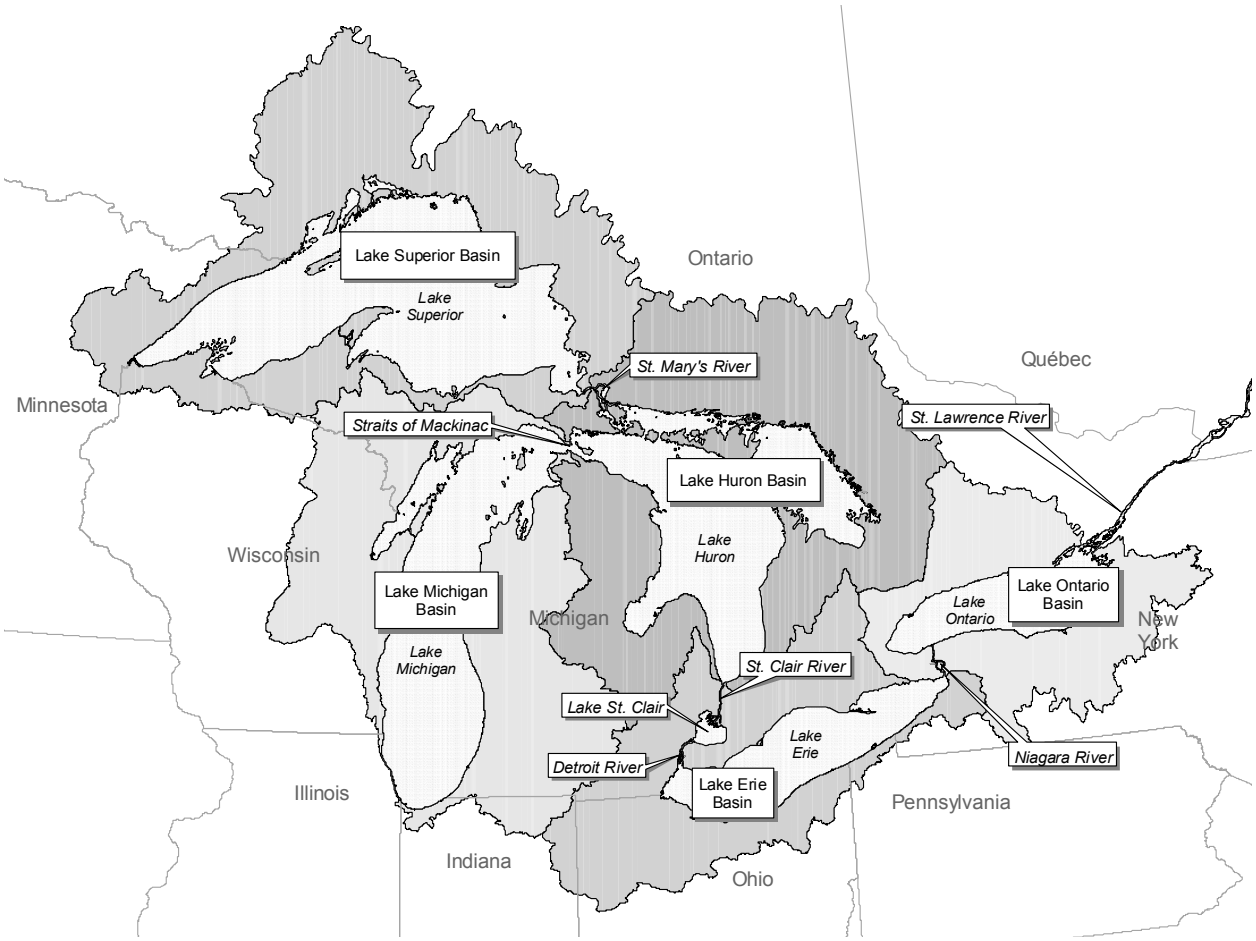


Figure F-1: Great Lakes drainage basins

Data submitted to the Regional Water Use Database is provided in either million gallons per day (U.S.) (mgd) or million liters per day (mld). There are also two measures of the quality of data provided for each record: level of accuracy and level of aggregation. The accuracy level indicates whether the withdrawals are 100 percent measured, more than 50 percent measured, or estimated. The level of aggregation indicates whether the withdrawal data originate from site-specific sources or from higher-level aggregate sources such as county or census databases.

Most jurisdictions collect some data at or below the 1985 Great Lakes Charter established 100,000 gallon per day threshold, but the ability of several jurisdictions to collect and report water use data for all water use categories is lacking. Even in those jurisdictions with strong data collection and reporting programs, limitations to obtaining comprehensive and complete water use data may still exist due to the lack of high-quality data at the sector or facility level, inadequate enforcement, or often scarce resources for personnel and other needs to carry out the programs.

Jurisdictions where multiple agencies (state or federal) are involved in the water use data collection and reporting process face additional challenges because of the additional coordination required. Jurisdictions that have mandatory reporting requirements built into their programs seem to be more effective than those that do not, due to the more stringent requirements that can be presented to water users and the availability of enforcement mechanisms. Currently, many states and provinces lack the appropriate statutory or regulatory authority to implement mandatory reporting and/or permitting programs.

Progress has been made in the area of water use data collection and reporting since the Great Lakes Regional Water Use Database became operational in 1988, but the database has limited utility as a management tool due primarily to constraints in the data collection and reporting programs at the state/provincial level. The Great Lakes Regional Water Use Database does not meet all the objectives as a management tool as envisioned by the Water Resources Management Committee in 1987 because it lacks the high data quality that forms the scientific basis needed to inform activities such as trend analysis, demand forecasting and water resources planning in general.

Data are available for the years 1987-1993 and for years 1998-2000. Data was not collected and reported during the years 1994-1997 due to lack of financial resources to support the operation and maintenance of the Regional Water Use Data Base. As resources permit at the state and provincial level, data for 1994 to 1997 will be gathered and incorporated into the database. The reports for years 1999 and 2000 were completed in early 2004. Reports for subsequent years (2001 and 2002) are due to be completed by the end of the calendar year of 2004. Because the database is missing the four years of data and also for the data quality reasons mentioned above, the region lacks the ability to identify trends in water use, such as changes in overall demand, changes in demand for a single jurisdiction, and changes in demand for a single water use category. Trend analysis would provide a valuable planning tool and would allow decisionmakers to project the possible cumulative effects of water use.

The utility of any water use data depends on several factors. The first of these factors is the frequency with which data are gathered or summarized to create a database record. Less frequent usage summaries mean that the factors which influence water use must be generalized, even if information about those factors is available at frequencies that would otherwise allow more refined models and analyses. Annual summaries, for instance, are of little use in evaluating anything other than broad trends that happen over a period of several years. Even for studies of seasonal water use changes, monthly data would be much more effective. Weekly records would allow the incorporation of even more factors and the determination of their influence on monthly patterns and other relatively short periods.

The level of detail within the water use datasets being reported is also important. Number of water use type categories, measured use vs. estimated use, level of accuracy, level of aggregation, all influence whether or not and to what extent the database can be incorporated into modeling, analysis and planning efforts.

Finally, the geographic scale at which the data are gathered determines much of what can be said about how location contributes to use. Data handling technologies and geographic information processing tools allow location information to be treated as an analysis attribute in its own right: Detailed coordinates mean that location counts as a detailed analysis factor and can be used at many levels, while more general location information, such as a city or county name, means that location counts as a factor only in more general analysis efforts. Thus, water use data linked to more precise location information can be mapped and

analyzed with respect to more characteristics of the region than can water use data linked only to a general location such as a large political unit or jurisdiction.

Jurisdictions are likely to continue to encounter difficulties in securing funding and other resources for their individual data collection and reporting programs, and the region will continue to be unable to identify water use trends accurately. The greatest obstacle to overcome is that most jurisdictions are unable to collect and report water use data on an annual basis for at least one water use category.

Periodic reporting of water withdrawals and use is needed to track changes in water use, model future use, and assess cumulative impacts of withdrawals.

In response to this, the following has been determined:

Task: The USGS, in cooperation with regional interests, needs to implement periodic reporting of water withdrawals and use for the Great Lakes-St. Lawrence River basin.

All measurements, calculations and estimates have uncertainties associated with them. In a qualitative sense, uncertainty refers to errors and biases associated with measurements, calculations and estimates. In some cases, uncertainty in a measurement or calculation will exist despite the use of state-of-the-art instrumentation or estimation methods. Although the uncertainty associated with the data presented to the Great Lakes Water Use Database has yet to be quantified, there are inherent errors in the data and problems with the data collection and reporting process that make science-based decisionmaking and policy development to protect and conserve the region's water resources extremely difficult. Following is a brief description of the limitations and shortcomings associated with the Regional Water Use Database.

Overall, the Great Lakes Regional Water Use Database suffers from the following limitations:

- Measured or metered data are lacking and the use of measurements or estimates to collect data varies by jurisdiction;
- The level of accuracy (overall quality) of water use data varies significantly by jurisdiction;
- Accuracy levels are not well documented (accounted) in the database to show the usefulness of data in analyses;
- Each jurisdiction follows its own schedule and protocols in data collection and reporting; and
- Jurisdictional programs differ from one another and suffer from lack of funding support and authority to fully develop and implement programs consistent with the Great Lakes Charter.

The usefulness of the Great Lakes Regional Water Use Database is dependent on its ability to provide uniform and consistent water use data in order to support decisionmaking under the Great Lakes Charter Annex. In addition to supporting decisions on individual water withdrawal and use proposals, good quality water use data are critical for a variety of other purposes, including:

- Ensuring adequate availability of water as future water demands fluctuate;
- Settling interstate and intrastate conflicts over water use; and
- Identifying annual, or seasonal, trends of water use with the level of confidence needed for demand forecasts and other planning activities.
- Evaluating impacts to water use.

Given the widespread economic and political implications of approval of water use proposals that require an expansion of water supply, it is very important that water use data be compiled with metadata defining the uncertainty in the data itself. Metadata document how data are obtained and enhance the usefulness of the data by assigning qualitative accuracy and precision to data. Without systematic scientific studies testing the reliability of compiled water use data, the usefulness of the data to decisionmakers is questionable (National Research Council, 2002).

Uncertainties in water use and withdrawal data are not well known or documented. Development and implementation of standards for metadata for this information would substantially improve the utility of this information.

In response to this, the following has been determined:

Task: The USGS, in cooperation with regional, state and provincial authorities, needs to define and implement metadata standards to improve knowledge of inherent uncertainties in water use and withdrawal data for the Great Lakes – St. Lawrence River basin.

All measurements and calculations have uncertainty associated with them. In some cases, uncertainty in a measurement or a calculation may reflect the level of accuracy of instrumentation used for the measurement or might refer to the estimation methods used. Uncertainty may be reduced by employing more advanced instrumentation or improving estimation methods. Due to the lack of metadata and the absence of a metadata standard, the utility of the data housed in the current database is limited.

The development of a metadata standard is essential to ensure that the information provided to the Great Lakes Regional Water Use Database is of the highest quality to allow the data to be used by project partners as well as aid in the processing and interpreting of the data. It will also help in the update of internal records describing the data holdings.

In lieu of more extensive measurements, estimation techniques of water withdrawal and use for both surface and groundwater need to be improved to support water resources decisionmaking.

In response to this, the following has been determined:

Task: The USGS, in cooperation with regional, state and provincial authorities needs to improve estimation techniques of water withdrawal and use for surface and groundwater whenever direct measurements are unavailable to support Great Lakes Annex decisionmaking.

Accuracy of data are a key consideration for water resources decisionmaking, but the regional water use database only indicates whether data are based on estimated use, some higher level of aggregation (e.g., census data) or in some cases, site-specific metering or direct measurement. Measured data however, is not available for most of the water use categories. Clarification of category definitions including possible reclassification of some uses would also help database utility. A prime example is the need to track self-supply domestic uses separately from self-supply commercial uses.

Direct measurements of water withdrawal and use, wherever technically feasible and implementable, are needed to support water use accounting.

In response to this, the following task has been determined:

Task: The USGS needs to work collaboratively with regional, state and provincial authorities to implement direct measurements of water withdrawal and use, wherever technically feasible and implementable, to support decisionmaking under the Great Lakes Charter Annex.

Consumptive Use of Great Lakes Water

Consumptive use, as defined by the Great Lakes Regional Water Use Database is "that portion of water withdrawn or withheld from the Great Lakes basin and assumed to be lost or otherwise not returned to the Great Lakes basin due to evapotranspiration, incorporation into products, or other processes."[2] Consumptive use is one of several factors that affect the amount of water in lakes and other water bodies. In the Great Lakes Charter, the Great Lakes states and provinces agreed, "that new or increased diversions and consumptive uses of Great Lakes basin water resources are of serious concern" (Great Lakes Charter, 1985).

The IJC, in its recent report to the Governments of Canada and the United States, recommended that federal, state, and provincial governments should exercise caution with regard to consumptive use of Great Lakes basin waters. (International Joint Commission, 2000) Under the Great Lakes Charter, the governors and premiers set forth provisions for notifying and consulting each other on proposed diversions or consumptive uses of more than 5 million gallons per day and called for increased and improved data collection on water use, diversion and consumptive use.

Conceptualizing consumptive water use is difficult because the amount of water lost to the system is not easily determined, and means are not readily available to measure all water withdrawal and use processes. For instance, if water is "consumed" through evapotranspiration, the water may remain within the basin depending upon where it returns to the earth's surface as rainfall. Similarly, water incorporated into food or beverage products may or may not remain in the basin depending upon where the product is consumed. Calculated or measured consumptive uses need to consider the quality of return flows, which may be altered through chemical or thermal processes. The return flow of water

[2] All the Great Lakes states and provinces use this definition, except Minnesota, which defines consumptive use as any water, not returned to its source (i.e., all groundwater). The U.S. Geological Survey (USGS) and the IJC use similar, but slightly different consumptive use definitions.

may be so severely degraded as to render it unusable, in which case the water is essentially lost to the watershed.

Two primary methods of calculating consumptive use are currently employed in the Great Lakes region: subtracting return flows from overall withdrawals and multiplying withdrawal quantities by a coefficient that reflects the percentage of water loss. This latter method is the one predominantly used in the Great Lakes-St. Lawrence River basin. Greater cooperation and coordination on the part of the Great Lakes states and provinces is needed to establish a workable methodology for calculating, measuring or estimating consumptive uses (Great Lakes Commission, 2003). A common definition along with coefficients that are agreed upon and consistently applied will be an important first step for water resource managers to begin to make professional water consumption calculations in a more uniform manner.

Most Great Lakes states and provinces estimate consumptive use at the jurisdictional level, but Wisconsin and Michigan have basic legislative authority to require consumptive use reporting by facilities. Prompted by the Great Lakes Charter of 1985, Wisconsin passed legislation in the late 1980s that requires consumptive use reporting for seven water use categories: irrigation, livestock, thermoelectric power, commercial, industrial, mining, and public water systems. Michigan requires consumptive use reporting for the self-supply thermoelectric (fossil fuel) and self-supply industrial categories only.

Voluntary facility consumptive use reporting occurs in Indiana, New York, Ohio and Pennsylvania through water use registration forms or reports for facilities that use or have the capacity to withdraw 100,000 gallons of water per day. New York and Ohio request return flow from registered facilities in withdrawal reports, and Indiana collects return flow data in initial registration forms. In Pennsylvania, the reporting of withdrawals and return flows is only requested for thermoelectric (fossil fuel and nuclear) and industrial (not including mining). Pennsylvania uses this data to calculate consumptive use, but Indiana, New York and Ohio rely on established coefficients due to concerns over its accuracy. Ontario also has some voluntary reporting by industrial facilities, and this data are used for database submissions.

The overall voluntary compliance rate for consumptive use reporting varies, which is another factor that influences whether jurisdictions use these data to calculate consumptive use or whether they rely upon consumptive use coefficients. Table F-1 describes the facility consumptive use reporting processes and applications.

Table F-1: Non-Estimated Processes for Consumptive Use Reporting by Facilities

Jurisdiction	Description	Application
Mandatory Reporting		
Michigan	Required for self-supply fossil fuel and self-supply industrial only	Submitted for database reports
Wisconsin	Required for all water use categories	Submitted for database reports
Voluntary Reporting		
Indiana	Return flow data for all facilities with the capacity of more than 100,000 gal/day included in initial registration form	Not used (concerns over accuracy)
New York	Consumption data for facilities using more than 100,000 gal/day included in withdrawal reports (public supply not included)	Not used (concerns over accuracy)
Ohio	Return flow data for self supply fossil fuel and self-supply nuclear facilities with capacity of more than 100,000 gal/day	Not used (concerns over accuracy)*
Ontario	Many industrial facilities provide data	Submitted for database reports
Pennsylvania	Return flow data included in withdrawal reports for self-supply categories of fossil fuel, nuclear and non-mining industrial	Submitted for database reports

*Although Ohio does not use this data, consumptive use for the self-supply fossil fuel category is reported by facilities, which apparently base their calculations on withdrawal and return flow data.

Source: WRMDSS 2003

Accurate and reliable water withdrawal and use data are essential in generating meaningful and defensible consumptive use figures. Currently, such data are generated by multiplying the aggregate withdrawal quantity for each use category by a category-specific coefficient.

Coefficients to estimate consumptive water use were originally developed to provide consistent consumptive use estimates in cases where information for calculating the difference between withdrawals and return flows was insufficient.

In the first report on estimated use of water in the U.S. for 1980 (USGS Circular 1001), consumptive uses were estimated by subtracting return flow and conveyance losses from withdrawals; there is no mention of coefficients. In the NWIP water use report for 1985 (USGS Circular 1004), coefficients were used for the first time to estimate consumptive use for the U.S. In the NWIP water use report for 1990 (USGS Circular 1081), consumptive use estimates are based on coefficients multiplied by withdrawals and deliveries. In the NWIP water use report for 1995 (USGS Circular 1200), the most recent report, consumptive use estimates are also based on coefficients multiplied by withdrawals and deliveries.

All consumptive use figures contained in the Great Lakes Regional Water Use Database annual reports are provided by the individual jurisdiction to the Great Lakes Commission. The reports include a table of coefficients used by each of the Great Lakes states and provinces in calculating consumptive use but do not discuss the origin or application of the coefficients by jurisdictions. The Great Lakes Commission does not use the coefficients in

any way to compile the data, which are received from the states and provinces, but does note the coefficients as a reference.

There is a paucity of records about the origins of coefficients, such as scientific or other rationale. Great Lakes states and provinces generally are unable to find documentation, either published or unpublished, to validate the coefficients that they have adopted. Most jurisdictions employ coefficients based on the USGS research or work done by the Great Lakes Commission's Technical Work Group of the Water Resources Management Committee, which was established in 1988. This work group was charged with developing uniform estimation procedures for water withdrawal and consumptive use information.

Notwithstanding the lack of documentation or scientific basis for the consumptive use coefficients, state and provincial officials generally believe that the coefficients are worthwhile for providing a sense of consumptive use lost to various water uses. However, the way states use this information is different and sometimes inconsistent. Officials generally agree that all Great Lakes jurisdictions should use consistent coefficients for making Great Lakes water resource policy decisions.

While the use of coefficients does provide valuable information, confidence in their application is often limited. For example, coefficient-calculated consumptive use data may not be accurate at a site-specific level and is more useful at a larger scale. Consumptive use data are most reliable when they are based on measured, location-specific withdrawals and return flows. Obtaining credible, location-specific consumptive use data will require substantial commitments of time and resources in all Great Lakes jurisdictions.

Some of the larger water withdrawal categories use the same coefficients for many types of distinct activities that, in reality, have very different consumption characteristics. Similarly, there is great variability among the types of uses in the self-supply domestic and livestock categories, suggesting that a single coefficient for each category may be inadequate in determining actual consumptive use.

Where actual measurements of withdrawals or return flows/discharges are not feasible, such as for irrigation, livestock and rural uses, other reliable methods for calculating or estimating consumptive uses must be developed and applied. Current consumptive use coefficients cannot be validated by existing data and information and, due to the variance in use of coefficients among Great Lakes jurisdictions, data comparability can be problematic. (Great Lakes Commission, 2003)

Systematic methods need to be developed to estimate consumptive uses for those categories where direct measurements are not possible.

In response to this, the following has been determined:

Task: The USGS, in cooperation with regional, state and provincial authorities needs to develop a systematic method for estimating consumptive use for those water use categories where direct measurements are not possible.

Demand Forecasting

Water supplies and future water demand within and out of the Great Lakes-St. Lawrence River basin remain uncertain. Water demand forecasting has been shown to be a useful tool in reducing this uncertainty and in aiding the regional management of the Great Lakes water resources. (International Joint Commission, 2000)

The Great Lakes Charter (1985) also acknowledges the need for future water use demand assessments to guide future development, management and conservation of the water resources of the Great Lakes basin. The Charter recognizes that a key element of a Great Lakes basin water resources program is the "identification and assessment of existing and future demands for diversions, into as well as out of the Basin, withdrawals, and consumptive uses for municipal, domestic, agricultural, manufacturing, mining, navigation, power production, recreation, fish and wildlife, and other uses and ecological considerations." (Great Lakes Charter, 1985)

Presently, five of the ten Great Lakes jurisdictions (Illinois, Minnesota, Ohio, Ontario, and Pennsylvania) have employed demand forecasting in their water management programs. Table F-2 below describes the status of demand forecasts within these five jurisdictions.

Table F-2: Jurisdiction Demand Forecasting Efforts

Jurisdiction	Demand Forecasting Efforts
Illinois	The DNR does demand forecasting every 8 to 10 years, at which time the long-term demands of all permittees is reevaluated for a 20 to 40 year period.
Minnesota	Demand forecasting is done for the Twin Cities Metro Area, but not statewide. Projections of water demands are required for new permit requests.
Ohio	The state periodically produces regional water plans that include water use demand forecasting. The most recent forecasts were done in 1988 for northeast Ohio and 1986 for northwest Ohio. Other forecasts were done in the 1970s.
Ontario	Currently, MNR, MOE, Conservation Authorities and Environment Canada are involved in a multi-year study on water use and supply in the Ontario portion of the Great Lakes basin. This study includes demand forecasting. Previous demand forecasting has been undertaken at irregular intervals by the federal government
Pennsylvania	Demand forecasting is done for public water supply systems on a five to ten year basis with 50-year projections. The last demand forecasts were made in 1995 using the 1990 U.S. Census. With the assistance of the Pennsylvania State Data Center, the Division of Water Use Planning projects municipal populations for counties, which are applied to public water supply service areas with a system per capita usage.

Factors influencing the outcomes of demand forecasts include future economic activity, population growth, technological advances, and climate change, among others (Great Lakes Commission, 2003)

Climate change is a key example of an influential factor for which the future impacts in the Great Lakes basin are not well known and debated among experts. Predicting climate change impacts in a specific geographic location is particularly difficult given the current

uncertainty associated with the state of the science. However, several general conclusions were presented in a 2002 report commissioned by the province of Ontario (International Joint Commission, 2003):

- climate change will enhance natural climatic variability;
- average temperatures in North America will rise between 2 to 7 degrees Fahrenheit, and
- changes in the atmosphere associated with climate change are beginning to affect the hydrologic cycle.

Collaborative research with Environment Canada and NOAA show a lowering of water levels of up to one meter (3.28 feet), which may result in serious social, economic and environmental impacts. Climate change is a slow process and may have long-term adverse effects on water availability. Scientific understanding of global climate change must be integrated in long-term water demand forecasts as it evolves.

Well-developed demand forecasts can provide crucial information to planners and policymakers. The indications these forecasts provide about where water demand is likely to increase and where financial and other resources may need to be applied help define priority areas. Without an understanding of where and how strong future demand is likely to be, planners and policymakers will have difficulty developing and implementing effective and comprehensive water management programs that include elements such as targeted water conservation and drought contingency planning.

However, for purposes of regional water use planning and management, the weaknesses of current demand forecasting must be recognized. A number of factors used in developing demand forecasts contain elements of uncertainty that constrain the final result. This uncertainty is reflected in the range between high and low projections that result from the forecasts and in the need to run the forecasting model through a variety of future scenarios as a means of accommodating the various factors. Because uncertainty increases as the time period of the projection increases, forecasts typically project no more than ten years into the future. This presents a challenge to water managers who handle projects with planning horizons beyond ten years. More sophisticated forecasting approaches which more accurately address factors that contribute to uncertainty would benefit water management at all levels.

Among the weak factors in demand forecasting is the accuracy of current water use data, which forms the basis of the entire process. Varied in scope and quality, water use data are dependent on the collection and compilation processes of individual jurisdictions. Some regional and local jurisdictions have experienced resource cuts which hamper their water use data collection programs, leaving demand forecasters to look to less detailed federal and state/provincial programs for the data necessary to run their models.

Demand forecasting as an activity has also suffered from a lack of financial and programmatic support at the jurisdictional level, indicating that a stronger federal presence in the area of demand forecasting is necessary and should be integrated with the NWUIP to ensure a consistent and uniform approach to both data and modeling on a regionwide level.

Many of the limitations and weaknesses of demand forecasting as a tool could be reduced or eliminated by a comprehensive federal program to support local water use data collection and reporting programs, standard requirements for the ancillary information necessary to integrate water use data from multiple jurisdictions (metadata), and local land use and planning data.

Detailed water use data are best acquired at the local level, but this work may be hampered by budget cuts or other resource issues that could be alleviated through federal support. At the same time, standard metadata requirements would ease the process of integrating data from multiple jurisdictions, allowing the development of better forecasting models for metropolitan areas, full watersheds and other larger extents. And finally, data on current and future land use, the latter shown by local community master plans, will become crucial to effective demand forecasting over longer time spans and for more sensitive regions. Land use is a significant indicator of water use, so much so that as methodologies are broadened and improved to incorporate concrete information about likely future use and development patterns, demand forecasts will become more accurate and will be applicable over a longer time span.

Consistent demand forecasts of water withdrawals and uses for all USGS major watersheds in the Great Lakes-St. Lawrence basin do not exist, compromising the ability to predict ecological impacts of cumulative water withdrawal.

In response to this, the following task has been determined:

Task: The USGS needs to coordinate development of consistent demand forecasts of water withdrawals and uses for all USGS major watersheds in the Great Lakes-St. Lawrence River basin at the state and local levels, including integration current and projected land use information.

Federal Programs and Databases Relevant to Water Withdrawal and Use

With this brief explanation of the history and workings of the water use data and information programs in the Great Lakes region, a discussion of the current federal presence and role in these programs will be important to help discern what the ideal federal role will be to support Great Lakes water resources decisionmaking through water use data collection and reporting programs. Numerous federal agencies have a strong mission-driven interest and technical expertise in areas related to water withdrawal and use. These interests include planning, management and regulatory responsibilities associated with water use. Following are brief summaries of federal programs dealing with water withdrawal and use data and information.

Water Quality Programs

It is important to integrate the NWUIP with other relevant federal programs especially the National Water Quality Assessment Program (NAWQA) and the Great Lakes Aquatic Gap Analysis Program (GAP) coordinated by USGS.

The NAWQA Program has been existence since 1991. Since the inception of the program, USGS scientists working with the NAWQA program have been collecting and analyzing data and information in more than 50 major river basins and aquifers across the Nation. The goal is to develop long-term consistent and comparable information on streams, ground water,

and aquatic ecosystems to support sound management and policy decisions. The NAWQA program is designed to answer the following important questions:

- What is the condition of our nation's streams and ground water?
- How are these conditions changing over time?
- How do natural features and human activities affect these conditions?

NAWQA studies that have been completed in the Great Lakes-St. Lawrence River basin include the Western Lake Michigan Drainages Study, the Lake Erie-Lake St. Clair Drainages Study and the Upper Illinois River Drainages Study.

Currently, the relationship between NAWQA and NWUIP is limited. The ability to link the water quality issues with the water supply management issues will be a key point to the understanding of how water withdrawal and use proposals will impact the Great Lakes basin ecosystem.

The Great Lakes Aquatic GAP program is underway for the riverine and coastal systems of the Great Lakes region. The Great Lakes, as the largest system of fresh water on earth, provide habitat for a wide variety of aquatic organisms unique to these systems. The aquatic biodiversity of the region is being threatened due to urban expansion, more intensive agricultural practices, continued logging, coastal zone shoreline destruction, and other human activities.

The goal of the Great Lakes Aquatic GAP Program is to evaluate the biological diversity of aquatic species and their habitat, and to identify gaps in the distribution and protection of these species and their habitats within the Great Lakes basin. This information will provide managers, planners, scientists, and policy makers with the information they need to identify priority areas for conservation before a species is threatened or endangered. The objectives of the Aquatic GAP are to:

- Develop maps of ecoregions by drainage units in a GIS framework,
- Provide hierarchical habitat classifications schemes for riverine and coastal habitat, and
- Collect and build aquatic biological databases.

The feasibility for conducting an Aquatic Gap for both riverine and coastal systems was assessed by summarizing the status and availability of existing data for the Great Lakes states, including aquatic biological data (fish, freshwater mussels, benthos), and spatial data layers related to physical characteristics of land, in-stream, and coastal habitats. Stakeholders were identified and contacted for their input. An integrated approach is being developed in which common methods and protocols will be established and results will be comparable across the landscape. The Aquatic GAP provides an important link between the biological data and the physical data necessary to make informed water resources decisions under Great Lakes Charter Annex.

Regulatory Programs

The U.S. Army Corps of Engineers (USACE) has a well-defined interest in water use activities in support of its national water resources planning and management responsibilities. As part of these responsibilities, the Corps also regulates water use,

including the construction of water withdrawal structures, dams and impoundments in navigable waterways. The role of the USACE in water use has traditionally been focused on municipal, industrial, hydropower and navigational-related uses. The U.S. Environmental Protection Agency (EPA) also has strong interest in water use from a regulatory perspective because it is the primary federal agency regulatory drinking water and wastewater discharges. The U.S. EPA's traditional interest has been through programs such as wellhead protection and source water protection that focus on risk management. The Safe Drinking Water Act is the primary legislative vehicle through which these programs are carried out.

Public Water Supply
The U.S. EPA has compiled a Safe Drinking Water Information System (SDWIS) to support the Safe Drinking Water Act. This database covers all public water supply systems in the United States serving at least 25 people or 15 connections on a year-round basis. The USGS collaborates with the USEPA on this effort by providing location information for surface and intakes and groundwater withdrawal locations documented in the SDWIS. For more information contact: http://www.epa.gov/safewater/sdwisfed/sdwis.htm.

Wastewater Discharge Databases
The U.S. EPA maintains a Permit Compliance System (PCS) to document information on facilities that have permits to discharge wastewater into rivers. This system contains information on the life of the permit, the permitted discharge and discharge monitoring data. Wastewater discharge data may be useful in estimating water uses particularly in the industrial category.

Energy Generation Facilities
The Energy Information Administration (EIA) manages extensive databases on locations and characteristics of energy generation facilities in the United States. This information includes monthly time series information on electricity production at power plants. These consistent national data are useful to support the estimation of water use for power generation by nuclear and fossil fuel thermoelectric power plants.

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. The FERC also maintains databases for power plants as part of its regulatory mandate for natural gas and hydropower projects. The FERC's responsibility in the area of hydropower includes:

- The licensing and inspection of private, municipal, and state hydroelectric projects;
- The oversight of environmental matters related to hydroelectricity projects and major electricity policy initiatives; and
- The administration of accounting and financial reporting regulations and conduct of regulated companies.

Hydropower
The federal government provides information on hydropower to the states and provinces that compile this information for the Great Lakes Regional Water Use Database. On the U.S. side, this information is provided by the USACE acting as an agent for the International Joint Commission (IJC) which oversees the Boards of Control for the St. Lawrence River and Lake Superior.

The IJC was created under the Boundary Waters Treaty of 1909 to help prevent and resolve disputes over the use of waters along the Canada-United States boundary. Its responsibilities include approving certain projects that would change water levels on the other side of the boundary. If it approves a project, the IJC's Orders of Approval may require that flows through the project meet certain conditions to protect interests in both countries. Hydropower development in the international reach of the St. Lawrence River is one such project.

The International St. Lawrence River Board of Control was established by the IJC in its 1952 Order of Approval. Its main duty is to ensure that outflows from Lake Ontario meet the requirements of the IJC's order. The Board also develops regulation plans and conducts special studies as requested by the IJC.

Water empties from Lake Ontario into the St. Lawrence River and passes through the hydropower project near Cornwall, Ontario and Massena, New York. The IJC approved this project in 1952. During construction, the IJC amended its order of approval with the concurrence of the United States and Canadian Governments. The 1956 amendments added requirements to reduce the range of Lake Ontario water levels, and to provide dependable flow for hydropower, adequate navigation depths and protection for shoreline and other interests downstream in the Province of Quebec.

Lake Ontario outflows have been regulated since 1960, primarily through the Moses-Saunders power dam near Cornwall and Massena, about 100 miles from the lake. This facility is jointly owned and operated by Ontario Hydro and the New York Power Authority. Another dam, located near Long Sault, Ontario, acts as a spillway when outflows are larger than the capacity of the power dam. A third structure at Iroquois, Ontario, is principally used to help to form a stable ice cover and regulate water levels at the power dam.

The International St. Lawrence River Board of Control has ten members, five each from the United States and Canada. Members serve in both their personal and professional capacities. The current United States Section chair of the Board is from the USACE, while other U.S. members are from the New York Power Authority, the New York State Department of Environmental Conservation and the Rochester Institute of Technology, and one independent engineer. The current Canadian Section chair is from the Canadian Coast Guard, while other Canadian members are from Ontario Hydro, Quebec Ministry of Environment and Environment Canada, as well as the mayor of a downstream community.

The Lake Superior Board of Control was established by the IJC in its 1914 Order of Approval granting permission for increased hydropower development in the St. Marys River. The Board's duties include setting Lake Superior outflows, and overseeing the operation of the various control works. Activities related to these responsibilities include:

- conducting studies to develop and improve the regulation plan;
- monitoring repairs and maintenance of the control facilities; and
- directing flow measurements in the St. Marys River for the purpose of determining the discharge capacities of the various control works.

Water flows out of Lake Superior through the St. Marys River into Lake Huron and Lake Michigan. Near the cities of Sault Ste. Marie, Michigan and Ontario, the St. Marys River falls about 20 feet in a distance of 0.75 mile as it passes the St. Marys Rapids. Since 1797, when

the first lock was built to allow boats to bypass these rapids, various navigation and power structures have been constructed along the river.

Today, the water from Lake Superior flows through a collection of structures that stretch across the river. These works include three hydropower plants, five navigation locks, and a gated dam at the head of the rapids known as the Compensating Works. The release of water from Lake Superior through the various structures has been completely regulated since the completion of the Compensating Works in 1921.

The International Lake Superior Board of Control is a two-member board, one from each the United States and Canada. The member for the United States is from the USACE, while the member for Canada is with Environment Canada.

Agricultural Databases

One important large category of water withdrawal that is not federally regulated at the individual water use site is irrigated agriculture (National Research Council, 2002). Several large national databases help to partially address this data need.

Census of Agriculture

Every five years, the U.S. Department of Agriculture (USDA) compiles information on national agricultural activities as part of a Census of Agriculture (http://www.nass.usda.gov/census/) (National Research Council, 2002). As part of the census, irrigated agriculture is estimated for every county in the United States.

Farm and Ranch Irrigation Survey (FRIS)

This survey is also conducted by the USDA the year following the Census of Agriculture. It provides supplemental data on irrigation water use by source (groundwater, on-farm surface water and off-farm), water application type, and irrigation practices (http://www.nass.usda.gov/census/census97/fris/fris.htm). The stratified random sample design of the FRIS provides rigorous confidence limits on estimated quantities of water (National Research Council, 2002).

National Resource Inventory (NRI)

The NRI is a statistical survey designed to help gauge natural resource status, conditions, and trends on the nation's nonfederal land. Nonfederal land includes privately owned lands, tribal and trust lands, and lands controlled by state and local governments. (see http://www.nrcs.usda.gov/technical/land/nri01/). The NRI has been conducted every 5 years since 1977, but today it is in transition to a continuous, or annual, inventory process. This shift helps align the NRI with the need for timely information to support agricultural and conservation policy development and the assessment of the impacts of policy choices and conservation program implementation.

For the Annual NRI, data are gathered for a scientifically selected subset of the 800,000 sample sites that were established for previous NRIs. This sub-sample includes a set of "Core" sample sites, which are sampled each year, and "Rotation" (or "supplemental") sample sites that vary by inventory year and allow an inventory to focus on an emerging issue. Additional on-site data gathering is conducted for items that cannot be determined remotely, to establish baseline conditions, and for quality assurance purposes.

The 2001 Annual NRI is the first of the annual NRI releases and presents national level estimates for land use, soil erosion, and urbanization and development status and trends on nonfederal lands in the contiguous United States. Subsequent Annual NRIs will provide a broader spectrum of results – additional topics, and estimates at additional geographic levels (regional, then state-level, and eventually sub-state).

Status and trend estimates on wetlands and irrigated cropland are not available in the 2001 Annual NRI. Changes in wetlands and irrigation occur on a very small portion of the landscape; therefore data from several inventory years must be assimilated and analyzed in order to present estimates that meet statistical standards and that are scientifically credible in accordance with NRCS policy and Office of Management and Budget (OMB) and USDA Quality of Information Guidelines. In the interim, the 1997 NRI estimates remain the best available, nationally consistent information on irrigated cropland and wetlands status and trends.

Other Relevant U.S. Federal Data Programs

Census Data
The Bureau of the Census which is part of the U.S. Department of Commerce provides high quality data about the nation's people and the economy. Decadal population data provided by the Bureau of the Census is critical to providing estimates for certain water uses.

The North American Industry Classification System (NAICS), which is part of the U.S. Bureau of the Census, has replaced the U.S. Standard Industrial Classification (SIC) system. NAICS was developed jointly by the U.S., Canada, and Mexico to provide new comparability in statistics about business activity across North America. The first glimpse of data based on NAICS 2002 will be published in early 2004 in the *2002 Economic Census: Advance* report. That report will provide information on employment, payroll, receipts, and number of establishments using both NAICS 2002 and NAICS 1997 at the sector and subsector (2- and 3-digit NAICS) levels. Beginning in early 2004, industry and geographic data will be published on a NAICS 2002 basis only. These reports will provide NAICS 2002 data down to the six-digit U.S. industry detail level.

Hydrologic Unit Classifications and Geographic Information Systems (GIS) Data
Hydrologic unit boundaries define the areal extent of surface water drainage to a point. The goal of classifying hydrologic boundaries is to provide a hydrologically correct, seamless and consistent national GIS database at a scale of 1:24,000, that has been extensively reviewed and matches the USGS topographical 7.5 minute quads. The levels are called watershed (5th level, 10-digit) and subwatershed (6th level, 12-digit). An estimated 22,000 watersheds and 160,000 subwatersheds will be mapped to the 5th and 6th level. The GIS coverages will be available by the Internet to the public. The database will assist in planning and describing water use and related land use activities.

During the 1970's the USGS developed a hierarchical hydrologic unit code (HUC) for the United States. This system divides the country into 21 Regions, 222 Subregions, 352 Accounting Units, and 2,149 Cataloging units based on surface hydrologic features. During the late 1970's the NRCS initiated a national program to further subdivide HUCs into

smaller watersheds for water resources planning. A 3-digit extension was added to the 8-digit I.D. By the early 1980's this 11-digit HUC mapping was completed for most of the U.S. During the 1980's several NRCS state offices starting mapping watersheds into subwatersheds by adding 2 or 3-digits to the 11-digit HUC. By the late 1980's and early 1990's the advent of GIS made the mapping of digital HUC boundaries feasible. At this time, the NRCS decided to delineate and map the entire U.S. to the 11 and 14-digit level.

Over the last several years many federal and state agencies have realized current 8-digit HUC maps are unsatisfactory for many purposes, because of inadequate bases or scales. Because of this, the NRCS has continued to work with other federal and state agencies to establish a federal interagency standard covering mapping and delineation of hydrologic units that would be suitable for all agencies.

Canadian Federal Water Withdrawal and Use Data Programs

There are four main federal data sets that are relied on by the Province of Ontario in the conduct of its water withdrawal and use data collection and reporting program. These include Population Census and Agricultural Census data from Statistics Canada, Environment Canada's Municipal Water Use Database (MUD), and a joint collaboration by Statistics Canada and Environment Canada on the Industrial Water Use Survey.

The MUD was initially started in 1975. It has been updated every two to three years since 1989, with 1999 being the most recent publication. It is a survey of municipalities serving a population greater than 1,000, with information being provided on topics such as water supply, use, wastewater treatment and sewer use. Although the data are reliable, it still only covers municipalities greater than 1,000 people. In Ontario that covers approximately 90% of the population. However, the lack of information for smaller municipalities requires the provincial government to estimate water use for this sector.

The Agricultural Census is collected every five years concurrently with the Population Census. It became a national survey in 1956, collecting information on the rapidly growing sector. Data are collected at the local level referred to as Census Subdivisions. Due to sensitivity issues, this data are not available to most authorities in the country. Data from this source is used to report Irrigation and Livestock water uses. The Aquaculture sector is not a part of the survey.

The Population Census is a survey of all population and dwelling counts in the country. It is collected for cities and municipalities to develop a picture of demographic characteristics. This data are used along with the MUD use survey data to estimate where needed, public and self supply domestic water use.

The Industrial Water Use Survey is a survey conducted every five years by Environment Canada. It began in 1976, with an agreement with Statistics Canada under the Federal Statistics Act. The Survey was discontinued after 1996, but discussions are now underway to rebuild and continue the program. The survey collected information on water use volumes, water treatment and type of uses. It is mailed to establishments falling in the manufacturing, mining and power sectors. Since this is the only source for industrial water use data, Ontario is hopeful that the survey will start back up again in the near future.

A main observation in regard to each of these data sets is that they are collected at five year intervals except the MUD data which is every two to three years. In terms of water use data reporting requirements, this forces Ontario to estimate water use by using best assumptions between report years.

The U.S. Federal Role in Water Use Data Collection and Reporting

Many agencies, organizations, users and consumers, such as federal, state local and regional water management agencies, policymakers, scientists, educators, business and industry employ data on water use. Water supply planning is critical to the understanding and the management of uncertainty related to the complex web of issues surrounding water withdrawal, conveyance, distribution, application, discharge and reuse. There is a need for a federal role in water supply management related to water withdrawals and use programs because the national water supply is finite and there is growing competition for a limited resource. The federal role in the Great Lakes-St. Lawrence River region seems even more obvious.

The Great Lakes are an international resource and considered the greatest freshwater system on Earth. The Great Lakes, their connecting channels and the St. Lawrence River provide the region's eight states and two provinces with high quality fresh surface water. The Great Lakes influence and are inseparably linked to the region's environmental health, economic prosperity and quality of life and play an important role in advancing and sustaining regional, national and international economies. The Great Lakes ecosystem is fragile, and even minor physical, chemical or biological changes can individually and cumulatively have lasting implications for the conservation, protection and use of the resource (Great Lakes Commission, 2003).

While in-basin demand for Great Lakes water has remained fairly constant over the past fifteen years, uncertainty associated with long-term trends in lake level fluctuations, potential increases in water demand due to population and industrial growth and regional consequences of global warming has challenged the region to do a better job of compiling and reporting the data and information necessary for informed decisionmaking (Great Lakes Commission, 2003). All of these issues speak to the need for a strong federal presence in the area of water use data collection and reporting.

In the development of the plan presented in the body of this report, four options have been considered with an accompanying evaluation of what the status of the various programs and the commitment of the federal government will be for each option.

Implementation Alternatives – Water Withdrawals and Use

Tasks for improving the information base related to water use data collection and reporting are presented in this section. These tasks are defined within a comprehensive framework of identifying the U.S. federal role in creating and maintaining water use information to support science-based decisions on water withdrawals and diversions. Each task is defined at different levels of implementation under the USACE plan formulation approach. This approach is used to develop systematic alternative plans that Congress could consider for supporting the states' Great Lakes Charter Annex decisionmaking process.

Five implementation options are presented, each as a separate integrated approach. This, however, is not an exclusive list and does not represent an "all or nothing" approach. Individual elements from one option could be pulled out and funded separately, making an important contribution to Great Lakes - St. Lawrence River basin information base. Even modest increases in funding over the "Without Plan" option can enhance decisionmaking. Water resources managers should examine each particular integrated plan option as well as individual findings to discern where important progress can be made.

Described below are five implementation alternatives considered:

- **Without Plan** – Describes the status of the recommended activity as it currently exists. Without change, this current status may actually decline, representing negative impacts. If negative impacts are expected, they are highlighted wherever possible.

- **Minimum Investment** – Describes the least costly measures needed to insure minimum functionality of the decision support system. Not all system components of an implementation plan are included in this option.

- **Selective Implementation** – Describes an integrated system comprised of prioritized components. Few components are fully funded, but no essential components are excluded.

- **Enhanced Implementation** – Describes an integrated system that includes all essential components at funding levels which enhance information accuracies and decision support system functionalities.

- **Full Implementation** – Describes an integrated system that fully implements the recommended activity. Technical staff and financial resources are not restricted. Information accuracies and completeness approaches state-of-the science.

Due to the interdependent nature of many issues described in the appendices, some findings may be repeated in total or in part elsewhere in another appendix. The interdependence of findings is noted explicitly in the appendices wherever appropriate.

A dollar value has been estimated for the four potential alternatives that require additional investment over a 10-year implementation schedule. Monetary value is based on the best available information through extensive research and review by project collaborators and is presented in 2004 U.S. dollars. Further information is provided in Appendix K – Cost Estimation, including an analysis of the uncertainty associated with these estimates.

Comparisons of costs at various implementation levels provide a useful measure of investment versus return. It is important to remember that the primary objective of all investments is to reduce uncertainties associated with decisionmaking. Since the hydrology, climatology, geology and biology of the Great Lakes – St. Lawrence River system is highly complex, reductions in uncertainty are sought for each task outlined for the integrated information system.

The definition of the individual tasks outlined in this report has sought to eliminate "double-counting" as much as possible. Costs for the various tasks also explicitly address any interdependencies that occur under a particular implementation alternative. Cost estimates for each task under each implementation alternative also reflect anticipated economies of scale.

Risk and Uncertainty

Risk and uncertainty are inherent aspects of all facets of an integrated information system for water management of the Great Lakes – St. Lawrence River system. Risk can be viewed relative to human and aquatic health, to real property, to the ability to attain profit from a commercial venture, or to relative benefits that can be attained at given investment levels.

The integrated information system described within this report, once improved above current conditions, has a very low likelihood of adverse risk to human health, life or personal property. It is simply a monitoring, modeling and predictive system that does not include significant physical structures or construction. The converse does apply however; continued financial stressors on the monitoring system can cause atrophy of monitoring abilities which could, in turn, mask physical, chemical and biologic change to natural streamflow throughout the system.

Risk is also factored in throughout this report related to the prospective reward or benefit attained at increasing levels of investment. Each task in the integrated information system is evaluated in terms of cost effectiveness, whenever practical. This discussion is addressed in detail in the Main Report, although each appendix includes detailed information on the risk/return for each task under each implementation alternative.

Uncertainty is pervasive throughout the design, implementation and operation of any integrated water management system. At the current level of investment in groundwater, surface water and open lake monitoring and modeling, cumulative withdrawals from headwater systems can not be detected, measured or adequately estimated. Hence, the uncertainty of cumulative hydrologic effects is extremely large under the Without Plan and Minimum Investment alternatives. Even under the Full Implementation alternative, uncertainty will continue to exist, albeit at a much lower level. This uncertainty would be accompanied, however, with an accurate error budget including almost all hydrologic and biologic factors, which currently does not exist.

The analytical functions of the integrated information system will generally have reduced uncertainties as funding increases from one implementation alternative to the next. In addition, these uncertainties can be computed with greater confidence as more investment is made in the monitoring frame and computer modeling. The legal defensibility of permitting water withdrawal improves as uncertainty is reduced, in part or in total.

Integrated Information System Tasks

Tasks 26-32 described in this appendix present an integrated approach towards collecting and managing information on water use data and information for the Great Lakes - Lawrence River system. It is important to see these tasks as "building blocks" for the integrated information system. Improvements under any specific task will provide incremental benefit, but the sum of the parts provides the greatest opportunity for reducing uncertainties under each implementation alternative. These tasks are repeated below.

Task 26: The USGS needs to strengthen the National Water Use Information Program (NWUIP) and integrate this program with other related federal programs to support implementation of the Great Lakes Charter Annex.

Task 27: The USGS, in cooperation with regional interests, needs to implement periodic reporting of water withdrawals and use for the Great Lakes-St. Lawrence River basin.

Task 28: The USGS, in cooperation with regional, state and provincial authorities, needs to define and implement metadata standards to improve knowledge of inherent uncertainties in water use and withdrawal data for the Great Lakes – St. Lawrence River basin.

Task 29: The USGS, in cooperation with regional, state and provincial authorities needs to improve estimation techniques of water withdrawal and use for surface and groundwater whenever direct measurements are unavailable to support Great Lakes Annex decisionmaking.

Task 30: The USGS needs to work collaboratively with regional, state and provincial authorities to implement direct measurements of water withdrawal and use, wherever technically feasible and implementable, to support decisionmaking under the Great Lakes Charter Annex.

Task 31: The USGS, in cooperation with regional, state and provincial authorities needs to develop a systematic method for estimating consumptive use for those water use categories where direct measurements are not possible.

Task 32: The USGS needs to coordinate development of consistent demand forecasts of water withdrawals and uses for all USGS major watersheds in the Great Lakes-St. Lawrence River basin at the state and local levels, including integration current and projected land use information.

Implementation Mechanisms and Costs

The proposed approaches/mechanisms for implementing the tasks and associated costs are provided below for each of the five implementation alternatives considered. The U.S. federal agency which has the assigned mission responsibility for implementing these activities is identified, whenever clear. If potential overlap occurs between U.S. federal agencies in mission responsibilities, one is proposed over the other based on perceived technical or administrative competencies to complete the necessary work within budget and schedule.

Task 26: The USGS needs to strengthen the National Water Use Information Program (NWUIP) and integrate this program with other related federal programs to support implementation of the Great Lakes Charter Annex.

Without Plan (26) – The USGS NWUIP will continue to receive limited federal funding.** Inconsistent information on water withdrawals and uses will continue due to differing levels of cooperation by states, inside and outside of the Great Lakes region. Incomplete, non-uniform and unreliable information will continue to be the norm, compromising science-based water resources management decisions to implement Great Lakes Charter Annex.
Minimum Investment (26) – Change existing authorities to increase the federal funding to ensure effective operation of NWUIP in each USGS state district in the Great Lakes basin. Additionally, this will ensure consistent and uniform water withdrawal and use information within the region. The cost for this action is estimated to be $1 M over ten years, with commensurate per annum funding thereafter.

Selective Implementation (26) **–** Change existing authorities to increase the federal funding by 250% to ensure effective operation of NWUIP in each USGS state district in the Great Lakes basin. Additionally, this will ensure consistent and uniform water withdrawal and use information within the region. The cost for this action is estimated to be $16 M over ten years, with commensurate per annum funding thereafter.

Enhanced Implementation (26) – Change existing authorities to increase federal funding by 375% to ensure participation of all Great Lakes states in the NWUIP. Also, provide pass-through funding to the Great Lakes Commission to coordinate and expand state program infrastructure and facilitate linkages with other federal programs including the North American Water Quality Assessment (NAWQA) program, the Gap Analysis Program (GAP). These actions would coincide with increased withdrawal monitoring and improved estimation under related tasks. The estimated cost for this program is $32 M over ten years, with commensurate per annum funding thereafter.

Full Implementation (26) – Change existing authorities to increase federal funding by 500% to ensure participation of all Great Lakes states in the NWUIP. Also, provide pass-through funding to the Great Lakes Commission to fund state program infrastructure and facilitate linkages with other federal programs, including the North American Water Quality Assessment (NAWQA) program and the Gap Analysis Program (GAP). These actions would coincide with increased withdrawal monitoring and improved estimation under related tasks. The estimated cost for this program is $60 M over ten years, with commensurate per annum funding thereafter.

Footnotes (26)
**Current budget of NWUIP is $4 M, or $ 80,000 for each USGS state district office.

Task 27: The USGS, in cooperation with regional interests, needs to implement periodic reporting of water withdrawals and use for the Great Lakes-St. Lawrence River basin.

Without Plan (27) – Without additional funding, periodic water use updates will not occur.

Minimum Investment (27) – Provide authority to the USGS to work in partnership with the Great Lakes Commission to report water withdrawal and use within the Great Lakes basin annually, with pass-through funding to the Great Lakes states to build infrastructure. The estimate cost for this program is $2 M over 10 years, with commensurate funding per annum thereafter.

Selective Implementation (27) – Provide authority to the USGS to work in partnership with the Great Lakes Commission in support of annual reporting of water withdrawal and use within the Great Lakes basin, with pass-through funding to the Great Lakes states to build requisite infrastructure. The estimate cost for this program is $5 M over 10 years, with commensurate funding per annum thereafter.

Enhanced Implementation (27) – Provide authority to the USGS to work in partnership with the Great Lakes Commission in support of annual reporting of water withdrawal and use within the Great Lakes basin, with pass-through funding to the Great Lakes states to build requisite infrastructure. The estimate cost for this program is $10 M over ten years, with commensurate funding per annum thereafter.

Full Implementation (27) – Provide authority to the USGS to work in partnership with the Great Lakes Commission in support of annual reporting of water withdrawal and use within the Great Lakes basin, with pass-through funding to the Great Lakes states to build requisite infrastructure. The estimate cost for this program is $10 M ** over ten years, with commensurate funding per annum thereafter.

Footnotes (27)
** The reason why the costs of partial and full implementation option are the same is as follows; if investment in quality data are high, the costs of reporting may go down.

Task 28: The USGS, in cooperation with regional, state and provincial authorities, needs to define and implement metadata standards to improve knowledge of inherent uncertainties in water use and withdrawal data for the Great Lakes – St. Lawrence River basin.

Without Plan (28) – Documentation of water use data and information will continue to be highly variable from state to state resulting in inconsistencies and a lack of scientific rigor. The resulting poor quality data will contribute to indefensible water withdrawal decisions under Great Lakes Charter Annex.

Minimum Investment (28) – No additional investment considered.

Selective Implementation (28) – Develop metadata standards for water use and withdrawal data for all water use categories and all Great Lakes states at a cost of $500 K over two years.

Enhanced Implementation (28) – Provide authority to the USGS to require state compliancy to federal metadata standards for water withdrawal and use data at a 50-50 cost-share with the states to implement this program at the estimated federal cost of $2 M over ten years, with commensurate per annum funding thereafter.

Full Implementation (28) – Provide authority to the USGS to require state compliancy to federal metadata standards for water withdrawal and use data. This authority would be 100% federal funded, with pass-through to the states. The estimated cost for this program would be $4 M over ten years, with commensurate per annum funding thereafter.

Task 29: The USGS, in cooperation with regional, state and provincial authorities needs to improve estimation techniques of water withdrawal and use for surface and groundwater whenever direct measurements are unavailable to support Great Lakes Annex decisionmaking.

Without Plan (29) – The quality of water use data will continue to be low especially for those categories that rely on estimation rather than direct measurement. The reliability of estimated data will show little improvement as estimation techniques are varied and untested, with no single approach identified and recommended to implement the Great Lakes Charter Annex.

Minimum Investment (29) – Undertake a systematic comparison of water use estimation methods in the Great Lakes states for all categories of use where estimation is currently utilized. The USGS would need to develop a manual of procedures including the definition of statistical sampling approaches to improve estimation techniques at a cost of $1 M over two years.

Selective Implementation (29) – Provide authority to the USGS to implement periodic estimations of water withdrawal for the livestock, irrigation, self-supplied domestic and other use categories, and withdrawals not directly measured for public water supplies uses below the state registration level of 100,000 gal/day. This program would require pass-through funding to the Great Lakes states. The estimated cost for this program is $4 M over ten years, with commensurate per annum funding thereafter.

Enhanced Implementation (29) – Provide authority to the USGS to implement periodic estimations of water withdrawal for the livestock, irrigation, self-supplied domestic and other use categories, and withdrawals not directly measured for electric power facilities, public water supplies, and industrial uses below the state registration level of 100,000 gal/day. This program would require pass-through funding to the Great Lakes states. The estimated cost for this program is $10 M over ten years, with commensurate per annum funding thereafter.

Full Implementation (29) – The full implementation option considers that all withdrawals above the state registration level of 100,000 gal/day would be measured directly. Development of appropriate estimation techniques and annual reporting would still be needed for cumulative withdrawals below the state registration level. This program would be 100% federally funded with pass through to the Great Lakes states at a cost of $20 M over ten years, with commensurate per annum funding thereafter.

Task 30: The USGS needs to work collaboratively with regional, state and provincial authorities to implement direct measurements of water withdrawal and use, wherever technically feasible and implementable, to support decisionmaking under the Great Lakes Charter Annex.

Without Plan (30) – Currently water withdrawal and use data are at least partially measured for the public water supply, thermal-electric, thermal-nuclear, hydroelectric power, and industrial categories. Without additional authority and funding, improvements in direct measurements of these categories will not occur.

Minimum Investment (30) – No additional investment considered.

Selective Implementation (30) – Require that all facilities in the public water supply and power generating facilities to measure and report withdrawals from surface and groundwater above the state registration level of 100,000 gal/day. This program would require pass-through funding to the Great Lakes states to develop infrastructure to implement this program. The estimated cost for this program is $10 M over ten years, with commensurate per annum funding thereafter.

Enhanced Implementation (30) – Require that all facilities in the public water supply, thermal-electric, thermal-nuclear, hydroelectric power, and industrial categories to measure and report withdrawals from surface and groundwater above the state registration level of 100,000 gal/day. This program would require pass-through funding to the Great Lakes states to develop infrastructure to implement this program. The estimated cost for this program is $24 M over ten years, with commensurate per annum funding thereafter.

Full Implementation (30) – Require all facilities to implement direct measurements of surface and groundwater withdrawals for all categories of use above the state registration level of 100,000 gal/per day. Establish a federal program to assist the states in requiring full measurements of withdrawals at a cost of $50 M over 10 years, and continued thereafter.

Task 31: The USGS, in cooperation with regional, state and provincial authorities needs to develop a systematic method for estimating consumptive use for those water use categories where direct measurements are not possible.

Without Plan (31) – Without significant additional funding, research and collaboration, current consumptive use coefficients will continue to be used to estimate consumption. Consumptive use estimates will continue to be inconsistent and unreliable.

Minimum Investment (31) – Develop systematic methods to estimate consumptive use by water use category for both surface and groundwater. Conduct pilot studies that directly measure consumptive use for both surface and groundwater for selective water use categories or facility types at a cost of $500 K over 2 years.

Selective Implementation (31) – Develop systematic methods to estimate consumptive use by water use category for both surface and groundwater. Conduct pilot studies that directly measure consumptive use for both surface and groundwater for selective water use categories or facility types at a cost of $500 K over 2 years.

Enhanced Implementation (31) – Require all facilities within the power generating, public water supply and industrial categories to directly measure consumptive uses from both surface and groundwater. Apply systematic methods to estimate consumptive use for those categories where consumptive use measurements are not possible. Federal funding to support this mandate as pass-through to the states is estimated to be $20 M over 10 years, with commensurate funding per annum thereafter.

Full Implementation (31) – Require all facilities for all categories of use to directly measure consumptive uses for both surface and groundwater. Apply systematic methods to estimate consumptive use for those categories where consumptive use measurements are not

possible. Federal funding to support this mandate as pass-through to the states could be as high as $50 M over 10 years, with commensurate funding per annum thereafter.

Task 32: The USGS needs to coordinate development of consistent demand forecasts of water withdrawals and uses for all USGS major watersheds in the Great Lakes-St. Lawrence River basin at the state and local levels, including integration current and projected land use information.

Without Plan (32) – Demand forecasting will occur sporadically with no coordination among or between jurisdictions. This will negatively impact implementation of the Great Lakes Charter Annex due to the paucity of data. With little or no financial and programmatic support at the state level, demand forecasting tools will not be developed.

Minimum Investment (32) – Develop a consistent and uniform methodology for demand forecasting of water withdrawals and uses for all USGS major watersheds and establish a uniform schedule for conducting demand forecasts. The estimated cost for this program is $200 K over two years.

Selective Implementation (32) – Develop a consistent and uniform methodology for demand forecasting of water withdrawals and uses for all USGS major watersheds and establish a uniform schedule for conducting demand forecasts. Conduct one pilot demand forecast for one USGS major watershed in the Great Lakes basin. The estimated cost for this program is $1.5 M over two years.

Enhanced Implementation (32) – Develop a consistent and uniform methodology for demand forecasting of water withdrawals and uses for all USGS major watersheds and establish a uniform schedule for conducting demand forecasts. Conduct a pilot demand forecast for one USGS major watershed in each of the Great Lakes states. Estimated cost of this program is $12 M over three years.

Full Implementation (32) – Conduct demand forecasts for all 109 USGS major watersheds in the U.S. Great Lakes basin on a coordinated schedule at a cost of $150 M over five years, with updates occurring every decade thereafter.

Total Costs Over 10 Years

Without Plan (TOTAL) – $0 M

Minimum Investment (TOTAL) – $4.7 M

Selective Implementation (TOTAL) – $37.5 M

Enhanced Implementation (TOTAL) – $110 M

Full Implementation (TOTAL) – $344 M

References

The Great Lakes Charter: Principles for the Management of Great Lakes Water Resources. 1985.

Great Lakes Commission. 2003. Toward a Water Resources Management Decision Support System for the Great Lakes – St. Lawrence River Basin.

International Joint Commission. 2000. Protection of the Waters of the Great Lakes: Final Report to the Governments of Canada and the United States.

National Research Council. 2002. Estimating Water Use in the United States: A New Paradigm for the National Water-Use Information Program. Washington, D.C.: National Academy Press.