Annotated Bibliography

Australian Academy of Technological Sciences and Engineering, 1999, Water and the Australian economy: Victoria, Australia, 127 p.

This document contains water-use information on Australia, but the only data on consumptive use are in a table listing gross water consumed per hectare of irrigated area for 1983–84, by region. Australia is divided into 18 regions, or spatial units. Consumptive-use estimates were computed by subtracting return flows from withdrawals. For each spatial unit (the Queensland coast, for example), the gross water consumed by pasture, crops, and horticulture is listed. For pastures, the gross water consumption is 2.5–13.8 million liters per hectare (ML/ha); for crops, 0.6–25.0 ML/ha; and for horticultural, 2.1–13.7 ML/ha (table 3.5, p. 37). Regionally, the gross water consumption is lowest in the areas with the highest rainfall, such as the southern and eastern coastal areas from south-east Victoria to the Burdekin region in Queensland, and Tasmania. In these areas, irrigation withdrawals from streams and ground water are usually used to supplement rather than replace rainfall and are typically less than 3 ML/ha (p. 38). For arid areas such as the Western Australian and Northern Territory irrigated areas, the South Australian part of the Murray-Darling Basin, and Burdekin in Queensland, gross water consumption is higher, 8–14 ML/ha. For other regions, including the southern and northwestern parts of the Murray-Darling Basin, an intermediate amount of water per hectare is consumed.

Avery, Charles, 1998, Water withdrawals in Illinois, 1995: U.S. Geological Survey Fact Sheet FS–063–98, 4 p., accessed May 15, 2006, at *http://il.water.usgs.gov/pubs/water_use95/wateruse95.html*

This document predominantly discusses water withdrawals in 1995 in Illinois and has a small section on consumptive use. For 1995, the water consumption in Illinois was 4 percent of all withdrawals in the State. The two categories in Illinois with the largest amount of water consumed were thermoelectric power and irrigation.

Barlow, L.K., 2003, Estimated water use and availability in the Lower Blackstone River Basin, northern Rhode Island and south-central Massachusetts, 1995–99: U.S. Geological Survey Water-Resources Investigations Report 2003–4190, 75 p., accessed July 30, 2006, at *http://pubs.usgs.gov/wri/wri034190/pdf/wrir034190.pdf*

Water-use data—including withdrawals, use, and return flows—were collected for the Lower Blackstone River Basin in northern Rhode Island and south-central Massachusetts. From these data, water availability (base flow plus safe-yield estimates minus streamflow criteria) was estimated for the low-flow period (June–September). As part of this study, consumptive use and unaccounted-for use were estimated. The study used consumptive-use coefficients of 15 percent for domestic use, 10 percent for commercial and industrial use, and 76 percent for irrigation (p. 26). Barlow states that the domestic, commercial and industrial consumptive-use coefficients are consistent with traditional consumptive-use rates in New England. The irrigation consumptive-use coefficient is in Solley and others (1993). The irrigation coefficient includes both conveyance losses and consumptive use. By subbasin, the water use not accounted for was 0.007–0.944 Mgal/d. The largest proportion consisted of leakage and exfiltration at 62 percent, followed by firefighting (12.0 percent) and major water-utility breaks (6.4 percent). Also of interest in this basin was a thermoelectric facility that withdrew water in one subbasin, used the water in a different subbasin, and trucked in water when the flows were too low in the river from which the water was withdrawn. The facility was classified as a zero-liquid-discharge facility; all water was consumed through evaporation and given a 100-percent consumptive-use coefficient (Gary Coutre, Etts Engineer, Ocean State Power, written commun., 2000).

Brill, E.D., Jr., Stout, G.E., Fuessle, R.W., Lyon, R.M., and Wojnarowski, K.E., 1977, Issues related to water allocation in the Lower Ohio River Basin: University of Illinois at Urbana-Champaign, Ohio River Energy Study, v.III–G, 81 p.

As part of a report projecting water use for Illinois, Indiana, Kentucky, and Ohio, this volume includes water-use data (withdrawals and water consumption) for 1970 from the Ohio River Basin Energy Study. Estimated municipal water consumption was 20 percent of the withdrawals and industrial water consumption was 6 percent. Thermoelectric power water consumption was about 0.1 percent for the four states (p. III-G-6).

College of Exploration [n.d.], Global water cycle: Global Hydrology and Climate Center, 12 p., accessed May 1, 2006, at *http://www.coexploration.org/howsthewater/html/body_earth.html*

In addition to data from Solley and others (1998), this document includes a table of global water demand and consumption (source of data is unknown). By sector, agriculture has a consumptive-use coefficient of 65 percent (1,870 km^3/yr divided by 2,880 km^3/yr); industry, 9 percent (90 km^3/yr divided by 975 km^3/yr); and domestic, 17 percent (50 km^3/yr divided by 300 km^3/yr; p. 7).

Cosgrove, W.J., and Rijsberman, F.R., 2000, The use of water today, *chap. 2 of* World wide vision, making water everybody's business: World Water Council, p. 4–21, accessed April 28, 2006, at *http://www.worldwatercouncil.org/fileadmin/wwc/Library/WWVision/Chapter2.pdf*

A comprehensive document on world water use, this report includes consumptive-use data and numerous figures. In 1995, about 10 percent of the available blue water—renewable surface-water runoff and ground-water recharge—was withdrawn, and approximately 5 percent of the available blue water was consumed (p. 6). Although this amount might seem low, other factors play a role in water availability for use and consumption.

Some of the world's water resources are in areas not readily accessible and where human demands are small, such as Canada, Alaska, and the Amazon Basin. In some arid and semiarid areas of the world, the human water use is reaching 80–90 percent of the water available. Timing and location of rainfall also contribute to the accessibility of water, such as the sometimes limited accessibility of large amounts of rain falling in a short period. Many areas of the world do not have the storage facilities (tanks, reservoirs, and aquifers) to hold water from intermittent storms until it is needed.

Another water-availability concern is the quality of water: water might be reused so many times that the quality of the water degrades to the point that safe reuse is impossible (p. 7).

About 70 percent of total withdrawals for 1995 are used for irrigation, 20 percent for industrial, and 10 percent for municipalities (Shiklomanov, 1999). For 1995, consumptive use for irrigation was 70 percent, industrial was 11 percent, and municipal was 14 percent (Shiklomanov, 1999). It also is noted that, depending on technology, irrigation methods range in consumption from 30 to 40 percent for flood irrigation and as high as 90 percent for drip irrigation (p. 8). Also of interest is that between 1961 and 1997, the irrigated area or the world has doubled, the greatest increases being in the United States and Asia (fig. 2.1, p. 8).

A figure depicting the annual renewable water resources by region on each continent shows the annual water resources in cubic kilometers by source of water (either local resources and inflows; p. 13). Another concern with water availability is that "worldwide, 20 percent of freshwater fish are vulnerable, endangered, or extinct" (box 2.4, p. 16) and "half the rivers and lakes in Europe and North America are seriously polluted, though their condition has improved in the past 30 years" (p. 16). Another concern given is that many streams will dry up before they reach the ocean (p. 17).

[Withdrawal and consumption are in cubic kilometers. Coefficient is in percent. Source is Shiklomanov (1999).]

Statistic	1900	1950	1995
Agriculture			
Withdrawal	500	1,100	2,500
Consumption	300	700	1,750
Coefficient	60	64	70
Industry			
Withdrawal	40	200	750
Consumption	5	20	80
Coefficient	12	10	11
Municipalities			
Withdrawal	20	90	350
Consumption	5	15	50
Coefficient	25	17	14
Reservoirs			
Evaporation	0	10	200
Totals			
Withdrawal	600	1,400	3,800
Consumption	300	750	2,100
Coefficient	50	54	55

Delaware River Basin Commission [n.d.], Year 2004 water withdrawal and consumptive use by large users on the tidal Delaware River: Accessed September 28, 2006, at *http://www.state.nj.us/drbc/wateruse/ largeusers_04.htm*

This Web page is a large table showing the large water users in the Delaware River Basin by state and water-use category. Included in this table are the surface-water withdrawals, ground-water withdrawals, purchased-water amounts, total water use, and consumptive use. Consumptive use is shown in million gallons per year and as a percentage of the total for the power, industry, and public-water-supply facilities in the Delaware River Basin in Pennsylvania, Delaware, and New Jersey. For public-water-supply facilities, the consumptive-use coefficient was 10 percent and was estimated by the Delaware River Basin Commission staff. For the power water-use category, the consumptive use was from 0.1 to 100 percent, most likely because of various types of facilities (once through versus other than once through). Overall, the thermoelectric power consumptive-use coefficient for all facilities was 1 percent. The industrial consumptive-use coefficients were from 0.1 to 100 percent, most likely reflecting the wide variety of industrial uses of the water. Overall, the industrial consumptive use for all facilities was 4 percent.

DeSimone, L.A., 2002, Simulation of ground-water flow and evaluation of water-management alternatives in the Assabet River Basin, eastern Massachusetts: U.S. Geological Survey Scientific Investigations Report 2004–5114, 133 p.

Water quality in the Assabet River Basin in Massachusetts is adversely affected by wastewater discharges and streamflow depletion from ground-water withdrawals. Ground-water-flow models were developed to simulate the flow in the Assabet River Basin during altered withdrawals and discharges. The results of three scenarios are presented. Conditions were based on 1997–2001 data.

Consumptive use in 11 of 20 towns in the basin was estimated from analysis of seasonal water use. "Consumptive use was assumed to result from irrigation or other water use during the high-use months of spring, summer, and fall [April–October] . . . Months were identified as low- or high-use months based on the seasonal patterns of public-supply withdrawals in 1997–2001." Consumptive use was computed for each town by first determining the mean withdrawal rate for the low-water-use months of November through March (summing the withdrawals for each of the five months and dividing by 5). Then, for each high-water-use month (April–October), the mean withdrawal rate was subtracted from each month's total withdrawal, as follows:

$$\begin{aligned}&\textit{June consumptive use} =\\ &\textit{June withdrawals} -\\ &\textit{Sum of low water-use months withdrawals}\\ &(\textit{Nov.} + \textit{Dec.} + \textit{Jan.} + \textit{Feb.} + \textit{Mar. withdrawals})/5\end{aligned}$$

Within the extent of the public-water systems, the areas in the town were identified as areas of residential, commercial, industrial, or urban public land use. Next, areal rates were computed by applying consumptive-use coefficients to each of the identified areas of residential, commercial, industrial, or urban public land use. "Monthly areal rates of consumptive water use ranged from 0.4 in/yr in April to 2.59 in/yr in July; the mean annual rate was 0.92 in/yr. These rates were applied to developed land-use areas in privately supplied towns to estimate a mean annual consumptive use for privately supplied parts of the basin of 0.72 Mgal/d. This volume is a net outflow from the ground-water system in privately supplied, developed areas . . . Consumptive use in publicly supplied parts of the basin was estimated similarly at 0.71 Mgal/d."

Ellefson, B.R., Rury, K.S., and Krohelski, J.T., 1987, Water use in Wisconsin, 1985: U.S. Geological Survey Open-File Report 87–699 [poster].

Water-use and water-disposition information for Wisconsin in 1985 are displayed on this poster, which contains 15 illustrations. For the State, only 4.8 percent of the total amount of withdrawals was consumed. Coefficients used to compute consumptive use by water-use categories were 1 percent for thermoelectric, 100 percent for irrigation, 80 percent for nonirrigation agricultural uses, 20 percent for industrial ground-water use, and 10 percent for industrial surface-water withdrawals.

Endreny, T.A., 2005, New York State water and hydrology, *in* The encyclopedia of New York State: Syracuse University Press, p. 1664–1670.

This article is an overview of water-resource supply and demand in New York State, as well as issues concerning water quality and quantity. For 2000, a total volume of 16,800 Mgal/d of water was withdrawn from the State's water resources. Of this, 54 percent was from fresh surface water and 6 percent was from ground water. The remaining 40 percent was saline water used primarily for thermoelectric power generation. Total water withdrawal and consumption per water-use category per day in New York State are presented in a table reproduced below. The data source for this table is from *New York State Water Quality 2000*, published by the New York State Department of Environmental Conservation, Division of Water, in October 2000.

[Mgal/d, million gallons per day.]

Category	Water consumed (Mgal/d)	Withdrawal (Mgal/d)	Coefficient (in percent)
Domestic	107	1,954	5.48
Commercial	61	609	10
Industrial	62	615	10
Public use	0	424	0
Irrigation	26	30	86.7
Livestock	30	34	88.2
Mining	17	62	27.4
Fossil fuel	212	10,600	2
Nuclear	88	2,440	3.6
Total	603	16,800	3.59

Environment Canada, 2004, Threats to water availability in Canada, Burlington, Ontario, National Water Research Institute, Scientific Assessment Report Series no. 3 and Atmospheric and Climate Science Directorate Science Assessment Series no. 1, 128 p., accessed June 15, 2006, at *http://www.nwri.ca/threats2full/intro-e.html*

Chapter 5, "Municipal Water Supply and Urban Developments" has a diagram showing "Water use in Canada, 1996," which includes the intake from a water supply, gross water, recirculated water, consumed water, and discharged water for thermal power, manufacturing, municipal, agriculture, and mining categories. Also of interest is that "on average, about 20 percent of total daily municipal water use is attributed mostly to distribution losses and also to unaccounted-for-water" (p. 38). Municipal water use accounts for only 11 percent of the total water use (withdrawals) for Canada (p. 37).

In Chapter 6, "Manufacturing and Thermal Energy Demands," water use and consumptive use for Canada are discussed. "Paper and allied products, primary metals, chemicals and chemical products industries made up 82 percent of total water intake in 1996 " (p. 41). Also, 82 percent of the water supply for the manufacturing sector was from self-supplied freshwater surface sources (p. 41). "Nationally, water consumption was 9 percent of total withdrawals in 1996, up from 7 percent in 1991 (p. 42). Whereas consumption rates have been increasing, total water intake withdrawals decreased from 1981 (p. 41). Although the purpose of water use will vary by manufacturing sector, on the whole, 49 percent of the total intake was used for process water, 47 percent for cooling, condensing, and steam generation, and 2 percent for sanitary uses (p. 41).

Chapter 7, "Land Use Practices and Changes—Agriculture," states that approximately 7 percent of the land in Canada is used for agriculture, but only 13 percent of this total is in Ontario and Quebec (82 percent is in the Prairie provinces) (p. 49). Agriculture comprises 9 percent of the total water withdrawals for Canada but had a consumptive-use coefficient of 71 percent and is the largest consumer of water. Most of the irrigation in Canada uses sprinkler irrigation systems (p. 50).

Chapter 9, "Land-Use Practices and Changes—Mining and Petroleum Production" has a note in a table that "no reliable mining water consumption values can be estimated due to a high level of discrepancies between intake and discharge, probably due to unaccounted for tailings pond losses to evaporation and subsurface seepage (p. 68)."

[Modified from table 1, Environment Canada (2004), chapter 6, "Selected Characteristics of Manufacturing and Thermal Energy Water Use (million cubic meters water/year, MCM per year), by Parameter and Industry Group, 1996." Total water intake and water consumption are in million cubic meters.]

Industry	Total water intake	Water consumption	Consumptive-use coefficient[1] (percent)
Food	269.5	29.5	10.9
Beverages	73.1	16.9	23.1
Rubber products	12.3	1.0	7.8
Plastic products	13.3	1.3	9.4
Primary products	86.7	2.1	2.4
Textiles products	15.0	2.1	14.1
Wood products	45.1	12.1	26.9
Paper & allied products	2,421.3	214.3	8.9
Primary metals	1,423.0	120	8.4
Fabricated metals	19.4	1.1	5.6
Transportation equipment	65.4	19.0	29.0
Non-metallic mineral products	102.3	19.2	18.7
Petroleum & coal products	370.5	22.5	6.1
Chemicals & chemical products	1,121.3	90.7	8.1
Total manufacturing	6,038.3	551.6	9.1
Total thermal power generation	28,749	508	1.8

[1] Coefficients from Environment Canada (not computed by authors of this bibliography).

European Environment Agency, 2005, The European environment—State and outlook 2005: Luxembourg, 570 p., accessed on June 19, 2006, at *http://reports.eea.europa.eu/state_of_environment_report_2005_1/en/tab_content_RLR*

About one-third of the water withdrawal in Europe is used to irrigate crops, a little less than one-third is used in cooling towers for thermoelectric power, 25 percent is used for domestic purposes (taps and toilets), and 13 percent is used in manufacturing. The amount of water used by each water-use category (domestic, manufacturing, thermoelectric, and irrigation) varies across the continent. For example, in most of the northern Europe countries, less than 10 percent of water withdrawals are used for irrigation, whereas in southern Europe more than 60 percent of withdrawals are used for irrigation. Two-thirds of the water withdrawals for Belgium and Germany are used for thermoelectric power. With regard to consumption, reported coefficients are 80 percent of the water withdrawals for agriculture (absorption by crops or evaporation from fields), 20 percent of manufacturing and domestic water withdrawals, and 5 percent of thermoelectric power water withdrawals. It also is noted that the 95 percent of the thermoelectric withdrawal that is returned to the environment is typically warmer than before it is used and can negatively affect local ecosystems. Also, the 80 percent of the industrial and domestic withdrawals returned are often contaminated and are returned at a different location than the withdrawals. Of special note is that "the greatest potential for water saving lies in reducing leakage rates in water distribution systems, particularly for domestic use (p. 3)." Water losses (through leakage) account for over one-third of the withdrawals in some older cities in Europe. Although some of this leakage recharges ground water and can be pumped and used again, in other locations the water cannot be reused because the water beneath the city is too contaminated.

Government of Canada and the U.S. Environmental Protection Agency, Great Lakes National Program Office, 1995, The Great Lakes—An environmental atlas and resource book (3d ed.): Toronto, Ontario, and Chicago, Ill., 46 p.

This publication describes the physical characteristics of the Great Lakes water system, as well as the settlement and industrialization of the area. Climate, hydrologic cycle, and water resources are described. Water levels, effects of diversions, and outcomes from consumptive-use studies are also given. Tables included in this report (summarized below) list Great Lakes municipal, manufacturing, and power production water withdrawals and consumption per lake.

Consumptive use per category per lake (in cubic feet per second) for Great Lake Basins, 1985.

[Modified from Michigan State University (1985); %, percent; coefficient is calculated and rounded to the nearest whole number.]

Category and Country		Superior	Michigan	Huron	Erie	Ontario	Totals
Municipal:							
Canada							
	Withdrawn	40		120	190	660	1,010
	Consumed	10		20	30	100	160
	Coefficient	25%		17%	16%	15%	16%
United States							
	Withdrawn	70	2,940	310	2,820	380	6,520
	Consumed	10	190	170	280	70	720
	Coefficient	14%	6%	55%	10%	18%	11%
Manufacturing:							
Canada							
	Withdrawn	860		1,360	1,900	2,760	6,880
	Consumed	20		70	80	100	270
	Coefficient	2%		5%	4%	4%	4%
United States							
	Withdrawn	410	9,650	1,060	9,110	530	20,760
	Consumed	60	880	30	1500	40	2510
	Coefficient	15%	9%	3%	16%	8%	12%
Power production:							
Canada							
	Withdrawn	70		2,870	1,160	8,370	12,470
	Consumed	0		20	10	60	90
	Coefficient	0%		1%	1%	1%	1%
United States							
	Withdrawn	760	13,600	2,570	13,180	6,520	36,360
	Consumed	10	240	50	190	120	610
	Coefficient	1%	2%	2%	1%	2%	2%
Total withdrawn		2,210	26,190	8,290	28,360	19,220	84,270
Total consumed		110	1,310	360	1,990	490	4,260
Coefficient		5%	5%	4%	7%	3%	5%

Grannemann, N.G. Hunt, R.J., Nicholas, J.R., Reilly, T.E., and Winter, T.C., 2000, The importance of ground water in the Great Lakes Region: U.S. Geological Survey Water-Resources Investigations Report 00–4008, 14 p.

This report states that the total ground-water withdrawal in the Great Lakes Region was estimated to be about 1,510 Mgal/d (from Solley and others, 1998) with an additional 200 Mgal/d withdrawn in the Chicago area just outside the basin. About 5 percent of the ground water withdrawn in the Great Lakes Basin was consumed. Irrigation is identified as the largest consumptive use of water in the Great Lakes Basin. The irrigation withdrawals were equally supplied by ground water and surface water; but if new irrigation systems are installed in areas where surface-water sources are not available, ground water would be used as the water source. This report gives an example water budget for Lake Michigan.

Great Lakes Commission, 2003, Water Resources Management Decision Support System for the Great Lakes—Status of data and information on water resources, water use, and related ecological impacts: Ann Arbor, Mich., final report, chap. 3, p. 49–68, accessed July 30, 2006, at *http://www.glc.org/wateruse/wrmdss/finalreport/pdf/WR-Ch.3-2003.pdf*

Chapter 3 of this report discusses the commission's inventory of water-withdrawal and water-use data and related information for the Great Lakes. This chapter includes the following tables: a self-assessment by jurisdiction for "Fulfilling Data Collection Commitments Under the Great Lakes Charter" (table 3-1, p. 51), a "Summary of Water Use Reporting Programs by Jurisdiction" (table 3-2, p. 53), a "Summary Characterization of Water Use Permitting, Registration and Reporting Programs" (table 3-3, p. 54), "Consumptive Use Coefficients by Water Use Category," (table 3-4, p. 60) and

"Measured Processes for Consumptive Use Reporting by Facilities" (table 3-5, p. 61). Most of these tables are reproduced in or derived from other Great Lakes Commission documents. The table "Consumptive Use Coefficients by Water Use Category" is reproduced in this report in appendix table 3–1.

Great Lakes Commission, 2005a, Annual reports from the Great Lakes Regional Water Use Database Repository, representing 1998 to 2002 water-use data: Ann Arbor, Mich., accessed on May 31, 2006, at *http://www.glc.org/wateruse/database/downloads.html*

For each year from 1998 to 2002 there are three reports: Introduction, Summary Reports, and Jurisdictional (states or provinces) Analyses; Basin Tables; and Water Use Category Tables (each are available in gallons or liters). Water-use data (reported to the Great Lakes Commission by the individual agencies in states and provinces) are organized by jurisdiction, water-use category, and basin for each year of data. Also included in the more recent reports is a table of consumptive-use coefficients used by jurisdictions for each water use-category. (This table is repeated in several Great Lakes Commission documents.) For public supply and self-supplied domestic use, the consumptive-use coefficient used by jurisdiction is from 10 to 15 percent. Most jurisdictions use a 90-percent consumptive-use coefficient for self-supplied irrigation with the exceptions being Ontario (78 percent) and Wisconsin (70 percent, p. 10). For self-supplied livestock, eight jurisdictions use 80 percent as the consumptive-use coefficient and two (New York and Wisconsin) use 90 percent. Hydroelectric power has no consumptive use (0 percent). For the remainder of the categories—self-supplied industrial, self-supplied thermoelectric (fossil fuel or nuclear), self-supplied other, each jurisdiction has a different basis for estimating consumptive use, including a single coefficient, a range of coefficients, and plant and Standard Industrial Classification code (SIC), among others (p. 10). The table "Consumptive Use Coefficients by Water Use Category" is reproduced in this report in appendix table 3–1. Additionally, consumptive-use coefficients derived from the annual report data are in this report as tables 3–2 to 3–9.

Great Lakes Commission, 2005b, Great Lakes Regional Water Use Database: Ann Arbor, Mich., accessed May 31, 2006, at *http://www.glc.org/wateruse/database/search.html*

The database is a repository of water-use data published in annual reports of the commission and includes a search engine for 1998–2002 data. Users can search by geographic area: Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, St. Lawrence River, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Ontario, Pennsylvania, Quebec, and Wisconsin. Additional searches include water-use category and type of water used (ground water, Great Lakes surface water, and other surface water). Data can be displayed as either million gallons or million liters per day. Users are advised to read the metadata sheet before using this database because the data from each jurisdiction were compiled differently and should not be directly compared. On the metadata page is a link to the table "Consumptive-Use Coefficients by water use category among Great Lakes Jurisdictions and USGS." This table is from a Great Lakes Commission Survey in the spring 2002, is found in other Great Lake Commission documents, and is reproduced in this report in appendix table 3–1.

Great Lakes Commission and U.S. Army Corps of Engineers, 1999, Living with the lakes—Understanding and adapting to Great Lakes water level changes: Ann Arbor, Mich., 39 p.

As part of this document on Great Lakes water-level fluctuations, consumptive use is discussed. It is noted that, owing to the large volume of the lakes, consumptive use has only a minor effect on water levels. It is further noted that the average household uses 100 gallons of water per person per day (p. 10). For industry, about 10 percent of the water used in industrial processes is consumed; for thermoelectric power, less than 2 percent of withdrawals is consumed (p. 10).

Guldin, R.W., 1989, An analysis of the water situation in the United States, 1989–2040: Ft. Collins, Colo., U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM–177, 178 p.

Mandated by the Forests and Rangelands Renewable Resources Planning Act of 1974, this document fulfills a requirement for a national analysis of water availability and quality, with emphasis on implications for forest and rangeland management. Social, environmental, and economic issues are considered in addition to quantity and quality issues. Much of the information used in the analysis was derived from previous publications. The regional tabulation of categorical consumptive-use data for (table 9, p. 44) was based on the USGS 5-year water-use circulars from 1960 through 1985; projections of consumptive use beyond 1985 were made by Soil Conservation Service personnel on the basis of "trends in the historical data."

Horn, M.A., 2000, Method for estimating water use and interbasin transfers of freshwater and wastewater in an urbanized basin: U.S. Geological Survey Water-Resources Investigations Report 99–4287, 34 p.

A 10-step method to estimate interbasin transfers of freshwater and wastewater was tested in the Ten Mile River Basin in southeastern Massachusetts. The method for estimating basin withdrawals, interbasin transfers or freshwater and wastewater, unaccounted-for uses, water use, consumptive use, inflow and infiltration, and basin return flow made use of available statewide data (p. 3). The study area covered 46 mi^2 and contained about 50 lakes and ponds, many of which are along the Ten Mile River.

Consumptive use was estimated by the author using a consumptive-use coefficient of 15 percent for domestic and 10 percent for the commercial and industrial. Horn also estimated unaccounted-for water public suppliers using an assumed average of 10 percent.

Horn, M.A., Craft, P.A., and Bratton, Lisa, 1994, Estimation of water withdrawal and distribution, water use, and wastewater collection and return flow in Cumberland, Rhode Island, 1988: U.S. Geological Survey Water-Resources Investigations Report 93–4023, 54 p.

This report is a case study demonstrating the integration of water-use data from different agencies and facilities in Cumberland, R.I. In this study, domestic consumptive use was estimated by use of a consumptive-use coefficient of 15 percent from Solley and others (1993). The domestic consumptive-use coefficient (15 percent) is primarily due to evaporation from lawn and garden watering, car and sidewalk washing, and pools (p. 27). Industrial consumptive use was estimated to be 4 percent of the withdrawals from estimation of evaporation and incorporation into the products estimated by the industries (p. 30). Horn and others (1994) applied an 8 percent consumptive-use coefficient to commercial withdrawals to get commercial consumptive use. For the study area, the authors stated, commercial consumptive use is less than domestic consumptive use because commercial use does not include as much lawn and garden watering, car or sidewalk washing, or as many pools (p. 31). Livestock consumptive use was estimated as 80 percent, where 60 percent was evaporated, 20 percent was consumed by livestock, and 20 percent was returned to the ground-water system (p. 32). Irrigation was virtually all consumptive use (100 percent) because of evaporation (p. 32).

Hutson, S.S., 1998, Water use in Tennessee, 1995: U.S. Geological Survey Fact Sheet 98–087, 4 p., accessed July 30, 2006, at *http://tn.water.usgs.gov/wustates/tn/factoffstream.html*

Data for the publication were compiled the U.S. Geological Survey and the Tennessee Department of Environmental and Conservation, Division of Water Supply. This fact sheet states that about 11 percent of industrial and mining water withdrawals in Tennessee were consumed in the production process, about 10 percent of the domestic and commercial water withdrawals were consumed, and virtually all the withdrawals for agriculture were consumed. Also of interest is that, for public utilities, about 10 percent of the withdrawals (78 Mgal/d divided by 777 Mgal/d) was either used for public uses (fire fighting, parks, and municipal swimming pools) or lost in conveyance.

Hutson, S.S., Koroa, M.C., and Murphree, C.M., 2004, Estimated use of water in the Tennessee River watershed in 2000 and projections of water use to 2030: U.S. Geological Survey Water-Resources Investigations Report 03–4302, 89 p., accessed July 30, 2006, at *http://pubs.usgs.gov/wri/wri034302/PDF/wrir034302part2.pdf*

This report presents water-use data for the Tennessee River watershed for 2000 and gives projections for 2030. Consumptive use, defined as the "difference between water withdrawals and return flow" (p. 1), was estimated as only 5 percent of the total withdrawals for the watershed. More specifically, consumptive use was less than 1 percent for all thermoelectric power water withdrawals, 22 percent for industrial withdrawals, 43 percent for public-supply withdrawals (based on comparison of community-water-system withdrawals and wastewater return flows), and 100 percent for irrigation withdrawals. Detailed tables list withdrawals, return flows, and the net water demand (consumptive use) by reservoir catchment areas as well as by Hydrologic Unit Code (HUC) and county. The report also includes a figure showing "cumulative consumptive use at major water-tabulation area junctures and net water demand for reservoir catchment areas in the Tennessee River watershed in 2000" (fig. 9, p. 13).

International Great Lakes Diversions and Consumptive Use Study Board, 1981a, Great Lakes diversions and consumptive uses: Ottawa, Ontario, and Chicago, Ill., Report to the International Joint Commission (under the Reference of February 21, 1977), main report plus 6 annexes and 3 appendixes.

International Great Lakes Diversions and Consumptive Use Study Board, 1981b, Great Lakes diversions and consumptive uses: Ottawa, Ontario, and Chicago, Ill., Annex F, Consumptive water use, 151 p.

In response to a reference from the governments of the United States and Canada, the International Joint Commission established the International Great Lakes Diversions and Consumptive Use Study Board to examine possibilities of diversion management to alleviate extreme high and low levels of the Great Lakes. The consumptive-use part of the study gathered available data to establish a baseline of water withdrawal, recirculation, and consumptive use for 1975, to be used in conjunction with economic and population data for projections through 2035. Forecasts for the U.S. part of the basin leaned heavily on water information from previous forecast efforts and data compilations, including the U.S. Water Resource Council's Second National Water Assessment, USGS 5-year water-use censuses, and the Great Lakes Basin Commission Framework Study. Forecasts for the Canadian part were done largely by computer simulation with available data because no national water-demand forecast had been done at the time of the study. Section 6 of the main report summarizes this work, and the separately bound Annex F presents descriptions and data in detail.

Despite the detail in Annex F, simple withdrawal/consumption ratios are reported only sparsely, in part because projection methods either used variable coefficients or arrived at consumption figures through more complicated avenues. Among the few reported coefficients for the Canadian part of the basin are

- municipal water consumption (assumed), 20 percent of total withdrawal (p. 26) or 15 percent of residential plus commercial water uses plus estimated losses (p. 25);
- rural residential, 60 percent of intake (assumed; p. 27);
- golf-course irrigation basinwide, 75 percent (p. 87; Great Lakes Basin Commission);
- and livestock, 100 percent (assumed; p. 81–82; rates by type of animal given on p. 84).

Other data related to standard consumptive-use coefficients are

- the U.S. percentage of municipal commercial withdrawals that are consumption, by lake basin (range, 11–54 percent; p. 11);
- U.S. ratios of manufacturing withdrawals to consumptive use for best available technology, by lake basin (range, 1.26–1.55; p. 39);
- consumption and water intake for Canadian SICs for 1975 (p. 50);
- 1975 Canadian withdrawal and consumption figures for the top five SICs, by lake basin (p. 62–63);
- and estimated water consumption for thermoelectric power categories, in million gallons per day per gigawatt-hour per year (Mgal/d/GWh/yr), 0.21–0.33 Mgal/d/GWh/yr for fossil-fueled plants and 0.35–0.56 Mgal/d/GWh/yr for nuclear plants (p. 114).

Extensive tables at the back of the annex list U.S. and Canadian and non-lake water withdrawals and consumption, in aggregate and by lake basin.

[Modified from Tate (1979) table 22. Total water intake and water consumption are in million gallons per day.]

Industry	Total water intake	Water consumption	Consumptive-use coefficient (percent)
Mines & mineral fuels	93.600	10.400	11.1
Food & beverages	103.335	9.279	9
Tobacco	0.568	0.278	49
Rubber & plastics	268.250	1.611	0.6
Leather	2.672	0.277	10
Textiles, knitting mills and clothing	44.508	1.189	3
Wood, furniture, & fixtures	5.276	0.476	9
Paper & allied products	463.053	20.978	4.5
Printing & publishing	1.525	0.064	4.2
Iron & steel	645.000	14.819	2.3
Other primary metals	42.155	0.969	2.3
Metal fabricating	13.543	0.737	5.4
Machinery	3.039	0.172	5.7
Transportation equipment	103.979	3.222	3.1
Electrical products	16.118	0.480	3.0
Non-metallic mineral products	27.611	3.610	13
Petroleum & coal	187.173	8.558	4.6
Chemicals & chemical products	713.167	37.960	5.3
Misc. manufacturing	5.230	0.216	4.1

Kaufman, Alvin, 1967, Water use in the mineral industry: Transactions of the Society of Mining Engineers, AIME, v. 238, p. 83–90.

In this eight-page document, data from the 1962 Bureau of Mines statistical canvass of water-use data are further analyzed for consumptive use, recirculated water, and concerns regarding water resources for the mineral industries. Consumptive-use coefficients for commodities and by major drainage basin region are reported as a percentage of gross water use, which is the total of recirculated water plus intake water. (These coefficients differ from those computed for this bibliography, which are based on the amount of water withdrawn (intake).) Kaufman postulated a relation between gross-water-based consumption, climate, and recirculation; results from multiple regression analysis using consumed water per river basin, recirculated water, and a 30-year average river-basin temperatures and humidity showed a medium to high correlation between consumed water and recirculated water and a low correlation between consumed water and temperate and humidity.

Although consumptive-use coefficients based on gross water used are an interesting alternative, they cannot be computed unless gross water amounts are known. Many industries know and report volumes of water withdrawn (intake), but far fewer know and report water recirculated volumes. Also, in other documents examined for this bibliography, recirculated-water and gross-water volumes, where listed, are usually noted as being less accurate than water-withdrawn (intake) volumes.

Kaufman, Alvin, and Nadler, Mildred, 1966, Water use in the mineral industry: U.S. Bureau of Mines Information Circular 8285, 58 p.

In 1963, the U.S. Bureau of Mines canvassed mineral producers to determine water use in 1962. The major water-using mineral industries at the time were natural gas processing, phosphate rock, sand and gravel, and iron ore. As part of the questionnaire, two statistical forms were used: one for petroleum and natural gas drilling contractors, secondary recovery operators, and natural gas processing plants, and another for mineral and coal producers. For nonmetals, 80 percent of the value of production was represented in the questionnaire respondents, and 95 percent of all metals were represented (table 2, p. 9). Respondents were surveyed on how much new water was used, how the water was used, the amount of water discharged, and the water consumed. (Evaporation and the amount of water lost in products should equal the amount of wastewater subtracted from the amount of new water.) For the entire United States, 16 percent of the new water intake by the mineral industry was consumed either through evaporation or as loss in product (p. 20). For the Great Lakes States, the mining consumptive use was from 3 to 12 percent, with a mean of 6 percent. For the states climatically similar to the Great Lakes, the consumptive use was from 2 to 34 percent, with a mean of 20 percent; if West Virginia and Tennessee (consumptive-use coefficients of 23 and 34 percent) were omitted from the computation, the consumptive use would be 2–12 percent with a mean of 7 percent (computed from tables below). For water-use regions including the Great Lakes and climatically similar regions, the consumptive use was from 5 to 34 percent, with a mean of 11 percent. If the Tennessee region were excluded (34 percent consumptive use coefficient), the consumptive use would be 5–12 percent with a mean of 7 percent.

[Modified from Kaufman and Nadler (1966; tables 3 (p. 10) and 4 (p. 15)). New water withdrawn and water consumed are in gallons per year; coefficient is the percentage of water withdrawn that was consumed (computed from the new water-withdrawn and water-consumed figures).]

State	New water withdrawn	Water consumed	Coefficient (percent)	Total operations	Number replying	Response (percent)
Illinois	14,765	679	5	1,094	874	80
Indiana	8,920	431	5	616	419	68
Michigan	47,296	1,202	3	539	459	85
Minnesota	102,314	4,376	4	440	412	94
New York	20,172	2,108	10	466	393	84
Ohio	32,701	3,919	12	795	657	83
Pennsylvania	41,972	3,654	9	893	717	80
Wisconsin	1,870	52	3	452	396	88
Great Lakes States	270,010	16,421	6	5,295	4,327	82
Connecticut	2,274	169	7	117	92	79
Delaware	112	7	6	16	12	75
Iowa	2,011	45	2	344	319	93
Kentucky	9,612	746	8	373	326	87
Maine	206	11	5	101	99	98
Maryland	5,195	391	8	117	91	78
Massachusetts	2,614	172	7	179	144	80
Missouri	15,776	765	5	440	303	89
New Hampshire	643	34	5	74	70	95
New Jersey	12,890	439	3	154	120	78
North Carolina	7,898	674	9	321	223	69
Rhode Island	506	45	9	31	28	90
Tennessee	57,304	19,485	34	194	173	89
Vermont	582	57	10	80	66	83
Virginia	6,968	825	12	254	208	82
West Virginia	20,464	4748	23	346	265	77
Other States	145,055	28,613	20	3,141	2,539	81

[Modified from Kaufman and Nadler (1966, from table 5 (p. 16)). New water withdrawn and water consumed are in gallons per year; coefficient is the percentage of water withdrawn that was consumed (computed from the new-water-withdrawn and water-consumed figures).]

Water-use region	New water withdrawn	Water consumed	Coefficient (percent)
Chesapeake Bay	37,468	2,560	7
Cumberland	597	68	11
Delaware and Hudson	31,638	1,955	6
Great Lakes[1]	167,850	9,033	5
Mississippi, upper	34,322	2,262	7
New England	6,343	438	7
Ohio	66,110	7,859	12
Tennessee	61,926	19,953	32
Region	406,254	44,128	11

[1] Combined Eastern Great Lakes—St. Lawrence and Western Great Lakes regions.

[Modified from Kaufman and Nadler (1966, from table 6 (p. 17)). New water withdrawn and water consumed are in gallons per year; coefficient is the percentage of water withdrawn that was consumed (computed from the new-water-withdrawn and water-consumed figures).]

Commodities	New water withdrawn	Water consumed	Coefficient (percent)
Anthracite	16,938	1,353	8
Barite	4,855	414	9
Bituminous coal	31,814	5,679	18
Clays	7,118	836	12
Copper ores	81,035	30,328	37
Gold	54,566	645	1
Iron ores	112,575	6,903	6
Lead and zinc ores	22,885	1,535	7
Lignite	18	10	56
Natural gas processing plants	102,358	33,700	33
Petroleum and natural gas production	121,538	110,578	91
Phosphate rock	117,167	29,981	26
Potash, soda, and borate	7,325	2,891	39
Salt	28,933	6,921	24
Sand and gravel	217,601	11,365	5
Stone, crushed	50,415	3,378	7
Stone, dimension	3,207	128	4
Sulfur	17,604	4,648	26
Undistributed	25,201	2,230	9
Uranium, vanadium, and radium ores	7,243	3,042	42
Total or mean	1,030,396	256,565	25

[Modified from Kaufman and Nadler (1966, from table 7). New water withdrawn and water consumed are in gallons per year; coefficient is the percentage of water withdrawn that was consumed (computed from the new-water-withdrawn and water-consumed figures).]

Type of operation	New water withdrawn	Water consumed	Coefficient (percent)
Underground mines	84,131	15,656	19
Surface mines	426,304	71,618	17
Mills, preparation plants, sand and gravel washing plants, and natural gas processing plants	327, 098	47,542	15
Chemical or solution extraction	16,267	6,326	39
Petroleum and natural gas production	121,538	110,578	91
Other	55,058	4,845	9
Total or average	1,030,396	256,565	25

Kay, R.T., 2002, Estimated water withdrawals, water use, and water consumption in Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, and Wisconsin, 1950–95: U.S. Geological Survey Water-Resources Investigations Report 01–4116, 29 p.

Compiled from previously published USGS 5-year water-use reports, the data for the listed north-central states are presented graphically to highlight trends. The section on “Estimated Water Consumption” (p. 20–27) describes methods by which consumption data were manipulated to take into account, for example, losses from public-supply water, as well as self-supplied water where both sources are used. Consumption by various categories is graphed over the study period as consumption in million gallons per day and as a percentage of the total consumption for each state. Rural domestic use is the only category presented in terms of percentage consumed with respect to total withdrawal; the values graphed for 1995 appear to be near 10–15 percent for Illinois, Indiana, Kentucky, and Michigan; 20 percent for Wisconsin; 25 percent for Missouri; and 40 percent in Iowa. (None of the data are tabulated.) Percentages reported before 1985 ranged widely, apparently because of substantially different assumptions by the estimators. For these north-central states, more than 90 percent of all water withdrawn for irrigation was consumed; the exception is Missouri, for which the coefficient was 75 percent. For self-supplied industrial systems, the following consumptive-use coefficients since 1980 were reported: Kentucky, 4 percent; Indiana, 7 percent; Michigan, 7 percent; Iowa and Missouri, 10 percent; Illinois and Wisconsin, 15 percent. Less than 4 percent of the water withdrawn for thermoelectric power in these states from 1960 to 1995 was consumed. During 1960–1995, less than 4 percent of withdrawn water was consumed in the north-central states.

LaTour, J.K., 1991, Determination of water use in Rockford and Kankakee areas, Illinois:, U.S. Geological Survey Water-Resources Investigations Report 90–4166, 70 p.

Amounts of water withdrawn, delivered, released, consumed, and returned, as well as conveyance losses and gains, were determined for six communities in Illinois in the Rockford and Kankakee areas. Although consumptive-use data were not available for the communities, consumptive use was estimated with a consumption-budget method and a types-of-use method. The consumption budget uses the following equation to determine consumptive uses:

Consumptive use = (deliveries + self-supplied withdrawals) – (releases to sewage-treatment plants + direct returns to surface- and ground-water sources) (p. 24)

The types-of-use estimates involved taking a percentage of the water withdrawals for the categories of cooling systems, boilers, and lawn watering. In Illinois, the percentage for cooling systems and lawn watering was 80 percent, and for boilers, 90 percent.

If data were insufficient for these methods, consumptive use was estimated from a minimum consumptive-use ratio per category (commercial = 0.096 and municipal = 0.284). For outside domestic-use estimates, a winter base-rate method was used wherein water withdrawal from November to April is summed and divided by 6 to yield a monthly winter base. By subtracting the base rate from water use for each month from May through October, outdoor water use is determined. Outdoor water use is then aggregated, and an evapotranspiration factor of 80 percent is applied to determine the consumptive use.

This report also discusses the maximum lawn-watering method (MLW; p. 31), which is determined by taking May–October monthly potential evapotranspiration and subtracting the difference of the monthly precipitation and monthly runoff, then multiplying that number by the average lawn site:

$$MLW = \Sigma_i \, (PE - [P - R]) * LS_i$$

where

MLW is annual maximum lawn watering estimate per lawn,
i is months when lawns are typically watered (May through October),
PE is monthly potential evapotranspiration,
P is monthly precipitation,
R is monthly runoff,
and
LS is average lawn size.

For the six communities, domestic consumptive-use ratios (consumptive-use estimates divided by deliveries and self-supply withdrawals) were derived using the types-of-use, maximum lawn-watering, and the winter base-rate methods and were compared. “Because the maximum lawn-watering estimates represent maximum domestic consumptive use, reasonable domestic consumptive-use estimates should be less than or similar to estimates calculated from the maximum lawn-watering method” (p. 32). “The winter base-rate method seems to be a more reasonable means of estimating domestic consumptive use than the types-of-use method because its ratios do not exceed the maximum lawn-watering ratios” (p. 33).

[Modified from LaTour (1991, table 11). SIC, Standard Industrial Classification: Category: C, commercial; D, domestic; I, industrial; and M, municipal: Water user is an establishment or household: Mgal/yr, million gallons per year; DEL and SSWD, deliveries and (or) self-supply withdrawals.]

SIC code	Category	Sample (number of water users)	Consumptive-use ratio (average consumptive uses divided by DEL and SSWD)
15-17	C	2	0.798
20	I	12	.322
23	I	2	.192
24-26	I	6	.544
27	I	6	.364
28-29	I	9	.277
30	I	4	.266
32	I	2	.116
33	I	10	.318
34	I	23	.318
35	I	18	.350
36	I	8	.364
37	I	2	.454
38-39	I	4	.371
43	C	1	.096
48	C	1	.273
50-53, 55-57, 59	C	33	.271
54	C	11	.332
58	C	31	.266
60-65	C	14	.482
67	C	6	.313
70	C	5	.256
72	C	6	.096
73	C	2	.531
75	C	3	.172
79	M[1],C	6	.386
80	C	10	.267
81	C	2	.215
82	M[1],C	2	.434
83	M[1], C	5	.343
86	C	13	.174
88	D[1]	1,033	.423
89	C	2	.400
91-96	M[1], C	6	.284
Mean			.325

[1]Estimated from types-of-use method only.

[Modified from LaTour (1991, table 12). Categories from Rockford and Kankakee areas, Illinois, 1984. SIC, Standard Industrial Classification code; DEL and SSWD, deliveries and (or) self-supply withdrawals.]

Category	Sample (number of water users)	Range of consumptive-use ratios (by SIC code)	Consumptive-use ratio (average consumptive uses divided by DEL and SSWD)
Commercial	149	0.096 - .0798	0.292
Industrial	106	0.116 - 0.554	.336
Domestic[1]	1,033	--	.423
Municipal[1]	12	0.284 - 0.434	.336

[1] Estimated from types-of-use method only.

The above tables show consumptive-use coefficients (ratios) of SIC code and categories. LaTour states that although "these ratios may be used as coefficients to estimate consumptive uses for systems whose water uses and climate are similar, they should be used with caution. Some of the ratios were estimated from types-of-use data that probably represent the largest consumptive use in the study areas, and many were derived from a small number of water users sampled" (p. 26). LaTour found that the "winter base-rate method provided the best domestic consumptive-use estimates" and ranged from 0.030 (3 percent) to 0.136 (13.6 percent) and averaged 0.068 (6.8 percent).

[Modified from LaTour (1991, fig. 8). Consumptive-use coefficient is in percent and was presented in report.]

Category	Rockford area consumptive-use coefficient	Kankakee area consumptive-use coeffficient
Commercial and industrial	17.9	15.7
Domestic	7.4	3.8
Municipal	25.8	28.4
All categories	13.8	12.1

In addition, LaTour assumed that "conveyance losses or gains" were zero for self-suppliers, but he noted that the national median for conveyance-loss was 11 percent and that most northern Illinois cities had a public-supply conveyance loss ranging from 0.5 to 40.0 percent of public-supply withdrawals. LaTour also noted that the public-supply conveyance losses are affected by the age and the size of the public-supply conveyance systems and the public-supply maintenance programs. LaTour found that the conveyance losses were 12 percent (Rockford, Ill. area) and 17 percent (Kankakee, Ill. area).

LaTour (1991) noted that public-supply conveyance systems are under pressure and water is typically lost, not gained; but when conveyance systems are not adequately pressurized (when water-main breaks are being repaired, for example) they may gain water. LaTour (1991) also estimated sewer-conveyance gains (inflow and infiltration) by determining the difference between sewage-treatment returns and releases but stated that unrecognized releases or significant meter errors could result in erroneous estimates. The sewer conveyance gains for the Rockford and Kankakee, Ill., areas were 35 percent of the public-supply withdrawals.

Lee, D.H., ed., 1993, Basis of comparison—Great Lakes-St. Lawrence River system: Ann Arbor, Mich., National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, NOAA Technical Memorandum ERL GLERL–79, 119 p.

Consumptive-use data for the basins of the individual Great Lakes are included in this document, which describes a 90-year set of lake levels and flows developed as a basis of comparison for future regulation plans. This document defines consumptive use of water as "that portion of water withdrawn or withheld from the Great Lakes-St. Lawrence River system and assumed to be lost due to evaporation during use, transpiration from irrigated crops, leakage, incorporation into manufactured products, or similar occurrences during use." Other factors defining the hydraulic regime are diversion rates into and out of the system, "time series of water supplies to the system, outlet conditions of each lake, flow retardation due to ice or weeds in connecting channels, initial starting elevations for the simulation, and the hydraulic condition of the St. Lawrence River and tidal levels at its outlet." Consumptive use is referred to as "a small but significant component of the water balance of the Great Lakes" (p. 2).

[Modified from Lee (1993, table 2). Consumptive use is in cubic feet per second.]

Basin	1989 consumptive use	Rounded value
Lake Superior	128	100
Lake Michigan	893	900
Lake Huron	256	300
Lake St. Clair	184	200
Lake Erie	714	700
Lake Ontario	342	300
St. Lawrence River	325	300

Loper, C.A., Lent, S.D., and Wetzel, K.L., 1989, Withdrawals and consumptive use of water in Pennsylvania, 1984: U.S. Geological Survey Water-Resources Investigations Report 88–4095, 50 p.

Total water withdrawal in Pennsylvania in 1984 was 14,033.66 Mgal/d, of which 729.53 Mgal/d was from ground water and 13,304.12 Mgal/d was from surface water. Thermoelectric power generation accounted for 71 percent of total withdrawal, followed by self-supplied industry, 15 percent; public supply, 11 percent; and mining, supplied domestic use, livestock and poultry, and irrigation (collectively) about 3 percent. Consumptive use was computed for public supply, self-supplied domestic use, irrigation, and livestock by use of coefficients. Mining, power generation, and self-supplied industry consumptive-use estimates were compiled from estimates received from facilities. For the industrial facilities that did not have facility estimates, consumptive-use totals were computed by use of Standard industrial Classification codes. The percentage of consumptive use to self-supplied withdrawals varied by county and hydrologic unit code (HUC). The table that follows lists derived consumptive-use coefficients based on withdrawal and consumption amounts tabulated in the report. The self-supplied industry coefficient of 9 percent might be artificially high because some of the facilities used both self-supplied and public-supplied water.

Public supply	10 percent
Self-supplied domestic use	10 percent consumptive-use factor multiplied by the total withdrawals to obtain consumptive use for individual counties
Agriculture:	
Irrigation	100 percent
Livestock	75 percent
Self-supplied industry	9 percent
Mining	13.5 percent
Power generation:	
Thermoelectric	1.7 percent
Hydroelectric	0

"Water consumed through evaporation or incorporation into a manufactured product totaled 615.22 Mgal/d. Self-supplied industry was responsible for 30 percent of total consumptive use followed by power generation (28 percent), public supply (26 percent), livestock (10 percent), mining (3 percent), self-supplied domestic use (2 percent), and irrigation (less than 1 percent)" (p. 48).

Ludlow, R.A., and Gast, W.A., 2000, Estimated water withdrawals and use in Pennsylvania, 1995: U.S. Geological Survey Fact Sheet 174–99, 4 p.

This fact sheet gives a brief summary of Pennsylvania's water use, by category. Most of the data used by the USGS are collected by the Pennsylvania Department of Environmental Protection (DEP), which receives annual reports of water use and consumptive use from public suppliers, power-generation facilities, and some industries. In addition, the DEP surveys other industrial, commercial, and mining facilities on a cyclical schedule. Consumptive use is one of the statistics compiled in each category. Irrigation and livestock are computed by the authors (Russ Ludlow, USGS, oral commun, October 5, 2006). The fact sheet includes a graphic (fig. 1) showing amounts of consumptive use and total use (self-supplied plus public-supply deliveries). Those data and the derived consumptive-use coefficients are the following:

[Modified from Ludlow and Gast (2000). Water consumed and withdrawn are in million gallons per day (Mgal/d). Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Industrial	158	1,870	8.4
Irrigation	15.9	15.9	100
Mining	14.0	182	7.7
Commercial	11.5	247	4.6
Public supply	574[1]	1,550	37
Domestic	74.0	740	10
Livestock	41.0	55.3	74
Thermoelectric power	239	5,930	4

[1] Public use and losses.

MacKichan, K.A., 1957—See listing under 'USGS Circulars' near the end of this section.

MacKichan, K.A, and Kammerer, J.C., 1961—See listing under 'USGS Circulars' near the end of this section.

Marcuello, Conchita, and Lallana, Concha, 2003, Water exploitation index: European Environment Agency, accessed May 24, 2006, at *http://themes.eea.europa.eu/Specific_media/water/indicators/WQ01c%2C2003.1001/WEI_101003v2.pdf*

This document includes consumption and exploitation indexes in European countries. The water consumption index is the total water consumed divided by the long-term freshwater resources of a country. Indexes ranged from about 0 for Iceland to about 27 percent for Cyprus, with an average of 3 percent. The water exploitation index (WEI) or withdrawal ratio is the mean annual total withdrawal of freshwater divided by the long-term average freshwater resources. The exploitation index is used to classify countries as non-stressed (less than 10 percent), low-water stress (between 10 and 20 percent), or water stressed (greater than 20 percent). Cyprus, Malta, Italy, and Spain have 18 percent of Europe's population and are considered water stressed. For this assessment, it was assumed that the consumptive use was 80 percent of the total water withdrawals for agriculture, 20 percent for urban use, 20 percent for industry, and 5 percent for energy production. The authors note that these consumptive use coefficients are "widely accepted, though they may vary by about 5 to 10 percent depending on the sectors and other factors." As an example, actual consumption of water for agriculture depends on climate, crops, and irrigation methods.

Medalie, Laura, 1996, Wastewater collection and return flow in New England, 1990: U.S. Geological Survey Water-Resources Investigations Report 95–4144, 79 p.

A compilation of state and drainage-basin site-specific data on municipal wastewater-collection systems, municipal wastewater-treatment facilities, and municipal wastewater return, this document is a source of information for state and municipal planners. For some facilities that did not have return-flow data, return-flow amounts were estimated by multiplying the per capita water-use coefficient of 65 gal/d and the population served. The per capita water-use coefficient was determined by taking the average self-supplied per capita domestic use of 76 gal/d in New England and subtracting 14 percent for consumptive use (p. 11; Solley and others, 1993).

Medalie, Laura, 1997a, Estimated water withdrawals and use in Vermont, 1995: U.S. Geological Survey Water-Resources Investigations Report 97–4178, 14 p.

Water withdrawals by county and by Hydrologic Unit Code for Vermont are tabulated for 1995 in this document. Although the report does not present consumptive-use information, it states that “about 90 percent of the water used for irrigation is lost through evapotranspiration” (p. 11) and cites the University of Vermont Cooperative Extension as a source.

Medalie, Laura, 1997b, Estimated water withdrawals and use in New Hampshire, 1995: U.S. Geological Survey Water-Resources Investigations Report 97–4177, 13 p.

Water withdrawals by county and by Hydrologic Unit Code for New Hampshire are tabulated for 1995 in this document. Although the report does not present consumptive-use information, it states that “about 90 percent of the water used for irrigation is lost through evapotranspiration” (p. 9) and cites the University of Vermont Cooperative Extension as a source.

Mullaney, J.R., 2004, Water use, ground-water recharge and availability, and quality of water in the Greenwich area, Fairfield County, Connecticut and Westchester County, New York, 2000–2002: U.S. Geological Survey Water-Resources Investigations Report 03–4300, 64 p.

This document reports on a detailed study of the wealthy Greenwich area of Connecticut and New York, which may be atypical of the rest of the two states in its apparently greater residential use of water: 113–416 gal/person/d, depending on residential lot size, in contrast to an estimated 76 gal/person/d statewide. Public-supply data were used to develop regression models for estimating ground-water withdrawals for year-round, summer, and winter water use on self-supplied lots; model variables included unforested area, swimming-pool size, and total footprint of buildings. Detailed water-use estimates are tabulated for 32 zones (small basins) in the Greenwich area. Also estimated was return flow of public-supply water via septic systems. Consumptive water use was estimated to be the outdoor water use “by subtracting the winter water-use data from the average daily water use.” Consumptive use for Greenwich properties with public supply averaged 20 percent, consistent with previously published estimates for Connecticut (in Solley, 1998); the median was 19 percent, and the interquartile range was from 3 to 39 percent. A higher coefficient—29 percent—was estimated by use of the regression models.

Murray, C.R., 1968—See listing under ‘USGS Circulars’ near the end of this section.

Murray, C.R. and Reeves, E.B., 1972—See listing under ‘USGS Circulars’ near the end of this section.

Murray, C.R. and Reeves, E.B., 1977—See listing under ‘USGS Circulars’ near the end of this section.

National Land and Water Resources Audit Australia, 2001, 1985 review of Australia’s water resources and water use: Accessed May 24, 2006, at *http://www.nlwra.gov.au/archive/full/20_products/05_by_subject/10_water_resources_and_mgt/00_Water_Review_1985/10_water_use/water_use.html*

Included in this fact sheet are maps showing the gross water consumed in Australia by total water, surface-water resources, and ground-water resources. Maps of drainage basins in Australia are color coded to show the water consumed (in gigaliters) between July 1, 1983, and June 30, 1984. Gross water consumed is defined as the “water supplied that was not returned to a stream or body of fresh water or diverted for use a second time (reclaimed water). It is the difference between gross water supplied and return flow plus reclaimed water.”

Nawyn, J.P., 1997, Water use in Camden County, New Jersey, 1991: U.S. Geological Survey Open-File Report 97–12, 39 p.

The study described in this report examined water use (from withdrawal to return flow) during 1991 in Camden County, N.J. “Coefficients of consumptive water use that were developed in other studies were modified and applied to data on water users in Camden County” (p. 10). Consumptive use was estimated by use of coefficients for both publicly supplied and self-supplied water. Coefficients of consumptive use by category of water use—public supply, domestic, commercial, industrial, irrigation, and mining—are given for all water users in the county. Per capita use of domestic users also was computed. For public-supply facilities, 12 percent of withdrawal was unaccounted for by facilities that submitted a report. Because of unusually high losses in one public-supply facility, unaccounted-for water was estimated to be 10 percent (instead of 12 percent) of water deliveries for public suppliers who did not submit a report.

[Modified from Nawyn (1997). Distributed water/withdrawals and consumptive use are in million gallons per day; coefficient is in percent.]

Category of use	Coefficient	Distributed water/withdrawals	Consumptive use
Public-supply deliveries			
Domestic	18	44	8
Commercial	4	9	<1
Industrial	8	1	<1
Public water use[1]	20	3	1
Total	NA	57	9
Self-supply withdrawals			
Domestic	20	2	<1
Commercial	4	NA	<1
Industrial	90	2	2
Irrigation	90	2	2
Mining	8	1	<1
Total	NA	10	3

[1]Does not include distribution losses or bulk sales to other public suppliers.

Neff, B.P., and Killian, J.R., 2003, The Great Lakes water balance—Data availability and annotated bibliography of selected references: U.S. Geological Survey Water-Resources Investigations Report 02–4296, 37 p.

Although this document does not specifically list consumptive-use coefficients, it includes references to published and agency sources of consumptive-use information.

Neff, B. P., and Nicholas, J.R., 2005, Uncertainty in the Great Lakes water balance: U.S. Geological Survey Scientific Investigations Report 2004–5100, 42 p.

In this report, the water balance of the Great Lakes hydrologic system is discussed. Because consumptive use is a small component of the overall water balance, it is not addressed in this document; however, readers are referred to chapter 3 of the Great Lakes Commission report (2003; p. 19).

Nimiroski, M.T., and Wild, E.C., 2005, Water use and availability in the Woonasquatucket and Moshassuck River Basins, north-central Rhode Island: U.S. Geological Survey Scientific Investigations Report 2005–5031, 43 p.

Withdrawal, use, and return-flow data were collected for the Woonasquatucket and Moshassuck River Basins in north-central Rhode Island. This study used a consumptive use coefficient of 10 percent for commercial and industrial categories (tables 6 and 9, p. 11 and 25; Solley and others, 1998). For the basin, the domestic public-supplied and self-supplied domestic consumptive-use coefficient was 15 percent (Solley and others, 1998). The agricultural (livestock, crop irrigation and golf course irrigation) consumptive use coefficient was assumed to be 100 percent. The authors noted that Horn and others (1994) had a specific coefficient for livestock, but they did not use this coefficient because of negligible livestock water use in the study area.

Ohlsson, Leif, 1997, Water scarcity and conflict: University of Göteborg, Sweden, 25 p., accessed May 1, 2006, at *http://www.padrigu.gu.se/ohlsson/files/Bonn97.pdf*

As part of this document, water use is discussed by category and sector (p. 4). The largest water user in terms of global water withdrawals is agriculture at 65–70 percent, followed by industrial withdrawals at 20–25 percent, followed by domestic water use at 5–10 percent. For agriculture, 65 percent of total withdrawal is considered consumptive use (from Postel and others, 1996); for industrial and domestic use, the coefficients are 9 percent and 17 percent, respectively (p. 4). It should be noted that the actual water consumed in agriculture varies by water-use efficiency, climate, and types of harvests.

Paulson, R.W., Chase, E.B., and Carr, J.E., 1988, Water supply and use in the United States—U.S. Geological Survey National Water Summary 1987 *in* Waterstone, Marvin, and Burt, J.R., eds., Proceedings of the Symposium on Water-Use Data for Water Resources Management, Tucson, Ariz., August 28–31, 1988: Bethesda, Md., American Water Resources Association, p. 41–49.

This paper is a general overview of the U.S. Geological Survey 1987 National Water Summary, which was focused on the source, use, and disposition of water in the United States. In a diagram citing the U.S. Geological Survey National Water Data Storage and Retrieval System, this document shows consumption-to-withdrawal rates of 19.5 percent of domestic and commercial water use, 16 percent for industrial-mining, 3.3 percent for thermoelectric power generation, and 53.9 percent for irrigation.

Pebbles, Victoria, 2003a, Consumptive use in the Great Lakes Region and Basin—Annotated bibliography of selected references: Ann Arbor, Mich., Great Lakes Commission, 10 p.

Narrower in geographic scope than the current bibliography, this document reports consumptive-use coefficients in some of its annotations and served as a starting point for the current bibliography. In all, 27 publications and data sources are described.

Pebbles, Victoria, 2003b, Measuring and estimating consumptive use of the Great Lakes water: Ann Arbor, Mich., Great Lakes Commission, prepared in cooperation with the Water Withdrawal Subcommittee of the Water Resources Decision Support System Project, 18 p.

The purpose of this document was to describe the "current state of knowledge of consumptive use of water in the Great Lakes basin" as background for development of a decision-support system for water-resources management. It is based on a bibliography compiled by the author (see preceding listing), informal interviews and correspondence with water experts in the region, and results of a 2002 Great Lakes Commission (GLC) survey of the states and provinces within the basin regarding consumptive-use information and estimating methods. The author begins by listing varied definitions of consumptive use over time and by different agencies, then follows with brief descriptions of estimating methods, comparisons of consumptive-use coefficients used by the USGS and the GLC, comparisons of USGS and GLC water-use categories and estimating procedures and consumptive-use reporting by jurisdictions, and recommended actions for consumptive-use estimating, calculating, and reporting. Of particular interest are a small summary table listing ranges of USGS consumptive-use coefficients in the 1985–95 water-use circulars (p. 5) and a large table listing ranges of coefficients by water-use category and jurisdiction (USGS included); the latter table is reproduced in this report as appendix table 3–1. An interesting side note is a discussion of how a general coefficient of 6.8 percent for all types of self-supplied industry in Ontario was largely substantiated by aggregating facility-measured data (p. 11).

Pennsylvania Department of Environmental Resources, Office of Resources Management, 1975–83, The State Water Plan: 20 v. [Planning Principles document plus 19 reports on individual subbasins].

Each individual subbasin volume of this series contains a table listing water withdrawals (surface water, ground water, and total), interbasin-transfer losses, and consumptive losses for 1970 (known or estimated), plus projections for 1980 and 1990. Consumptive-use coefficients used across the board were 10 percent for municipal, 100 percent for irrigation (including golf course), 75 percent for livestock, and 10 percent for "other self-supplied institutions." For mineral industries, manufacturing, and power production, however, consumptive-loss figures were varied and appear to have been based on reported data. Data for the 20 subbasins are tabulated below for these latter categories. Ranges of coefficients (in percent) are mineral industries, 5.0–17.6 (with a median of 8.1); manufacturing, 6.2–11.4 (with a median of 7.5); and power, <0.1–8.6 (with a median of 1.23).

[Modified from Pennsylvania Department of Environmental Resources (1975–1983). Wdl, total withdrawal, in million gallons per day; CL, consumptive losses, in million gallons per day; Coef, coefficient (CL/Wdl × 100)]

Type of use	Subbasin 1			Subbasin 2			Subbasin 3			Subbasin 4		
	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef
Mineral	3.926	0.225	5.7	27.75	1.925	6.9	11.25	0.896	8.0	0.510	0.028	5.5
Manufacturing	3.752	0.374	10	650.2	43.97	6.8	0.369	0.026	7.0	23.03	1.666	7.2
Power	485.8	2.800	0.6	0	0	--	0	0	--	0	0	--

Type of use	Subbasin 5			Subbasin 6			Subbasin 7			Subbasin 8		
	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef
Mineral	15.26	1.165	7.6	17.94	1.425	7.9	32.22	2.117	6.6	0.301	0.053	17.6
Manufacturing	23.20	1.757	7.6	0.887	0.068	7.7	96.65	6.594	6.8	0.486	0.031	6.4
Power	120.9	1.397	1.2	291.0	2.100	0.7	1119	7.855	0.7	425.2	3.100	0.7

Type of use	Subbasin 9			Subbasin 10			Subbasin 11			Subbasin 12		
	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef
Mineral	1.300	0.087	6.7	0.249	0.014	5.6	0.691	0.048	6.9	9.578	0.519	5.4
Manufacturing	32.58	3.124	9.6	1.954	0.137	7.0	10.21	0.790	7.7	27.54	1.770	6.4
Power	44.70	0.030	0.1	0	0	--	84.67	0.667	0.8	0	0	--

Type of use	Subbasin 13			Subbasin 14			Subbasin 15			Subbasin 16		
	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef
Mineral	1.626	0.165	10.1	0	0	--	0.020	0.001	5.0	2.999	0.156	5.2
Manufacturing	0.915	0.070	7.6	0	0	--	36.14	2.762	7.6	42.95	4.880	11.4
Power	0	0	--	0	0	--	299.9	0.155	0.052	89.00	0.210	0.2

Type of use	Subbasin 17			Subbasin 18			Subbasin 19			Subbasin 20		
	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef	Wdl	CL	Coef
Mineral	2.280	0.191	8.4	8.201	0.824	10.0	3.626	0.638	17.6	6.273	0.414	6.6
Manufacturing	94.83	6.783	7.1	481.3	29.91	6.2	1651	102.0	6.2	726.2	46.28	6.4
Power	235.2	20.16	8.6	855.4	16.65	1.9	1688	7.43	0.4	1011	0.200	0.02

Postel, Sandra, 1996, Dividing the waters—Food security, ecosystem health, and the new politics of scarcity: Washington D.C., Worldwatch Paper 132, 76 p.

This book is a blueprint for using water more efficiently, sharing water equitably, and protecting freshwater ecosystems. This document includes estimated demand and estimated consumption by water-use sector for the world in 1990 from Postel and others (1996). For agriculture, the consumption was 1,870 cubic kilometers per year (km^3/yr) of a demand of 2,880 km^3/yr, yielding a consumption coefficient of 65 percent. For industrial uses, the consumption was 90 km^3/yr of a demand of 975 km^3/year, yielding a consumption coefficient of 10 percent. For municipalities, the consumption was 50 km^3/year of a demand of 300 km^3/yr, yielding a consumption coefficient of 17 percent. Also, reservoir losses constituted both a consumption and demand of 275 km^3/yr, yielding, in effect, a consumption coefficient of 100 percent (table 2, p. 14).

Postel, S.L., Daily, G.C., and Ehrlich, P.R., 1996, Human appropriation of renewable fresh water: Science, v. 271, no. 5250, p. 785–788.

This article includes an estimate of how much of Earth's renewable water is realistically accessible to humans; the portion of the renewable water that humans use, divert, or appropriate; and the likely expansion of human access to freshwater in the next 30 years (p. 785). Currently, humans use 26 percent of the total. As part of this analysis, the document includes estimated use and estimated consumption by water-use sector for the world for 1990. For agriculture, the consumption was 1,870 cubic kilometers per year (km^3/yr) of a demand of 2,880 km^3/yr with a consumption coefficient of 65 percent (p. 787, table 4). For industrial uses, the consumption was 90 km^3/yr of demand of 975 km^3/year with a consumption coefficient of 10 percent. For municipalities, the consumption was 50 km^3/year of a demand of 300 km^3/yr with a consumption coefficient of 17 percent. Reservoir losses had both a consumption and demand of 275 km^3/yr with a consumption coefficient of 100 percent (p. 787, table 4). Also of interest is the statement that humans now use "26 percent of total terrestrial evapotranspiration and 54 percent of runoff that is geographically and temporally accessible. Increased use of evapotranspiration will confer minimal benefits globally because most land suitable for rain-fed agriculture is already in production. New dam construction could increase accessible runoff by about 10 percent over the next 30 years, whereas population is projected to increase by more than 45 percent during that period" (p. 785).

Quan, C.K., 1988, Water use in the domestic nonfuel minerals industry: U.S. Bureau of Mines Information Circular 9196, 62 p.

Nonfuel mineral industries were canvassed, and the information gathered is presented in this report. Appendix B, tables B–1 and B–5 (p. 39, 42) list number of respondents; appendix C, tables C–1 and C–7 (p. 46, 52) list water consumed by type of metal and by state. With this information, as well as the amount of new water that is withdrawn, consumptive-use coefficients were computed. (See table that follows this entry.) Also of interest are tables listing water use by short ton of crude ore produced and water use per dollar of mined production. For the Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin), the mean consumptive use was 20 percent of the water withdrawn, and the range of consumptive-use coefficients was 14–34 (table C–7, p. 52). For the 16 climatically similar states (Connecticut, Delaware, Iowa, Kentucky, Maine, Maryland, Massachusetts, Missouri, New Hampshire, New Jersey, North Carolina, Rhode Island, Tennessee, Vermont, Virginia, West Virginia), the consumptive-use coefficient was 30 percent, but this figure is skewed by two states, New Jersey and West Virginia, that had high coefficients of 86 and 55, respectively (table C–7, p. 52). Consumptive-use figures for both states were based on a small number of facilities that reported water use, 9 and 15, respectively (table B–6, p. 43), so inaccurate reporting or an unusual type of facility mining process could be skewing the consumptive-use coefficient. Omitting these two states, the consumptive-use coefficient for the climatically similar states is 22 percent. If only New Jersey is omitted, the coefficient is 23 percent.

[Modified from Quan (1988). Total withdrawn and water discharged are in billion gallons; coefficient is the percentage of water withdrawn that was consumed (computed from the total withdrawn and water discharged numbers).]

Commodity	Water withdrawn	Water consumed	Coefficient	Respondents	Respondents with water use
Metals					
Copper	81,460	62,590	77	20	18
Gold:					
Lode	6,220	4,240	68	27	21
Placer	3,490	250	7	17	13
Iron ore	67,740	10,720	16	19	12
Lead	2,500	30	1	10	8
Silver	2,490	1,010	41	16	14
Uranium-vanadium	6,980	1,020	15	55	24
Zinc	2,400	510	21	11	9
Other metals	6,250	2,480	40	21	12
Metal total	179,530	82,850	46	196	131
Nonmetals					
Clays	22,600	7,790	34	181	48
Diatomite	520	520	100	5	5
Feldspar	1,430	350	24	10	10
Gypsum	560	530	95	47	10
Magnesium compounds	960	0	0	5	4
Mica, scrap	1,140	410	36	4	4
Phosphate rock	117,690	60,850	52	35	28
Potash	4,400	2,160	49	8	7
Salt					
Evaporated	22,580	1,990	9	23	19
Rock	3,570	170	5	13	4
Salt in brine	6,310	6,310	100	25	18
Sand and gravel					
Construction	100,500	32,780	33	10	9
Industrial	23,710	16,090	68	41	37
Sodium carbonate, natural	9,480	5,920	62	6	6
Stone, crushed	64,960	19,320	30	1,443	683
Sulfur, Frasch	7,550	2,000	26	6	6
Other nonmetals	3,510	2,710	77	52	33
Nonmetal total	391,470	159,900	41	1,894	931
Grand total	571,000	242,750	43	2,090	1,062

[Modified from Quan (1988, table C–7). Total withdrawn and water discharged are in billion gallons; coefficient is the percentage of water withdrawn that was consumed (computed from the total withdrawn and water discharged numbers)]

State	Total withdrawn	Water consumed	Coefficient
Great Lake States			
Illinois	13,610	4,590	34
Indiana	3,660	730	20
Michigan	26,910	3,740	14
Minnesota	65,000	11,420	18
New York	18,200	4,050	22
Ohio	9,220	2,540	28
Pennsylvania	11,240	2,280	20
Wisconsin	2,820	830	29
GL States, mean	150,660	30,180	20
Climatically Similar states to the Great Lake States			
Connecticut	1,140	300	26
Delaware	260	40	15
Iowa	2,650	640	24
Kentucky	1,850	380	21
Maine	1,030	340	33
Maryland	2,380	820	34
Massachusetts	2,500	640	26
Missouri	7,630	1,080	14
New Hampshire	730	240	33
New Jersey	8,670	7,420	86
North Carolina	27,320	7,060	26
Rhode Island	220	60	27
Tennessee	14,960	1,650	11
Vermont	490	160	33
Virginia	2,280	940	41
West Virginia	1,330	730	55
States mean	75,440	22,500	30

Shiklomanov, I.A., and Rodda, J.C., 2003, World water resources at the beginning of the 21st century: Cambridge U.K., Cambridge University Press [for] UNESCO, 435 p.

This comprehensive volume includes data on global water resources, water use, and water availability, by continent. Water use for domestic (urban and rural) was based on population totals, changes in population totals, and per capita use of water. Consumption of water was from published data and country analogues (38). Water consumption for irrigation ranged from 50 to 90 percent and varied by country and region, depending on physiographic conditions and irrigation techniques employed. Irrigation-water assessments were made by analyzing population, area irrigated by years (including specific values), and the annual gross national product expressed in U.S. dollars per capita from 1960 to 1994. Water abstracted and consumed was determined from national estimates or country analogues (p. 38). Industrial water use was determined by available industrial water use data or was calculated from industrial production trends in different regions (p. 39).

For Europe, industrial consumption (including thermal power production, processing, and mining) was 11 percent of withdrawals (p. 55), domestic consumption was about 12 percent (p. 58), and agricultural consumption was about 70 percent (p. 59). Also of interest are assessments of water use and consumptive use by type of economic activity in Europe, by region, and by economic activity for the regions of Europe. For parts of Asia, South America, Australia, Africa, and the world as a whole, water use and consumptive use are shown by regions and by water-use category. Unfortunately, the document is not segmented by both region and water-use category such that data for countries climatically similar to the Great Lakes region could be reviewed.

For Africa, water consumption in agriculture is largest (75–90 percent) in the developed countries in the northern and southern parts of the continent and in exceptionally dry countries in the Sahel and western Africa (South Africa, p. 191–192); in the central region, agriculture consumption coefficients are 65–70 percent (p. 192). For North America, there are three regions—south (Mexico), central (contiguous United States), and northern (Canada and Alaska) (p. 237)—and data are presented by region and water-use category. Also of interest are water-use forecasts for 2000, 2010, and 2025.

The consumptive-use coefficients for the Shiklomanov and Rodda report are summarized in appendix 4 (tables 4-1–4-6) of this report.

Sholar, C.J., 1988, Water use in Kentucky, 1985, with emphasis on the Kentucky River Basin, *in* Waterstone, Marvin, and Burt, J.R., eds., Proceedings of the Symposium on Water-Use Data for Water Resources Management, Tucson, Ariz., August 28–31, 1988: Bethesda, Md., American Water Resources Association, p. 85–92.

This paper presents 1985 water-use data for eight major water-use categories in Kentucky and the Kentucky River Basin. The total amount of consumptive use in 1985 was 260 Mgal/d for Kentucky (p. 85). For public-supply systems, 10 percent of the public-supply deliveries was either lost in the distribution systems or was used for public uses such as firefighting (p. 86). For the State, 4 percent of the water used in industry was consumed, and 3.6 percent of the water used for thermoelectric purposes was consumed. Most of the water consumed in the Kentucky River Basin was used for domestic, thermoelectric, and agricultural purposes. For domestic use in the Kentucky River Basin, 38 percent of the withdrawals were consumed (see table below); and for thermoelectric use, 5 percent of the withdrawals were consumed (see table below). For agricultural purposes, both livestock and irrigation, the water consumed was estimated to be “almost 10 Mgal/d” (p. 90) for withdrawals that totaled 9.85 Mgal/day (see table below); therefore, 95–100 percent of the agricultural water withdrawal was consumed.

[Modified from Sholar (1988). Water withdrawn and water consumed in million gallon per day. Coefficient is in percent.]

Water-use category	Water withdrawn	Water consumed	Coefficient
Public supply:			
Domestic	70.1	15.4	38
Commercial	40.8		
Industrial	5.2		
Mining	37.7		
Thermoelectric Power generation	3.1	8	5
Hydroelectric Power generation	153	0	0
Agricultural	9.85	Almost 10	95-100
Livestock	7.35		
Irrigation	2.5		

Sholar, C.J. and Lee, V.D., 1988, Water use in Kentucky, 1985: U.S. Geological Survey Water-Resources Investigations Report 88–4043, 53 p.

This report presents 1985 water-use data for eight major water-use categories in Kentucky by county. Included are withdrawals and consumptive use data that are collected and presented in the report. Some of these data are also given in the proceedings from a “Symposium on Water-Use Data for Water Resources Management” (Sholar, 1988).

[Modified from Sholar and Lee (1988, tables 2– 8). Water withdrawn includes withdrawals and deliveries and is million gallons per day. Water consumed is also in million gallons per day. Consumptive use is in percent.]

Water-use category	Water withdrawn	Water consumed	Consumptive use
Domestic	226.21	59.68	26
Commercial	34.52	1.33	4
Industrial	407.69	17.20	4
Mining	25.37	.74	3
Thermoelectric power generation	3,407.39	123.52	4
Irrigation	7.67	7.33	96
Livestock	50.17	50.17	100

Sholar, C.J., and Wood, P.A., 1991, Evaluation of the drought susceptibility of water supplies used in the Kentucky River Basin in 1988: U.S. Geological Survey Water-Resources Investigations Report 91–4105, 34 p.

Of interest in this report is a table that ranks public-water facilities in the Kentucky River Basin by drought susceptibility. Another table includes method and frequency of leak-detection programs for public-supply facilities in the Kentucky River Basin. For public-supply systems, 21 percent of the withdrawals was either lost in the distribution system or used in public uses such as firefighting.

Sholar, C.J., and Wood, P.A., 1995, Water use in Kentucky, 1990: U.S. Geological Survey Water-Resources Investigations Report 95–4032, 51 p.

This report contains detailed county-by-county and statewide analysis of water use including withdrawals, deliveries, and consumptive use. Data for public supply, commercial, industrial, mining, and power generation were compiled and estimated through a cooperative program between the USGS and the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water. Irrigation (minus conveyance loss) and livestock withdrawals are assumed to be about 100 percent consumed. Thermoelectric-power figures are particularly interesting in that they show consumptive use ranging from 0 to 85 percent of withdrawals and deliveries.

[Modified from Sholar and Wood (1995). Water consumed and withdrawn is in million gallons per day. Consumptive use is in percent.]

Water-use category	Consumed	Withdrawn[1]	Coefficient
Domestic[2]	41.34	235.05	18
Commercial	1.26	36.66	3
Industrial	19.16	512.09	4
Irrigation	11.50	10.94	95
Livestock	32.85	32.85	100
Mining	0.54	18.22	3
Thermoelectric power	203.15	3443.92	6

[1]Withdrawals and deliveries.

[2] Self-supply plus public supply. Per capita use is 69.88 gal/d.

Snavely, D.S., 1986, Water-use data-collection programs and regional data base of the Great Lakes-St. Lawrence River Basin states and provinces: U.S. Geological Survey Open-File Report 86–546, 204 p.

This compilation contains results from a detailed survey of state, provincial, and national agencies regarding water-use data collection, estimation, and reporting. The survey was a mandate of the Great Lakes Charter of 1985 and provided background for construction of a Great Lakes regional water-use database. The second of the three main sections of the report describes water-use data-collection programs in each of the states and provinces, methods of estimation used by each for data categories for which records were unavailable, and inconsistencies among the respective programs at the time of writing. The report concludes with a comparison of database requirements and available data, as well as suggestions for future database refinements; among the suggestions are to "improve methods of estimation and techniques of collecting data and calculating consumptive use" and to"agree to some uniformity of methods within the region" (p. 58). Consumptive-use coefficients used or reported by each state are listed in the text and are too detailed and inconsistent for a short tabulation here. Also of interest in the report is a full-page table of water-use coefficients by Standard Industrial Classification (SIC) code and state (table 7B, p. 188).

Snavely, D.S., 1987, Great Lakes water-use data base—Planning for the 21st century: U.S. Geological Survey Yearbook, Fiscal Year 1987, p. 93–98.

A synopsis of the Great Lakes Charter, Great Lakes Project, and the regional water-use database, this document includes a graph of percentages of total water withdrawals that are returned in Great Lakes data for 1983. This data were from U.S. Geological Survey Circular 1001 (Solley and others, 1983). For thermoelectric power, 99.7 percent of withdrawal was returned and 0.3 percent consumed. For domestic use, 73.7 percent was returned and 26.3 percent consumed. Livestock and irrigation categories had the smallest proportion of withdrawals returned, 8.3 percent and 3.3 percent, respectively; and the largest portion consumed, 91.7 percent and 96.7 percent, respectively (fig. 14, p. 96). For public water supply, 92.1 percent of withdrawals was returned and 7.9 percent consumed. For industrial water use, 93.5 percent of withdrawals was returned and 6.5 percent consumed. Also of interest in this document is a pie chart of consumptive water use in the Great Lakes Basin in the United States in 1980. Industry, irrigation, and public water supply made up more than 80 percent of the consumptive use in the Great Lakes (fig. 15, p. 96).

[Modified from Snavely (1988). Data are as reported by the International Great Lakes Diversions and Consumptive Uses Study Board and the U.S. Geological Survey. Coefficient is the consumptive use as a percentage of the withdrawal; a dash indicates no data]

Water-use category	1975		1980		1985	
	Study Board[2]	USGS	Study Board	USGS	Study Board	USGS
Manufacturing[1]	11	6.5	13	6.5	14	9.4
Public water supply	11	13	11	8	11	--
Thermoelectric power	1.2	0.21	1.7	0.34	2.1	4.9
Irrigation	74	95	76	100	80	100
Domestic[3]	60	21	64	27	62	74
Livestock	100	93	100	92	100	88
Totals	6.6	3.3	7.4	3.3	7.8	6.8

[1] For manufacturing, the 1975 figures exclude mining, but the 1980 and 1985 figures include mining.

[2] The Study Board coefficient is from the International Joint Commission.

[3] The USGS 1975 and 1980 domestic consumptive-use coefficients were based on only self-supplied water use, whereas the 1985 consumptive-use coefficient represented both self-supplied and publicly supplied water use.

Snavely, D.S., 1988, Estimation, analysis, sources, and verification of consumptive water use data in the Great Lakes–St. Lawrence River Basin: U.S. Geological Survey Water-Resources Investigations Report 88–4146, 28 p.

This document is a review of consumptive water-use data (withdrawals and consumptive use) and consumptive-use coefficients from the International Joint Commission (IJC), the International Great Lakes Diversions and Consumptive Uses Study Board (Study Board), and the U.S. Geological Survey (USGS). Reasons for discrepancies in consumptive water-use estimates are discussed, as well as methods that could be used for future consumptive-use data compilation. Also as part of this report, the USGS analyzed the data and computed a range of projected consumptive use from 1980 to 2000. From 1975 to 1985, the Study Board's overall consumptive use totals increased from 6.6 to 7.8 (p. 10), whereas the USGS's overall consumptive-use total increased from 3.3 to 6.8 percent. The large increase in consumptive use for the USGS numbers could be attributed to an increase in percentage of water consumed, an increase in the accuracy of the USGS data, or a combination of both. Snavely states that the accuracy of USGS data improved in response to a more careful analysis of methods and use of reported data instead of estimated values.

Solley, W.B., Chase, E.B., and Mann, W.B., 1983—See listing under 'USGS Circulars' near the end of this section.

Solley, W.B., Merk, C.F., and Pierce, R.R., 1988—See listing under 'USGS Circulars' near the end of this section.

Solley, W.B., Pierce, R.R., and Perlman, H.A, 1993—See listing under 'USGS Circulars' near the end of this section.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1998—See listing under 'USGS Circulars' near the end of this section.

Stevens, H.C., Suder, K.E., and Lessing, Peter, 1984, Water use in West Virginia for 1981: West Virginia Geological and Economic Survey Circular C–33, 94 p.

This comprehensive inventory of withdrawals and instream uses of water for 1981 in West Virginia includes data that are aggregated on the state, county, and Hydrologic Unit Code (HUC) levels. In cooperation with the USGS, the West Virginia Geological and Economic Survey compiled and computed data for this report from Federal, and state sources, as well as from water users for the thermoelectric power and industrial categories. Water-use data included withdrawal and return-flow data. In the following table are the water-withdrawal and consumptive-use data that were reported in the document (p. 5) and the coefficients that were derived from the reported data.

[Modified from Stevens and others (1984). Water consumed and water withdrawn are in million gallons per day. Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Agriculture	6.03[1]	6.03	100
Industry	-	-	-
Irrigation	4.42[1]	4.42	100
Mining discharge	0	101.92	0
Public suppliers[1]	133.06[1]	133.06	100
Rural domestic	18.77[1]	18.77	100
Sewage treatment	N/A	220.74	N/A
Thermoelectric power	607.01	4,382.06	13.85

[1]Reported as "No water returned."

[2] Water returned. Reported as "No water withdrawn." Total exceeds reported withdrawals for public suppliers.

Suder, K.E., and Lessing, Peter, 1984, Water use in West Virginia in 1982: West Virginia Geological and Economic Survey Circular C–35, 96 p.

This comprehensive inventory of withdrawal and instream uses of water for 1982 was compiled by the West Virginia Geological and Economic Survey and the USGS. Data are summarized statewide and also by county and eight-digit hydrologic unit. Withdrawal and (or) return data are reported for withdrawal categories in the following table (coefficients computed from reported data).

[Modified from Suder and Lessing (1984). Water consumed and water withdrawn are in million gallon per day. Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Industry	27.9	783.62	3.56
Irrigation	2.21[1]	2.21	100
Mining discharge	0	101.92	0
Public suppliers[1]	103.91[1]	103.91	100
Rural domestic	18.77[1]	18.77	100
Sewage treatment	N/A	181.55[2]	N/A
Thermoelectric power	436.20	4,089.55	10.7

[1] Reported as "No water returned."

[2] Water returned. Reported as "No water withdrawn." Total exceeds reported withdrawals for public suppliers.

Suder, K.E., and Lessing, Peter, 1985, Water use in West Virginia in 1983: West Virginia Geological and Economic Survey, Circular C–37, 95 p.

This comprehensive inventory of withdrawals, return flows, and instream uses of water for 1983 in West Virginia includes data that are aggregated on the state, county, and Hydrologic Unit Code (HUC) levels. Data for this report were compiled from Federal and state sources, as well as from water users for the thermoelectric power and industrial categories, by the West Virginia Geological and Economic Survey in cooperation with USGS. In the following table are the water-withdrawal and consumptive-use data reported in the document (p. 7) and the coefficients derived from the reported data.

[Modified from Suder and Lessing (1985). Water consumed and water withdrawn are in million gallon per day. Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Agriculture	5.86[1]	5.86	100
Industry	27.92	786.38	3.55
Irrigation	3.64[1]	3.64	100
Mining discharge	0	101.92	0
Public suppliers	103.76[1]	103.76	100
Rural domestic	18.77[1]	18.77	100
Sewage treatment[2]	N/A	161.20	N/A
Thermoelectric power	691.48	4,303.92	16

[1]Reported as "No water returned."

[2] Water returned. Reported as "No water withdrawn." Total exceeds reported withdrawals for public suppliers.

Suder, K.E., and Lessing, Peter, 1986, Water use in West Virginia for 1984: West Virginia Geological and Economic Survey, Circular C–39, 99 p.

This comprehensive inventory of withdrawals, return flows, and instream uses of water for 1984 in West Virginia includes data aggregated on the state, county, and Hydrologic Unit Code (HUC) levels. Data for this report were compiled and computed from Federal and state sources, as well as from water users for the thermoelectric power and industrial categories, by the West Virginia Geological and Economic Survey in cooperation with USGS. In the following table are the water-withdrawal and consumptive-use data reported in the document (p. 10) and the coefficients computed from the reported data.

[Modified from Suder and Lessing (1986). Water consumed and water withdrawn are in million gallon per day. Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Agriculture	5.98[1]	5.98	100
Industry	30.4	890.06	3.4
Irrigation	3.64[1]	3.64	100
Mining discharge	0	101.92	0
Public suppliers	101.78	101.78	100
Rural domestic	18.77[1]	18.77	100
Sewage treatment[2]	N/A	191.40	N/A
Thermoelectric power	571.47	4,487.36	12.7

[1]Reported as "No water returned."

[2] Water returned. Reported as "No water withdrawn." Total exceeds reported withdrawals for public suppliers.

Suder, K.E., and Lessing, Peter, 1987, Water use in West Virginia for 1985: West Virginia Geological and Economic Survey, Circular C–41, 96 p.

This comprehensive inventory of withdrawals, return flows, and instream uses of water for 1985 in West Virginia includes data aggregated by the state, county, and Hydrologic Unit Code (HUC). Data for this report were compiled and computed from Federal and state sources, as well as from water users for the thermoelectric power and industrial categories, by the West Virginia Geological and Economic Survey in cooperation with USGS. In the following table are the water-withdrawal and consumptive-use data reported in the document (p. 9) and the coefficients computed from the reported data.

[Modified from Suder and Lessing (1987). Water consumed and water withdrawn are in million gallon per day. Coefficient is in percent.]

Water-use category	Consumed	Withdrawn	Coefficient
Agriculture	9.68[1]	9.68	100
Industry	38.44	1,170.07	3.4
Irrigation	2.52[1]	2.52	100
Mining discharge	0	101.92	0
Public suppliers[2]	—[2]	308.45[2]	N/A
Rural domestic	18.77[1]	18.77	100
Sewage treatment[2]	233.32	—[2]	N/A
Thermoelectric power	658.08	4,207.03	15.6

[1]Reported as "No water returned."

[2] For public suppliers, water withdrawn includes surface water distributed, surface water sold, ground-water distributed, ground water sold, and transfer water sold. It does not include transfer water purchased because this would be counting the transfer water twice. It was noted that no water was returned for public suppliers, and there were no withdrawals for sewage treatment.

Sweat, M.J., and Van Til, R.L., 1988, Water use and methods of data acquisition in Michigan, *in* Waterstone, Marvin, and Burt, J.R., eds., Proceedings of the Symposium on Water-Use Data for Water Resources Management, Tucson, Ariz., August 28–31, 1988: Bethesda, Md., American Water Resources Association, p. 133–141.

A summary of water use in Michigan, this paper includes withdrawal and consumptive-use data for 1985 from Solley and others (1988). From this information, consumptive-use coefficients can be computed. For thermoelectric power generation, the consumptive-use coefficient was 1.3 percent, whereas for irrigation, the consumptive-use coefficient was 96 percent (table 1, p. 35). For self-supplied industry and public supply, the consumptive-use coefficient was 10 percent (table 1, p. 35).

[Modified from Table 1, p. 35 of Sweat and Van Til (1988). Water withdrawn and water consumed are in million gallons per day (Mgal/day). Coefficient is in percent.]

Water-use category	Withdrawn	Consumed	Coefficient
Thermoelectric power generation	8,400	110	1.3
Self-supplied industry	1,300	130	10
Public supply	1,200	120	10
Irrigation	240	230	96

Tate, D.M., 1988, Industrial water use and structural change, *in* Waterstone, Marvin, and Burt, J.R., eds., Proceedings of the Symposium on Water-Use Data for Water Resources Management, Tucson, Ariz., August 28–31, 1988: Bethesda, Md. American Water Resources Association, p. 601–608.

As part of a study examining the effects on technological and structural change on industrial water use in Canada, water-intake and water-consumption data are presented in this paper for the agriculture, mineral extractions, manufacturing, thermal power, and trade water-use categories for Canada for 5-year intervals from 1966 to 1976. Data in the following table are from Environment Canada surveys from the water-intake and water-consumption data and used to compute the coefficients included.

[Modified from Tate (1988; table 1, p. 606). Water intake and consumption are in millions of cubic meters; coefficient is in percent.]

Category	Water intake	Water consumption	Coefficient
1966 industrial water use			
Agriculture	3,193	2,285	72
Mineral extraction	365	86	24
Manufacturing	8,049	329	4
Thermal power	6,559	71	1
Trade	771	0	0
Total	18,938	2,771	15
1972 industrial water use			
Agriculture	2,855	2,043	72
Mineral extraction	362	87	24
Manufacturing	8,409	330	4
Thermal power	9,320	101	1
Trade	987	0	0
Total	21,933	2,561	12
1976 industrial water use			
Agriculture	3,299	2,369	72
Mineral extraction	667	105	16
Manufacturing	8,672	457	5
Thermal power	13,163	160	1
Trade	1,091	0	0
Total	26,893	3,091	11

Tate, Donald, and Harris, Jeff, 1999a, Water demands in the Canadian section of the Great Lakes Basin, 1972–2021: Gaia Economic Research Associates, unpublished report to the Canadian Section, International Joint Commission, 57 p.

This report presents and evaluates water-use data collected by Environment Canada and the Great Lakes Commission and forecasts trends in water use for the Canadian part of the Great Lakes Basin. The document gives a history of water-use data collection and forecasting in Canada, describes forecasting methodology, presents scenarios used to project water demand and the results of models, and summarizes principal conclusions of the research, including recommendations for future studies. For the forecasts, a structural, input-output model study was used to estimate water intake and consumption for scenarios of low, medium, and high economic growth, as well as scenarios representing high and low change in consumptive-use coefficients and a technological-change scenario. In this model, “coefficients” were water intake and consumption per million dollars of economic output, not a simple relation between water withdrawn and water consumed. Water-use coefficients for the base period 1986–96 (in percent) were agriculture, 0.5; mineral extraction, 2.2; manufacturing, -2.1; and municipal, -1.9. Some traditional consumptive-use coefficients mentioned in the historical overview are 78–80 percent for agriculture (based on Great Lakes Commission data from 1996), 20 percent for municipal (based on engineering estimates and Environment Canada survey results) and 0.09 percent for once-through thermoelectric power generation (based Environment Canada survey results), and 5 percent for manufacturing (1991 and 1996 water demand summaries, table 2.1).

Of special interest is a series of detailed summary tables that present data by type of economic activity for the six Canadian water-use censuses between 1972 and 1996. Coefficients for each activity type for each census year can be derived from the withdrawal and consumption data presented; those tables are further summarized in the appendix, tables 4–1 and 4–2 of this report.

Tate, Donald, and Harris, Jeff, 1999b, Water demands in the United States section of the Great Lakes Basin, 1985–2020: GeoEconomics Associates, unpublished report to the United States Section, International Joint Commission, 57 p.

A followup companion report to the preceding entry, this document describes a structural, input-output model study to estimate U.S. water intake and consumption for scenarios of low, medium, and high economic growth, as well as scenarios representing high and low change in consumptive-use coefficients and a conservation scenario. As in the model described above, "coefficients" were water intake and consumption per million dollars of economic output, not a simple relation between water withdrawn and water consumed. Water-use data used in the model were from the USGS water-use database for the years 1985, 1990, and 1995. Historical annual real growth rates for water consumption for the base period 1985–95 (in percent) were agriculture, 3.4; mineral extraction, -1.3; manufacturing, -1.0; municipal, -0.09; and thermal power, -1.3.

Thompson, S.A., 1999, Water use, management, and planning in the United States: San Diego, Calif., Academic Press, 371 p.

This comprehensive textbook covers historical, legal, economic, and technical aspects of water-resources development in the Nation. The chapter on offstream water use includes monthly consumptive-use coefficients for various crops in selected locations for use with the Blaney-Criddle method of estimating crop evapotranspiration. None of the locations, however, are near the Great Lakes; moreover, the coefficient is used in combination with air temperature and monthly daytime hours and does not represent a percentage of water withdrawal.

Titus, E.O., Clawges, R.M., and Qualls, C.L., 1990, Estimated demand for agricultural water for irrigation use in New Jersey, 1990: U.S. Geological Survey Open-Filer Report 90–156, 23 p.

"This report describes the results of an effort to estimate short-term consumptive demand for agricultural water for irrigation use in New Jersey in 1990" (p. 2). The focus of this report is consumptive demand for field-grown crops. This report does not examine greenhouse water use or nonconsumptive water use by crops. For example, cranberry bogs are considered a nonconsumptive water use. For the field-grown crops, the Thornthwaite method is used to compute the water deficit for irrigated crops.

Todd, D.K., ed., 1970, The water encyclopedia: Port Washington, N.Y., Water Information Center, 559 p.

This resource, as the name suggests, is a reference volume containing water data, facts, and statistics. Included in the consumptive-use sections of the reference are consumptive use by irrigated crops in the Western States, water requirements for farm animals and poultry, the 1965 USGS water-use data, water requirements for selected industries in the world, projected water requirements in the United States by the U.S. Water Resources Council, and a figure of use of water in an average home in Akron, Ohio. From the National Association of Manufacturers is a table with the percentage of water intake consumed by selected industries in the United States (reproduced below).

[In Todd (1970; table 5-25, p. 263). Source: National Association of Manufacturers, data as of 1959.]

Industry	Water consumption (percent of intake)
Automobile	6.2
Beet sugar	10.5
Chemicals	5.9
Coal preparation	18.2
Corn and wheat milling	20.6
Distillery	10.4
Food processing	33.6
Machinery	21.4
Meat	3.2
Petroleum	7.2
Poultry processing	5.3
Pulp and paper	4.3
Salt	27.6
Soap and detergents	8.5
Steel	7.3
Sugar, cane	15.9
Textiles	6.7

Torcellini, P., Long, N., and Judkoff, R., 2003, Consumptive water use for U.S. power production: Golden, Colo., U.S. Department of Energy, National Renewable Energy Laboratory, NREL/TP–550–33905, 12 p.

This document present the results of a study of water consumed by thermoelectric and hydroelectric power production, including loss by evaporation from reservoirs, compiled as a basis for evaluating energy-saving versus water-use potential of evaporative cooling systems for buildings. The authors estimated a coefficient of 2.5 percent evaporation or consumptive-use rate for thermoelectric plants nationwide, amounting to 0.47 gal of water used for each kilowatt-hour of electricity consumed at the point of end use. For thermoelectric plants in the Eastern electrical grid interconnect (which includes the Great Lakes area), the rate is 0.49 gal/kWh. Water-use data—including thermoelectric consumptive-use figures—are from the USGS (Solley and others, 1998). Evaporative losses in reservoirs behind hydroelectric dams were computed by the authors. Water-consumption figures for Great Lakes and climatically similar states are as follows (reproduced from table 3, p. 5):

[Modified from Torcellini and others (2003). Thermoelectric, hydroelectric, and weighted total are in gallons per kilowatt per hour.]

State	Thermoelectric	Hydroelectric	Weighted total
Connecticut	0.08	N/A	0.07
Delaware	0.01	N/A	0.01
Illinois	1.05	N/A	1.05
Indiana	0.41	N/A	0.41
Iowa	0.12	N/A	0.11
Kentucky	1.10	154.34	5.32
Maine	0.29	N/A	0.12
Maryland	0.03	6.72	0.21
Massachusetts	0	N/A	0
Michigan	0.50	N/A	0.48
Minnesota	0.44	N/A	0.41
Missouri	0.31	N/A	0.30
New Hampshire	0.12	N/A	0.10
New Jersey	0.07	N/A	0.07
New York	0.85	5.57	1.62
North Carolina	0.23	10.37	0.55
Ohio	0.95	N/A	0.94
Pennsylvania	0.54	N/A	0.53
Rhode Island	0	N/A	0
Tennessee	0	43.35	3.60
Vermont	0.35	N/A	0.25
Virginia	0.07	N/A	0.06
West Virginia	0.59	N/A	0.58
Wisconsin	0.49	136.96	4.15
U.S. totals, weighted average	0.47	18.27	2.00

Trotta, L.C., 1988, Water use for aquaculture in Minnesota, 1984: U.S. Geological Survey Water-Resources Investigations Report 88–4159, 6 p.

This resource describes aquaculture in Minnesota for 1984 and states that aquaculture withdrawals are nonconsumptive. The aquaculture withdrawals were small compared to withdrawals in other Minnesota water-use categories, and about 15 percent of the withdrawals for aquaculture came from municipal water systems (p. 4). Also of interest was one thermoelectric plant that began reusing water to raise catfish (p. 5).

U.S. Bureau of the Census, 1985, 1982 Census of mineral industries: Washington, D.C., Subject Series, Water Use in Mineral Industries: Washington, D.C., 32 p.

This publication describes water by intake and discharge for the mineral industries by state, by Standard Industrial Classification (SIC), and by water-resource regions. From these values, general consumptive coefficients could be derived; however for many of the states, SIC codes, and regions, reported amounts of water discharged were greater than reported amounts of water withdrawn by intake. It was noted that this may be caused by mine water that is drained and discharged. Therefore, computing a representative consumptive-use coefficient was not possible for the reported data.

U. S. Bureau of the Census, 1986, 1982 Census of manufactures: Washington, D.C., Subject series, Water Use in Manufacturing, MC82–S–6, 72 p.

This resource provides many tables on water information in industries in the United States in 1983. One table includes water-intake data and water-discharged data for major SIC codes 20 through 39 for the census years 1954, 1959, 1964, 1968, 1973, 1978, and 1983 (table 1c, p. 6–6 to 6–8). Also published were water-use statistics for industry groups and industries. Of interest are 1983 water-use statistics for states (water-intake and water-discharged data in table 2b, p. 6–13 to 6–17) and water-resource regions for the major SIC code groups (7c, p. 6–60 to 6–65). Table 2a includes a “Summary of Water Use Statistics for Industry Groups and Industries: 1983” (p. 6–8 to 6–13). The consumptive-use coefficients from the Census of Manufactures are summarized in Appendix 2 of this bibliography (tables 2–1 to 2–5).

U.S. Business and Defense Services Administration, 1967, Water use by Appalachian manufacturers, 1964: Water Industries and Engineering Services Division, U.S. Department of Commerce, 60 p.

Manufacturing in Appalachia accounted for 19 percent of the total water withdrawn for manufacturing in the United States in 1967 (p. vi). Although "Water use by Appalachian Manufacturers" includes withdrawal and discharge data, the data are from the "1963 Census of Manufactures." Appendix B includes the U.S. Bureau of Census tables "Water Use by Manufacturers," for both Appalachian and non-Appalachian areas (p. 33). The Appalachian area includes part of the states of Alabama, Georgia, Maryland, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia.

For the total United States, 14,045 Ggal was withdrawn and 13,157 Ggal of water was discharged, yielding a consumptive-use coefficient of 6.3 percent (table 1, Appendix B, p. 34). For non-Appalachian areas, the manufacturing consumptive-use coefficient was 6.6 percent (11,360 Ggal of water intake and 10,611 Ggal water discharged); and for Appalachia, the consumptive-use coefficient was 5.2 percent (2,686 Ggal water intake and 2,546 Ggal water discharged). Although many consumptive-use coefficients could be derived from these data, the U.S. Bureau of the Census (1986) reference includes more recent data and has a more thorough analysis.

U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environment Division, 1994, Agricultural resources and environmental indicators: Washington, D.C., 205 p.

In the section "Water Use and Pricing in Agriculture," this report discusses water use as well as consumptive use. Most of the data referenced in this report are from the USGS (Solley and others, 1993). The percentage of the total withdrawals consumed varied by category: for irrigation, 56 percent of the withdrawals was consumed (p. 47), for public and rural supplies, 17 percent; for industrial other than thermoelectric, 16 percent; and for thermoelectric power, 3 percent (p. 47). Of interest are an illustration showing water consumption in irrigation and other uses by region (fig. 2.1.2, p. 49) and a table listing irrigation's share of total consumptive use for states with major irrigation water use (table 2.1.1, p. 48).

U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environment Division, 1997, Agricultural resources and environmental indicators, 1996–97, Washington, D.C., 347 p.

In the section "Water Use and Pricing in Agriculture," this report discusses water use as well as consumptive use. Most of the data referenced in this report are from the USGS (Solley and others, 1993). The percentage of the total withdrawals that consumed varied by category: for irrigation, 81 percent of the withdrawals was consumed; for public and rural supplies, 17 percent; for industrial other than thermoelectric, 16 percent; and for thermoelectric power, 3 percent (p. 70).

U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environment Division, 2003, Agricultural resources and environmental indicators, 2003, Washington, D.C., 347 p.

In the section "Water Use and Pricing in Agriculture," this report discusses water use as well as consumptive use. Most of the data referenced in this report are from the USGS (Solley and others, 1998). The percentage of the total withdrawals consumed varied by category: for irrigation, 81 percent of the withdrawals was consumed; for public and rural supplies, 17 percent; for industrial other than thermoelectric, 22 percent; and for thermoelectric power, 3 percent (p. 6). Of interest are some illustrations showing irrigated area by region for 1899, 1949, and 2000 (fig. 2.1.4, p. 9) and irrigated land in farms for 1949 and 1997 (figs. 2.1.6 and 2.1.7, p. 12).

U.S. Department of Agriculture, National Agricultural Statistics Service, 2001, 1998 Census of horticultural specialties: Accessed August 2, 2005, at *http://www.nass.usda.gov/census/census97/horticulture/horticulture.htm*

The Web page displays links to the horticulture specialties 1997 census data, which include a table of "Operations by Percent of Water Recycled by State: 1998" (table 53). The table subdivides horticultural operations into those that do or do not recycle water, as well as notes whether the amounts of recycled water are in the ranges of 1–4 percent, 5–9 percent, 10–24 percent, or 25 percent or more of water withdrawn or supplied. For the United States as a whole, 86 percent of the horticultural operations reported no recycling of water, and 93 percent of the horticultural operations reported recycling less than 9 percent of water withdrawn or supplied. The Great Lakes States compared fairly reasonably to the National average, ranging from 78 to 90 percent of horticultural operations reporting no recycled water and from 91 to 97 percent of horticultural operations reporting less than 9 percent recycled water.

U.S. Department of Energy, 2004, Year 2004 annual steam-electric plant operation and design data: Department of Energy Form EIA-767 data file: Accessed January 5, 2006, at *http://www.eia.doe.gov/cneaf/electricity/page/eia767.html*

From this Web page, spreadsheet files can be downloaded that include the average annual rate of cooling-water withdrawals, the average annual rate of cooling-water discharge, and the average annual rate of cooling-water consumption to the nearest 0.1 ft^3/s. Data for 2001, 2002, and 2003 also can be accessed through this Web page.

USGS Circulars

MacKichan, K.A., 1957, Estimated use of water in the United States, 1955: U.S. Geological Survey Circular 398, 18 p.

The USGS 1955 water-use circular includes state and regional water-withdrawal data for public-supply, rural, irrigation, self-supplied industrial, and fuel-electric power water-use categories. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. For 1955, "only about a fourth of all withdrawn water was consumed" (p. 12). For public-supply consumptive use and the domestic fraction of rural use, approximately 10 percent of water was consumed; a larger percentage was consumed in the summer because of lawn watering. For irrigation, about 60 percent of irrigation water was used by crops; however, if a sprinkler irrigation system was used, a much greater percentage of the water applied was transpired or evaporated. For self-supplied industrial use, only about 2 percent of water used was consumed. The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this report.

MacKichan, K.A, and Kammerer, J.C., 1961, Estimated use of water in the United States, 1960: U.S. Geological Survey Circular 456, 26 p.

The USGS 1960 circular includes state and regional water-withdrawal and consumptive use data for the following water-use categories: public supply, rural use (domestic use and livestock use), irrigation, self-supplied industrial, and fuel-electric power. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. For public water-supply systems, 17 percent of water withdrawn was consumed (p. 3). Rural water use consisted of 2,000 Mgal/d withdrawals for domestic use, 1,200 Mgal/d or 60 percent of which was consumed; and 1,600 Mgal/d withdrawal for livestock, 1,500 Mgal/d or 94 percent of which was consumed (table 4, p. 16). For irrigation, about 60 percent of the water withdrawn was consumed (p. 4). Fuel-electric power water use consumed less than 1 percent of the water withdrawn (p. 6). For industrial water use, approximately 8 percent of the water withdrawn was consumed (table 8, p. 20). For the contiguous United States, 20 percent of the total amount of water consumed was in the 31 Eastern States, and 80 percent of the water consumed was in the 17 Western States (fig. 6, p. 7). The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this report.

Murray, C.R., 1968, Estimated use of water in the United States, 1965: U.S. Geological Survey Circular 556, 53 p.

The USGS 1965 circular includes state and regional water-withdrawal data for public-supply, rural, irrigation, industrial, thermoelectric-power, and hydroelectric-power water-use categories. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. It also includes trends from 1950 to 1965. For 1965, "about 22 percent of the total withdrawals for public supply is estimated to have been consumed" (p. 3). Rural use includes self-supplied domestic water and livestock water use. For self-supplied domestic use, 1,600 of 2,300 Mgal/d was consumed (approximately 70 percent). Livestock water use was 1,700 Mgal/d and the water consumed was 1,600 Mgal/d, approximately 94 percent. Irrigation water withdrawn for the United States was 120,000 Mgal/d, 24,000 Mgal/d of which was lost in conveyance and 66,000 Mgal/d of which was consumed (table 13, p. 28). An undetermined part of the conveyance loss was transpired or evaporated, and another undetermined part of the conveyance loss returned to ground water or surface water and was thus available for use. Because of these uncertainties, the consumptive use for irrigation could range from 55 to 75 percent. For industrial water use, about 7.5 percent was consumed (p. 4); and for thermoelectric water use, less than 0.5 percent was consumed (p. 4, under self-supplied industrial water). Only 15 percent of the water consumed in the contignous United States was in the 31 Eastern States, whereas 85 percent of the water consumed was in the 17 Western States (fig. 8, p. 8). The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to –16 of this report.

Murray, C.R. and Reeves, E.B., 1972, Estimated use of water in the United States in 1970: U.S. Geological Survey Circular 676, 37 p.

The USGS 1970 circular includes water-withdrawal and water-consumption data for 1970, as well as historical trends in water use from 1950 to 1970. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. In 1970, 86 percent of the water consumed was in the 17 Western States, and 14 percent was in the 31 Eastern States (fig. 6). For public-supply systems, 22 percent of the withdrawals was consumed. Rural domestic and livestock water consumption were 65 and 90 percent, respectively (p. 4 and table 6, p. 20–21). Irrigation water consumption was 59 percent (p.4), and conveyance loss was an additional 17 percent (p. 4). For thermoelectric freshwater use, 0.67 percent was consumed (p. 5, under self-supplied industrial water). Water consumed for the industrial water-use category was about 10 percent of withdrawals (p. 5). The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this report.

Murray, C.R. and Reeves, E.B., 1977, Estimated use of water in the United States in 1975: U.S. Geological Survey Circular 765, 39 p.

The USGS 1975 circular includes state and regional water-withdrawal and water-consumption data for 1975, as well as historical trends in water use from 1950 to 1975. Public-supply consumptive use was almost 23 percent of the water withdrawals (p. 4). Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. Fifty percent of the rural domestic water withdrawals and 95 percent of the livestock withdrawals were consumed. For irrigation water use, 56.4 percent of the water withdrawn was consumed, and 16 percent was lost through conveyance (p. 5). Thermoelectric plants consumed about 1.5 percent of their freshwater withdrawals (p. 6, under self-supplied industrial water), and self-supplied industrial facilities consumed 11 percent of their freshwater withdrawals (p. 6). For the contiguous United States, 16 percent of the water consumed was in the Eastern States, and 84 percent of the water consumed in the Western States (fig. 6, p. 9). The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this report.

Solley, W.B., Chase, E.B., and Mann, W.B., 1983, Estimated use of water in the United States in 1980: U.S. Geological Survey Circular 1001, 56 p.

USGS circular 1001 includes water-withdrawal and consumptive-use data for states and water-resources regions in the United States for 1980. Categories include public supply, rural use (domestic use and livestock), irrigation, self-supplied industrial, thermoelectric power and hydroelectric power. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. For public supply, 21 percent of the withdrawals was consumed (p. 8 and table 2, p. 11), approximately the same as in 1965, 1970, and 1975. In 1980, the total consumptive use was 69 percent for rural withdrawals (p. 12); 57 percent for domestic withdrawals, with state values ranging from 0 to 100 percent (p. 12); and 86 percent for livestock withdrawals, with state values ranging from 50 to 100 percent (p. 12). Irrigation consumptive use, which accounted for 81 percent of the consumptive use for the nation, was 55 percent of the irrigation water withdrawals, with state values ranging from 24 to 100 percent (p. 18). An additional 16 percent of the 1980 irrigation withdrawals was lost through conveyance (p. 16). Self-supplied industrial consumptive use was 13 percent of the 1980 self-supplied industrial withdrawals, with state values ranging from 2 to 82 percent (p. 22); and thermoelectric consumptive use was 2 percent of the thermoelectric withdrawals with state values ranging from 0 to 85 percent (p. 26). “These [industrial and thermoelectric] consumptive use figures are higher than in previous years and indicated an increased reuse of water” (p. 20). Included in this report is a section on trends in water use during 1950–1980, which discusses the changes in water use and consumption during the period.

The water withdrawal data, water consumed data, and the consumptive-use coefficients are summarized in appendix tables 1–1 to 1–16 of this report.

Solley, W.B., Merk, C.F., and Pierce, R.R., 1988, Estimated use of water in the United States in 1985: U.S. Geological Survey Circular 1004, 82 p.

USGS Circular 1004 includes 1985 water-withdrawal and consumptive-use data for states and water-resource regions for public supply, domestic, commercial, irrigation, livestock, industrial, mining, thermoelectric power water-use categories. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. This compilation of water-use data included new categories of mining and commercial, as well as some reorganization of historic categories. Rural use, which formerly comprised both livestock and domestic uses, was replaced with a livestock section and a revised domestic category that included data from self-supplied and publicly supplied households. Public-supply consumptive use was no longer reported, but each of the categories that public-supply delivers to had a consumptive-use coefficient. For the new domestic-use category, the consumptive use was 23 percent of the water withdrawn, with state values ranging from 2 to 70 percent (table 3, p. 15). Commercial water use, which included “motels, hotels, restaurants, office buildings, other commercial facilities, and civilian and military institutions,” had a consumptive-use rate of 17 percent of the total commercial withdrawals, with state values ranging from 1 to 38 percent (self-supplied and publicly supplied; table 6, p. 21). For irrigation water use, 54 percent of the withdrawals were consumed, with state values ranging from 21 to 100 percent, and 17 percent was lost through conveyance (table 8, p. 25). The livestock consumption rate was 53 percent, with state values ranging from 0 to 100 percent (table 9, p. 27)—a substantial reduction from that reported in previous USGS circulars. The change was due, in part, to certain states that had included fish farming in the industrial category for previous water-use compilations but included it in with the livestock category for the 1985 compilation. Self-supplied industrial consumptive use was 16 percent of the 1985 self-supplied industrial withdrawals, with state values ranging from 3 to 84 percent. The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this bibliography.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.

USGS Circular 1081 for 1990 includes water-use and consumptive-use data for public-supply, domestic, commercial, irrigation, livestock, industrial, mining, and thermoelectric-power water-use categories. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. Consumption in the domestic water-use category, which includes the self-supplied and public-supplied users, ranged from 2 percent (Idaho) to 56 percent (New Mexico) of withdrawals and deliveries (table 11, p. 27), and was 23 percent for the United States as a whole (p. 26). For the commercial water-use category, 11 percent of the withdrawals and deliveries was consumed, with state values ranging from 1 to 59 percent (table 14, p. 33). “In most States, consumptive use was based on coefficients ranging from 40 to 100 percent of withdrawals, or on theoretical crop requirements. In a few States, consumptive use was calculated as the difference between reported withdrawals and reported return flows” (p. 34). Overall, 56 percent of the total water withdrawn for irrigation was consumed, with state values ranging from 22 to 100 percent (table 16, p. 37); 20 percent was lost through conveyance (p. 34). For 1990, the livestock category was further divided into two categories: livestock and animal specialties. Although the consumptive-use estimates were based on coefficients that ranged from 2 to 100 percent for livestock and from 0 to 100 percent for animal specialties, overall averages for consumption were 88 percent of water withdrawals for livestock, 47 percent for animal specialties, and 68 percent for livestock and animal specialties combined (table 18, p. 41). The industrial consumptive use for 1990 was 14 percent for freshwater withdrawals, with state ranges from 3 to 92 percent. For industrial saline-water withdrawals, overall consumptive use was 28 percent, with state ranges from 0 to 55 percent (table 20, p. 45). Mining consumptive use was 31 percent of the total withdrawals, with state ranges from 0 to 100 percent (p. 46). Thermoelectric power consumed 2 percent (p. 50) of the water withdrawn, with state values ranging from 0 to 99 percent. The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this bibliography.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1998, Estimated use of water in the United States in 1995: U.S. Geological Survey Circular 1200, 71 p.

This publication, like the previous USGS circular for 1990, reports withdrawal and consumptive-use data for public supply, domestic, commercial, irrigation, livestock, industrial, mining, and thermoelectric water-use categories. Water-use data (withdrawals and consumptive use) were compiled by USGS offices in each state and water-use project chiefs. For self-supplied and public-supplied domestic water use, about 26 percent was consumed, with state values ranging from 5 to 55 percent (table 12, p. 27); for commercial water use, about 14 percent was consumed, with state values ranging from 0 to 58 percent (table 14, p. 31). About 61 percent of water used for irrigation was consumed, with state values ranging from 21 to 100 percent (table 16, p. 35), and another 19 percent was lost through conveyance (p. 32). Under the livestock category, around 96 percent of livestock withdrawal was consumed, with state values ranging from 20 to 100 percent, and about 32 percent of animal-specialties withdrawal was consumed, with state values ranging from 0 to 100 percent; for livestock and animal specialties combined, about 58 percent was consumed (p. 36). For industrial water use, 15 percent of combined fresh and saline withdrawals was consumed, with state values ranging from 2 to 92 percent (table 20, p. 43); and for mining withdrawals, 27 percent was consumed, with state values ranging from 0 to 100 percent (table 22, p. 47). For thermoelectric power, freshwater plants consumed about 2.5 percent of withdrawals, with state values ranging from 0 to 100 percent; whereas saline-water plants consumed less than 1 percent, with state values ranging from 0 to 3 percent (table 24, p. 51). The consumptive-use coefficients from the USGS circulars are summarized in appendix tables 1–1 to 1–16 of this bibliography.

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U.S. Geological Survey, 1984, National water summary 1983—Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

This report describes and analyzes the condition of the Nation's water and summarizes the water issues of concern for each state, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and western Pacific Islands under the United States jurisdiction. It includes a summary of withdrawal and consumptive use for each state from USGS Circular 1001 (Solley and others, 1980).

U.S. Geological Survey, 2000, Consumptive use and renewable water supply, by water-resources region: Accessed August 2, 2005, at *http:// water.usgs.gov/watuse/misc/consuse-renewable.html*

This Web page lists the 1995 water consumed (in billion gallons per day based on data from Solley and others, 1998) over the renewable water supply by U.S. water-resources region. Renewable water supply is a simplified sum of precipitation and imports of water, minus water not available for use because of natural evapotranspiration and exports. It is used as an upper limit for water consumption in a region on a sustained basis. The ratios of consumed water over renewable water supply for water-resources regions in the Great Lakes and climatically similar areas are Upper Mississippi, 2.3/77.2; Great Lakes, 1.9/74.3; Ohio, 2.8/139.6; Mid-Atlantic, 1.3/80.7; New England, 0.6/78.4; and Tennessee, 0.3/41.2.

U.S. Geological Survey and Tennessee Department of Environment and Conservation, 2003, Water use in Tennessee: Accessed June 20, 2005, at *http://tn.water.usgs.gov/wustates/tn/octodiagram.html*

The Web page shows the source, use, and disposition of water in Tennessee in 1995. Overall, only 3 percent of freshwater was consumed in Tennessee in 1995. This percentage is largely skewed by the large amount of thermoelectric withdrawals and the low percentage of consumption of these withdrawals. For individual water-use categories, consumptive-use coefficients are more representative. For domestic and public losses, 24 percent of the withdrawals was consumed. For industry (which includes commercial and mining), 11 percent of the withdrawals was consumed. Of the thermoelectric withdrawals, only 0.5 percent was consumed. Agriculture, which includes irrigation and livestock, is listed at 100 percent consumption.

van der Leeden, Frits, 1975, Water resources of the world — Selected statistics: Port Washington, N.Y., Water Information Center, 568 p.

Water-availability and water-use information from references around the world are summarized in this publication. For the United States, this book summarizes the 1970 USGS water-use circular information, includes a profile of the Great Lakes drainage system, and includes per capita figures from municipal water-supply systems (fig. 5–8, p. 365). Many countries included in the tables report domestic consumption as part of their municipal water-supply system. It is unclear whether these figures represent actual consumption or just what was delivered because the numbers seem fairly high. For example, U.S. Geological Survey "consumption" refers to water removed from the immediate hydrologic environment, whereas "consumption gallons per capita per day" as reported by the American Water Works Association reflects withdrawal in gallons per capita per day and not actual consumption. Although this document summarizes a wealth of information, it is probably best used as a means of finding original sources of information than as a data source itself. One data table in this document (reconstructed below) lists ground-water withdrawal and consumption amounts for industrial categories in Belgium. The consumptive use coefficient is calculated.

[Withdrawal and consumption are in thousands of cubic meters, Consumptive-use coefficient is computed by dividing the water consumption by the water withdrawal and multiplying by 100. Modified from table 1–12, p. 11, of van der Leeden (1975)]

Category	Withdrawal	Consumption	Consumptive-use coefficient
Coal mines	139,311	10,427	7
Quarries	41,209	1,972	5
Food (margarine, oils, etc.)	120,528	14,140	12
Textiles	57,796	4,713	8
Wood	2,988	551	18
Paper	96,832	10,138	10
Leather	5,368	332	6
Chemical	650,292	39,711	6
Rubber	7,987	754	9
Petroleum refineries	335,426	160	0
Coke plant (gas)	81,029	9,458	12
Terra cotta	1,476	752	51
Glass	20,842	1,968	9
Ceramic	1,051	301	29
Cement	17,190	5,093	30
Iron & steel	1,099,867	66,626	6
Non-ferrous	202,913	39,137	19
Metallic construction	66,604	4,980	7
Hydroelectric power	13,257,900	-	-
Thermoelectric power	3,703,580	11,866	0

Van Til, Ronald, and Scott, G. M., 1986, Water use for thermoelectric power generation in Michigan: Michigan Department of Natural Resources, 42 p.

A compilation of withdrawal data and consumptive use data for thermoelectric plants in Michigan, this report recognizes that there are "substantial differences in the rate of water consumed by different cooling systems." The report was a cooperative effort by the USGS and the Michigan Department of Natural Resources. Once-through cooling requires a larger volume of water, but it is estimated that only 1–2 percent of the water is consumed in the cooling process." The report notes that, because most of the Michigan thermoelectric plants do not have reservoir storage, 1 percent is the more representative end of the range. Wet cooling towers require smaller water withdrawals than once-through cooling, but the evaporation and drift losses are estimated to be 66 percent. A third type of cooling system, cooling ponds, has a varied consumptive use because "heat dissipation is highly dependent on local meteorological conditions (p. 21)." In Michigan, cooling-pond systems are rarely used.

[Water withdrawn and water consumed are in million gallons per day (Mgal/d). Consumptive-use coefficient is computed by dividing the water consumed by the water withdrawn and multiplying by 100. Modified from Van Til and Scott (1986; table 7, p. 22), all for Michigan.]

Type of cooling	Water withdrawn	Water consumed	Average consumptive-use rate
Once-through	8,178.64	81.79	1
Wet tower	2.31	1.52	66
Wet tower/discharge	202.04	26.27	13[1]
Radiator/dry	0.00	0.00	0
Cooling ponds	4.30	2.84	66
Combination	<0.01	-	-
Total	8,387.29	112.42	1.3

[1] There were four plants in this category, and the individual consumptive rates varied widely.

Veeger, A.I., Vinhateiro, N.D., Nakao, M., and Craft, P.A., 2003, Water use and availability, Block Island, Rhode Island, 2000: Rhode Island Geological Survey Report 03–01, 22 p.

As part of estimating the water use and availability on Block Island, R.I., for 2000, consumptive use was estimated by use of the following coefficients: domestic, 15 percent; public use and commercial, 10 percent; and livestock 100 percent (p. 12), referenced from Horn (2000).

Vickers, Amy, 2001, Handbook of water use and conservation: Amherst, Mass., Water Plow Press, 446 p.

Geared largely at promoting water efficiency through designing and retrofitting of water-using devices and facilities, this reference work nevertheless contains interesting facts and figures related to consumptive use, particularly with regard to new technologies. Each chapter is liberally referenced to other literature. Among the types of water use data given are per capita rates of indoor and outdoor residential use, per capita use rates (visitors and employees) for a variety of industrial, commercial, and institutional facility types (p. 234), and detailed data on water consumption by cooling towers.

Water Resources Council (U.S.), 1978, The Nation's water resources, 1975–2000: Washington, D.C., four volumes and 6 appendixes.

Water Resources Council (U.S.), 1978, The Nation's water resources, 1975–2000: Volume 3: Analytical data summary, 89 p.

Annual water withdrawals and consumption are provided by water-use categories by regions for base conditions in table 11–4, p. 42–53, "Annual water requirements for off-stream uses." This table includes 1975 data and estimates data for 1985 and 2000. The consumptive-use coefficients from the report "The Nation's water resources, 1975–2000" are summarized in appendix 5 of this report (tables 5–1 to 5–4). Withdrawal and consumptive data are from multiple Federal agencies, including the U.S. Departments of Agriculture, Energy, and Commerce; the Water Resources Council; and U.S. Department of the Interior (USGS, National Park Service, Bureau of Mines, Bureau of Land Management, and Fish and Wildlife Service.)

Water Resources Council (U.S.), 1978, The Nation's water resources, 1975–2000—Volume 3— Analytical data, Appendix II, Annual water supply and use analysis, 174 p.

Annual water withdrawals and consumption are provided by water-use categories by subregions for base conditions in table 11–4, p. 40–105, "Annual water requirements for off-stream uses." This table includes 1975 data and estimates data for 1985 and 2000.

Water Resources Council (U.S.), 1978, The Nation's water resources, 1975–2000—Volume 3— Analytical data, Appendix III, Monthly water supply and use analysis, 302 p.

Monthly water withdrawals and consumption are provided by water-use categories and by subregions for base conditions in table III–4, p. 82–187, "Monthly water requirements for offstream uses." This table includes 1975 data and estimates data for 1985 and 2000. Also of interest in this publication are monthly streamflow frequency analyses for surface-water resources for subregions (or HUCs), and monthly imports, exports, and net evaporation by subregions.

Water Resources Council (U.S), 1978, The Nation's water resources, 1975–2000—Volume 3— Analytical data, Appendix IV, dry conditions water supply and use analysis, 337 p.

Annual water withdrawals and consumption are provided by water-use categories by regions for dry conditions in table IV–1, p. 22–86, "Annual water requirements for off-stream uses." This table includes 1975 data and estimates for 1985 and 2000. Monthly water withdrawals and consumption are provided by water-use categories and by subregions for dry conditions in table IV–3, p. 104–209, "Monthly water requirements for offstream uses." This table includes 1975 data and estimates for 1985 and 2000. Also of interest is a table for monthly water-adequacy analyses for subregions in dry conditions.

Wild, E.C., and Nimiroski, M.T., 2004, Estimated water use and availability in the Pawcatuck Basin, southern Rhode Island and southeastern Connecticut, 1995–99: U.S. Geological Survey Scientific Investigations Report 2004–5020, 72 p.

Withdrawal, use, and return-flow data were collected for the Pawcatuck Basin in southern Rhode Island and southeastern Connecticut. This study used consumptive-use coefficients of 10 percent for commercial and industrial categories (p. 32) (Solley and others, 1998) and 100 percent for agricultural use (livestock, crop irrigation and golf course irrigation) (p. 37). The authors referenced Horn and others (1994) for livestock consumptive use, but did not use these coefficients because of negligible livestock water use in the study area. For the basin, the domestic publicly supplied consumptive use was 9.4 percent (tables 11 and 12, p. 30–31, 33–34) and domestic self-supplied consumptive use was 20.6 percent (tables 11 and 12, p. 30–31, 33–34).

Wild, E.C., and Nimiroski, M.T., 2005, Estimated water use and availability in the South Coastal Drainage Basin, southern Rhode Island, 1995–99: U.S. Geological Survey Scientific Investigations Report 2004–5288, 46 p.

Withdrawal, use, and return flow data were collected for the South Coastal Drainage Basin in southern Rhode Island. This study used consumptive-use coefficients of 10 percent for commercial and industrial categories (p. 26) (Solley and others, 1998) and 100 percent for agricultural use (livestock, crop irrigation and golf course irrigation) (Horn and others, 1994). The authors referenced Horn and others (1994) for livestock consumptive use but did not use these coefficients because of negligible livestock water use in the study area. For the basin, the domestic publicly-supplied consumptive use was 6.3 percent (tables 11 and 12, p. 26, 28) and the domestic self-supplied consumptive use was 46 percent (tables 11 and 12, p. 26, 28).

Woldorf, A.F., 1959, Irrigation and rural water use in Ohio: Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory Report 7, 57 p.

As part of this report, water use and water consumption for Ohio were summarized. The rate of consumption for irrigation was at least 90 percent, and the rate of consumption was less than 10 percent for manufacturing (p. 2). By using the figure 1 on page 7, the rate of consumption is 3 percent for rural home, 97 percent for irrigation, 1 percent for power, 11 percent for municipal, and 5 percent for manufacturing (see below). Of particular interest was that fewer than 1,000 property managers (farmers and golf course operators) controlled 13 percent of the total water consumption of Ohio at the time Woldorf's report was written (p. 6). The bulk of the water consumption for rural water use is by golf-course irrigation; farm irrigation is the next largest rural consumer.

[Modified from figure 1, p. 7 of Woldorf (1959). Coefficient is expressed as percent. Water consumption and water withdrawals are in million of gallons per day (Mgal/d). Ggal/d; billion gallons per day.]

Water –use category	Percent of statewide total withdrawal (Total withdrawal is 12 Ggal/d)	Water withdrawal (Mgal/d)	Percent of statewide total consumption (Total consumption is 410 Mgal/d)	Water consumption (Mgal/d)	Coefficient
Rural home	1	120	1	4.1	3
Irrigation	0.6	72	17	69.7	97
Power	62	7,440	18	73.8	1
Municipal	6	720	19	77.9	11
Manufacturing	31	3,720	45	184	5

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