

Consumptive Use in the Great Lakes Region and Basin:

Annotated Bibliography of Selected References

GREAT LAKES COMMISSION

Prepared by the
Great Lakes Commission for the Great Lakes States and Provinces
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Commonwealth of Pennsylvania, 1975. State Water Plan. Planning Principles, Goals, Objectives, Standards, Criteria, Work Program and Methodology. Prepared by the Office of Resources Management, Bureau of Resources Programming. Harrisburg, PA.

This document includes a section on “analyses of consumptive uses and reuses.” Page 19 of the plan includes a list of coefficients that “approximate percentages of withdrawal amount that are consumptive uses.” Municipal is 10 percent; non-power industrial varies as does power; livestock is 75 percent; and irrigation is 100 percent.

Council of Great Lakes Governors, 1985. Water Diversion and Great Lakes Institutions. Final Report and Recommendations of the Great Lakes Governors Task Force on Water Diversions and Great Lakes Institutions. Chicago, Illinois. 46p.

The report was developed in response to two resolutions adopted by the Council of Great Lakes Governors; one resolution called for an examination of Great Lakes institutions, and the other called for federal and state legislation to prohibit out of state diversions for the establishment of a state/provincial task force to strengthen the states’ and provinces’ abilities to resist water diversions. As part of the reports appendices, the Great Lakes Charter contains a series of 5 principles and associated findings for managing Great Lakes water resources. Principles III of the Charter notes that consumptive use is a serious concern and Principle IV states that it is the intent of the signatory States and Provinces to not permit or approve an increased diversion or consumptive use by any state or province without notifying and consulting with all of the affected states and provinces. The report calls for each state and province to “collect and maintain comparable form data regarding the location, type and quantities of water use, diversion, and consumptive use and information regarding projections of current and future needs.” The report acknowledges that the process established by the fourth principle known as “prior notice and consultation” cannot be meaningfully implemented until states and provinces have adopted legislation setting in place the water use registration and regulation program recommended in the Charter. The definition of consumptive use is identical to that used in the Great Lakes Commission’s regional water use data base repository. A technical discussion of consumptive use coefficients or other methods for calculating or estimating consumptive use does not exist in this report.

Great Lakes Commission, 1992. Liquid Asset: Great Lakes Water Quality and Industry Needs. Ann Arbor, Michigan. 12 p.

This booklet describes the significance of the relationship between industry and water in the Great Lakes. Industrial water needs and uses are described for different industrial sectors and water use projections are made for selected sectors. Industrial water use changes as a result of pollution control regulations, technological advances and economic shifts are also discussed. Consumptive use is mentioned only in terms of the differences between industrial consumption in the U.S. overall and Great Lakes states. Consumptive use by industry in the U.S. overall is 11.7 percent whereas it is nearly 15 percent for the Great Lakes states.

Great Lakes Commission, 1987-1993. Annual Reports of the Great Lakes Regional Water

Use Database.

This series of annual reports provides a centralized source of information on Great Lakes water withdrawals, diversions and consumptive uses throughout the US-Canada Great Lakes Basin. The reports are based on data submitted by the eight Great Lakes states and two Great Lakes provinces. The data is organized on the basis of political jurisdiction, entire Great Lakes Basin, lake sub-basin and nine categories of water withdrawals, including: 1) public supply; 2) domestic self-supply; 3) irrigation; 4) livestock; 5) industrial; 6) thermoelectric (fossil fuel); 7) thermoelectric (nuclear); 8) hydroelectric; and 9) other. Consumptive use information is provided for each water withdrawal category by jurisdiction and, where available, the portion of consumption from the Great Lakes basin. Information in the reports is housed in a database at the Great Lakes Commission, which has been operational since 1989.

International Joint Commission, 2000. Protection of the Waters of the Great Lakes. Final Report to the Governments of Canada and the United States. Washington, DC and Ottawa, Ontario. 69 p.

On-line document at <http://www.ijc.org/boards/cde/finalreport/finalreport.html#1>

This is the final report of the International Joint Commission to the governments of Canada and the United States in response to a 1999 reference from the governments. That reference asked the IJC to address existing and potential consumptive uses of water, existing and potential diversions of water and the cumulative effects of such diversions, and the current laws and policy that may affect the sustainability of the water resources in the Great Lakes basin. The report includes a table that compares consumptive use among various databases. However, the discussion of consumptive use is based on 1993 data provided by the Great Lakes Commission's Regional Water Use Data Base. Accordingly, the report notes that consumptive use varies with the type of water use (e.g., industrial, irrigation, etc.). Irrigation represents over 70 percent consumptive use while thermoelectric power generation represents less than 1 percent. Charts and tables illustrate consumptive use by jurisdiction and by water withdrawal category and compare consumptive uses by category to overall withdrawals. Projections are made for future water use demands, but the report does not address the future of consumptive use due to lack of consensus on the topic. A discussion of consumptive use coefficients or methodologies for estimating or calculating consumptive use does not exist in this report.

International Joint Commission, 1985. Great Lakes Diversions and Consumptive Uses. A Report to the Governments of the United States and Canada. Washington, DC and Ottawa, Ontario. 82 p.

This report was prepared by the International Joint Commission in response to a 1977 reference from the governments of the U.S. and Canada. The report addresses diversions and consumptive uses separately in a first part, discusses a several relevant policy issues in a second part, and makes a series of recommendations. The consumptive use component of the report identifies patterns of consumptive uses in the Great Lakes basin using 1975 data. The report highlights the differences between the consumptive use estimates of made by the IJC and those made by the U.S. Geological Survey. Of particular note is that the two studies employ different coefficients, most notably in the power sector. The study does not advocate one approach over the other. Rather it emphasizes that the accuracy of consumptive use estimates depend as much on the choice of coefficients as on the measurement of withdrawals. It underscores the need for continued improvement in water use and consumptive use information. Recommendations

regarding consumptive use include: establishment of a bilateral data committee to monitor Great Lakes basin consumptive uses; establishment of a bilateral task force to update previous consumptive use projections, assess the impacts of those projections and make recommendations; and institution of a cooperative review of state/provincial and federal policies that have an effect on consumptive uses.

International Joint Commission, 1981. International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Burlington, Ontario and Chicago, Illinois. 258 p.

This report was developed by the International Joint Commission's Great Lakes Diversion and Consumptive Uses Study Board in response to a 1977 request by the U.S. and Canada for the International Joint Commission to investigate the effect on water levels and outflows of the Great Lakes from existing and proposed new or changed diversions into, out of, and within the Great Lakes basin; and existing and reasonably foreseeable patterns of consumptive use. This detailed report, which includes three appendices and seven annexes, provided the basis for the 1985 report of the IJC to the governments of the U.S. and Canada. The consumptive use component of the study involved a determination of present (1975) water withdrawals and consumptive uses, together with projections from a base year of 1975 to 2035. Withdrawal and consumption quantities are broken down by lake basins, nations, lake vs. non-lake (e.g., tributaries or groundwater), and economic sectors. The seven economic sectors considered are: municipal; rural-domestic; manufacturing; mining; rural-stock; irrigation; and thermal power generation. The study estimated consumptive use in the Great Lakes basin in 1975 at 4,900 cfs. The forecasts projected this figure to increase to 25,400 cfs by 2035 and this projected increase was primarily attributed to growth in the municipal, manufacturing and thermal power generation sectors. The report acknowledges many assumptions were used in developing the forecasts due to insufficient data and socio-economic uncertainties.

International Joint Commission, 1981. International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Appendix A: Coordinated Basic Data. Burlington, Ontario and Chicago, Illinois. 233 p.

This Appendix was prepared by a Diversions Subcommittee of the IJC Great Lakes Diversions and Consumptive Uses Study Board. The Appendix describes the methods and techniques used to obtain water supply data and the development of the basis-of-comparison, used in the main report. It also contains tabulations of the basic data employed in their derivation.

International Joint Commission, 1981. International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Appendix B: Computer Models - Great Lakes. Burlington, Ontario and Chicago, Illinois. 203 p.

This Appendix documents three computer procedures used extensively in the study. The first model, known as the Great Lakes regulation model, was used to develop diversion scenarios. The second computed monthly average power output and determined the cost or value of power generated by two U.S. power plants. The third model used the Great Lakes regulation model and projected consumptive use to determine the effect on levels and flows from future consumptive use in the manufacturing and mining sectors in Ontario.

International Joint Commission, 1981. International Great Lakes Diversions and

Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Appendix C: Diversion Management Scenarios. Burlington, Ontario and Chicago, Illinois. 324 p.

This Appendix describes various alternative diversion management scenarios considered in the study. Levels and flows for 43 scenarios were generated and reviewed. Thirteen of these were selected for economic evaluation and one was evaluated for environmental impacts.

International Joint Commission, 1981. International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Annex F: Consumptive Water Use. Burlington, Ontario and Chicago, Illinois. 151 p.

This Annex describes the approach and methodology used to project consumptive water use in the U.S. and Canadian portions of the Great Lakes basin from 1975 to 2035. Projections are an integration of consumption in the five Great Lakes and their drainage basins. The U.S. projections are based on data and analyses from the U.S. Departments of Commerce, Agriculture, Interior, Energy, the Federal Energy Regulatory Commission and the U.S. Water Resources Council. In Canada a comprehensive database was not available; more fundamental data analysis and model development was required. Overall, however, the approaches to determine projections used in the two countries are compatible. The discussion of coefficients centers on those coefficients used to forecast future withdrawals/consumption. Consumptive use is discussed for each water withdrawal category and coefficients are often provided along with a methodology or rationale based on the various projection scenarios.

International Joint Commission, 1981. International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses. Annex G: Evaluation of Diversion Management Scenarios and Consumptive Water Use Projections. Burlington, Ontario and Chicago, Illinois. 147 p.

This Annex documents the detailed hydrologic, economic and environmental evaluations for selected diversion management scenarios and the hydrologic evaluation of consumptive use projections. The consumptive use portion of the annex contains additional hydrologic evaluations for the most likely projection as well as for the high and low projections contained in Section 8 of the main report. It includes figures that illustrate the consumptive use scenarios using each evaluation technique for each lake basin and the Great Lakes basin as a whole. Results from applying the various evaluation techniques indicate that the magnitude of decrease in levels and flows is directly related to the projected reduction in water supplies caused by increases in consumptive use. The annex also highlights that an increase in consumptive use throughout the basin will result in a reduction in outflow from Lake Ontario by an equivalent amount.

Horn, M.A. 2000. U.S. Department of the Interior, U.S. Geological Survey Water Resources Investigations Report 99-4287. Northborough, Massachusetts. 34 p.

This report uses examples from the Ten Mile River Basin in southeastern Massachusetts to illustrate a new 10-step method to improve estimates of inflow and infiltration and interbasin transfers. The accuracy and precision of water-use estimates determined by this method are improved through careful application of coefficients for small users and the use of metered values for large users.

Ludlow, R.A., Gast, W.A, _____. Estimated Water Withdrawals and Use in Pennsylvania,

1995. U.S. Geological Survey and Pennsylvania Department of Environmental Protection Office of Water Quality Management.

Online document at <http://pa.water.usgs.gov/reports/fs174-99.html>

This online publication describes water withdrawals and use in Pennsylvania in 1995 and describes changes since 1985 for 6 categories of water use: 1) public supply; 2) domestic; 3) commercial and industrial; 4) hydroelectric and thermoelectric power generation; 5) mining; and 6) livestock and irrigation. The document discusses consumptive uses in 1985 and 1995 and changes during that decade for industrial and thermoelectric users. Pennsylvania and U.S. Geological Survey water use programs are described. The document discusses the state consumptive use authority held by the Delaware River and Susquehanna River Basin Commissions. These Commissions have review and approval authority for ground-water and surface-water withdrawals and consumptive uses. Withdrawal or consumptive use capacity that was in place and operative when each commission was formed (DRBC, October 1961; SRBC, December 1970) remains unregulated. Increases in or new withdrawals that exceed 100,000 gal/day require approvals. Increases in or new consumptive uses that exceed 10,000 gal/day also require approvals. SRBC imposes fees for consumptive uses. Those fees pay for water storage that provides for releases to make up for consumptive-use losses in the basin during low-flow events.

Raymond, L. H and Owen-Joyce, S. 1986. Remote Sensing Applications for Consumptive Use (Evapotranspiration). American Water Resources Association Monograph Series No. 6, edited by A.I. Johnson and A. Rango. Presented at 21st Annual AWRA Conference and Symposium, 1985. Tucson, Arizona. 9 p.

This study compares the consumptive use and evapotranspiration estimates in Palo Verde Valley California to 1981 and 1983. Consumptive use was calculated using a water budget, and evapotranspiration was calculated using vegetation types and acreage determined from Landsat digital-image and two sets of water-use rates. Consumptive use for Palo Verde Valley is the sum of consumptive use for the two ground-water drainage areas. A water budget was used to calculate consumptive use for the area drained by drainage ditches. Consumptive use for the area drained by the river was estimated using the average consumptive use determined for the area drained by drainage ditches multiplied by the vegetated area and adjusted for the unequal distribution of vegetation types in the two drainage areas.

Snaveley, D. S., 1986, Water-use data-collection programs and regional database of the Great Lakes-St. Lawrence River basin States and Provinces: U.S. Geological Survey Open-File Report 86-546. 204 p.

This report presents results of a 1986 survey of water-use data collection programs within the Great Lakes as conducted by the U.S. Geological Survey in cooperation with the Council of Great Lakes Governors. The first part describes the economic setting and the legislation that prompted the survey. The second part describes current water-use data collection programs in the Great Lakes states and provinces and inconsistencies among the respective programs by water-use category. The third part describes the design of the Great Lakes regional water use data base and discusses: 1) inconsistencies between the data required and the data currently available; 2) proposed refinements to the design; 3) methods for transmittal of data by each category; 4) selection of the data base repository location; and 5) how the data base could be used in water management decisionmaking and in hydrologic models to determine the effects of

withdrawals, consumptive uses, and diversions on lake levels.

_____ 1988a, Estimation, analysis, sources, and verification of consumptive water use in the Great Lakes-St. Lawrence River basin: U.S. Department of the Interior, U.S. Geological Survey Water Resources Investigations Report 88-4146. 28 p.

This report analyzes consumptive use water data provided by the International Joint Commission's Great Lakes Diversions and Consumptive Uses Study Board (Study Board), the International Joint Commission (IJC) and the United States Geological Survey (USGS) and calculates a range of consumptive use water estimates within the U.S. from 1980 to 2000 as well as presents methods of obtaining consumptive use data. Discrepancies in methods of data collection are noted due to "differences in: 1) methods by which the base-year values were developed, including which facilities were inventoried, whether data was estimated or reported, which methods of estimation and constants (e.g., coefficients) were used, the size of sampled areas, whether data were obtained directly by users or supplied by government agencies, and how often the data base is updated; and 2) methods or models that were used to project consumptive use to the future and the equations used in these models." The report highlights that coefficients and questionnaires can be used to estimate consumptive use where legislation does not mandate consumptive use reporting. It also finds great variability in coefficients among industries [facilities] producing the same product, and argues for legislation that mandates water use data collection. However, it is unclear how such legislation would address issues of quality control of data reported or scientifically validate coefficients.

Solley, Wayne B., Pierce R. R. and Perlman, H.A. 1998. Estimated Use of Water in the United States in 1995. U.S. Geologic Survey Circular 1200. U.S. Department of the Interior, U.S. Geologic Survey. ISBN 0-607-90075-X. 71 p.

<http://water.usgs.gov/watuse/pdf1995/html/>

Conducted every five years, this is the most recent U.S. Geologic Survey compilation of estimates of national water usage in the U.S. under the National Water-Use Information Program. USGS staff compiled and analyzed information from various state agencies, developed estimates of missing data elements, and prepared documentation that identifies the sources of water use information for each state and describes how the water use estimates were determined for this report. Water use information is separated into offstream use and instream use. Offstream uses are represented by: public supply; domestic, commercial, irrigation, livestock, industrial, mining and thermoelectric power. Instream use is represented by hydroelectric power. Estimates of consumptive use are given for seven categories by state and by region, including the Great Lakes basin. It is assumed that none of the water used for hydroelectric power is consumptively used. Consumptive use is not estimated for public supply because consumptive use is accounted for by deliveries to individual water users (e.g., industrial, commercial) served by public water suppliers. Accordingly, public suppliers do not consume water; they withdraw and deliver it. Consumption occurs by the individual users of the water delivered. Conveyance losses are not considered consumptive use because those losses are assumed to be redelivered to groundwater table and returned to the hydrologic system. Consumptive use estimates are based on coefficients multiplied by withdrawals and deliveries. For the domestic category the coefficient ranges from 0.1 to 0.5; for commercial, the coefficient ranges from 0.05 to 0.30; for irrigation, the coefficient ranges from 0.4 to 1.0 (a change from 1985); for livestock the coefficient ranges from 0.1 to 1.0; for industrial the coefficient ranges

from 0.03 to 0.8 (a change from 1985), depending on the type of industry; for mining the coefficient ranges from 0.1 to 1.0 depending on the type of mining activity; for thermoelectric, the coefficient ranges from 0.01 to 1.0 depending on the type of plant.

Solley, Wayne B., Pierce R. R. and Perlman, H.A. 1993. Estimated Use of Water in the United States in 1990. U.S. Geologic Survey Circular 1081. U.S. Department of the Interior, U.S. Geologic Survey. 76 p.

On-line document at <http://water.usgs.gov/watuse/wucircular2.html>

This is the third of the USGS reports under the National Water Use Information Program. The report describes water use in the United States by nine major water-use categories: public supply, domestic, commercial, irrigation, livestock, industrial, mining, thermoelectric power and hydroelectric power. Water use information is separated into offstream use and instream use. Offstream uses are represented by: public supply; domestic, commercial, irrigation, livestock, industrial, mining and thermoelectric power. Instream use is represented by hydroelectric power. Estimates of consumptive use are given for seven categories by state and by region, including the Great Lakes basin. Consumptive use for hydroelectric power is considered negligible and is not discussed. Consumptive use is not estimated for public supply because consumptive use is accounted for by deliveries to individual water users (e.g., industrial, commercial) served by public water suppliers. Accordingly, public suppliers do not consume water; they withdraw and deliver it. Consumption occurs by the individual users of the water delivered. Conveyance losses are not considered consumptive use because those losses are assumed to be redelivered to groundwater table and returned to the hydrologic system. Consumptive use estimates are based on coefficients multiplied by withdrawals and deliveries. For the domestic category the coefficient ranges from 0.1 to 0.5; for commercial, the coefficient ranges from 0.05 to 0.30; for irrigation, the coefficient ranges from 0.4 to 1.0 (a change from 1985); for livestock the coefficient ranges from 0.1 to 1.0; for industrial the coefficient ranges from 0.03 to 0.8 (a change from 1985), depending on the type of industry; for mining the coefficient ranges from 0.1 to 1.0 depending on the type of mining activity; for thermoelectric, the coefficient ranges from 0.01 to 1.0 depending on the type of plant.

Solley, Wayne B., Merk, Charles, F. and Pierce R. R. 1988. Estimated Use of Water in the United States in 1985. U.S. Geologic Survey Circular 1004. U.S. Department of the Interior, U.S. Geologic Survey. 82 p.

This is the second of the USGS reports under the National Water Use Information Program. The report describes water use in the United States by nine major water-use categories: public supply, domestic, commercial, irrigation, livestock, industrial, mining, thermoelectric power and hydroelectric power. Water use information is separated into offstream use and instream use. Offstream uses are represented by: public supply; domestic, commercial, irrigation, livestock, industrial, mining and thermoelectric power. Instream use is represented by hydroelectric power. Estimates of consumptive use are given for seven categories by state and by region, including the Great Lakes basin. Consumptive use for hydroelectric power is considered negligible and is not discussed. Consumptive use is not estimated for public supply because consumptive use is accounted for by deliveries to individual water users (e.g., industrial, commercial) served by public water suppliers. Accordingly, public suppliers do not consume water; they withdraw and deliver it. Consumption occurs by the individual users of the water delivered. Conveyance losses are not considered consumptive use because those losses are

assumed to be redelivered to groundwater table and returned to the hydrologic system. Consumptive use estimates are based on coefficients multiplied by withdrawals and deliveries. For the domestic category the coefficient ranges from 0.1 to 0.5; for commercial, the coefficient ranges from 0.05 to 0.30; for irrigation, the coefficient ranges from 0.8 to 1.0; for livestock the coefficient ranges from 0.1 to 1.0; for industrial the coefficient ranges from 0.07 to 0.72, depending on the type of industry; for mining the coefficient ranges from 0.1 to 1.0 depending on the type of mining activity; for thermoelectric, the coefficient ranges from 0.01 to 1.0 depending on the type of plant.

Solley, Wayne B., Chase, Edith B., and Mann, William B. 1983. Estimated Use of Water in the United States in 1980. U.S. Geologic Survey Circular 1001. U.S. Department of the Interior, U.S. Geologic Survey. 56 p.

This is the first of the USGS reports under the National Water Use Information Program established in 1978. The report describes water use in the United States by five major water-use categories, including public supply; rural use (includes self-supply domestic and livestock); irrigation; self-supplied industrial (including thermoelectric power) and hydroelectric power. Consumptive uses are estimated by subtracting return flow and conveyance losses from withdrawals. Estimates of consumptive use are given for four water categories: public supply, rural use, irrigation and self-supplied industrial. For 1980, the percentage of total consumptive use for these categories nationwide was: public supply-21 percent; rural use- 69 percent; irrigation-55 percent; and self-supplied industrial- 4 percent. Consumptive use for hydroelectric power is considered negligible and is not discussed. A section discussing trends in water use from 1950 to 1980 notes that “the rate of increase of consumptive use of fresh water has steadily decreased from 13 percent of r the 1965-1970 period to 7 percent for the period 1975-1980. The report attributes this reduction in consumptive use to three factors: 1) more efficient use of groundwater, particularly by irrigators; 2) water price increases encouraging greater water reuse and conservation; and 3) water availability fluctuations due to climate/precipitation.

Sweat, M. J., VanTil, R.L., 1988. Water Use and Methods of Data Acquisition in Michigan, in Symposium on Water-Use Date for Water Resources Management. Proceedings: American Water Resources Association, TPS 88-2, 872 p. Tucson, Ariz.

Thermoelectric power generation, self-supplied industry, public supply, and irrigation water use categories account for approximately 98 percent of Michigan’s water use. Water withdrawals for these categories during 1985 were estimated to be about 11,000 million gallons/day; consumptive water losses were estimated to be 590 million gallons/day or about 5 percent of the total water withdrawn from the principal water use categories. Thermoelectric was only estimated at 1 percent consumption while irrigation was estimated at about 95 percent. (Methods of consumptive use estimation are not discussed.) Systematic collection and analysis of water use data in Michigan began in 1970. From 1970-1986, the data collection efforts focused on compiling and analyzing data collected by various agencies, on statistical surveys of sample populations, and on projecting current withdrawals using estimates of past withdrawals. Legislation was introduced in Michigan in 1987 to improve data collection by requiring reports on all withdrawals greater than 100,000 gallons/day. The four principal water use categories were selected for intensive data collection over ten years. This effort involved incorporation of data from USGS, Michigan DNR and local agencies into a GIS database.

Tate, D. M. and D. N. Scharf. 1995. Water Use in Canadian Industry, 1991. Social Science Series No. 31. Water and Habitat Conservation Branch Canadian Wildlife Service. Environment Canada. 41p.

Published by Environment Canada, Ottawa.

Series from surveys of industrial water use conducted in 1991, 1986, 1981, 1976, and 1972. This report presents the analysis and findings of the surveys' results. The report highlighted where water may be used more efficiently in various industry sectors. In addition, the consumptive rates in various manufacturing industries, including food, beverage, rubber, and plastics industries, were calculated. The report noted that consumptive use rates in manufacturing industries may range from 3.4% to 34.0% of water intake. The Canadian national average rate of consumption was 7.1% for 1991.

Tate, D. M. and Harris, J. 1999. Water Demands in the Canadian Section of the Great Lakes Basin, 1972 - 2021. Gaia Economic Research Associates. Unpublished background document prepared under contract to the Canadian Section of the International Joint Commission. Ottawa, Ontario. 95 p.

This report documents a multi-purpose study to compile time series of water use for the Canadian portion of the Great Lakes basin from 1972 to 1996; to review and comment upon past forecasts of water demand that have been carried for the region; to provide a means of breaking the data down by the five principal lake basins comprising the Great Lakes region, based on the period 1991-1996; and to produce forecasts of water use in the region for the time period 1996-2021. The report estimated consumptive use to grow by approximately 44% from 1972 to 1996, with a 16% growth from 1986 to 1996. The largest rate of consumptive use occurs in the agricultural sector, followed by 20% rate of growth in the municipal sector.

Tate, D. M. and Harris, J. 1999. Water Demands in the United States Section of the Great Lakes Basin, 1972 - 2021. GeoEconomics Associates. Unpublished background document prepared under contract to the U.S. Section of the International Joint Commission. Washington, D.C. 61 p.

Besides producing a set of water use forecasts in the U.S. portion of the Great Lakes basin, the study also aims to break the forecasts down into the water use categories commonly used by both the U.S. Geological Survey and the Great Lakes Commission; to provide the forecasts broken down by the 5 lake sub-basins of Superior, Huron, Michigan, Erie-St.Clair, and Ontario-St. Lawrence river; and to provide "integrated" basin-wide results for water use covering the U.S. and Canada. The report discusses the complexity of the consumptive use concept and the process of measuring consumptive use. The report notes the best way to measure the difference between intake and discharge is to survey firms, municipalities, etc., to formulate actual estimates of the amount of water being consumed.

U.S. Department of the Interior, U.S. Geological Survey. _____ National Handbook of Recommended Methods for Water Data Acquisition; Chapter 11 - Water Use
<http://water.usgs.gov/pubs/chapter11/>

This handbook provides standards and guidance in measuring, estimating, collecting, compiling, and analyzing water-use data. This chapter includes a brief description of (1) water-use activities and commonly used water-use terminology, (2) approaches and methods used in measuring and estimating water use, (3) water-use-data-management systems, and (4) methods for determining

water use for specific water-use categories. Where appropriate, descriptions include accuracy, quality assurance procedures, and water-use data collection instrumentation. Water-use categories covered include: public water supply, domestic, commercial, industrial, mining, irrigation, livestock and animal specialties, thermoelectric power, and hydroelectric power. A section also is included on wastewater collection and return flow. Each water-use category section describes (1) water-use activities contained in the use category; (2) sources of information; (3) methods of data collection, measurement, and estimation; (4) selected references and (5) consumptive use in the category (except hydroelectric). Standard Industrial Classification (SIC) codes that are used in defining use categories are based on the U.S. Office of Management and Budget (1987) Standard Industrial Classification Manual. The methods and estimation techniques described in this chapter are designed for the technical aspects of data acquisition and analysis.

U.S. Environmental Protection Agency Region V, 1975. Great Lakes Basin Framework Study Appendix 6: Water Supply—Municipal, Industrial, Rural. Great Lakes Basin Commission. Ann Arbor, Michigan. 266 p.

The Great Lakes Basin Framework Study involved a detailed examination of a multitude of issues affecting the Great Lakes Basin ecosystem. Each element was examined in detail in numerous appendices to a final report. Water supply is examined in Appendix 6. This Appendix is concerned with quantitative requirements for water used by three water use categories: municipal, industrial and rural. In this Appendix, municipal includes all communities served by public water supply; industrial water supply includes only manufacturing industries and does not include electric power generation; and rural water use includes rural communities, livestock farms, isolated dwellings and other rural non-farm uses not supplied by public systems, but does not include irrigation, which is addressed in Appendix 16 of the study. Appendix 6 examines water use in the base year of 1970 and projects water use the year 2020 using a forecasting methodology. Uses and projections are broken down by individual lake basin and by sub-areas within each lake basin. Water consumption by the three user categories is also assessed and projected. In this appendix, consumptive use is the estimated quantity of water that becomes unavailable for immediate reuse in a river basin as a result of its domestic use, its incorporation into farm produce and manufactured products, evaporation, transpiration, and other losses. Consumptive use losses are estimated by using the difference between withdrawals and discharges of water and general assumptions that relate climatic factors to water use and storage. In 1970 consumptive losses for the three categories examined were estimated at 1,400 million gallons/day (mgd), approximately 60 percent of which were industrial. By 2020, the appendix predicts that annual consumptive uses to reach 7,600 mgd, 80 percent of which is expected to be from industrial users. For domestic and commercial users in the municipal water use category, consumption is assumed to average 10 percent. Consumptive uses for the [self-supplied] industrial category vary by the particular industry examined (by SIC code). Rural consumptive uses are estimated to be 15 percent for nonfarm uses; 25 percent for domestic rural farm uses; 90 percent for livestock; and 100 percent for spray water. Domestic rural nonfarm is assumed to be less than domestic rural farm due to greater distribution and recovery efficiencies of nonfarm residences.

Water Resources Management Committee, 1987. Managing the Waters of the Great Lakes Basin. Report to the Governors and Premiers of the Great Lakes States and Provinces. Ann Arbor, Michigan and Chicago, Illinois. 47p. (English) and 52 p. (French).

The Great Lakes Charter of 1985 mandated the formation of a Water Resources Management Committee. It includes three chapters with findings addressing key principles in the Great Lakes Charter: water quantity data collection and management; prior notice and consultation; and institutional arrangements. Regarding consumptive use, the report notes that “most jurisdictions do not collect consumptive use information, and estimate it for only one category: public water supply.” Five recommendations are offered to improve Great Lakes water resource management. Those pertaining to consumptive use include formation of a database that includes consumptive use information by withdrawal type (compare with GLC database categories) geographic area for nine water use categories and improved estimation techniques and use of coefficients by all jurisdictions. The balance of the recommendations address the three above-noted key principles, but do not make reference to consumptive use.