Industrial

Industrial water use is water used for industrial fabrication, washing, processing, and cooling and includes industries such as chemical and allied products, paper and allied products, steel, and petroleum refining (Hutson and others, 2004a). Industrial consumptive use may occur through **product incorporation**, evaporation from cooling and heating processes, cleaning, and lawn watering.

Growing public awareness and concern for water pollution led to the Federal Water Pollution Control Act Amendments of 1972, amended in 1977 and otherwise known as Clean Water Act of 1977. This act established regulation of discharges of pollutants into the waters of the United States and brought changes to industrial facilities and their use of water (including consumptive use). As is evident from figure 11, the median industrial consumptive-use coefficients from **USGS circular reports** for the Great Lakes States and climatically similar states show how the industrial coefficients increased between 1970 and the 1990s. Because of the changes in data-collection methods (under the new USGS National Water-Use Information Program (NWUIP) authorized by Congress in 1977) and the possible changes caused by the Clean Water Act in how water was used in industrial facilities, only consumptive-use coefficients from the 1980s to the present were used to calculate the statistics used in this report.

The type of industrial facilities (defined by the Standard Industrial Classification (SIC) code or the North American Industrial Classification (NAICS) code), the geographic area, and the type of processes and equipment in an industrial facility all affect the amount of water consumed. Information on the consumptive use by major SIC codes are presented in the section "Industrial by major groups." This information shows the variance of the consumptive-use coefficient by major SIC codes in comparison to general industrial consumptive-use coefficients found in this section. Table 19 lists industrial consumptive-use coefficients not associated with a specific SIC code but rather, with a geographic area. These general industrial coefficients may be based on a mixture of industrial facility types (SIC codes), and these mixtures are not known.

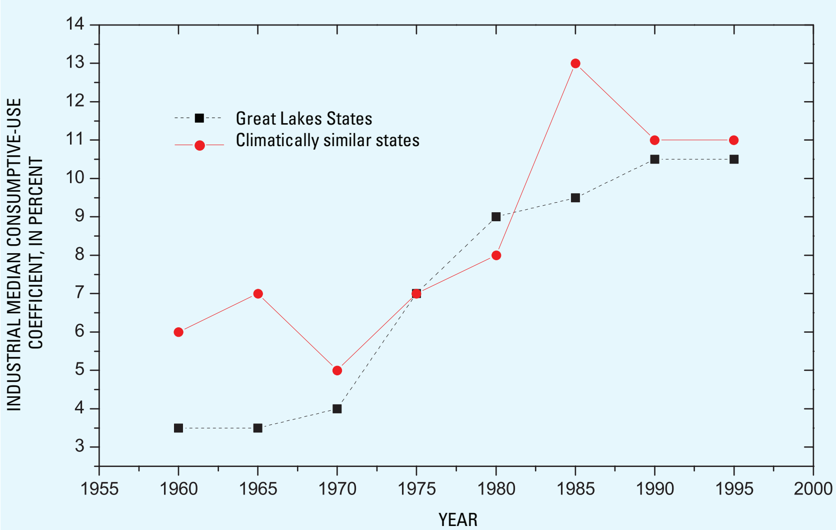


Figure 11. Median industrial consumptive-use coefficients for the Great Lakes States and climatically similar states from 1960 to 1995, from USGS Circulars.

Table 19. Summary of industrial consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics Area	Used in statistics	Coefficient or other	Data source
Barlow, 2003[1]	Rhode Island, Massachusetts	10		1	Clim sim	Yes	Coefficient	Secondary
Brill and others, 1977	Illinois, Indiana, Kentucky, Ohio	6		-	Clim sim	No	Coefficient	Primary
College of Exploration, [n.d]	World	9		-	Other	No	CW	Unknown
Cosgrove and Rijsberman, 2000	World	11		-	Other	No	CW	Secondary
Delaware River Basin Commission, [n.d]	Pennsylvania, Delaware, New Jersey	4[2]		1	Clim sim	Yes	CW	Primary
Ellefson and others, 1987	Wisconsin	20[3]		1	Great Lakes	Yes	Coefficient	Primary
		10[3]		1	Great Lakes	Yes	Coefficient	Primary
Endreny, 2005	New York	10		1	Great Lakes	Yes	Coefficient	Secondary
European Environment Agency, 2005	Europe	20		-	Other	No	Coefficient	Primary
Great Lakes Commission and U.S. Army Corps of Engineers, 1999	Great Lakes	10		1	Great Lakes	Yes	Coefficient	Primary
Great Lakes Commission, 2005a	Great Lakes		10	50	Great Lakes	Yes	CW	Secondary
Government of Canada and the U.S. Environmental Protection Agency, 1995	Great Lakes:							
	Canada, Lake Superior	2		1	Great Lakes	Yes	CW	Secondary
	Canada, Lake Huron	5		1	Great Lakes	Yes	CW	Secondary
	Canada, Lake Erie	4		1	Great Lakes	Yes	CW	Secondary
	Canada, Lake Ontario	4		1	Great Lakes	Yes	CW	Secondary
	United States, Lake Superior	15		1	Great Lakes	Yes	CW	Secondary
	United States, Lake Michigan	9		1	Great Lakes	Yes	CW	Secondary
	United States, Lake Huron	3		1	Great Lakes	Yes	CW	Secondary
	United States, Lake Erie	16		1	Great Lakes	Yes	CW	Secondary
	United States, Lake Ontario	8		1	Great Lakes	Yes	CW	Secondary
Horn and others, 1994	Rhode Island	4		1	Clim sim	Yes	Coefficient	Secondary
Horn, 2000	Massachusetts	10		1	Clim sim	Yes	Coefficient	Primary
Hutson, 1998	Tennessee	11		1	Clim sim	Yes	CW	Primary
Hutson and others, 2004b	Tennessee	22		1	Clim sim	Yes	RW	Primary
International Great Lakes Diversions and Consumptive Use Study Board,1981	Great Lakes	By SIC Code		-	Great Lakes	No	CW	Secondary
Kay, 2002	By state:							
	Kentucky	4		1	Clim sim	Yes	CW	Secondary
	Indiana	7		1	Great Lakes	Yes	CW	Secondary
	Michigan	7		1	Great Lakes	Yes	CW	Secondary
	Iowa	10		1	Clim sim	Yes	CW	Secondary
	Missouri	10		1	Clim sim	Yes	CW	Secondary
	Illinois	15		1	Great Lakes	Yes	CW	Secondary
	Wisconsin	15		1	Great Lakes	Yes	CW	Secondary
LaTour, 1991[4]	Illinois	12 By SIC Code		1	Great Lakes	Yes	CW	Primary
Loper and others, 1989	Pennsylvania	9[5]		1	Great Lakes	Yes	CW	Secondary
Ludlow and Gast, 2000	Pennsylvania	8		1	Great Lakes	Yes	CW	Primary
Marcuello and Lallana, 2003	Europe	20[6]		-	Other	No	Coefficient	Secondary
Nawyn, 1997	New Jersey	8[7]		1	Clim Sim	Yes	Coefficient	Secondary
Nimiroski and Wild, 2005	Rhode Island	10		1	Clim Sim	Yes	Coefficient	Secondary

Table 19. Summary of industrial consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics Area	Used in statistics	Coefficient or other	Data source
Ohlsson, 1997	World	9		-	Other	No	Coefficient	Secondary
Paulson and others, 1988	United States	16[8]		-	Other	No	Coefficient	Secondary
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania		7.5	1	Great Lakes	Yes	CW	Primary
Pebbles, 2003b	By state/province:							
	Illinois	Varies[9]		-	Great Lakes	No	Coefficient	Secondary
	Indiana	6		1	Great Lakes	Yes	Coefficient	Secondary
	Michigan	10-15[10]		1	Great Lakes	Yes	Coefficient	Secondary
	Minnesota	Varies[9]		-	Great Lakes	No	Coefficient	Secondary
	New York	25		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio	10		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio (salt mining)	90		-	Great Lakes	No	Coefficient	Secondary
	Ontario	Varies[11]		-	Great Lakes	No	Coefficient	Secondary
	Pennsylvania	Varies[9]		-	Great Lakes	No	Coefficient	Secondary
	Quebec (pulp and paper industry)	10		-	Great Lakes	No	Coefficient	Secondary
	Wisconsin	10.2		1	Great Lakes	Yes	Coefficient	Secondary
Postel, 1996	World	10		-	Other	No	CW	Secondary
Postel and others, 1996	World	10		-	Other	No	CW	Primary
Sholar and Lee, 1988	Kentucky	4		1	Clim Sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	4		1	Clim Sim	Yes	CW	Primary
Shiklomanov and Rodda, 2003	World	Continents		-	Other	No	CW	Primary
	World, 1995	11		-	Other	No	CW	Primary
	World, 1900–1995	9		-	Other	No	CW	Primary
Snavely, 1987	Great Lakes	6.5		1	Great Lakes	Yes	Coefficient	Secondary
Snavely, 1988	Great Lakes							
	1975 Study Board	11		-	Great Lakes	No	CW	Secondary
	1975 USGS	6.5		-	Great Lakes	No	CW	Secondary
	1980 Study Board	13		1	Great Lakes	Yes	CW	Secondary
	1980 USGS	6.5		1	Great Lakes	Yes	CW	Secondary
	1985 Study Board	14		1	Great Lakes	Yes	CW	Secondary
	1985 USGS	9.4		1	Great Lakes	Yes	CW	Secondary
Suder and Lessing, 1984	West Virginia	4		1	Clim sim	Yes	CW	Secondary
Suder and Lessing, 1985	West Virginia	4		1	Clim sim	Yes	CW	Secondary
Suder and Lessing, 1986	West Virginia	3		1	Clim sim	Yes	CW	Secondary
Suder and Lessing, 1987	West Virginia	3		1	Clim sim	Yes	CW	Secondary
Sweat and Van Til, 1988	Michigan	10		1	Great Lakes	Yes	CW	Secondary
Tate, 1988	Canada:							
	1966 Manufacturing	4		-	Other	No	CW	Secondary
	1972 Manufacturing	4		-	Other	No	CW	Secondary
	1976 Manufacturing	5		-	Other	No	CW	Secondary
Tate and Harris, 1999a	Great Lakes Basin-Canada	5		1	Great Lakes	Yes	CW	Secondary
Todd, 1970	United States	By SIC Code		-	Other	No	Coefficient	Secondary
U.S. Business and Defense, 1967	United States	6.3		-	Other	No	RW	Secondary
U.S. Bureau of the Census, 1986		By SIC Code						
	1954–1983	8		-	Other	No	RW	Primary
	By state:			-	Other	No	RW	Primary
	1983 Great Lake States		10	8	Great Lakes	Yes	RW	Primary
	1983 Climatically Similar		8	14	Clim sim	Yes	RW	Primary
U.S. Department of Agriculture, 1994	United States	16		-	Other	No	Coefficient	Secondary
U.S. Department of Agriculture, 1997	United States	16		-	Other	No	Coefficient	Secondary

Table 19. Summary of industrial consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics Area	Used in statistics	Coefficient or other	Data source
U.S. Department of Agriculture, 2003	United States	22		-	Other	No	Coefficient	Secondary
USGS Circulars, 1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	By state:							
	Great Lakes States		9	32	Great Lakes	Yes	CW	Secondary
	Climatically Similar States		9	63	Clim sim	Yes	CW	Secondary
	By basin or region:							
	Great Lake Basin		6	-	Great Lakes	No	CW	Secondary
	Mid-Atlantic Region		6	-	Clim sim	No	CW	Secondary
	New England Region		6	-	Clim sim	No	CW	Secondary
	Ohio Region		7	-	Clim sim	No	CW	Secondary
	Tennessee Region		12	-	Clim sim	No	CW	Secondary
	Upper Mississippi Region		5	-	Clim sim	No	CW	Secondary
USGS and Tennessee Department of Environment and Conservation, 2003	Tennessee	11		1	Clim sim	Yes	Coefficient	Primary
van der Leeden, 1975	Belgium	By major categories		-	Other	No	CW	Secondary
Water Resources Council (U.S.), 1978	By Basin:	By major categories						
	New England	9		-	Clim sim	No	CW	Secondary
	Mid-Atlantic	11		-	Clim sim	No	CW	Secondary
	Great Lakes	11		-	Great Lakes	No	CW	Secondary
	Ohio	8		-	Clim sim	No	CW	Secondary
	Tennessee	7		-	Clim sim	No	CW	Secondary
	Upper Mississippi	12		-	Clim sim	No	CW	Secondary
Wild and Nimiroski, 2004	Rhode Island, Connecticut	10		1	Clim sim	Yes	Coefficient	Secondary
Wild and Nimiroski, 2005	Rhode Island	10		1	Clim sim	Yes	Coefficient	Secondary
Woldorf, 1959	Ohio	5		-	Great Lakes	No	CW	Primary

[1] The consumptive-use coefficient is noted as "New England traditional rates."

[2] Single coefficient computed by the fraction of the total water consumed of the total water withdrawn.

[3] Consumptive-use coefficients for Ellefson and others was 20 percent for ground-water industrial water use and 10 percent of surface-water industrial withdrawals.

[4] In LaTour (1991) this was the "minimum consumptive-use ratio" for the industrial category (table 12); the "minimum consumptive-use ratio" method was used to estimate consumptive use for the municipal and commercial categories.

[5] 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.

[6] Marcuello and Lallana (2003) said that the consumptive-use coefficients were "widely accepted."

[7] Nawyn (1997) stated that "coefficients of consumptive water use that were developed in other studies were modified and applied to data on water users in Camden county." Both self-supplied withdrawals and public-supplied deliveries for industrial use had the same consumptive use coefficient.

[8] Consumptive-use coefficient for industrial-mining.

[9] Both manufacturing and mining varies by plant and Standard Industrial Code (SIC).

[10] For the summary statistics, the average of the consumptive-use coefficient range was used.

[11] Facility measured; varies by plant and facility.

The industrial consumptive-use coefficients in table 19 are organized by reference. Statistical values for references with multiple consumptive-use coefficients are listed in table 20. The industrial consumptive-use coefficients medians for the Great Lakes Basin and climatically similar areas were the same (10 percent; table 9, fig. 12). The 25^{th} and 75^{th} percentiles also were similar (7 to 14 percent for the Great Lakes Basin and 4 and 13 percent for climatically similar areas; fig. 12).

Table 20. Summary statistics of industrial consumptive-use coefficients from selected references.

[Reference refers to the annotated bibliography references. Consumptive-use coefficients are in percent. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References are listed in the appendix. All computed numbers (median, 25th and 75th percentiles) are rounded to the whole number, and reported numbers (minimum and maximum) are as listed in reference. The area referred to under "geographic area" may be the entire geographic area or a small study area.]

Reference	Geographic area	N	Coefficient statistics				
			Min	25th	Median	75th	Max
Delaware River Basin Commission [n.d]	Pennsylvania, Delaware, New Jersey	1	0.1	1	6	36	100
Great Lakes Commission, 2005a	Great Lakes States and Provinces	50	0	6	10	15	25
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania	-	6.2	7	7	8	11.4
U.S., Bureau of the Census, 1986	By state:						
	1983 Great Lake States	8	5	8	10	12	16
	1983 climatically similar states	14	0	4	8	12	21
USGS Circulars, 1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	By state:						
	Great Lakes States	32	2	4	9	10	35
	Climatically similar states	63	0	5	9	12	39
	By basin or region:						
	Great Lakes Basin	-	4	6	6	8	9
	Mid-Atlantic Region	-	4	6	6	9	10
	New England Region	-	5	5	6	9	20
	Ohio Region	-	4	5	7	10	15
	Tennessee Region	-	5	10	12	14	16
	Upper Mississippi Region	-	2	4	5	14	24

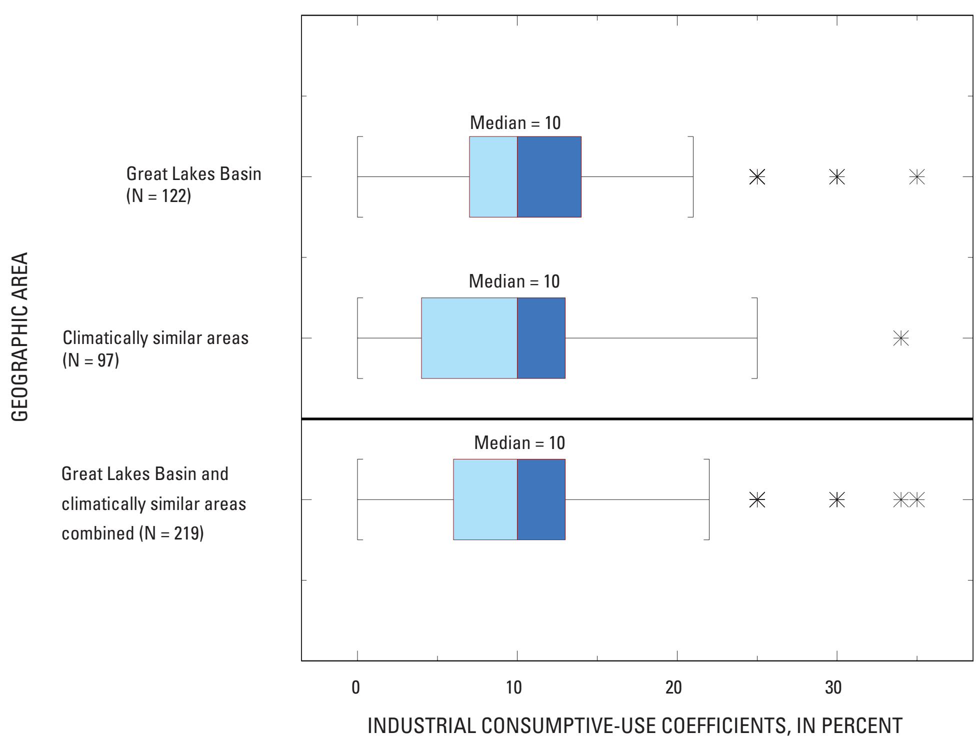
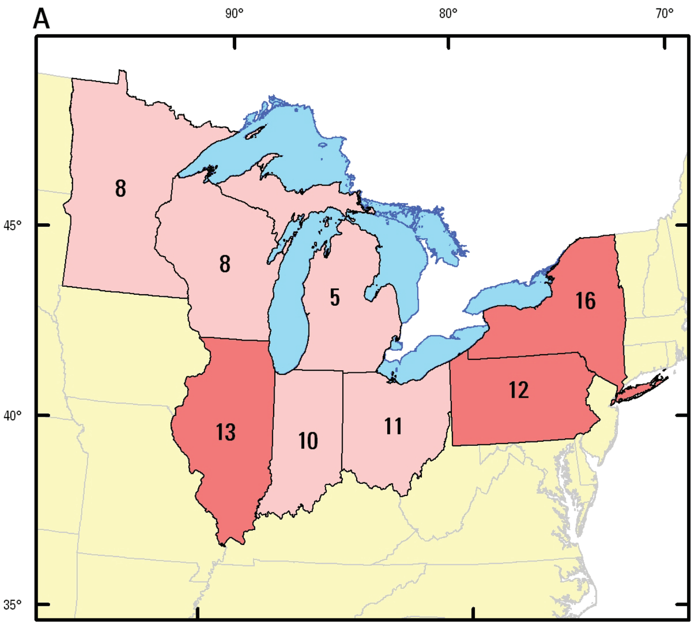
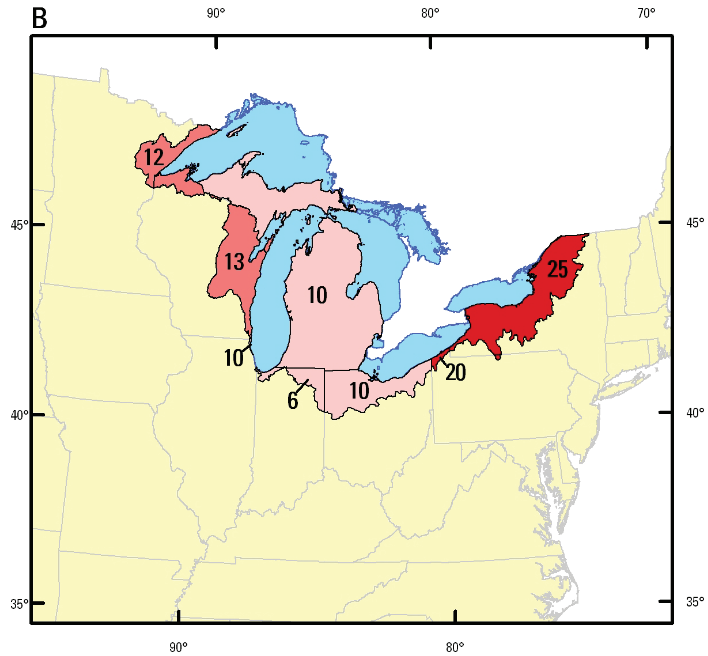


Figure 12. Distribution of industrial consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

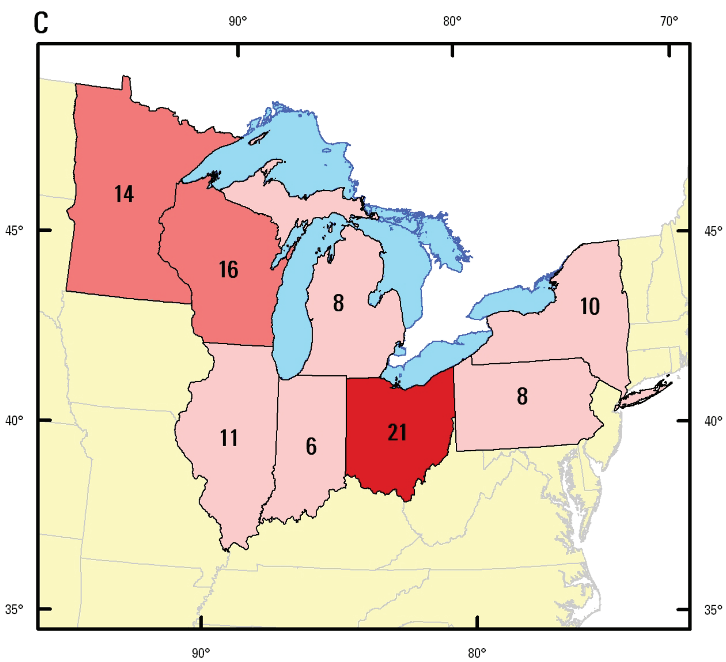
Figure 13 shows the industrial consumptive-use coefficients for the Great Lakes. Map *A* shows 1982 manufacturing coefficients from the U.S. Bureau of Census (1986) and is based on water withdrawals and water returned that industries reported to the Bureau for the entire state (appendix table 2-1). The census of 1982 data was the last U.S. Bureau of Census (1986) census of manufacturing prepared. Prior to 1986, the report was prepared about every 5 years between 1954 to 1983. More detailed information from this report is in appendix tables 2–1 to 2–5. The range of consumptive use coefficients is 5–16 percent for the Great Lakes states, and the median is 10 percent (table 20).

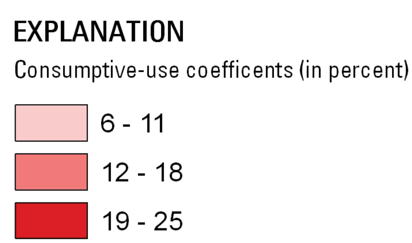


Data from U.S. Bureau of the Census, 1982, 1986. (The consumptive-use coefficient is for the entire state.)



Data from the Great Lakes Commission, 2005a. (The consumptive-use coefficient is for the Great Lakes Basin part of the state; Illinois data are for 2000.)





Data from Solley and others, 1998. (The consumptive-use coefficient is for the entire state.)

Figure 13. Industrial consumptive-use coefficients from various sources for the Great Lakes States.

In Pebbles (2003b) and other GLC publications, a table (appendix table 3–1) is included that lists the consumptive-use coefficients used by each jurisdiction and water-use category. As can be seen in this table, many states did not list a single coefficient to estimate consumptive use, so coefficients calculated from the GLC annual reports (1998–2002) (appendix table 3–3) were used in figure 13, Map *B*. The GLC data are the average of 5 years of data for each state, except for Illinois, whose coefficient is only for 2000. The GLC annual report coefficients are for the part of the Great Lakes drainage basin in each state. (The annual-report coefficients are also available for the Great Lakes Basin parts of Ontario and Quebec in Appendix table 3-3.) Withdrawal and consumptive-use data for each state are based on a variety of water-use programs and methods for compiling data. The Map *B* industrial consumptive-use coefficients range from 6 to 25 percent with a median of 10 (fig. 13*B*).

Map *C* shows the consumptive use of the Great Lakes Basin states from Solley and others (1998). Data were estimated by USGS water-use study chiefs in each state, many of whom were assisted by state and local agencies. Sources of information varied, but many study chiefs included data that were collected for individual facilities through permit programs. Industrial withdrawals also were estimated using the number of employees classified by industry group and per employee water-use coefficients (Hutson and others, 2004a). Others states estimated consumptive use by means of coefficients, most ranging from 10 to 40 percent of the withdrawals and deliveries, depending on the type of industry (Solley and others, 1998). For the Great Lakes States, the USGS coefficients were for the entire state in 1995, and they range from 6 to 21 percent; the median was 10 percent (appendix table 1–3).

Despite large ranges of consumptive-use coefficients for the Great Lakes States, the medians for each dataset were the same (10, U.S. Bureau of the Census; 10, GLC annual reports; 10, USGS Circulars). Each of the maps in figure 13 represents a different time period, and the GLC coefficients are only for the part of the Great Lakes drainage basin in each state.

Among the multiple reasons why coefficients between Maps *A*, *B*, and *C* (fig. 13) may differ are the following:

- Different time periods
- Different geographic areas
- Types of facilities active during the time of study
- Changes in processes at industrial facilities
- Differences in estimating methods
- Ways in which data are reported
- Differences in data-compilation methods

With respect to worldwide statistics (Shiklomanov and Rodda, 2003; table 21) industrial-use coefficients range from 3 to 25 percent (in 1900) and from 5 to 18 percent in 1995. The 1995 assessment had a consumptive-use coefficient median of 11 percent (table 22). From 1940 to 1980, there was a large increase in industrial water withdrawals in the world. Since 1980, the industrial water use has remained fairly steady for the world even though there may have been changes for individual continents.

Table 21. Industrial water withdrawals, consumptive use, and consumptive-use coefficients, by continent, for selected years from 1900 through 1995.

[Modified from Shiklomanov and Rodda (2003). Total withdrawn and consumptive use are in cubic kilometers per year and are as listed in reference; coefficient is the percentage of water withdrawn that was consumed, computed from the total withdrawn and consumptive-use data and rounded to the nearest whole number.]

Statistic	1900	1940	1950	1960	1970	1980	1990	1995	1900–1995
Europe[1]									
Total withdrawn	9.3	23.4	36.3	104	168	206	214	228	989
Consumptive use	1.1	2.2	3.2	7.0	11.6	22.3	26.9	28.5	102.8
Coefficient	12	9	9	7	7	11	13	13	10
Asia[2]									
Total withdrawn	4	18	33	51	107	153	176	184	726
Consumptive use	1	4	6	9	13	19	29	30	111
Coefficient	25	22	18	18	12	12	16	16	15
Africa[3]									
Total withdrawn	.4	.8	1.4	2.7	5.8	9.7	9.0	9.6	39.4
Consumptive use	.1	.1	.2	.5	.8	1.4	1.6	1.7	6.4
Coefficient	25	13	14	19	14	14	18	18	16
North America[4]									
Total withdrawn	21.8	-	104	165	246	293	259	266	1,354.8
Consumptive use	.7	-	3.9	6.4	10.2	13.4	13.8	14.6	63
Coefficient	3	-	4	4	4	5	5	5	5
South America[5]									
Total withdrawn	1.3	2.2	3.0	4.9	8.4	13.3	15.9	19.0	68
Consumptive use	.26	.4	.6	.8	.9	1.1	1.2	1.6	6.86
Coefficient	20	18	20	16	11	8	8	8	10
Australia and Oceania[6]									
Total withdrawn	1.00	3.00	4.10	6.20	8.30	10.5	6.70	7.20	47
Consumptive use	.20	.45	.50	.64	.69	.78	.46	.62	4.34
Coefficient	20	15	12	10	8	7	7	9	9
Total									
Total withdrawn	37.8	47.4	181.8	333.8	543.5	685.5	680.6	713.8	3,224.2
Consumptive use	3.36	7.15	14.4	24.34	37.19	57.98	72.96	77.02	294.4
Coefficient	9	15	8	7	7	8	11	11	9

[1] Shiklomanov and Rodda (2003) page 85, from table 4.

[2] Ibid., p. 135, from table 5.25.

[3] Ibid., p. 192, from table 6.18.

[4] Ibid., p. 258, from table 7.22.

[5] Ibid., p. 316, from table 8.19.

[6] Ibid., p. 346, From table 9.21.

Table 22. Industrial consumptive-use coefficients for major countries, continents, and the world.

[Coefficient is in percent and rounded to the nearest whole number]

Reference	Geographic area	Coefficient
College of Exploration [n.d.]	World	9
Cosgrove and Rijsberman, 2000	World	11
Environment Canada, 2004	Canada	9
European Environment Agency, 2005	Europe	20
Marcuello and Lallana, 2003	Europe	20
Postel and others, 1996	World	10
Shiklomanov and Rodda, 2003 (1995 assessment)	World	11
	By continent:	
	Europe	13
	Asia	16
	Africa	18
	North America	5
	South America	8
	Australia and Oceania	9
Solley and others, 1998	United States	15

The four references with industrial consumptive-use coefficients for the world listed in table 22 (9 to 11 percent) were similar to coefficients reported by Shiklomanov and Rodda (2003). Coefficients from other references for large countries or continents also were comparable to the coefficients published in Shiklomanov and Rodda (2003). Table 23 lists industrial withdrawals, consumptive use, and consumptive-use coefficients for European regions (Shiklomanov and Rodda, 2003); coefficients range from 6 to 22 percent.

Table 23. Industrial water withdrawal, consumptive use, and consumptive-use coefficients for European regions for selected years from 1980 through 1995.

[Modified from Shiklomanov and Rodda (2003) p. 88. Total withdrawn and consumptive use are in cubic kilometers per year and are as listed in reference; coefficient is the percentage of water withdrawn that was consumed, computed from the total withdrawn and consumptive-use data and rounded to the nearest whole number.]

Statistic	1980	1990	1995	1980–1995
Northern Europe				
Total withdrawn	6.64	6.29	7.01	19.94
Consumptive use	.60	.57	.67	1.84
Coefficient	9	9	10	9
Central Europe				
Total withdrawn	94.3	93.8	102.0	290.1
Consumptive use	7.5	8.4	9.8	25.7
Coefficient	8	9	10	9
Southern Europe				
Total withdrawn	38.3	40.5	45.1	123.9
Consumptive use	3.1	2.8	2.9	8.8
Coefficient	8	7	6	7
Northern slope of European territory of former Soviet Union				
Total withdrawn	11.2	13.00	12.20	36.4
Consumptive use	1.30	1.60	1.60	4.5
Coefficient	12	12	13	12
Southern slope of European territory of former Soviet Union				
Total withdrawn	55.9	60.0	60.5	176.4
Consumptive use	9.8	13.4	13.4	36.6
Coefficient	18	22	22	21
Total				
Total withdrawn	206.34	213.59	226.81	646.74
Consumptive use	22.3	26.77	28.37	77.44
Coefficient	11	13	13	12

Industrial Use by Major Standard Industrial Classification Codes

The U.S. Bureau of the Census (1986) formerly reported industrial water use for water-resource regions by major SIC code groups. In the Great Lakes region, approximately 93 percent of the industrial water withdrawals were from six major groups, which are listed in table 24 and appendix table 2–3. The remaining 7 percent of withdrawals are distributed among 12 other major categories (appendix table 2–3). The three largest industrial water-use groups were primary metal industries, chemicals and allied products, and paper and allied products. These three industrial groups made up 84 percent of the total industrial withdrawals for the Great Lakes Basin in 1983 (U.S. Bureau of Census, 1986) and 82 percent of the total withdrawals in Canada in 1996 (Environment Canada, 2004).

Consumptive-use coefficients in table 25 are organized by type of industry listed for the six major groups on the basis of reports with industrial water-use data. The consumptive-use coefficients vary by region. The differences in coefficients may in part be due to differences in the mix of industry types in each geographic area.

Table 24. Industrial consumptive use for six industrial major-group categories with the largest consumptive use in the Great Lakes Basin in 1983.

[Modified from U.S. Bureau of the Census (1986). Water withdrawn, water discharged, and water consumed are in billion gallons and are rounded to one decimal place as in the reference. Water consumed is calculated by subtracting the water discharged from the water withdrawn. The coefficient, in percent, is the consumptive-use coefficient derived by dividing the calculated water consumed by the water withdrawn and rounded to the nearest whole number.]

Industrial category	Water withdrawn	Water discharged	Water consumed	Coefficient (%)
SIC code 33: Primary metal industries	1,218.2	1,119.6	98.6	8
SIC code 26: Paper and allied products	228.5	181.1	47.4	21
SIC code 28: Chemicals and allied products	183.6	174.3	9.3	5
SIC code 20: Food and kindred products	70.8	62.4	8.4	12
SIC code 32: Stone, clay, and glass products	49.2	46.7	2.5	5
SIC code 37: Transportation equipment	48.8	44.6	4.2	9

Table 25. Industrial consumptive-use coefficients, by industrial category, for six industry groups.

[Reference refers to the annotated bibliography reference. Year of data refers to the year that data was compiled. Industrial group or Standard Industrial Code (SIC) is either the group name or the SIC major industry code that the reference used to define the type of water use. The coefficient is the percentage of the water consumed out of the water withdrawn. All numbers are rounded. – denotes that there was no consumptive-use coefficient either because of census masking or because water returned was greater than the water intake.]

Reference	Geographic area	Year of data	Industry group or SIC code	Coefficient (%)
		SIC code 20: Food and kindred products		
Environment Canada, 2004	Canada	1996	Food	11
		1996	Beverages	23
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Canada	1971	Food and beverages	9
Snavely, 1986	New York	1979	20	16
U.S. Bureau of the Census, 1986	United States	1983	20	15
		1983	Food	13
		1983	Beverages	23
		1978	20	12
		1973	20	7
		1968	20	7
		1964	20	9
		1959	20	8
		1954	20	11
	Great Lakes	1983	20	12
	New England	"		45
	Middle Atlantic	"		18
	Ohio	"		23
	Upper Mississippi	"		8
	Tennessee	"		22
Water Resources Council (U.S.), 1978	New England Region	1978	Food	16
	Mid-Atlantic Region	"		17
	Great Lakes Region	"		11
	Ohio Region	"		14
	Tennessee Region	"		5
	Upper Mississippi Region	"		12
van der Leeden, 1975	Belgium	1974	Food	12

Table 25. Industrial consumptive-use coefficients, by industrial category, for six industry groups.—Continued

[Reference refers to the annotated bibliography reference. Year of data refers to the year that data was compiled. Industrial group or Standard Industrial Code (SIC) is either the group name or the SIC major industry code that the reference used to define the type of water use. The coefficient is the percentage of the water consumed out of the water withdrawn. All numbers are rounded. – denotes that there was no consumptive-use coefficient either because of census masking or because water returned was greater than the water intake.]

Reference	Geographic area	Year of data	Industry group or SIC code	Coefficient (%)
SIC code 26: Paper and allied products				
Environment Canada, 2004	Canada	1996	Paper and allied products	9
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Canada	1971	Paper and allied products	5
Snavely, 1986	New York	1979	26	8
U.S. Bureau of the Census, 1986	United States	1983	26	7
		1978	26	10
		1973	26	5
		1968	26	8
		1964	26	6
		1959	26	6
		1954	26	9
	Great Lakes	1983	26	21
	New England	"		4
	Middle Atlantic	"		15
	Ohio	"		2
	Upper Mississippi	"		10
	Tennessee	"		4
Water Resources Council (U.S.), 1978	New England Region	1978	Paper	9
	Mid-Atlantic Region	"		10
	Great Lakes Region	"		15
	Ohio Region	"		10
	Tennessee Region	"		11
	Upper Mississippi Region	"		6
van der Leeden, 1975	Belgium	1974	Paper	10

Table 25. Industrial consumptive-use coefficients, by industrial category, for six industry groups.—Continued

[Reference refers to the annotated bibliography reference. Year of data refers to the year that data was compiled. Industrial group or Standard Industrial Code (SIC) is either the group name or the SIC major industry code that the reference used to define the type of water use. The coefficient is the percentage of the water consumed out of the water withdrawn. All numbers are rounded. – denotes that there was no consumptive-use coefficient either because of census masking or because water returned was greater than the water intake.]

Reference	Geographic area	Year of data	Industry group or SIC code	Coefficient (%)
		SIC code 28: Chemicals and allied products		
Environment Canada, 2004	Canada	1996	Chemicals and chemical products	8
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Canada	1971	Chemicals and chemical products	5
Snavely, 1986	New York	1979	28	4
U.S. Bureau of the Census, 1986	United States	1983	28	12
		1978	28	10
		1973	28	6
		1968	28	7
		1964	28	5
		1959	28	6
		1954	28	5
	Great Lakes	1983	28	5
	New England	"		0
	Middle Atlantic	"		4
	Ohio	"		3
	Upper Mississippi	"		15
	Tennessee	"		22
Water Resources Council (U.S.), 1978	New England Region	1978	Chemicals	14
	Mid-Atlantic Region	"		10
	Great Lakes Region	"		4
	Ohio Region	"		5
	Tennessee Region	"		5
	Upper Mississippi Region	"		14
van der Leeden, 1975	Belgium	1974	Chemical	6

Table 25. Industrial consumptive-use coefficients, by industrial category, for six industry groups.—Continued

[Reference refers to the annotated bibliography reference. Year of data refers to the year that data was compiled. Industrial group or Standard Industrial Code (SIC) is either the group name or the SIC major industry code that the reference used to define the type of water use. The coefficient is the percentage of the water consumed out of the water withdrawn. All numbers are rounded. – denotes that there was no consumptive-use coefficient either because of census masking or because water returned was greater than the water intake.]

Reference	Geographic area	Year of data	Industry group or SIC code	Coefficient (%)
SIC code 32: Stone, clay, and glass products				
Snavely, 1986	New York	1979	32	9
U.S. Bureau of the Census, 1986	United States	1983	32	14
		1978	32	12
		1973	32	12
		1968	32	13
		1964	32	12
		1959[1]	32	-
		1954	32	9
	Great Lakes	1983	32	5
	New England	"		15
	Middle Atlantic	"		7
	Ohio	"		12
	Upper Mississippi	"		14
	Tennessee	"		-
SIC code 33: Primary metal industries				
Environment Canada, 2004	Canada	1996	Primary Metals	8
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Canada	1971	Iron&Steel and other primary metals	2
Snavely, 1986	New York	1979	33	1
U.S. Bureau of the Census, 1986	United States	1983	33	11
		1978	33	8
		1973	33	4
		1968	33	6
		1964	33	6
		1959	33	4
		1954	33	4
	Great Lakes	1983	33	8
	New England	"		8
	Middle Atlantic	"		12
	Ohio	"		11
	Upper Mississippi	"		37
	Tennessee	"		-

Table 25. Industrial consumptive-use coefficients, by industrial category, for six industry groups.—Continued

[Reference refers to the annotated bibliography reference. Year of data refers to the year that data was compiled. Industrial group or Standard Industrial Code (SIC) is either the group name or the SIC major industry code that the reference used to define the type of water use. The coefficient is the percentage of the water consumed out of the water withdrawn. All numbers are rounded. – denotes that there was no consumptive-use coefficient either because of census masking or because water returned was greater than the water intake.]

Reference	Geographic area	Year of data	Industry group or SIC code	Coefficient (%)
SIC code 33: Primary metal industries—Continued				
Water Resources Council (U.S.), 1978	New England Region	1978	Primary metals	3
	Mid-Atlantic Region	"		15
	Great Lakes Region	"		14
	Ohio Region	"		7
	Tennessee Region	"		16
	Upper Mississippi Region	"		13
Van der Leeden, 1975	Belgium	1974	Iron & steel and non-ferrous	9
SIC code 37: Transportation equipment				
Environment Canada, 2004	Canada	1996	Transportation Equipment	29
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Canada	1971	Transportation Equipment	3
Snavely, 1986	New York	1979	37	<1
U.S. Bureau of the Census, 1986	United States	1983	37	9
		1978	37	6
		1973	37	6
		1968	37	6
		1964	37	4
		1959	37	1
		1954	37	7
	Great Lakes	1983	37	9
	New England	"		-
	Middle Atlantic	"		5
	Ohio	"		15
	Upper Mississippi	"		13
	Tennessee	"		7
Water Resources Council (U.S.), 1978	New England Region	1978	Transportation	8
	Mid-Atlantic Region	"		9
	Great Lakes Region	"		12
	Ohio Region	"		24
	Tennessee Region	"		-
	Upper Mississippi Region	"		19

With the exception of Environment Canada (2004), **all references** were for data collected more than 20 years ago (1954 to 1983). Consumptive-use coefficients from 20 or more years ago may not accurately reflect current consumptive-use coefficients because the industrial water-use processes might have changed over time. Summary statistics of the consumptive-use coefficients for the six largest industrial water-use SIC groups (table 24) are presented in table 26.

Paper and allied products, chemicals and allied products, and primary metal industries had a median within 2 percent of the most recent coefficient, that from Environment Canada (2004) (table 26).

Table 26. Summary statistics for industrial consumptive-use coefficients listed in table 25 for six industrial groups.

[Industry refers to the products produced for six major Standard Industrial Classification code categories. Environment Canada (2004) is the source for the consumptive-use coefficient for each of the major categories from this reference and is in percent. The minimum, median, maximum, 10th percentile, 25th percentile, 75th percentile and the 90th percentile are in percent. N is the number of references used in the statistical analysis.]

Industry	N	Min	10th percentile	25th percentile	Median	75th percentile	90th percentile	Max	Environment Canada (2004)
Food and kindred products	22	5	7	9	12	16	22	45	11 & 23[1]
Paper and allied products	23	2	4	6	9	10	14	21	9
Chemicals and allied products	23	0	4	5	6	10	14	22	8
Stone, clay, and glass products	12	5	7	9	12	13	14	15	-
Primary metal industries	22	1	3	4	8	12	15	37	8
Transportation equipment	19	1	4	6	8	12	20	29	29

[1] In the publication for Environment Canada (2004), food and kindred products are separated into Food (11 percent) and Beverages (23 percent). This same comparison was possible with the U.S. Bureau of the Census reference (1986), where food was 13 percent and beverages were 23 percent.

Environment Canada (2004) and U.S. Bureau of the Census (1986) separated the food and kindred products into two categories: food and beverages. For the food category, the consumptive-use coefficients from these two references were similar (11 and 13 percent), and both references listed a consumptive-use coefficient of 23 percent for beverages.

The bottled-water industry is omitted in both references, but it has increased sales in both Canada and the United States over the last 10 years (Canadian Environmental Law Association, 2004). Fahrenthold (2006) cites Robert Glennon (a law professor at the University of Arizona) as saying that 100 percent of bottled water is consumptive use and that once the water is put in the bottle, the water is gone. Similarly, the Canadian Bottled Water Association (n.d.) stated (in a response to the Ontario Ministry on watershed-based source protection planning) that more than 97 percent of the water for the bottling industry is intended for human consumption, implying that 97 percent of bottled water is consumed.

The ethanol fuel industry has been increasing since 1980 in the United States, but with 79 plants under construction and 7 plant expansions, the current capacity of ethanol production will more than double from 5,750.4 to 12,088.3 Mgal/yr (Renewable Fuels Association, 2007). In ethanol plants water is evaporated; recycled into plant-process streams; incorporated into plant by-products; used for sanitation, cleaning, and emergencies; and discharged from the plant as nonprocess wastewater (U.S. Department of Energy, 2005). New process technology has minimized both the volume of water use required in ethanol plants and the water discharge (Clean Fuels Development Coalition and Nebraska Ethanol Board, 2006), which increases the consumptive-use coefficient. Three site-specific references were found with water use and return flow estimates for ethanol plants, but consumptive-use coefficients varied (table 27). More data (water use and consumptive use) and further studies are needed on ethanol plants for water managers to better understand and plan for the water and consumptive use in ethanol plants.

Environment Canada (2004) found that the consumptive-use coefficient for the Transportation Equipment industrial category was 29 percent. This coefficient is substantially higher than the median transportation equipment coefficient of 8 percent (computed from 19 references, 18 of which are more than 20 years old) and the median industrial coefficients of 10 percent for the GLB, climatically similar areas, and the world (table 9). Interestingly, General Motors (2001) stated that in 2000, the global operations purchased and used 6 percent less water than in 1999 and the North American plants decreased water use on a per vehicle basis by 8 percent between 1999 and 2000.

Table 27. Ethanol-production water use, return flow, and consumptive-use coefficients.

[Water use and return flow are in million gallons per day. Coefficient (calculated by subtracting return flow from water use divided by water use) is in percent and rounded to the nearest whole number]

Reference	Water use	Return flow	Coefficient
Minnesota Pollution Control Agency, 2006 Existing Ethanol Plant[1]	0.402	0.178	56
Mark Muller, Institute for Agriculture and Trade Policy, written commun., 2007[2]	.0540	.0125	77
U.S. Department of Energy, 2005[3]	.576	.144	75

[1] Water use based on 2005 water reporting. Return flow is the "current discharge volume" "based on 2005 average flows." The return flow includes reverse-osmosis reject water/iron-filter backwash and cooling-tower blowdown.

[2] Water use and return flow based on external process **water balance** "water in" and "water out" for one ethanol plant in Wisconsin.

[3] Proposed withdrawal and discharge from an environmental assessment of a proposed fuel ethanol plant in Indiana. "Approximately one-quarter of this drawdown (100 gpm) would be discharged from the plant as non-process wastewater."

The medians of the SIC specific coefficients (table 26) (ranging from 6 to 12 percent) were similar to the median industrial coefficients for the Great Lakes Basin, climatically similar areas, and the world (table 9) (10 percent). Additionally, in the most recent water-availability publication of Environment Canada (2004), SIC coefficients were comparable to the median SIC specific coefficients (table 26) except for the transportation-equipment industrial category (8 versus 29 percent), implying that either the 8 percent coefficient may not reflect current consumptive-use coefficients for the transportation-equipment industry or the Environment Canada coefficient reflects facilities with a larger rate of consumption than most other transportation–equipment facilities. The median consumptive-use coefficients (23) for the beverage and bottle industries were also significantly higher than the median industrial coefficients (10 percent) for the Great Lakes Basin, climatically similar areas, and the world (table 9).

Appendix table 2–5 lists consumptive use coefficients from the Census of Manufacturing in 1983 by SIC and NAICS codes (U.S. Bureau of the Census, 1986). Table 28 includes a list of industries with consumptive-use coefficients greater than 30 percent. Industries that have a higher consumptive-use coefficient may have a greater percent of the water being either incorporated into products or evaporated. Many of these industries reported small withdrawal amounts, as noted in the table 28. Some industrial groups were withheld to avoid disclosing data for individual companies, and it is unknown what their consumptive-use coefficient was. (These industries are noted in appendix table 2–5).

Table 28. Industries with a consumptive-use coefficient greater than 30 percent in 1983.

[Modified from U.S. Bureau of the Census, 1986.]

SIC	Industry	Coefficient
2041	Flour and other grain mill products[1]	38
2043	Cereal breakfast foods	36
2044	Rice milling[1]	33
2051	Bread, cake, and related products[1]	42
2063	Beet sugar	34
2077	Animal and marine fats and oils	46
2086	Bottled and canned soft drinks	45
2296	Tie cord and fabric[1]	33
2297	Nonwoven fabrics[1]	33
2435	Hardwood veneer and plywood[1]	67
2436	Softwood veneer and plywood	43
2813	Industrial gases	36
2831	Biological products[1]	38
284	Soaps, cleaners, and toilet goods[2]	40
2873	Nitrogenous fertilizers	36
2874	Phosphatic fertilizers	34
2895	Carbon pack[1]	81
2992	Lubricating oils and greases[1]	50
2999	Petroleum and coal products	46
325	Structural clay products[1,2]	50
3264	Porcelain electrical supplies[1]	33
3275	Gypsum products	59
3293	Gaskets, packing, and sealing devices[1]	50
3332	Primary lead[1]	57
3433	Heating equipment, except electric[1]	33
351	Engines and turbines[2]	35
3563	Air and gas compressors[1]	50
3764	Space propulsion units and parts	30

[1] Coefficient based on less than 2 billion gallons of water withdrawn.

[2] Industrial group used due to census masking.

Thermoelectric Power

Thermoelectric-power water use is water used in the process of generating electric power by means of fossil-fuel, nuclear, and geothermal power sources. The amount of consumptive use (or evaporation) that occurs during the process of condenser and reactor cooling associated with the generation of electric power depends on the engineering at the plant. For condenser and reactor cooling, thermoelectric plants can use once-through cooling, cooling towers and ponds, or a combination of both. A **once-through thermoelectric power facility** is a facility that uses water only once in the condenser– and reactor–cooling process before returning the water to a surface-water source. Once-through cooling requires large amounts of water, but evaporation is small (usually less than 3 percent) (Solley and others, 1998). Thermoelectric plants that do not use once-through cooling (open-loop) are called "other than once-through cooling thermoelectric plants" (closed-loop or recirculating). **An other than once-through thermoelectric power facility** uses cooling towers or cooling ponds to recycle water repeatedly for condenser and reactor cooling; the water withdrawals are smaller, but consumptive use is larger, typically greater than 60 percent (Solley and others, 1998). Facilities that combine once-through cooling with cooling towers and cooling ponds can have varying consumptive-use coefficients depending on the characteristics of their operation.

The engineering at a thermoelectric plant depends on many factors including water availability. Facilities that have access to an abundant water supply may have once-though cooling and therefore will have a lower consumptive-use coefficient. Facilities with limited water availability may have cooling towers or cooling ponds to reuse their water until most (if not all) of the water is evaporated.

Table 29 is a compilation of thermoelectric consumptive-use coefficients listed by reference, and table 30 is a statistical summary for references with multiple coefficients and geographic areas. In many references, the thermoelectric consumptive-use coefficients reported had large ranges—as much as 0.1 to 100 percent in one source (table 30 and annotated bibliography). The medians also ranged significantly because of the number of facilities and the various types of engineering at the facilities (once-through in contrast to cooling ponds or cooling towers) (table 30). The overall consumptive-use coefficients (total water consumed divided by total water withdrawals for all sites) for these references in table 30 were all less than 2 percent (table 29) because the once-through cooling systems use significantly more water than the facilities with cooling towers and ponds.

Most of the thermoelectric consumptive-use coefficients were computed from the amount of water consumed divided by water withdrawals. However, coefficients calculated from the amount of water (gallons) consumed per kilowatt-hour (kWh) were given in two reports. Torcellini and others (2003) compiled thermoelectric consumptive-use coefficient by states and found that the total weighted average water consumption for the United States was 0.47 gal/kWh and 0.49 gal/kWh for the Eastern Electric grid (which includes the Great Lakes area). For Great Lakes States, the water consumption range was from 0.41 gal/kWh for Indiana to 1.05 gal/kWh for Illinois (Torcellini and others, 2003). The International Great Lakes diversions and consumptive-use study board (1981) found a range of consumptive-use coefficients from 0.21 to 0.33 million gallons per day per gigawatt hour per year (Mgal/d/gWh/yr) for fossil-fuel thermoelectric plants and 0.35 to 0.56 Mgal/d/gWh/yr for nuclear plants.

Table 29. Summary of thermoelectric power consumptive-use coefficients for the Great Lakes Basin and climatically similar areas.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. Gal/kwh is gallons per kilowatt hour.]

Reference	Geographic area	Single coefficient (in percent)	Median coefficient (in percent)	N	Statistics area	Used in statistics	Coefficient or Other	Data source
Barlow, 2003[1]	Rhode Island, Massachussetts	100		-	Clim sim	No	CW	Secondary
Brill and others, 1977	Illinois, Indiana, Kentucky, Ohio	.1		-	Clim sim	No	CW	Secondary
Delaware River Basin Commission [n.d.][2]	Pennsylvania, Delaware, New Jersey	1		1	Clim sim	Yes	CW	Primary
Ellefson and others, 1987	Wisconsin	1		1	Great Lakes	Yes	Coefficient	Primary
Endreny, 2005:	New York							
Fossil fuel		2		1	Great Lakes	Yes	CW	Secondary
Nuclear		3.6		1	Great Lakes	Yes	CW	Secondary
European Environment Agency, 2005	Europe	5		-	Other	No	Ceofficient	Primary
Great Lakes Commission, 2005a								
Annual reports 1998–2002:	Great Lakes							
Fossil fuel			1	45	Great Lakes	Yes	CW	Secondary
Nuclear			1	30	Great Lakes	Yes	CW	Secondary
Great Lakes Commission and U.S. Army Corps of Engineers, 1999	Great Lakes	<2		-	Great Lakes	No	Coefficient	Primary
Government of Canada and the U.S. Environmental Protection Agency, 1995	Great Lakes:							
	Canada:							
	Lake Superior	0		1	Great Lakes	Yes	CW	Secondary
	Lake Huron	1		1	Great Lakes	Yes	CW	Secondary
	Lake Erie	1		1	Great Lakes	Yes	CW	Secondary
	Lake Ontario	1		1	Great Lakes	Yes	CW	Secondary
	United States:							
	Lake Superior	1		1	Great Lakes	Yes	CW	Secondary
	Lake Michigan	2		1	Great Lakes	Yes	CW	Secondary
	Lake Huron	2		1	Great Lakes	Yes	CW	Secondary
	Lake Erie	1		1	Great Lakes	Yes	CW	Secondary
	Lake Ontario	2		1	Great Lakes	Yes	CW	Secondary
Hutson and others, 2004b	Tennessee	1		1	Clim sim	Yes	RW	Primary
International Great Lakes Diversions and Consumptive Use Study Board,1981[3]	Great Lakes	Gal/kwh		-	Great Lakes	No	Coefficient	Secondary
Kay, 2002	Kentucky, Indiana, Michigan, Iowa, Missouri, Illinois, Wisconsin	<4		-	Clim sim	No	CW	Secondary
Loper and others, 1989	Pennsylvania	1.7		1	Great Lakes	Yes	CW	Secondary
Ludlow and Gast, 2000	Pennsylvania	4		1	Great Lakes	Yes	CW	Primary
Marcuello and Lallana, 2003[4]	Europe	5		-	Other	No	Coefficient	Secondary
Paulson and others, 1988	United States	3.3		-	Other	No	Coefficient	Secondary
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania		1.23	-	Great Lakes	No	CW	Primary

Table 29. Summary of thermoelectric power consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. Gal/kwh is gallons per kilowatt hour.]

Reference	Geographic area	Single coefficient (in percent)	Median coefficient (in percent)	N	Statistics area	Used in statistics	Coefficient or Other	Data source
Pebbles, 2003b	By state/province:							
	Fossil fuel:							
	Illinois	By water[5]		-	Great Lakes	No	Coefficient	Secondary
	Indiana	2		1	Great Lakes	Yes	Coefficient	Secondary
	Michigan	1-2[6]		1	Great Lakes	Yes	Coefficient	Secondary
	Minnesota	2		1	Great Lakes	Yes	Coefficient	Secondary
	New York	2		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio	By water[5]		-	Great Lakes	No	Coefficient	Secondary
	Ontario	.9		1	Great Lakes	Yes	Coefficient	Secondary
	Pennsylvania	-		-	Great Lakes	No	Coefficient	Secondary
	Quebec	10		1	Great Lakes	Yes	Coefficient	Secondary
	Wisconsin	.5-1[6]		1	Great Lakes	Yes	Coefficient	Secondary
	Nuclear:							
	Illinois	By water[5]		-	Great Lakes	No	Coefficient	Secondary
	Indiana	-		-	Great Lakes	No	Coefficient	Secondary
	Michigan	1-2[6]		1	Great Lakes	Yes	Coefficient	Secondary
	Minnesota	-		-	Great Lakes	No	Coefficient	Secondary
	New York	5		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio	14		1	Great Lakes	Yes	Coefficient	Secondary
	Ontario	.9		1	Great Lakes	Yes	Coefficient	Secondary
	Pennsylvania	-		-	Great Lakes	No	Coefficient	Secondary
	Quebec	-		-	Great Lakes	No	Coefficient	Secondary
	Wisconsin	.5-1[6]		1	Great Lakes	Yes	Coefficient	Secondary
Sholar and Lee, 1988	Kentucky	4		1	Clim sim	Yes	CW	Primary
	Kentucky Basin	5		1	Clim sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	6		1	Clim sim	Yes	CW	Primary
Snavely, 1987	Great Lakes	.3		1	Great Lakes	Yes	Coefficient	Secondary
Snavely, 1988:	Great Lakes							
1975 Study Board		1.2		-	Great Lakes	No	CW	Secondary
1975 USGS		.21		-	Great Lakes	No	CW	Secondary
1980 Study Board		1.7		1	Great Lakes	Yes	CW	Secondary
1980 USGS		.34		1	Great Lakes	Yes	CW	Secondary
1985 Study Board		2.1		1	Great Lakes	Yes	CW	Secondary
1985 USGS		4.9		1	Great Lakes	Yes	CW	Secondary
Stevens and others, 1984	West Virginia	13.85		1	Clim Sim	Yes	RW	Primary
Suder and Lessing, 1984	West Virginia	10.7		1	Clim Sim	Yes	RW	Primary
Suder and Lessing, 1985	West Virginia	16		1	Clim Sim	Yes	RW	Primary
Suder and Lessing, 1986	West Virgina	12.7		1	Clim Sim	Yes	RW	Primary
Suder and Lessing, 1987	West Virgina	15.6		1	Clim Sim	Yes	RW	Primary
Sweat and Van Til, 1988	Michigan	1.3		1	Great Lakes	Yes	CW	Secondary
Tate, 1988:	Canada							
1966 Manufacturing		1		-	Other	No	CW	Secondary
1972 Manufacturing		1		-	Other	No	CW	Secondary
1976 Manufacturing		1		-	Other	No	CW	Secondary
Tate and Harris, 1999a[7]	Great Lakes Basin–Canada	.09		1	Great Lakes	Yes	Coefficient	Secondary
Torcellini and others, 2003[8]	United States	gal/kWh		-	Other	No	Coefficient	Secondary

Table 29. Summary of thermoelectric power consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. Gal/kwh is gallons per kilowatt hour.]

Reference	Geographic area	Single coefficient (in percent)	Median coefficient (in percent)	N	Statistics area	Used in statistics	Coefficient or Other	Data source
U.S. Department of Agriculture, 1994	United States	3		-	Other	No	Coefficient	Secondary
U.S. Department of Agriculture, 1997	United States	3		-	Other	No	Coefficient	Secondary
U.S. Department of Agriculture, 2003	United States	3		-	Other	No	Coefficient	Secondary
U.S. Department of Energy, 2004[9]	United States	By plant		-	Other	No	CW	Primary
USGS Circulars, 1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	By states:							
	Great Lakes States		2	32	Great Lakes	Yes	CW	Secondary
	Climatically similar states		2	4	Clim sim	Yes	CW	Secondary
	By basin or region:							
	Great Lake		2	-	Great Lakes	No	CW	Secondary
	Mid-Atlantic		2	-	Clim sim	No	CW	Secondary
	New England		2	-	Clim sim	No	CW	Secondary
	Ohio		4	-	Clim sim	No	CW	Secondary
	Tennessee		0	-	Clim sim	No	CW	Secondary
	Upper Mississippi		2	-	Clim sim	No	CW	Secondary
USGS and Tennessee Department of Environment and Conservation, 2003	Tennessee	.5		1	Clim sim	Yes	Coefficient	Primary
Water Resources Council (U.S.), 1978	By region or basin:	By major categories						
	New England	2		-	Clim sim	No	CW	Secondary
	Mid-Atlantic	1		-	Clim sim	No	CW	Secondary
	Great Lakes	1		-	Great Lakes	No	CW	Secondary
	Ohio	2		-	Clim sim	No	CW	Secondary
	Tennessee	1		-	Clim sim	No	CW	Secondary
	Upper Mississippi	2		-	Clim sim	No	CW	Secondary
van der Leeden, 1975	Belgium	0		-	Clim sim	No	CW	Secondary
Van Til and Scott, 1986	Michigan	1.3		1	Great Lakes	Yes	CW	Primary
Woldorf, 1959	Ohio	1		-	Great Lakes	No	CW	Primary

[1] Based on one facility and not used in the statistical analysis.

[2] This number is based on a couple of facilities and not used in the statistical analysis.

[3] Consumption based on using a coefficient based on the energy that is created. For fossil-fuel plants, the range was 0.21 to 0.33 million gallons per day per gigawatt-hour per year. For nuclear plants, the range was 0.35 to 0.56 Mgal/d/GWh/yr.

[4] Marcuello and Lallana (2003) said that the consumptive-use coefficients were “widely accepted.”

[5] Individually estimated based on the quantity of makeup water.

[6] For the summary statistics, the average of the consumptive-use coefficient range was used.

[7] This is for once-through thermoelectric power generation.

[8] Consumption based on water consumed per kilowatt.

[9] Reference is by each thermoelectric plant.

Table 30. Summary statistics of thermoelectric power consumptive-use coefficients from selected references.

[Reference refers to the annotated bibliography references. Consumptive-use coefficients are in percent. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References with more than one coefficient are listed in the appendix. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. The geographic area is defined by states, basins, or regions—it can be for the entire geographic area to a small study area within the geographic area.]

Reference	Geographic area	N	Coefficient statistics				
			Min	25th	Median	75th	Max
Delaware River Basin Commission [n.d][1]	Pennsylvania, New Jersey, Delaware	-	0.1	0.4	11	44	100
Pennsylvania Department of Environmental Resources, 1975–83[2]	Pennsylvania	-	.02	.2	.7	.8	8.6
USGS Circulars, 1983, 1988, 1993, 1998							
	By states:						
	Great Lakes States	32	0	1	2	3	21
	Climatically similar states	64	0	0	2	3	75[1]
	By basin or region:						
	Great Lakes Basin	-	0	2	2	3	5
	Mid-Atlantic Region	-	1	1	2	3	6
	New England Region	-	0	1	2	2	2
	Ohio Region	-	2	4	4	4	4
	Tennessee Region	-	0	0	0	0	0
	Upper Mississippi Region	-	2	2	2	2	4

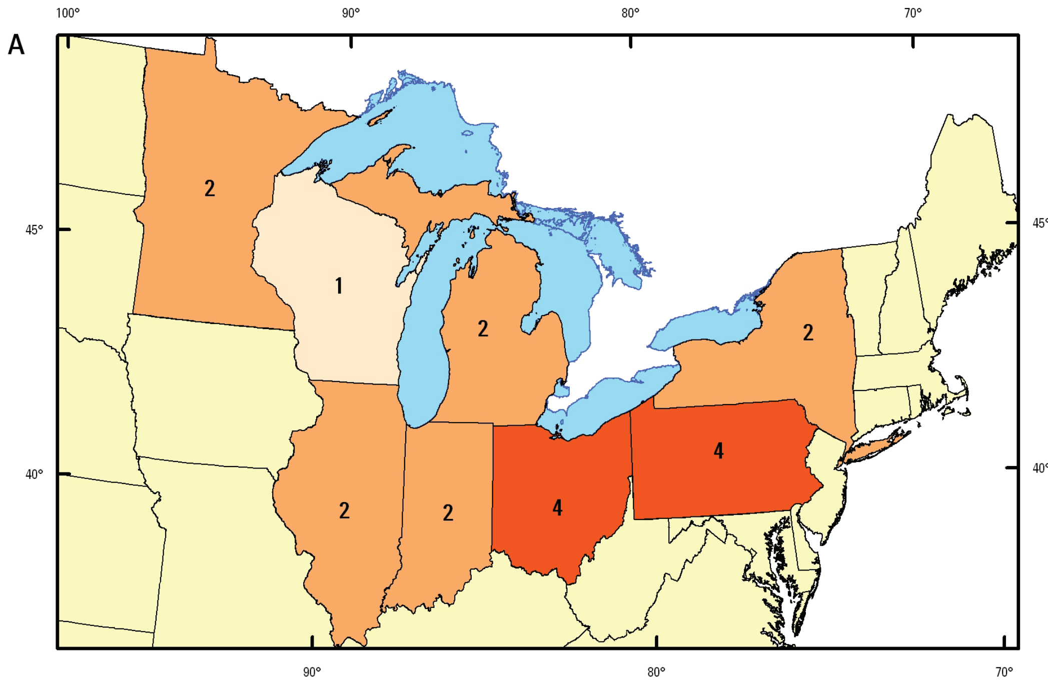
[1] Delaware River Basin Commission is considered climatically similar and used the single coefficient in table 29. Single coefficient computed by the fraction of the total water consumed of the total water withdrawn.

[2] Some volumes of this reference were published before and after 1980 and therefore were not used in the summary analysis in tables 9 and 43.

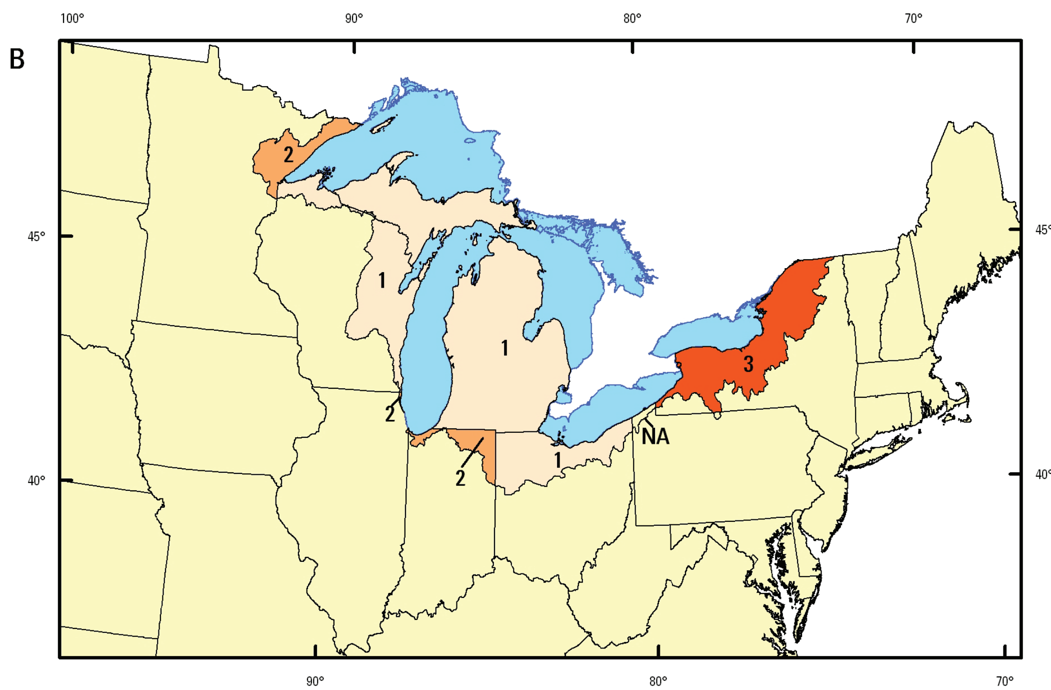
The U.S. Department of Energy (2004) Web site reports site-specific facility data for thermoelectric plants and includes the average annual rate of cooling-water withdrawals, the average annual rate of cooling-water discharge, and the average annual rate of cooling-water consumption to the nearest 0.1 ft^3/s per facility in the United States. Data for 2001, 2002, 2003, and 2004 are currently available and can serve as a starting point for determining the consumptive use or consumptive-use coefficient for a facility or a group of facilities.

Figure 14 shows the thermoelectric consumptive-use coefficients for the Great Lakes States and Basin for 1995 from Solley and others (1998) (Appendix table 1–5) and Great Lakes Commission (2005a) annual reports 1998–2002 (appendix table 3–4 and 3–5 combined). The ranges of coefficients from both references are similar, 1 to 4 percent and 1 to 3 percent, even though the references are for different years and different geographic areas. Four states—Indiana, Illinois, Wisconsin, and Minnesota—had the same thermoelectric consumptive-use coefficient. The coefficient differences for the other states may be from the variance of the number and type of thermoelectric plants in each area by year. Thermoelectric consumptive-use coefficients from both Solley and others (1998) and the Great Lakes Commission (2005a) annual reports (1998–2002) had a median of 2 percent (from fig. 14).

Although boxplots show many data outliers (fig. 15), the medians for the Great Lakes Basin and climatically similar areas (table 9) are consistent with the median of the references shown in figure 14 (2 percent). The 25th and 75th percentiles for the Great Lakes Basin (1 to 2 percent) and climatically similar areas (0 to 4 percent) compared closely (table 9).



Data from Solley and others, 1998. (The consumptive-use coefficient is for the entire state.)



Data from Great Lakes Commission, 2005a. (The consumptive-use coefficient is for the Great Lakes Basin part of the state; NA- Pennsylvania had no thermoelectric withdrawals or consumptive-use data. Adapted from appendix tables 3-4 and 3-5.)

EXPLANATION

Consumptive-use coefficents (in percent)

- 1
- 2
- 3 - 4

Figure 14. Thermoelectric power consumptive-use coefficients from various sources for the Great Lake States.

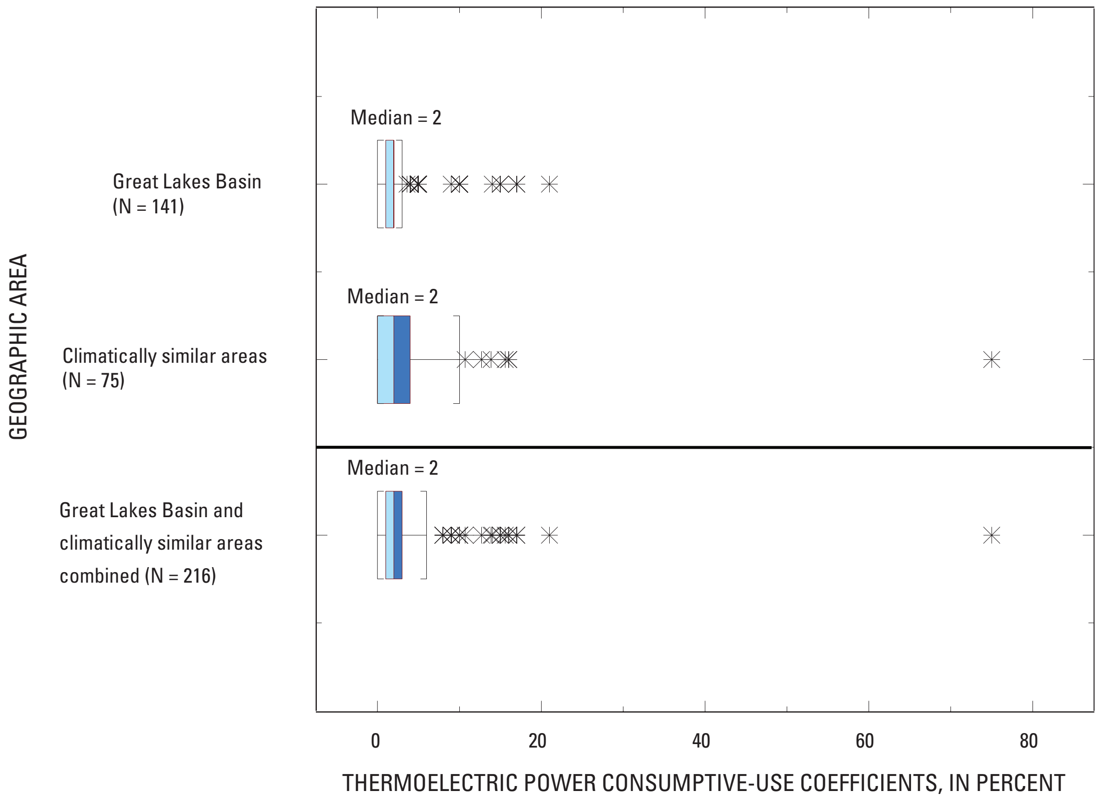


Figure 15. Distribution of thermoelectric power consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

Irrigation

Irrigation water use is the application of water on lands to assist in the growing of crops, pastures, or nurseries or to maintain vegetative growth in recreational lands such as parks and golf courses. Water use and consumptive use in crop irrigation are affected by annual rainfall, crops grown, soil type, and irrigation methods. Irrigation consumptive use is from evapotranspiration (the combination of evaporation and transpiration from watering vegetation). Irrigation in the eastern United States is used to supplement natural precipitation. During droughts, crops are irrigated to reduce the risk of crop failures. Additionally, irrigation helps increase crop yields and the number of plantings per year. Irrigation in the western United States developed as the West was settled because natural precipitation was not sufficient to raise many crops. Therefore, much larger amounts of water are withdrawn for irrigation in the western United States than in the eastern United States and the Great Lakes Basin.

Irrigation methods also affect water consumption. Depending on technology, irrigation methods range in consumption from 30 to 40 percent for flood irrigation to 90 percent for drip irrigation (Cosgrove and others, 2000).

Table 31 lists irrigation consumptive-use coefficients by reference. The consumptive-use coefficient may be listed as a single coefficient or the median for references with multiple coefficients. Summary statistics for references with multiple coefficients are listed in table 32.

Many references used the terms “agriculture withdrawals” and “agriculture consumptive use.” These terms represent both irrigation and livestock withdrawals and are listed in both the irrigation and livestock summary tables (tables 31 and 36). The statistical analysis was computed using coefficients from 1980 to 2005 because irrigation methods changed and compilation methods changed in the USGS National Water-Use Information Program (Solley and others, 1983). References that were not specific—for example, those that reported consumptive-use coefficients of “almost all” or “more than 90 percent”—were not used in the statistical summary (table 9).

Irrigation water and consumptive use at a day lily farm with microirrigation.

Table 31. Summary of irrigation consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Barlow, 2003	Rhode Island, Massachusetts	76		1	Clim sim	Yes	Coefficient	Secondary
College of Exploration [n.d][1]	World	65		-	Other	No	CW	Unknown
Cosgrove and Rijsberman, 2000	World	70		-	Other	No	CW	Secondary
Ellefson and others, 1987	Wisconsin	100		1	Great Lakes	Yes	Coefficient	Primary
Endreny, 2005	New York	87		1	Great Lakes	Yes	CW	Secondary
European Environment Agency, 2005[1]	Europe	80		-	Other	No	Coefficient	Primary
Great Lakes Commission, 2005a	Great Lakes		90	42	Great Lakes	Yes	CW	Secondary
Horn and others, 1994	Rhode Island	100		1	Clim sim	Yes	Coefficient	Primary
Hutson, 1998	Tennessee	Almost all		-	Clim sim	No	CW	Primary
Hutson and others, 2004b	Tennessee	100		1	Clim sim	Yes	RW	Primary
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Great Lakes	75[2]		1	Great Lakes	Yes	Coefficient	Secondary
Kay, 2002	Kentucky, Indiana, Iowa, Wisconsin, Minnesota	>90[3]		-	Clim sim	No	CW	Secondary
	Missouri	75		-	Clim sim	No	CW	Secondary
LaTour, 1991	Illinois	80[4]		1	Great Lakes	Yes	Coefficient	Primary
Loper and others, 1989	Pennsylvania	100		1	Great Lakes	Yes	Coefficient	Secondary
Ludlow and Gast, 2000	Pennsylvania	100		1	Great Lakes	Yes	Coefficient	Primary
Marcuello and Lallana, 2003[1]	Europe	80[5]		-	Other	No	Coefficient	Secondary
Medalie, 1997a	Vermont	90		1	Clim sim	Yes	Coefficient	Secondary
Medalie, 1997b	New Hampshire	90		1	Clim sim	Yes	Coefficient	Secondary
Nawyn, 1997	New Jersey	90		1	Clim sim	Yes	Coefficient	Secondary
Nimiroski and Wild, 2005[1]	Rhode Island	100[6]		1	Clim sim	Yes	Coefficient	Primary
Ohlsson, 1997[1]	World	65		-	Other	No	Coefficient	Secondary
Paulson and others, 1988	United States	53.9		-	Other	No	Coefficient	Secondary
Pebbles, 2003b	Great Lakes,		87					
	By state or province:							
	Illinois	90		1	Great Lakes	Yes	Coefficient	Secondary
	Indiana	90		1	Great Lakes	Yes	Coefficient	Secondary
	Michigan	90		1	Great Lakes	Yes	Coefficient	Secondary
	Minnesota	90		1	Great Lakes	Yes	Coefficient	Secondary
	New York	90		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio	90		1	Great Lakes	Yes	Coefficient	Secondary
	Ontario	78		1	Great Lakes	Yes	Coefficient	Secondary
	Pennsylvania	90		1	Great Lakes	Yes	Coefficient	Secondary
	Quebec	90		1	Great Lakes	Yes	Coefficient	Secondary
	Wisconsin	70		1	Great Lakes	Yes	Coefficient	Secondary

Table 31. Summary of irrigation consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania	100		-	Great Lakes	No	Coefficient	Primary
Postel, 1996[1]	World	65		-	Other	No	CW	Secondary
Postel and others, 1996[1]	World	65		-	Other	No	CW	Primary
Shiklamanov and Rodda, 2003[1]	World	70		-	Other	No	Coefficient	Primary
Sholar and Lee, 1988	Kentucky	96		1	Clim sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	95		1	Clim sim	Yes	CW	Primary
Snavely, 1988:	Great Lakes							
1975 Study Board		74		-	Great Lakes	No	CW	Secondary
1975 USGS		95		-	Great Lakes	No	CW	Secondary
1980 Study Board		76		1	Great Lakes	Yes	CW	Secondary
1980 USGS		100		1	Great Lakes	Yes	CW	Secondary
1985 Study Board		80		1	Great Lakes	Yes	CW	Secondary
1985 USGS		100		1	Great Lakes	Yes	CW	Secondary
Stevens and others, 1984[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1984[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1985[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1986[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1987[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Sweat and Van Til, 1988	Michigan	96		1	Great Lakes	Yes	CW	Secondary
Tate, 1988[1]:	Canada							
1966 Agriculture		72		-	Other	No	CW	Secondary
1972 Agriculture		72		-	Other	No	CW	Secondary
1976 Agriculture		72		-	Other	No	CW	Secondary
USGS Circulars, 1983, 1988, 1993, 1998	By state:							
	Great Lakes States		100	32	Great Lakes	Yes	CW	Secondary
	Climatically similar states		100	58	Clim Sim	Yes	CW	Secondary
1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	By basin or region:							
	Great Lakes		97	-	Great Lakes	No	CW	Secondary
	Mid-Atlantic		92	-	Clim Sim	No	CW	Secondary
	New England		99	-	Clim Sim	No	CW	Secondary
	Ohio		94	-	Clim Sim	No	CW	Secondary
	Tennessee		98	-	Clim Sim	No	CW	Secondary
	Upper Mississippi		94	-	Clim Sim	No	CW	Secondary
USGS and Tennessee Department of Environment and Conservation, 2003[1]	Tennessee	100		1	Clim sim	Yes	Coefficient	Primary
Water Resources Council (U.S.), 1978	By basin or region:							
	New England	71		-	Clim Sim	No	CW	Secondary
	Mid-Atlantic	74		-	Clim sim	No	CW	Secondary
	Great Lakes	79		-	Great Lakes	No	CW	Secondary
	Ohio	79		-	Clim sim	No	CW	Secondary
	Tennessee	79		-	Clim sim	No	CW	Secondary
	Upper Mississippi	80		-	Clim sim	No	CW	Secondary

Table 31. Summary of irrigation consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Wild and Nimiroski, 2004	Rhode Island, Connecticut	100[6]		1	Clim sim	Yes	Coefficient	Secondary
Wild and Nimiroski, 2005	Rhode Island	100[6]		1	Clim sim	Yes	Coefficient	Secondary
Woldorf, 1959	Ohio	97		-	Great Lakes	No	CW	Primary

[1] Noted as "Agriculture."

[2] Golf-course irrigation.

[3] Includes Indiana, Iowa, Kentucky, Michigan, Wisconsin, and Missouri.

[4] LaTour (1991) estimated irrigation consumptive use by using a consumptive-use coefficient based on lawn watering.

[5] Marcuello and Lallana (2003) said that the consumptive-use coefficients were "widely accepted."

[6] "Consumptive water use for agriculture was assumed to be 100 percent."

Table 32. Summary statistics of irrigation consumptive-use coefficients from selected references.

[Reference refers to the annotated–bibliography references. Consumptive-use coefficients are in percent. If a reference had only one coefficient for the water-use category, it will be under the single coefficient column; and if the reference had multiple coefficients by regions or years, the minimum (min), median, maximum (max) statistics will be listed, as well as the 25th and 75th percentiles. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References with more than one coefficient are listed in the appendix. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. The geographic area is defined by lakes, states, provinces, regions and basins—it can be for the entire geographic area to a small study area within the geographic area.]

Reference	Geographic area	Single coefficient	N	Coefficient statistics				
				Min	25th	Median	75th	Max
Great Lakes Commission, 2005a	Great Lakes	-	42	70	89	90	90	100
Pebbles, 2003b	Great Lakes			70	90	90	90	90
	By state or province:							
	Illinois	90	1					
	Indiana	90	1					
	Michigan	90	1					
	Minnesota	90	1					
	New York	90	1					
	Ohio	90	1					
	Ontario	78	1					
	Pennsylvania	90	1					
	Quebec	90	1					
	Wisconsin	70	1					
USGS circulars, 1983, 1988, 1993, 1998	By state:							
	Great Lakes States		32	74	91	100	100	100
	Climatically similar states		58	37	90	100	100	100
	By basin or region:							
1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	Great Lakes	-		94	95	97	97	100
	Mid-Atlantic	-		68	86	92	97	100
	New England	-		63	93	99	100	100
	Ohio	-		87	93	94	100	100
	Tennessee	-		70	91	98	100	100
	Upper Mississippi	-		91	93	94	96	100

For irrigation consumptive-use coefficients, the median and 25th and 75th percentiles for the Great Lakes Basin (90, 90 and 96 percent) and climatically similar areas were similar (90, 100, and 100 percent) (table 9 and fig. 16). For the Great Lakes Basin and climatically similar area combined, 75 percent of the irrigation consumptive-use coefficients were between 90 and 100 percent (25th percentile and maximum) (table 4 and fig. 16).

Only a few references differentiated between crop and golf-course irrigation. The International Great Lakes Diversions and Consumptive Use Study Board (1981) used a consumptive-use coefficient of 75 percent for golf courses. The Pennsylvania Department of Environmental Resources (1983) stated that its 100 percent consumptive-use coefficient included golf courses. Often, 100 percent consumptive use is based on the assumption that best management practices are implemented.

Figure 17 shows the consumptive-use coefficients for the Great Lakes States from two references. Solley and others (1998) reported irrigation consumptive-use coefficients ranging from 87 to 100 percent (appendix table 1–7); coefficients in the Great Lakes Commission (2005a) annual reports (1998–2002) ranged from 70 to 90 for the Great Lakes drainage basin in each state, but only Wisconsin reported a value as low as 70 percent (tables 31 and 32, appendix table 3–1). The medians of irrigation consumptive-use coefficients from Solley and others (1998) and the GLC annual reports (1998–2002) are similar (92 and 90 percent from fig. 17).

Horticultural facilities are a special case of irrigation. The U.S. Department of Agriculture, National Agricultural Statistics Service (2001) reported on the number of horticulture facilities that do or do not recycle water. Those that recycle were further separated into groups based on the percentage of water recycled (1 to 4 percent, 5 to 9 percent, 10 to 24 percent, or 25 percent or more). For the Great Lakes States, 78 to 90 percent of the horticultural facilities reported no recycled water, and 91 to 97 percent reported that less than 9 percent of the withdrawal was recycled. Therefore, for most horticulture facilities, more than 91 percent of withdrawal was not recycled (U.S. Department of Agriculture, National Agricultural Statistics Service, 2001, and annotated bibliography). This is consistent with the irrigation consumptive-use coefficients 10th and 90th percentiles (80 and 100 percent).

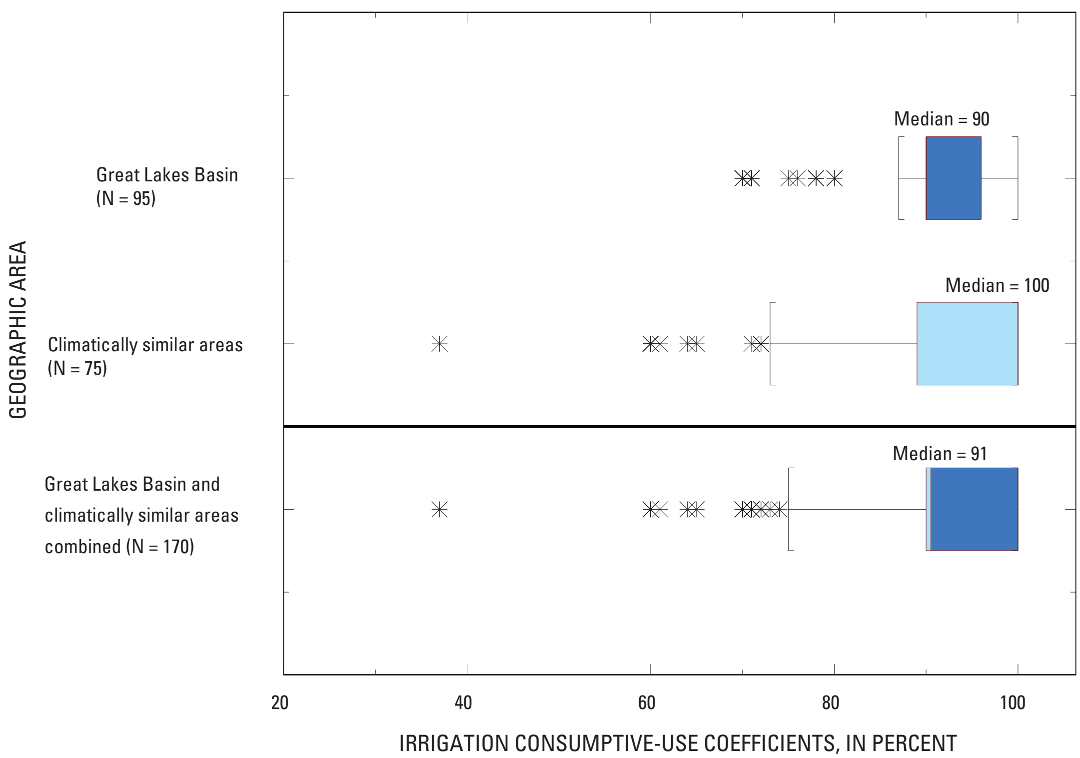


Figure 16. Distribution of irrigation consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

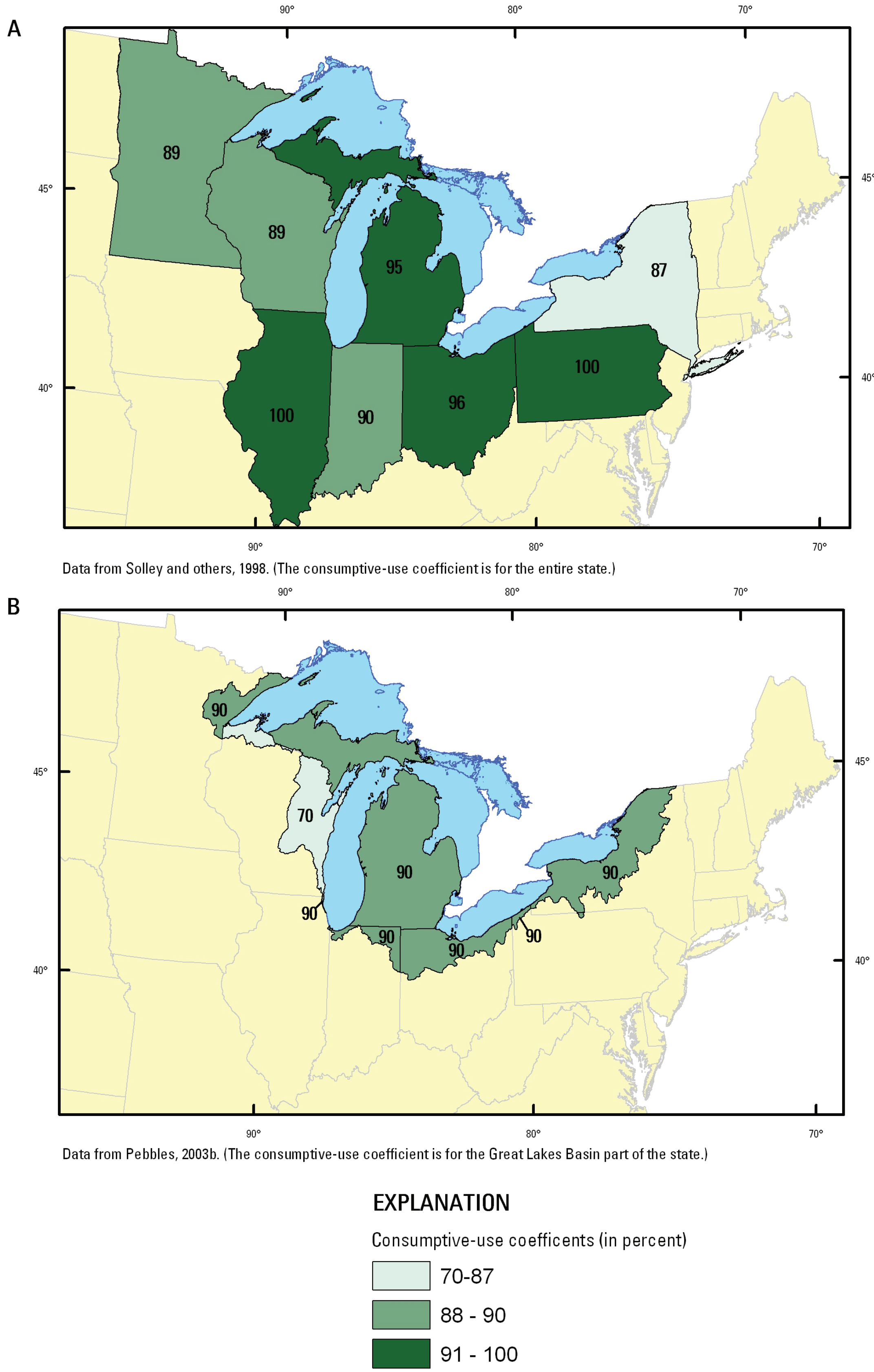


Figure 17. Irrigation consumptive-use coefficients from various sources for Great Lakes States.

For worldwide data, Shiklomanov and Rodda (2003) found that agriculture consumptive-use coefficients ranged from 58 to 84 percent for the 1900 to 1995 assessments for all the continents (table 33). In the most recent assessment (1995), the agriculture coefficients ranged from 60 to 82 percent, with a median of 76 percent.

Additional world, continent, and major-country agriculture coefficients are listed in table 35. The consumptive-use coefficients by European region (table 34) also were compiled for 1980, 1990, and 1995 (Shiklomanov and Rodda, 2003). Although the range of coefficients for these regions was broad—from 47 to 92 percent—the median of 67 percent is comparable to the 68 percent for the entire continent of Europe in 1995 (Shiklomanov and Rodda, 2003) and the 70 percent for Europe from Shiklomanov and Markova (1987).

The 1995 agriculture consumptive-use coefficient for North America from Shiklomanov and Rodda (2003) (table 33, 60 percent) is comparable to that of Solley and others (1998) (61 percent for the United States) but somewhat less than that of Environment Canada (2004) (71 percent for Canada).

Overall, for the world references, the agricultural consumptive-use coefficients ranged from 65 to 78 percent (table 35). Coefficients may differ because of differences in crops, climate, irrigation methods, and irrigation practices.

Table 33. Agricultural water withdrawals, consumptive use, and consumptive-use coefficients, by continent, for selected years from 1900 through 1995.

[Modified from Shiklomanov and Rodda (2003). Total withdrawn and consumptive use are in cubic kilometers per year and are as listed in reference; coefficient is the percentage of water withdrawn that was consumed, computed from the total withdrawn and consumptive-use data and rounded to the nearest whole number.]

Statistic	1900	1940	1950	1960	1970	1980	1990	1995	1900–1995
					Europe[1]				
Total withdrawn	19.6	34.5	40.9	53.9	82.2	169	195	198	793.1
Consumptive use	14.6	25.0	31.5	38.4	55.6	117	133	135	550.1
Coefficient	74	72	77	71	68	69	68	68	69
					Asia[2]				
Total withdrawn	408	665	816	1,144	1,331	1,526	1,688	1,743	9,321
Consumptive use	320	521	643	907	1,066	1,247	1,411	1,434	7,549
Coefficient	78	78	79	79	80	82	84	82	81
					Africa[3]				
Total withdrawn	40.8	47.7	53.5	79.4	89.0	106	127	134	677.4
Consumptive use	33.1	38.4	43.6	63.3	71.3	85.4	98.0	102	535.1
Coefficient	81	81	81	80	80	81	77	76	79
					North America[4]				
Total withdrawn	39.3	-	149	198	244	286	274	286	1,476.3
Consumptive use	24.6	-	86.3	114	143	171	166	173	877.9
Coefficient	63	-	58	58	59	60	61	60	59
					South America[5]				
Total withdrawn	13.6	24.6	54.3	58.6	65.9	77.3	96.7	99.9	490.9
Consumptive use	10.9	19.7	40.2	41.7	51.4	59.3	74.3	76.3	373.8
Coefficient	80	80	74	71	78	77	77	76	76
					Australia and Oceania[6]				
Total withdrawn	.46	3.50	5.20	9.40	12.5	13.0	14.7	15.5	74.26
Consumptive use	.35	2.80	4.10	7.50	9.90	10.2	11.6	12.2	58.65
Coefficient	76	80	79	80	79	78	79	79	79
					Total				
Total withdrawn	521.76	775.3	1,118.9	1,543.3	1,824.6	2,177.3	2,395.4	2,476.4	12,832.96
Consumptive use	403.55	606.9	848.7	1,171.9	1,397.2	1,689.9	1,893.9	1,932.5	9,944.55
Coefficient	77	78	76	76	77	78	79	78	77

[1] Shiklomanov and Rodda (2003), p. 85, from table 4.19.

[2] Ibid., p. 135, from table 5.25.

[3] Ibid., p. 192, from table 6.18.

[4] Ibid., p. 258, from table 7.22.

[5] Ibid., p. 316, from table 8.19.

[6] Ibid., p. 346, From table 9.21.

Table 34. Agricultural water withdrawals, consumptive use, and consumptive-use coefficients for European regions for selected years from 1980 through 1995.

[Modified from Shiklomanov and Rodda (2003), p. 88. Total withdrawn and consumptive use are in cubic kilometers per year and are as listed in reference; coefficient is the percentage of water withdrawn that was consumed, computed from the total withdrawn and consumptive-use data and rounded to the nearest whole number.]

Statistic	1980	1990	1995	1980–1995
Northern Europe				
Total withdrawn	1.23	1.57	1.63	4.43
Consumptive use	.70	.97	1.01	2.68
Coefficient	57	62	62	60
Central Europe				
Total withdrawn	26.3	29.7	30.7	86.7
Consumptive use	18.4	20.8	21.6	60.8
Coefficient	70	70	70	70
Southern Europe				
Total withdrawn	93.8	108.0	112.0	313.8
Consumptive use	66.6	73.6	75.0	215.2
Coefficient	71	68	67	69
Northern slope of European territory of former Soviet Union				
Total withdrawn	.68	.72	.71	2.11
Consumptive use	.32	.65	.65	1.62
Coefficient	47	90	92	77
Southern slope of European territory of former Soviet Union				
Total withdrawn	47.7	54.9	53.7	156.3
Consumptive use	30.9	36.5	36.1	103.5
Coefficient	65	66	67	66
Total				
Total withdrawn	169.71	194.89	198.74	563.34
Consumptive use	116.92	132.52	134.36	383.8
Coefficient	69	68	68	68

Table 35. Agriculture consumptive-use coefficients for large countries, continents, and the world.

[Coefficient is in percent and rounded to the nearest whole number.]

Reference	Geographic area	Coefficient
College of Exploration [n.d.]	World	65
Cosgrove, and Rijsberman, 2000	World	70
Environment Canada, 2004	Canada	71
European Environment Agency, 2005	Europe	80
Marcuello and Lallana, 2003	Europe	80
Postel and others, 1996	World	65
Shiklomanov and Rodda, 2003 (1995 assessment only)	World	78
	By continent:	
	Europe	68
	Asia	82
	Africa	76
	North America	60
	South America	76
	Australia and Oceania	79
Solley and others, 1998[1]	United States	61

[1] It is also noted that 19 percent of the withdrawals was lost through conveyance.

Livestock

Livestock water use is water used for stock watering, feedlots, dairy operations, fish farming, and other on-farm needs. Livestock includes sheep, goats, cattle, hogs, poultry, horses, rabbits, bees, pets, fur-bearing animals in captivity, and fish in captivity (except fish hatcheries). Livestock consumptive use occurs through processes such as stock watering and facility and animal cleaning. Many references use the terms "agricultural withdrawals" and "agriculture consumptive use," which may describe both the irrigation and livestock withdrawals and consumptive use. Thus, the agriculture consumptive-use coefficients are presented in both the irrigation and livestock categories. Table 36 is a summary of livestock consumptive-use coefficients by reference, and table 37 is summary statistics of livestock consumptive-use coefficients for references with multiple coefficients.

As with the other water-use categories, publications starting in 1980 were used in the summary statistics (tables 9, 36, 37). As is evident in tables 36 and 37, livestock consumptive-use coefficients range from 0 to 100 percent. The large range in livestock consumptive-use coefficients may be due to:

- the mixture of livestock and animal specialties in each state,
- a wide range of consumptive-use coefficients for fish farming by itself, (where a small coefficient represents a facility that returns most of its withdrawals and a large coefficient represents a facility that returns either a small amount or none of its withdrawals),
- time, evaporation, and water quality (water that is used for or by livestock that is not discharged into a waste-treatment system is more likely to be evaporated before it reaches the water table and therefore not available for reuse, and degradation of water quality may limit the reuse of the water), or
- differences in compilation methods.

For example, between 1980 and 2005, the classification of certain aspects of the livestock water-use category changed in the USGS Circulars. In Solley and others (1983), livestock water use was listed under the category "Rural Freshwater Use." In Solley and others (1988) and subsequent publications, livestock water use was its own category. Solley and others (1988) found that a large increase in livestock use was due to increases in fish farming; additionally states that previously reported fish farming under the industrial water-use category had begun reporting it as livestock water use. As can be seen in appendix tables 1–9 and 1–10, some states reported large livestock consumptive-use coefficients in 1980 and much lower coefficients in 1985, which may have been a result of adding fish-farming withdrawals to the livestock category.

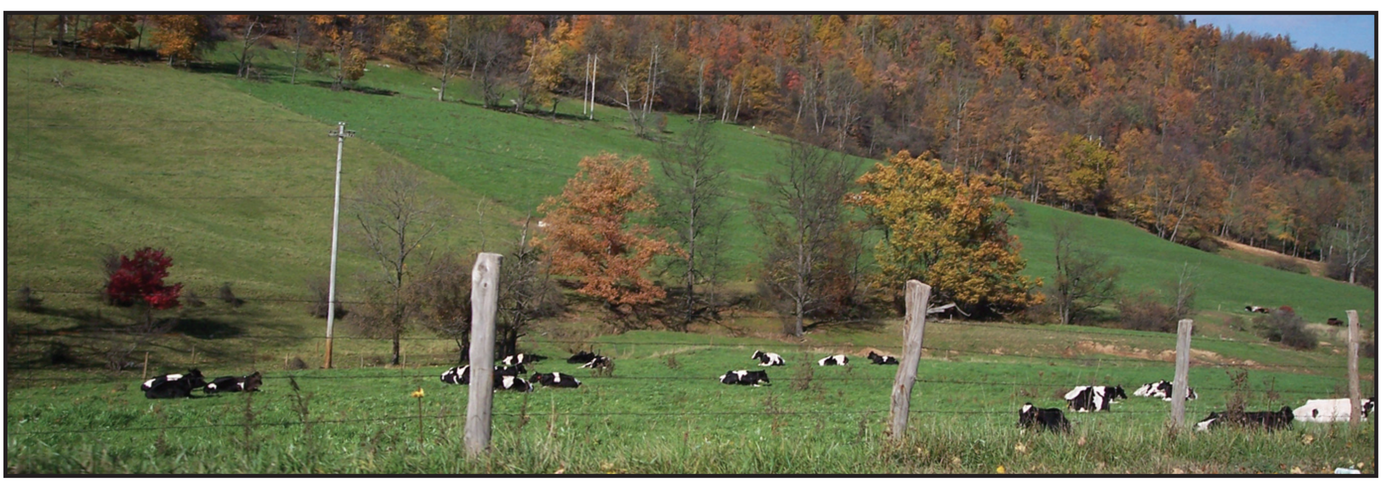


Table 36. Summary of livestock consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
College of Exploration [n.d.][1]	World	65		-	Other	No	CW	Unknown
Ellefson and others, 1987[2]	Wisconsin	80		1	Great Lakes	Yes	Coefficient	Primary
Endreny, 2004	New York	88		1	Great Lakes	Yes	CW	Secondary
European Environment Agency, 2005[1]	Europe	80		-	Other	No	Coefficient	Primary
Great Lakes Commission, 2005a	Great Lakes		80	32	Great Lakes	Yes	CW	Secondary
Horn and others, 1994	Rhode Island	80		1	Clim sim	Yes	Coefficient	Unknown
Hutson, 1998	Tennessee	Almost all		-	Clim sim	No	CW	Primary
International Great Lakes Diversions and Consumptive Use Study Board, 1981	Great Lakes	100		1	Great Lakes	Yes	Coefficient	Primary
Loper and others, 1989	Pennsylvania	75		1	Great Lakes	Yes	Coefficient	Secondary
Ludlow and Gast, 2000	Pennsylvania	74		1	Great Lakes	Yes	Coefficient	Primary
Marcuello and Lallana, 2003[1,3]	Europe	80		-	Other	No	Coefficient	Secondary
Nimiroski and Wild, 2005[4]	Rhode Island	100		1	Clim sim	Yes	Coefficient	Secondary
Ohlsson, 1997[1]	World	65		-	Other	No	Coefficient	Secondary
Paulson and others, 1988	United States	53.9		-	Other	No	Coefficient	Secondary
Pebbles, 2003b	Great Lakes, by state:							
	Illinois	80		1	Great Lakes	Yes	Coefficient	Secondary
	Indiana	80		1	Great Lakes	Yes	Coefficient	Secondary
	Michigan	80		1	Great Lakes	Yes	Coefficient	Secondary
	Minnesota	80		1	Great Lakes	Yes	Coefficient	Secondary
	New York	90		1	Great Lakes	Yes	Coefficient	Secondary
	Ohio	80		1	Great Lakes	Yes	Coefficient	Secondary
	Ontario	80		1	Great Lakes	Yes	Coefficient	Secondary
	Pennsylvania	80		1	Great Lakes	Yes	Coefficient	Secondary
	Quebec	80		1	Great Lakes	Yes	Coefficient	Secondary
	Wisconsin	90		1	Great Lakes	Yes	Coefficient	Secondary
Pennsylvania Department of Environment Resources, 1975–83	Pennsylvania	75		-	Great Lakes	No	Coefficient	Primary
Postel, 1996[1]	World	65		-	Other	No	CW	Secondary
Postel and others, 1996[1]	World	65		-	Other	No	CW	Primary
Shiklamanov and Rodda, 2003[1]	Europe	70		-	Other	No	Coefficient	Secondary
Sholar and Lee, 1988	Kentucky	100		1	Clim sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	100		1	Clim sim	Yes	CW	Primary
Snavely, 1988:	Great Lakes							
1975 Study Board		100		-	Great Lakes	No	CW	Secondary
1975 USGS		93		-	Great Lakes	No	CW	Secondary
1980 Study Board		100		1	Great Lakes	Yes	CW	Secondary
1980 USGS		92		1	Great Lakes	Yes	CW	Secondary
1985 Study Board		100		1	Great Lakes	Yes	CW	Secondary
1985 USGS		88		1	Great Lakes	Yes	CW	Secondary
Stevens and others, 1984[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary

Table 36. Summary of livestock consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and the world. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Suder and Lessing, 1984[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1985[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1986[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Suder and Lessing, 1987[1]	West Virginia	100		1	Clim sim	Yes	RW	Primary
Sweat and Van Til, 1988	Michigan	96		1	Great Lakes	Yes	CW	Secondary
Tate, 1988[1]:	Canada							
1966 Agriculture		72		-	Other	No	CW	Secondary
1972 Agriculture		72		-	Other	No	CW	Secondary
1976 Agriculture		72		-	Other	No	CW	Secondary
Tate and Harris, 1999a[1,5]	Canadian portion of Great Lakes	78-80[5]		1	Great Lakes	Yes	Coefficient	Secondary
USGS Circulars, 1983, 1988, 1993, 1998	By state:							
	Great Lakes States		89	32	Great Lakes	Yes	CW	Secondary
	Climatically similar states		100	60	Clim sim	Yes	CW	Secondary
1961, 1968, 1972, 1977, 1983, 1988, 1993, 1998	By basin or region:		92	-	Great Lakes	No	CW	Secondary
	Great Lakes		84	-	Clim sim	No	CW	Secondary
	Mid-Atlantic		100	-	Clim sim	No	CW	Secondary
	New England		94	-	Clim sim	No	CW	Secondary
	Ohio		98	-	Clim sim	No	CW	Secondary
	Tennessee		96	-	Clim sim	No	CW	Secondary
	Upper Mississippi							
USGS and Tennessee Department of Environment and Conservation, 2003[1]	Tennessee	100		1	Clim sim	Yes	Coefficient	Primary
Veeger and others, 2003	Rhode Island	100		1	Clim sim	Yes	Coefficient	Secondary
Water Resources Council (U.S.), 1978	By basin or region:							
	New England	100		-	Clim sim	No	CW	Secondary
	Mid-Atlantic	100		-	Clim sim	No	CW	Secondary
	Great Lakes	100		-	Great Lakes	No	CW	Secondary
	Ohio	100		-	Clim sim	No	CW	Secondary
	Tennessee	100		-	Clim sim	No	CW	Secondary
	Upper Mississippi	100		-	Clim sim	No	CW	Secondary
Wild and Nimiroski, 2004[4]	Rhode Island, Connecticut	100		1	Clim sim	Yes	Coefficient	Secondary
Wild and Nimiroski, 2005[4]	Rhode Island	100		1	Clim sim	Yes	Coefficient	Secondary

[1] Noted as “Agriculture.”

[2] Noted as “non-irrigation agricultural uses.”

[3] Marcuello and Lallana (2003) said that the consumptive-use coefficients were “widely accepted.”

[4] “Consumptive water use for agriculture was assumed to be 100 percent.”

[5] Noted as a range; therefore, the average of the range (79) is used in the statistical analysis.

Table 37. Summary statistics of livestock consumptive-use coefficients for selected references.

[Reference refers to the annotated-bibliography references. Consumptive-use coefficients are in percent. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References are listed in the appendix. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. The geographic area is defined by lakes, states, provinces, basins and regions—it can be for the entire geographic area to a small study area within the geographic area.]

Reference	Geographic area	N	Coefficient statistics				
			Min	25th	Median	75th	Max
USGS Circulars, 1983, 1988, 1993, 1998	By state:						
	Great Lakes States	32	67	81	89	100	100
	Climatically similar states	60	10	84	100	100	100
	By basin or region:						
	Great Lakes	-	86	88	92	92	95
	Mid-Atlantic	-	60	80	84	86	91
1960–95	New England	-	68	89	100	100	100
	Ohio	-	84	90	94	100	100
	Tennessee	-	47	94	98	100	100
	Upper Mississippi	-	92	93	96	98	100
Great Lakes Commission, 2005a	Great Lakes Basin, by states and provinces	32	01	80	80	90	91

[1] The range of coefficient may reflect differences in the definition of livestock use. Livestock use may be limited to the watering of livestock or may include the maintenance operations associated with raising livestock. Including aquaculture changes the definition and activity and results in a different livestock consumptive-use coefficient. The livestock low coefficient minimum (0) for the Great Lakes Commission (2005a) is from Minnesota in 1998. Minnesota reported 0.25 Mgal/d total withdrawn in 1998 and 0.0 Mgal/d consumptive use. The next lowest consumptive-use coefficient for this reference is 66 percent.

Although coefficients for 1985 (Solley and others, 1988) were included in the statistical analysis, it should be noted that many of the outliers are for this year. To better see the effect of these outliers, two statistics summaries are included in this report (table 38). Table 38 has statistics for irrigation with and without irrigation coefficients from Solley and others (1988). The 10th and 90th percentiles were computed to highlight the range of consumptive-use coefficients. Most of the statistics in table 38 were similar except the minimum for the climatically similar areas, the minimum for all references, and the 10th percentile for the climatically similar areas. The coefficients from Solley and others (1988) have the six smallest coefficients for the 1980 to 2005 period of all the references (Appendix tables 1–9 and 1–10). Table 38 also shows the statistics if the "agriculture" coefficients are not used. This exclusion varied a few numbers within only a 2-percent range.

In Solley and others (1993), the livestock category definition changed again when livestock was divided into subcategories: livestock and animal specialties. The **animal specialties** subcategory is the water used for fish farming and fish in captivity, with the exception of fish hatcheries. Animal specialties also includes water used for fur-bearing animals in captivity such as horses, rabbits, and pets. Animal-specialties water use (Solley and others, 1993, 1998) is in the back of this report in Appendix tables 1–11 and 1–12.

Although a wide range of livestock consumptive-use coefficients has been reported, 75 percent of all the livestock consumptive-use coefficients are between 80 and 100 percent (25th percentile and maximum) (fig. 18). Most of the livestock consumptive-use coefficients are based on assumptions and definitions, not studies for the most part. The major exception to this would be aquaculture, where water may either be continuously run through the hatchery or fish farm (low consumptive use coefficient) or be allowed to remain in a pond long enough for evaporation to become a significant factor (higher consumptive-use coefficient). The few world coefficients were noted on "agricultural" and not livestock. These coefficients tended to be lower than the livestock coefficients for the Great Lakes Basin.

Table 38. Livestock consumptive-use coefficient statistics for the Great Lakes Basin, climatically similar areas, and all references including and excluding Solley and others (1998) and excluding agriculture coefficients.

[Great Lakes Basin refers to basins and states in the Great Lakes Basin. Climatically similar areas are basins, states, and countries that are climatically similar to the Great Lakes Basin. All references are the combined references of the Great Lakes Basin and climatically similar areas. References used in the statistical analysis are only from publications printed after 1980 and do not include world coefficients, coefficients for all of Canada, or coefficients for all of the United States because they include areas that are not climatically similar to the Great Lakes. The minimum, median, maximum, 25th percentile, and the 75th percentile are in percent. N is the number of coefficients used in the statistical analysis.]

Type of reference	Statistics							
	Min	10th	25th	Median	75th	90th	Max	N
Including coefficients in Solley and others (1998)								
Great Lakes Basin	0[1]	76	80	83	90	100	100	85
Climatically similar areas	10	61	86	100	100	100	100	73
All references	0[1]	75	80	90	100	100	100	158
Excluding coefficients in Solley and others (1998)								
Great Lakes Basin	0[1]	75	80	80	90	100	100	77
Climatically similar areas	50	82	88	100	100	100	100	57
All references	0[1]	78	80	90	100	100	100	134
Excluding agriculture coefficients								
Great Lakes Basin	0[1]	76	80	85	90	100	100	85
Climatically similar areas	10	56	85	100	100	100	100	72
All references	0[1]	75	80	89	100	100	100	157

[1] The livestock low coefficient minimum (0) for the Great Lakes Commission (2005a) is from Minnesota in 1998. Minnesota reported 0.25 Mgal/d total withdrawn in 1998 and 0.0 Mgal/d consumptive use. The next lowest consumptive-use coefficient for this reference is 66 percent.

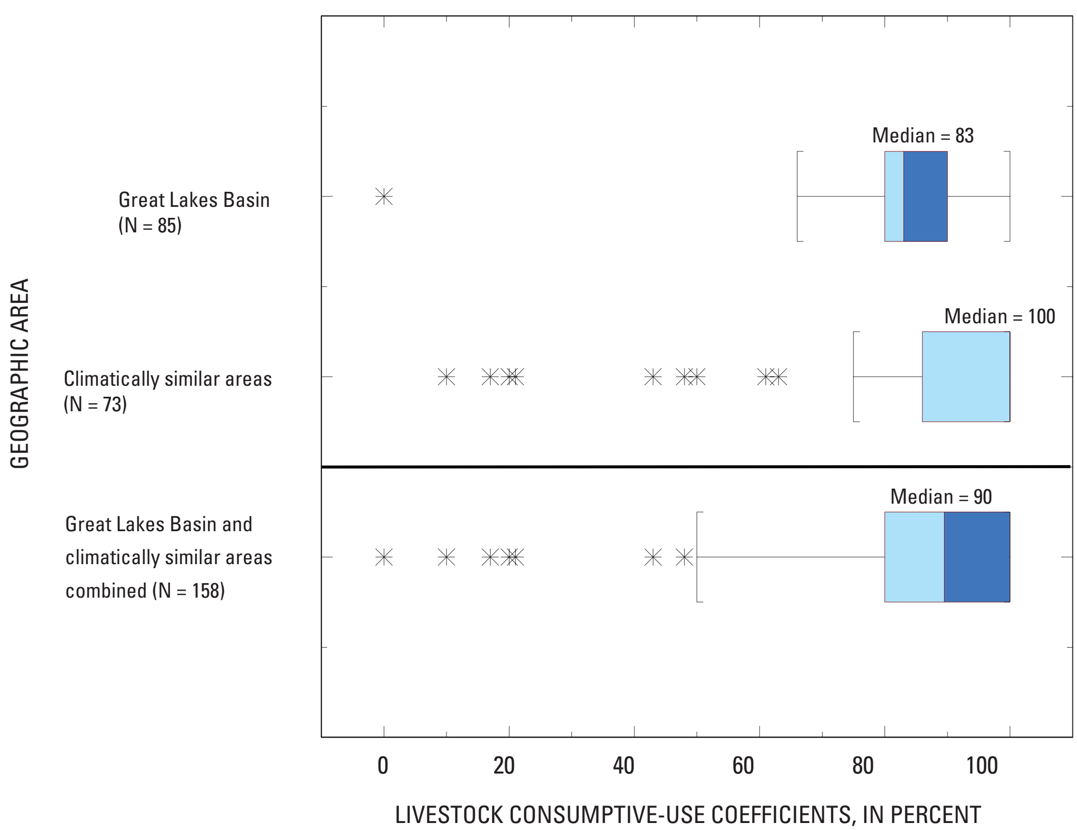


Figure 18. Livestock consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

Commercial

Commercial water use is water used in restaurants, motels, hotels, office buildings, military and nonmilitary institutions, snow making, and other commercial facilities; also, Solley and others (1993 and 1998) included water for offstream fish hatcheries. Processes that contribute to consumptive use of commercial water use would be lawn and landscape watering, sidewalk and car washing, snow making, evaporation from offstream fish hatcheries, and a lesser extent cooking, cleaning, showering, and clothes washing. Table 39 is a compilation of commercial consumptive-use coefficients listed by references, and table 40 lists summary statistics for references with multiple consumptive-use coefficients.

No world references were located for the commercial category, and most of the coefficients were from USGS reports. All the references were used for the summary statistics; the earliest coefficient was from 1975. Most of the commercial consumptive-use coefficients were from 1980 to 2005.

The commercial consumptive-use coefficients were similar between the Great Lakes Basin and climatically similar areas (fig. 19). Fifty percent of all coefficients from the references were between 8 and 13 percent (table 9 and fig. 19). Both the Great Lakes Basin and climatically similar areas had the same commercial consumptive-use coefficient median (10 percent; table 9 and fig. 19).

Schools, office buildings, and hospitals are commercial water- and consumptive-use facilities.

Table 39. Summary of commercial consumptive-use coefficients for the Great Lakes Basin and climatically similar areas.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Barlow, 2003	Rhode Island, Massachusetts	10[1]		1	Clim sim	Yes	Coefficient	Secondary
Endreny, 2005	New York	10		1	Great Lakes	Yes	CW	Secondary
Horn and others, 1994	Rhode Island	8		1	Clim sim	Yes	Coefficient	Primary
Horn, 2000	Massachusetts	10		1	Clim sim	Yes	Coefficient	Primary
Hutson, 1998	Tennessee	10		1	Clim sim	Yes	CW	Primary
LaTour, 1991	Illinois	9.6[2]		1	Great Lakes	Yes	CW	Primary
Ludlow and Gast, 2000	Pennsylvania	5		1	Great Lakes	Yes	CW	Primary
Nawyn, 1997	New Jersey	4		1		Yes	Coefficient	Secondary
Nimiroski and Wild, 2005	Rhode Island	10		1	Clim sim	Yes	Coefficient	Secondary
Paulson and others, 1988	United States	19.5[3]		-	Other	No	Coefficient	Secondary
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania	10[4]		1	Great Lakes	Yes	Coefficient	Primary
Sholar and Lee, 1988	Kentucky	4		1	Clim sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	3		1	Clim sim	Yes	CW	Primary
USGS Circulars, 1988, 1993, 1998	By states:							
	Great Lakes States		10	24	Great Lakes	Yes	CW	Secondary
	Climatically similar states		10	45	Clim sim	Yes	CW	Secondary
	By basin or region:							
	Great Lakes		9	-	Great Lakes	Yes	CW	Secondary
	Mid-Atlantic		9	-	Clim sim	Yes	CW	Secondary
	New England		12	-	Clim sim	Yes	CW	Secondary
	Ohio		10	-	Clim sim	Yes	CW	Secondary
	Tennessee		10	-	Clim sim	Yes	CW	Secondary
	Upper Mississippi		10	-	Clim sim	Yes	CW	Secondary
USGS and Tennessee Department of Environment and Conservation, 2003	Tennessee	11[5]		-	Clim sim	No	Coefficient	Primary
Veeger and others, 2003	Rhode Island	10		1	Clim sim	Yes	Coefficient	Secondary
Water Resources Council (U.S.), 1978	By basin or region:							
	New England	13		1	Clim sim	Yes	CW	Secondary
	Mid-Atlantic	14		1	Clim sim	Yes	CW	Secondary
	Great Lakes	11		1	Great Lakes	Yes	CW	Secondary
	Ohio	13		1	Clim sim	Yes	CW	Secondary
	Tennessee	12		1	Clim sim	Yes	CW	Secondary
	Upper Mississippi	12		1	Clim sim	Yes	CW	Secondary
Wild and Nimiroski, 2004	Rhode Island and Connecticut	10		1	Clim sim	Yes	Coefficient	Secondary
Wild and Nimiroski, 2005	Rhode Island	10		1	Clim sim	Yes	Coefficient	Secondary

[1] The commercial consumptive-use coefficient is from "New England traditional rates."

[2] Although LaTour (1991) reported a large range of consumptive-use coefficients for commercial, the "minimum consumptive-use ratio" 9.6 percent was used to estimate consumptive use when data were not available.

[3] Commercial and domestic are grouped together in this coefficient.

[4] Noted as 10 percent for "other self-supplied institutions."

[5] Not used because this coefficient is from an octopus diagram where commercial, industrial, and mining consumptive use are combined.

Table 40. Summary statistics of commercial consumptive-use coefficients for selected references.

[Reference refers to the annotated bibliography references. Consumptive-use coefficients are in percent. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References are listed in the appendix. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. The geographic area is defined by lakes, states, provinces, countries, continents, and the world—it can be for the entire geographic area to a small study area within the geographic area.]

Reference	Geographic area	N	Coefficient statistics				
			Min	25th	Median	75th	Max
USGS Circulars, 1988, 1993, 1998[1]	By states:						
	Great Lakes States	24	4	8	10	15	26
	Climatically similar states	45	4	7	10	13	33
	By basin or region:						
	Great Lakes	-	9	9	9	10	11
	Mid-Atlantic	-	8	8	9	10	12
	New England	-	11	12	12	18	23
	Ohio	-	8	9	10	12	15
	Tennessee	-	9	10	10	11	12
	Upper Mississippi	-	10	10	10	11	12

[1] Solley and others (1988, 1993, 1998).

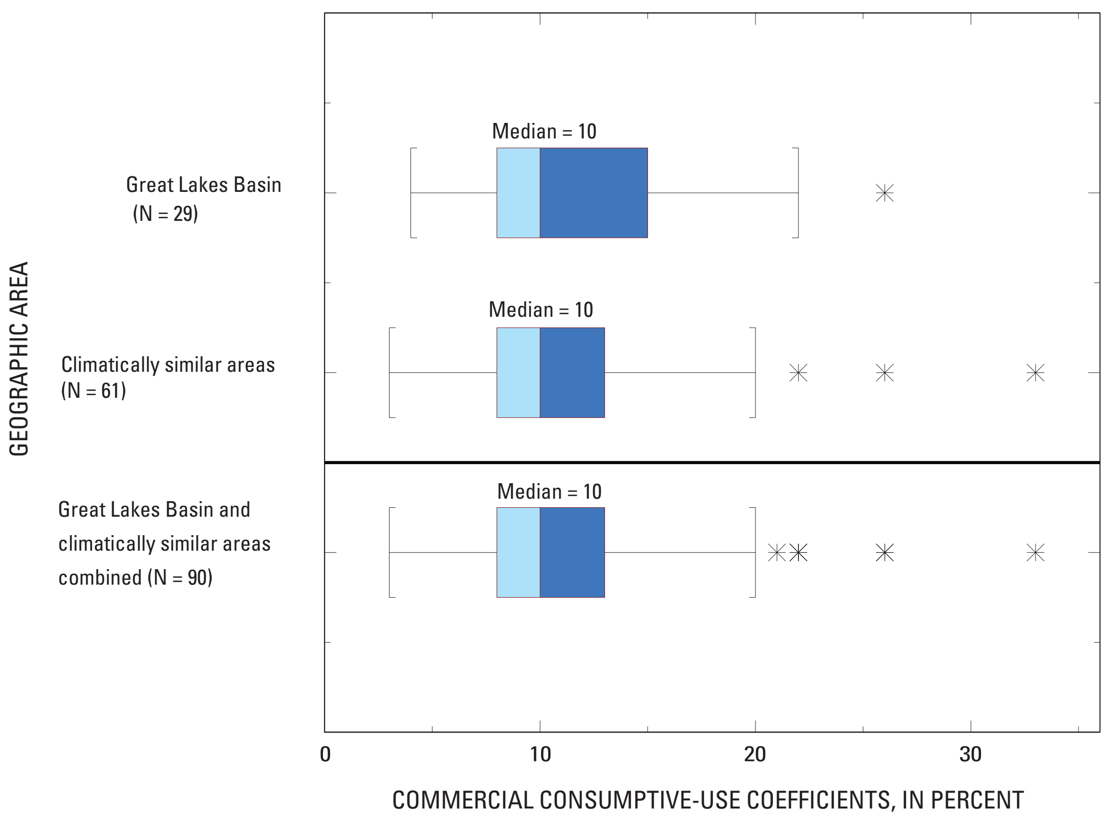


Figure 19. Commercial consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

Mining

Mining water use and consumptive use is the water withdrawn and the portion of water consumed during the extraction of minerals. Minerals may be metals or nonmetals, solid or liquid. Extraction of minerals includes the following activities: quarrying, milling (crushing, washing, screening, and flotation of mined materials), and other operations associated with mining activities (Hutson and others, 2004a).

Mining withdrawals, consumptive use, and consumptive-use coefficients in response vary to:

- the type of mining,
- the mining environment,
- the processes at the mining facility, and
- the methods used to estimate withdrawals and consumptive use.

In many documents, the authors noted that mining withdrawals were difficult to quantify. Solley and others (1998) stated that, with the exception of some washing and milling, water at mining sites tends to be an impediment to or a by-product of the extraction process. For many references, consumptive-use estimates were computed by use of consumptive-use coefficients specific to the type of mining. The consumptive-use coefficients were highly variable by type of mining. For example, Quan (1988) published a wide range of mining consumptive-use coefficients. For metal mining, the consumptive-use coefficients ranged from 1 (for lead) to 77 percent (for copper) and nonmetal mining ranged from 0 (for magnesium) to 100 percent (for diatomite) (Quan, 1988).

A few authors found that the water discharged was greater than the water withdrawn, for example the U.S. Bureau of the Census (1985). The reason for this discrepancy may be because of mine dewatering. During the dewatering process, excess water is drained from the mine and is a by-product of the extraction process. The amount of water discharged in the mining operation includes the return flow plus the excess water drained from the mine. A representative consumptive-use coefficient could not be computed from such references.

The references by Quan (1988), Kaufman and Nadler (1966), and the Water Resources Council 1978) contain detailed mining water use data. More information on these sites is in the annotated bibliography section.

Table 41 is a compilation of mining consumptive-use coefficients listed by reference and illustrates the range in the mining consumptive-use coefficients. Table 42 is the statistical summary for selected references that had multiple mining consumptive-use coefficients. As is evident in figure 20, there are many outliers in the boxplot.

Table 41. Summary of mining consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and Canada from 1975 through 2004.

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
Endreny, 2005	New York	27		1	Great Lakes	Yes	CW	Secondary
Hutson, 1998	Tennessee	11		1	Clim sim	Yes	CW	Primary
International Great Lakes Diversions and Consumptive Use Study Board, 1981[1]	Canada	11		-	Other	No	CW	Secondary
Kaufman and Nadler, 1966	United States	16		-	Other	No	CW	Primary
	Great Lakes States	6		-	Other	No	CW	Primary
	By state:							
	Illinois	5		-	Great Lakes	No	CW	Primary
	Indiana	5		-	Great Lakes	No	CW	Primary
	Michigan	3		-	Great Lakes	No	CW	Primary
	Minnesota	4		-	Great Lakes	No	CW	Primary
	New York	10		-	Great Lakes	No	CW	Primary
	Ohio	12		-	Great Lakes	No	CW	Primary
	Pennsylvania	9		-	Great Lakes	No	CW	Primary
	Wisconsin	3		-	Great Lakes	No	CW	Primary
	By basin or region:							
	Chesapeake Bay	7		-	Clim Sim	No	CW	Primary
	Cumberland	11		-	Clim Sim	No	CW	Primary
	Delaware and Hudson	6		-	Clim Sim	No	CW	Primary
	Great Lakes[2]	5		-	Great Lakes	No	CW	Primary
	Upper Mississippi	7		-	Clim sim	No	CW	Primary
	New England	7		-	Clim sim	No	CW	Primary
	Ohio	12		-	Clim sim	No	CW	Primary
	Tennessee	32		-	Clim sim	No	CW	Primary
Loper and others, 1989	Pennsylvania	14		1	Great Lakes	Yes	CW	Secondary
Ludlow and Gast, 2000	Pennsylvania	8		1	Great Lakes	Yes	CW	Primary
Nawyn, 1997	New Jersey	8		1	Clim sim	Yes	Coefficient	Secondary
Paulson and others, 1988	United States	16		-	Other	No	Coefficient	Secondary
Pebbles, 2003b	By state:							
	Ohio (salt mining)[3]	90		-	Great Lakes	No	Coeffiicent	Secondary
	Wisconsin	10		1	Great Lakes	Yes	Coefficient	Secondary
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania		7	19	Great Lakes	Yes	CW	Primary
Quan, 1988	By states:							
	Great Lakes States		21	8	Great Lakes	Yes	CW	Primary
	Climatically similar states		26	16	Clim Sim	Yes	CW	Primary
Sholar and Lee, 1988	Kentucky	3		1	Clim sim	Yes	CW	Primary
Sholar and Wood, 1995	Kentucky	3		1	Clim sim	Yes	CW	Primary
Tate, 1988:								
1966 Manufacturing		24	Canada	-	Other	No	CW	Secondary
1972 Manufacturing		24		-	Other	No	CW	Secondary
1976 Manufacturing		16		-	Other	No	CW	Secondary

Table 41. Summary of mining consumptive-use coefficients for the Great Lakes Basin, climatically similar areas, and Canada from 1975 through 2004. —Continued

[See fig. 7 and table 10 for explanation of column headings. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference.]

Reference	Geographic area	Single coefficient	Median coefficient	N	Statistics area	Used in statistics	Coefficient or other	Data source
USGS Circulars, 1988, 1993, 1998	By states:							
	Great Lakes States		14	23	Great Lakes	Yes	CW	Secondary
	Climatically similar states		11	42	Clim sim	Yes	CW	Secondary
	By basin or region:							
	Great Lakes		24	-	Great Lakes	No	CW	Secondary
	Mid-Atlantic		12	-	Clim sim	No	CW	Secondary
	New England		12	-	Clim sim	No	CW	Secondary
	Ohio		22	-	Clim sim	No	CW	Secondary
	Tennessee		12	-	Clim sim	No	CW	Secondary
	Upper Mississippi		21	-	Clim sim	No	CW	Secondary
USGS and Tennessee Department of Environment and Conservation, 2003	Tennessee	11		1	Clim sim	Yes	Coefficient	Primary
van der Leeden, 1975:	Belgium							
Coal mines		7		1	Clim sim	Yes	CW	Secondary
Quarries		5		1	Clim sim	Yes	CW	Secondary
Water Resources Council (U.S.), 1978	By basin or region:							
	Minerals							
	New England	12		1	Clim sim	Yes	CW	Secondary
	Mid-Atlantic	15		1	Clim sim	Yes	CW	Secondary
	Great Lakes	22		1	Great Lakes	Yes	CW	Secondary
	Ohio	18		1	Clim sim	Yes	CW	Secondary
	Tennessee	14		1	Clim sim	Yes	CW	Secondary
	Upper Mississippi	14		1	Clim sim	Yes	CW	Secondary
	Nonmetals							
	New England	13		1	Clim sim	Yes	CW	Secondary
	Mid-Atlantic	13		1	Clim sim	Yes	CW	Seondary
	Great Lakes	14		1	Great Lakes	Yes	CW	Secondary
	Ohio	11		1	Clim sim	Yes	CW	Secondary
	Tennessee	14		1	Clim sim	Yes	CW	Secondary
	Upper Mississippi	13		1	Clim sim	Yes	CW	Secondary
	Fuels							
	New England	-		-	Clim sim	No	CW	Secondary
	Mid-Atlantic	57		1	Clim sim	Yes	CW	Secondary
	Great Lakes	57		1	Great Lakes	Yes	CW	Secondary
	Ohio	31		1	Clim sim	Yes	CW	Secondary
	Tennessee	12		1	Clim sim	Yes	CW	Secondary
	Upper Mississippi	20		1	Clim sim	Yes	CW	Secondary
	Metals							
	New England	-		-	Clim sim	No	CW	Secondary
	Mid-Atlantic	14		1	Clim sim	Yes	CW	Secondary
	Great Lakes	37		1	Great Lakes	Yes	CW	Secondary
	Ohio	-		-	Clim sim	No	CW	Secondary
	Tennessee	12		1	Clim sim	Yes	CW	Secondary
	Upper Mississippi	16		1	Clim sim	Yes	CW	Secondary

[1] Noted as “Mines & Mineral Fuels.”

[2] Great Lakes includes Eastern Great Lakes—St. Lawrence River and Western Great Lakes.

[3] This is only for salt mining and was not used in the statistical analysis.

[4] This is noted as being the consumptive-use coefficient for industrial-mining.

Table 42. Summary statistics for mining consumptive-use coefficients from selected references.

[Reference refers to the annotated bibliography references. Consumptive-use coefficients are in percent. N is the number of coefficients used in the summary statistics tables (tables 9 and 43) and shown in the boxplots. References are listed in the appendix. All computed numbers are rounded to the whole number, and reported numbers are as listed in reference. The geographic area is defined by lakes, states, provinces, countries, continents, and the world—it can be for the entire geographic area to a small study area within the geographic area.]

Reference	Geographic area	N	Coefficient statistics				
			Min	25th	Median	75th	Max
Pennsylvania Department of Environmental Resources, 1975–83	Pennsylvania	19	5	6	7	8	17.6
Quan, 1988	By states:						
	Great Lakes States	8	14	20	21	28	34
	Climatically similar states	16	11	23	26	33	86
USGS Circulars, 1988, 1993, 1998							
	By states:						
	Great Lakes States	23	0	6	14	36	58
	Climatically similar states	42	0	8	11	19	70
	By basin or region:						
	Great Lakes	-	9	16	24	25	26
	Mid-Atlantic	-	11	12	12	16	19
	New England	-	11	12	12	14	16
	Ohio	-	16	19	22	37	52
	Tennessee	-	10	11	12	12	13
	Upper Mississippi	-	17	19	21	28	36

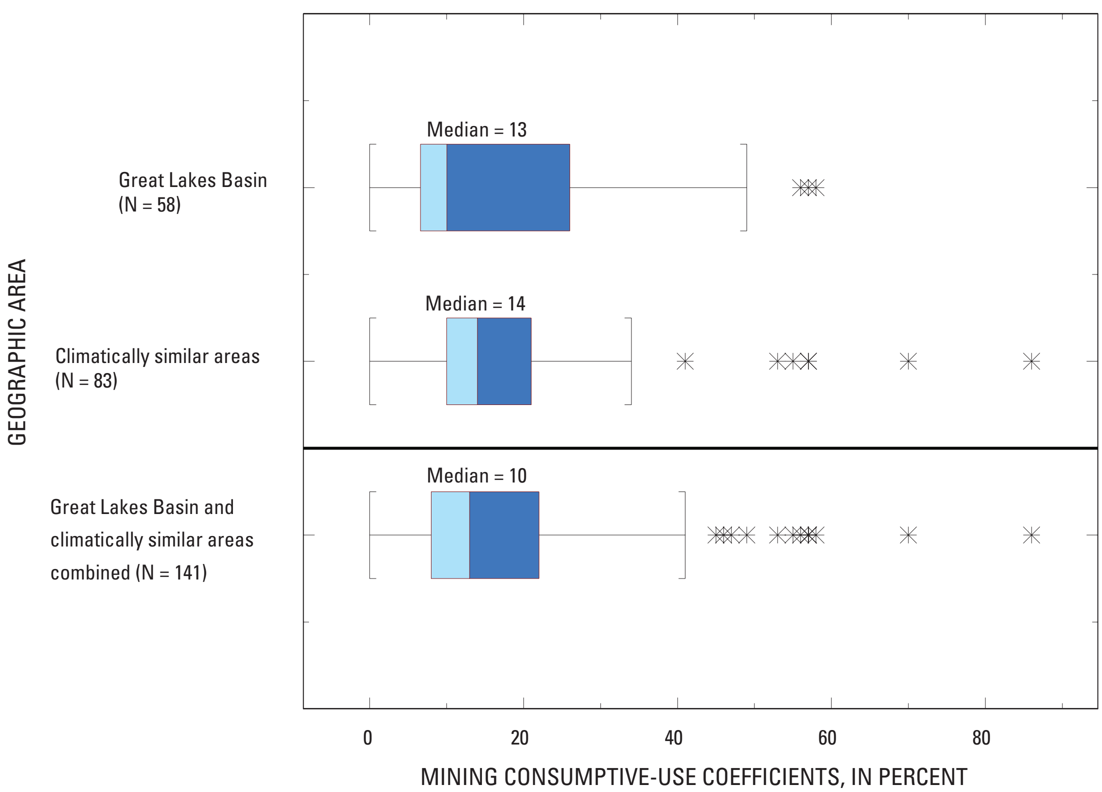


Figure 20. Distribution of mining consumptive-use coefficients for the Great Lakes Basin and climatically similar areas. (An explanation of boxplot components is given in figure 9.)

Comparison of Consumptive-Use Coefficients by Area

This section of the report compares the Great Lakes Basin, climatically similar areas, and the world consumptive-use coefficients for domestic and public supply, industrial, irrigation and livestock water-use categories; it also compares consumptive-use coefficients in the Great Lakes Basin and climatically similar areas for the thermoelectric power, commercial, and mining water-use categories. The dataset for the world statistics is small—only four numbers were found among all the references examined for this study.

The range of the world domestic and public-supply consumptive-use coefficients (14 to 19) was similar to the 25th and 75th percentiles for the Great Lakes Basin (10, 15) and climatically similar references (10, 20) (table 43). The domestic and public-supply consumptive-use coefficient medians were comparable: world, 16 percent; the Great Lakes Basin, 12 percent; and climatically similar areas, 15 percent.

The world industrial consumptive-use coefficients ranged from 9 to 11 percent, comparable to the medians for the Great Lakes Basin and climatically similar areas (10 percent) (table 43). The medians, 25th percentiles, and 75th percentiles of the Great Lakes Basin and the climatically similar areas also were similar.

Both the irrigation and livestock consumptive-use coefficients were compared to the world agriculture consumptive-use coefficients. Typically, irrigation withdrawals and consumptive use for agriculture are much larger than livestock withdrawals and consumptive use. Hutson and others (2004a) estimated that irrigation made up 34 percent of the total water withdrawn in the United States in 2000, whereas that for livestock was less than 1 percent. These proportions suggest that world consumptive-use coefficients for agriculture are more representative of irrigation than livestock water use even though both irrigation and livestock coefficients were compared.

The world agriculture consumptive-use coefficients (median 68 percent) are less than those for the Great Lakes Basin and climatically similar area combined for both irrigation (median 91 percent) and livestock (median 90 percent). These differences are reasonable because agricultural consumptive use is dependent on climate, crop type, and livestock mix. For example, the irrigation consumptive-use coefficients from Solley and others (1998) ranged from 33 percent in the Upper Colorado River Basin to 100 percent in the Tennessee River Basin, with an overall national average of 61 percent. It should also be noted that 19 percent of the withdrawals for irrigation in the United States in 1995 were lost during conveyance (Solley and others, 1998).

World consumptive-use coefficients for thermoelectric power were not available. The median, 25th percentile, and 75th percentile for the Great Lakes Basin and climatically similar areas were small, even though the maximum coefficients were high. Thermoelectric power facilities with small consumptive-use coefficients (once-through cooling) typically use much larger amounts of water but consume very little. The median (2 percent) for the Great Lakes Basin and climatically similar areas compared to the following thermoelectric-power consumptive-use coefficients:

- 5 percent of thermoelectric power withdrawals in Europe (European Environment Agency, 2005; Marcuello and Lallana, 2003)
- 2.5 percent of the freshwater withdrawn for thermoelectric power in the entire United States (Solley and others, 1998),
- 1.8 percent for thermoelectric power withdrawals in all of Canada (Environment Canada, 2004).

World commercial consumptive-use coefficients were not available, perhaps because commercial withdrawals are accounted for in the industrial or municipal coefficients. All the references were for the United States. The Great Lakes Basin and the climatically similar areas had the same consumptive-use coefficient median (10 percent), the same 25th percentile (8 percent), and similar 75th percentiles (15 and 13 percent). For the entire United States in 1995, the commercial consumptive-use was 14 percent of the commercial withdrawals (Solley and others, 1998).

No world references were found for mining consumptive-use coefficients. As previously mentioned, consumptive-use coefficients for mining vary greatly depending on the type of mining, the mining environment, the processes at the mining facility, and methods used to estimate withdrawals and consumptive use. The range between the 25th and 75th percentile was fairly large, as was the minimum and maximum for both the Great Lakes Basin and climatically similar areas (table 43). In 1995, the United States mining consumptive-use coefficient was 27 percent compared to 9 percent for the Great Lakes Basin (Solley and others, 1998).

Table 43. Consumptive-use coefficient statistics for the Great Lakes Basin, climatically similar areas, and the world, by water-use category.

[Great Lakes Basin refers to basins, parts of states, and states in the Great Lakes Basin. Climatically similar areas are basins and states with areas climatically similar to the Great Lakes Basin. Great Lakes and climatically similar references are the combination of references from these two areas. References are only from publications after either 1975 (mining and commercial), 1980 (industrial, irrigation, thermoelectric, and livestock), or 1985 (domestic and public supply) and do not include all of Canada coefficients, all of the United States coefficients, or continent coefficients because these have areas that are not climatically similar to the Great Lakes Basin. Minimum (min), median, maximum (max), 25th percentile, and 75th percentile are in percent and rounded to the nearest whole number. N is the number of references used in the statistical analysis.]

Geographic Area	Statistics					
	Min	25th	Median	75th	Max	N
Domestic and Public Supply						
Great Lakes Basin	0	10	12	15	74	161
Climatically similar areas	6	10	15	20	70	68
Great Lakes and climatically similar areas combined	0	10	13	15	74	229
World	14	16	16	18	19	4
Industrial						
Great Lakes Basin	0	7	10	14	35	122
Climatically similar areas	0	4	10	13	34	97
Great Lakes and climatically similar areas combined	0	6	10	13	35	219
World	9	10	10	11	11	4
Thermoelectric						
Great Lakes Basin	0	1	2	2	21	141
Climatically similar areas	0	0	2	4	75	75
Great Lakes and climatically similar areas combined	0	1	2	3	75	216
Irrigation						
Great Lakes Basin	70	90	90	96	100	95
Climatically similar areas	37	90	100	100	100	75
Great Lakes and climatically similar areas combined	37	90	91	100	100	170
World	65	65	68	72	78	4
Livestock						
Great Lakes Basin	0[1]	80	83	90	100	85
Climatically similar areas	10[2]	86	100	100	100	73
Great Lakes and climatically similar areas combined	0[1,2]	80	90	100	100	158
World (Agriculture)	65	65	68	72	78	4
Commercial						
Great Lakes Basin	4	8	10	15	26	29
Climatically similar areas	3	8	10	13	33	61
Great Lakes and climatically similar areas combined	3	8	10	13	33	90
Mining						
Great Lakes Basin	0	7	10	25	58	58
Climatically similar areas	0	10	14	20	86	83
Great Lakes and climatically similar areas combined	0	8	13	22	86	141

[1] The livestock low coefficient minimum (0 percent) is from Great Lakes Commission (2005a), where Minnesota reported 0.25 Mgal/d total withdrawn in 1998 and 0.0 Mgal/d consumptive use. The next lowest coefficient for the Great Lakes basin was 66 percent.

[2] The livestock low minimum coefficients are from Solley and others (1988) and may result from adding animal specialties (including fish farming) into the livestock water-use category. In previous and subsequent USGS reports, fish farming was in different water-use categories.

Summary and Conclusions

State agencies with jurisdiction within the Great Lakes Basin have indicated that refinement of consumptive-use data and coefficients for all water-use categories were of greatest interest and value to water-supply managers. As part of the USGS National Assessment of Water Availability and Use Program, consumptive-use coefficients were compiled and an annotated bibliography was prepared for the Great Lakes Basin and climatically similar areas. The consumptive-use coefficients are statistically summarized by water-use category and compared, where possible to coefficients from other parts of the world. This assembly of data and coefficients in this report addressed the following objectives:

- summarizing the range of coefficients by water-use categories listed in most bibliographic references
- comparing coefficients for the Great Lakes Basin and climatically similar area, to each other and to world coefficients
- summarizing methods and data used in previous studies to calculate consumptive use
- compiling available consumptive-use data and consumptive-use coefficients

The domestic and public-supply water-use categories were combined because inconsistent terminology among references made it unclear, in some cases, whether uses other than strictly domestic received deliveries from a public supply. Domestic and public-supply consumptive-use coefficient statistics (median and 25th and 75th percentile) were within 6 percent for the aggregated worldwide data, the Great Lakes Basin, and climatically similar areas.

Although industrial consumptive-use coefficients may differ substantially by industry and facility, the statistics for the Great Lakes Basin, climatically similar areas, and the world were similar: the 25th percentile ranged from 4 to 10 percent, the median was 10 percent for all three areas, and the 75th percentile ranged from 11 to 14 percent. Additionally, median consumptive-use coefficients for six industry groups compared well with the statistics for the general industrial coefficients. Industries that departed substantially from the norm are the beverage and bottled-water industries, which had higher consumptive-use coefficients than most other industrial categories. More data on consumptive use and consumptive-use coefficients for the ethanol and transportation equipment industries are needed for water managers to better understand and plan for the water and consumptive use for these industries.

The thermoelectric power consumptive-use coefficients differ by the type of cooling at each facility. Overall, the thermoelectric power consumptive-use coefficient median between 1980 and 2005 was 2 percent for the Great Lakes Basin and climatically similar areas. More than half of the thermoelectric coefficients were in the 0- to 5-percent range.

Irrigation consumptive-use coefficients for 1980 to 2005 for the Great Lakes and climatically similar areas references were similar: both had a 25th percentile of 90 percent and 75th percentile of 100 percent; the medians ranged from 91 to 100 percent. Irrigation coefficients for the Great Lakes Basin and climatically similar areas were typically higher than those for entire continents, some countries (Canada and United States), and the world as a whole. Differences may be due to climate, crop type, irrigation methods, and various ways of defining the category.

Three-fourths of the references on livestock reported consumptive-use coefficients between 80 and 100 percent. Median coefficients for livestock in the Great Lakes Basin and climatically similar areas were within 13 percent.

The commercial consumptive-use coefficients between 1975 and 2005 were almost identical for the Great Lakes Basin and climatically similar areas: 25th percentiles of 8 percent, medians of 10 percent, and 75th percentiles of 15 and 13 percent. More than half of the commercial consumptive-use coefficients were between 8 and 15 percent.

The range of mining consumptive-use coefficients was wide (0 to 86 percent). Although a little over half of the consumptive-use coefficients were between 7 to 25 percent, there was a large difference among mining types.

Acknowledgments

The authors appreciate the assistance of Margery Tibbetts of the USGS for her persistence in locating references for the report, organizing references, and checking numbers. The authors acknowledge Leah N. Hout (formerly of the USGS, now with the Defense Supply Center, Columbus Public Affairs Office) and Michael Eberle of the USGS, who wrote some of the annotations for the bibliography and reviewed others' annotations. Finally, the authors want to thank Laura Simonson, Daniel Button, and Michael Eberle of the USGS for assistance with illustrations for this publication.

References Cited

American Society of Civil Engineers, 1973, Consumptive use of water and irrigation water requirements: New York, Technical Committee on Irrigation Water Requirements of the Irrigation and Drainage Division of the American Society of Civil Engineers, 215 p.

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

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*

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*

Beecher, J.A., 2002, Survey of state agency water loss reporting practices—Final report to the American Water Works Associations, January 2002: Beecher Policy Research, Inc., 30 p.

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.

Canadian Bottled Water Association [n.d.], Response to Ontario Ministry of the Environment White Paper on watershed-based source protection planning, accessed July 4, 2006, at *http://www.cbwa-bottledwater.org/en/CBWA%20Official%20Response%20Summary%20(Final).pdf*

Canadian Environmental Law Association, 2004, Water sustainability—Bottled water FAQs, accessed July 4, 2006, at *http://www.cela.ca/faq/cltn_detail.shtml?x=1506*

Clean Fuels Development Coalition and Nebraska Ethanol Board, 2006, A guide for evaluating the requirements of ethanol plants, 48 p., accessed April 17, 2007, at *http://www.ne-ethanol.org/industry/evalreq.pdf*

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*

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*

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*

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.

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].

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

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*

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*

Fahrenthold, D.A., 2006, Bottlers, states and the public slug it out in water war: Washington Post, Monday, June 11, 2006, accessed on July 4, 2006, at *http://www.washingtonpost.com/wp-dyn/content/article/2006/06/11/AR2006061100797.html*

General Motors, 2001, GM Global Water Use, accessed June 28, 2006, at *http://www.gm.com/company/gmability/sustainability/reports/01/environmental_info/performance/water_use.html*

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.

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.

Grannemann, N.G., and Reeves, H.W., 2005, Great Lakes Basin water availability and use: U.S. Geological Survey Fact Sheet 2005–3113, 4 p.

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. 47–68, accessed July 30, 2006, at *http://www.glc.org/wateruse/wrmdss/finalreport/pdf/WR-Ch.3-2003.pdf*

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 May 31, 2006, at *http://www.glc.org/wateruse/database/downloads.html*

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*

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.

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.

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.

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.

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*

Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004a, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.

Hutson, S.S., Koroa, M.C., and Murphree, C.M., 2004b, 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*

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 app.

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.

International Joint Commission, 2004, Protection of the waters of the Great Lakes—Review of the recommendations in the February 2000 report: 20 p., accessed June 15, 2006, at *http://www.ijc.org/php/publications/pdf/ID1560.pdf*

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

Kaufman, Alvin, and Nadler, Mildred, 1966, Water use in the mineral industry, 1963: U.S. Bureau of Mines Information Circular 8285, 58 p.

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.

Kite, Geoff, and Droogers, Peter, 2000, Comparing estimates of actual evapotranspiration from satellites, hydrological models, and field data—A case study from Western Turkey: Colombo, Sri Lanka, International Water Management Institute, Research Report 42.

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.

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.

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.

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.

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*

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

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

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

Michigan State University, 1985, Sea Grant College Program: Cooperative Extension Service Bulletins E–1866–1870.

Minnesota Pollution Control Agency, 2006, Environmental Assessment Worksheet for the proposal of Al-Corn Clean Fuel Facility Expansion: 32 p., accessed April 17, 2007, at *http://www.pca.state.mn.us/news/eaw/alcorn-eaw.pdf*

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.

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*

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

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.

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.

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.

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

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.

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.

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.

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].

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

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.

Prism Group, 2006a, Minimum temperature—Annual climatology map (1971–2000): Oregon State University, accessed Oct. 13, 2006, at *http://www.ocs.orst.edu/prism/products/viewer.phtml?file=/pub/prism/us_30s/graphics/tmin/Normals/us_tmin_1971_2000.14.png&year=1971_2000&vartype=tmin&month=14&status=final*

Prism Group, 2006b, Precipitation—Annual climatology map (1971–2000): Oregon State University, accessed Oct. 13, 2006, at *http://www.ocs.orst.edu/prism/products/viewer.phtml?file=/pub/prism/us_30s/graphics/ppt/Normals/us_ppt_1971_2000.14.png&year=1971_2000&vartype=ppt&month=14&status=final*

Renewable Fuels Association (RFA), 2007, Historic U.S. fuel ethanol production and ethanol industry overview, accessed April 16, 2007, at *http://www.ethanolrfa.org/industry/statistics/*

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

Shiklomanov, I.A., 1999, World water resources and their use: St. Petersburg, Russia, Database for State Hydrological Institute and UNESCO, accessed August 13, 2007, at *http://webworld.unesco.org/water/ihp/db/shiklomanov/index.shtml*

Shiklomanov, I.A., and Markova, O.L., 1987, Specific water availability and river runoff transfers in the world: Leningrand, Hydrometeoizdat, 293 p. [in Russian].

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.

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.

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.

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.

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.

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.

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.

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.

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 in 1981: West Virginia Geological and Economic Survey Circular C–33, 94 p.

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.

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.

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

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

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.

Tate, D.M., 1979, Consumptive water use in the Canadian section of the Great Lakes Basin, 1975–2035: Ottawa, Ontario, Environment Canada.

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. 601–609.

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.

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.

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

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-File Report 90–156, 23 p.

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

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.

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

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

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.

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.

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

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

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

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*

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*

U.S. Department of Energy, 2005, Design and construction of a proposed fuel ethanol plant, Jasper County, Indiana: 114 p., accessed April 17, 2007, at *http://www.go.doe.gov/PDFs/ReadingRoom/Iroquois/Iroquois_EA.pdf*

U.S. Environmental Protection Agency, 1999, Safe Drinking Water Act—Glossary: EPA publication 810F99023, 4 p.

USGS Circulars

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

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.

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

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.

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.

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

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.

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.

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.

* * * * *

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

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*

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/index.html*

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

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

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.

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

Water Resources Council (U.S.), 1978, The Nation's water resources, 1975–2000: Washington, D.C., 4 v., 6 app.

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

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

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

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

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.

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.

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.

This page is intentionally blank.

Glossary

The terms in this glossary were compiled from numerous sources. Some definitions have been modified specifically in reference to this report and are not the only valid ones for those terms.

25th percentile The value in a rank of values below which one-fourth (25 percent) of the values fall. The 25th and 75th percentile together bracket half of the values.

75th percentile The value in a rank of values below which three-fourths (75 percent) of the values fall. The 25th and 75th percentile together bracket half of the values.

A

B

C

climatically similar areas (clim sim) Basins, states, or countries that have climates similar to the Great Lakes Basin.

commercial water use Water for motels, hotels, restaurants, office buildings, other commercial facilities, military and nonmilitary institutions—and in USGS water-use circulars for 1990 and 1995, water for offstream fish hatcheries.

community water system A public water system that delivers water for human consumption through pipes and other constructed conveyances if such a system regularly serves at least 25 year-round residents or has at least 15 service connections used by year-round residents. Community water systems might serve towns, cities, military bases, apartment complexes, or mobile home parks (U.S. Environmental Protection Agency, 1999).

consumptive use The part of water withdrawn [for a particular use] that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

consumptive-use coefficient Percentage of water removed from the immediate environment by evaporation, transpiration, incorporation into products or crops, or consumption by humans or livestock.

conveyance loss Water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. Generally, the water is not available for further use; however, leakage from an irrigation ditch, for example, may percolate to a ground-water source and be available for further use.

D

domestic water use Water used for all such indoor household purposes as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and such outdoor purposes as watering lawns and gardens.

E

evaporation The change of water from a liquid form into a vapor state such as water evaporating from pools, large bodies of water, and runoff from car-washing or irrigation systems; also includes evaporation through dehumidifiers, heating and cooling processes in industrial facilities and thermoelectric plants.

evapotranspiration A collective term used to include water discharged to the atmosphere as a result of plant transpiration and evaporation from soil and surface-water bodies.

F

G

Great Lakes Basin In this report, the eight United States and two Canadian provinces that have all or part of their states or provinces in the Great Lakes Basin. It also includes any areas in the eight states and two provinces that may or may not be in the Great Lakes Basin.

Great Lakes Basin and climatically similar areas The combination of bibliographic references for the Great Lakes Basin and climatically similar areas.

H

I

industrial water use Water used for fabrication, processing, washing, and cooling, and includes such industries as chemical and allied products, food, mining, paper and allied products, petroleum refining, and steel.

irrigation water use Water that is applied by an irrigation system to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands such as parks and golf courses.

J

K

L

M

maximum The largest number in a group of values.

median The point in a rank of values above and below which 50 percent of the values fall.

minimum The lowest number in a group of values.

mining water use Water used for the extraction of naturally occurring minerals including solids, such as coal, sand, gravel, and other ores; liquids, such as crude petroleum; and gases, such as natural gas. Also includes uses associated with quarrying, milling, and other preparations customarily done at the mine site or as part of a mining activity.

N

O

once-through thermoelectric power facility A facility that uses water only one time in the condenser-and reactor-cooling process before returning the water to a surface-water source. Although once-through cooling requires substantial water withdrawals, the consumption is low—usually less than 3 percent (Solley and others, 1998).

other than once-through thermoelectric power facility A facility that uses cooling towers or cooling ponds to recycle water repeatedly for condenser and reactor cooling. This type of facility typically uses less water than a once-through facility but has a higher percentage of consumptive use (evaporation), typically greater than 60 percent (Solley and others, 1998).

P

primary source A reference where the authors did most of the compilation, analysis, and computation of data. Often the primary source publication was completed in cooperation with multiple agencies, but the publication was the main product for the multiple agency effort.

product incorporation Inclusion of water as a component of industrial, food, and beverage products.

Q

R

return flow Water that reaches a ground-water or surface-water source after release from the point of use and thus becomes available for further use.

S

secondary source A reference that uses data or consumptive-use coefficients from another publication or person or organization to discuss or estimate consumptive use for the current report.

Standard industrial classification (SIC) codes Four-digit codes established by the Office of Management and Budget, published in 1987, and used in the classification of establishments by type of activity in which they are engaged.

T

thermoelectric-power water use Water used in the process of generating electricity with steam-driven turbine generators.

transfer Conveyance of water that occurs during distribution or collection of water and sewage.

transpiration The process in which water is absorbed by plants, usually from the roots and evaporated into the atmosphere from the plant surface. Transpiration occurs in all types of plants including crops, grass (lawns, golf courses), landscaping plants, and nursery plants.

U

unaccounted-for use Water that is either lost through conveyance losses or supplied from a public supplier and used for such purposes as firefighting, street washing, flushing of water lines, and maintaining municipal parks and swimming pools (public uses). Generally, public-use water is not billed by the public supplier.

unknown source A reference that does not indicate the publication, person, or organization where the coefficient or data came from.

V

W

water balance The mathematical equation of the inflows, outflows, and change in storage of water in a given area (Inflows = Outflows + Change in Storage).

water-use category The type of specific use (facility or consumer) for which water is withdrawn (for example, public supply, irrigation, industrial, thermoelectric power).

withdrawal Removal of water from either a surface-water or ground-water source.

world Represents single coefficients that have world-wide applicability for particualr water-use categories in this report.

X

Y

Z