

ESTIMATED WATER USE IN IOWA, 1985

By Melanie L. Clark and Joanna N. Thamke

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ESTIMATED WATER USE IN IOWA, 1985

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Abstract

Periodic assessments of water use in Iowa are needed to understand and manage the demands for the available water resources. This report summarizes where, how much, and for what purposes water was used in Iowa during 1985. The data are presented for the following categories: agricultural, self-supplied commercial, self-supplied domestic, self-supplied industrial, irrigation, mining, power generation (excluding hydroelectric plants), and public-water supply. The water-use data are further categorized by county, hydrologic unit subregion, and major aquifer system. During 1985, a total of 1,010,000 million gallons was estimated to have been withdrawn from Iowa's surface- and ground-water resources. Of this, 76 percent was withdrawn from surface-water sources and 24 percent from ground-water sources. Power generation was the largest water-use category, withdrawing 66 percent of the total withdrawals; 99 percent was from surface-water sources. Public-water supply was the second largest water-use category and accounted for 13 percent of total withdrawals; 74 percent was from ground-water sources. Self-supplied industries withdrew 7 percent of the total water use and agricultural withdrawals were 6 percent of the total water use. The remaining 8 percent was accounted for by irrigation (3 percent), self-supplied domestic (2 percent), mining (2 percent), and self-supplied commercial (1 percent) water users. The largest estimated water use occurred in Woodbury County where 201,000 million gallons was withdrawn. Pottawattamie County had the second largest water use with 182,000 million gallons. Other counties with significant withdrawals were Allamakee (74,900 million gallons), Muscatine (63,900 million gallons), and Clinton (62,300 million gallons). Power generation plants are in each of these counties. Surface-water withdrawals were most intensive along the Mississippi and Missouri Rivers. Nearly 80 percent of the surface water used in the State was by power generation plants on the border rivers. Surficial aquifers were the source of 60 percent of the ground-water withdrawals. The remaining 40 percent was with-

drawn from the following aquifers: Silurian-Devonian, 14 percent; Cambrian-Ordovician, 13 percent; Dakota, 8 percent; and Mississippian-Pennsylvanian, 5 percent. It was estimated that 17 percent of the total surface water and ground water withdrawn was consumed.

Introduction

During 1985, over one trillion gallons of water was diverted through water pipes in Iowa to meet the needs of homes, factories, farms, and power plants. After excluding the water withdrawn for power generation, it was estimated that for each person in Iowa during 1985, 330 gpd (gallons per day) was withdrawn from surface- and ground-water sources. About 83 percent of the water withdrawn was returned to surface- and ground-water sources for possible reuse. To better understand the demands placed on Iowa's available water resources, hydrologists have grouped water-use data into eight categories of use. The following are the principal water-use categories: agricultural, self-supplied commercial, self-supplied domestic, self-supplied industrial, irrigation, mining, power generation (excluding hydroelectric power), and public water supply. These water-use categories are considered as offstream use because water is withdrawn or diverted from a surface- or ground-water source. Instream water use, including navigation, fish hatcheries, and recreation, is defined as water use that takes place within the stream channel and is not included in this report.

The ability of water managers to effectively use the available water resources in Iowa requires careful estimations of water use. In order to store, aggregate, and retrieve water-use information, the U.S. Geological Survey developed the State Water Use Data System (SWUDS). In Iowa, SWUDS was structured using the water permit system of the Iowa Department of Natural Resources that requires all water users who use more than 25,000 gpd to obtain a water withdrawal permit. SWUDS contains both actual site-specific water withdrawals by permitted users and estimated water-use data based on past and current studies. The information presented in this report was compiled from SWUDS and is summarized by county, hydrologic unit subregion, and major aquifer system.

Acknowledgements

The authors would like to extend thanks to the Iowa Department of Natural Resources for providing the permitted water-use data and collecting water-use information over the years for this report.

Explanation of Data

Water use in this report is considered as offstream use and is equivalent to water withdrawals. Consumptive water use is considered to be that part of the water withdrawn that is no longer available for future use. For all categories except agricultural and self-supplied domestic use, the Iowa Department of Natural Resources water permit system identified most of the users. About 30 percent of the permitted users voluntarily sent water-use inventory sheets to the Iowa Department of Natural Resources. This information was entered into SWUDS and compared to the permitted water-use data. Ratios were set up that related actual water use to permitted water use. Coefficients were generated from these ratios for each of the water-use categories and applied to the nonreporting users. From this, a complete inventory of water use in Iowa was estimated.

Agricultural water use was estimated using a water-use rate for the different livestock in Iowa on a per-head basis. The cattle, hog, sheep, turkey and chicken populations were available from the 1985 Iowa Agricultural Statistics (Skow and Halley, 1985). The horse population was derived from an Iowa water-use study by Buchmiller and Karsten (1983). Water-use rates were determined to be the following: milk cows, 35 gpd; cattle, 12 gpd; horses, 12 gpd; hogs, 4 gpd; sheep, 2 gpd; turkeys, 0.12 gpd; and chickens, 0.06 gpd. Agricultural water use was considered to be 100 percent consumptive.

Self-supplied commercial water users are permitted water withdrawals by the Iowa Department of Natural Resources. About 40 percent of the commercial water users reported actual water use during 1985. Consumptive use was estimated to be 13 percent of withdrawals.

Self-supplied domestic water users are not required to obtain water-use permits. A generalized quantity of 85 gpd per person was applied (Buchmiller and Karsten, 1983) to the self-supplied rural population. Population figures were provided by the State Demog-

rapher and the Bureau of the Census. Consumptive use was estimated to be 40 percent of withdrawals.

Estimates of self-supplied industrial water use were based on reported quantities by individual users. About 25 percent of the permitted industrial users reported water use to the Iowa Department of Natural Resources. The remaining use was estimated from the coefficient generated by the reported use. Consumptive use was estimated to be 13 percent of withdrawals.

A complete inventory of acres permitted for irrigation in Iowa was provided by the Iowa Department of Natural Resources. Of the permitted irrigation water users, 20 percent submitted water-use data to the Iowa Department of Natural Resources. From this group, estimations were generated for the nonreporting users. Total irrigation water use was estimated by calculating that 60 percent of permitted acres were irrigated with an average of five inches of water per acre. Consumptive use was considered to be 100 percent of the water withdrawn.

Mining water use was estimated similar to the technique used for self-supplied commercial and industrial water use. About 70 percent of the mining companies reported water use. Dewatering and washing accounted for nearly all of the water used by mining companies. The consumptive use for these activities was considered to be negligible.

Power generation water use includes the water withdrawn for cooling and steam generation at fossil-fuel and nuclear plants. Ten percent of the power generation plants reported water use to the Iowa Department of Natural Resources. Data on water use for the remaining plants was obtained from an inventory taken by the Westinghouse Hanford Company (written commun., 1985) and by telephone inquiry. Consumptive use was estimated to be 3 percent of water withdrawals. Because the water required for hydroelectric power generation is considered an instream water use, hydroelectric power plants are not included in this report.

Public-water supplies in Iowa served a population of 2,130,000 people during 1985. About 40 percent of the public-water suppliers reported actual water use. The remaining public-water supplies were estimated from an inventory conducted by Buchmiller and Karsten (1983) for 1980 water use. Estimates of 1985 water use

were adjusted from the 1980 estimates by applying the percentage of population change to the withdrawal data.

In this report, surface-water sources include natural lakes, artificial lakes, farm ponds, reservoirs, lagoons, and streams. Surface-water withdrawals are compiled and illustrated on diagrams showing hydrologic unit subregions. The subregions serve as a standard geographical framework for detailed water-resources planning and, in general, the boundaries of the subregions coincide with basin boundaries for major river systems in Iowa (fig. 1).

Sand and gravel pits, quarries, and wells are considered ground-water sources. Ground-water withdrawals are derived from one or more of the following aquifers: surficial sand and gravel aquifers, Cretaceous Dakota sandstone aquifer, Mississippian-Pennsylvanian aquifer, Silurian-Devonian aquifer, and Cambrian-Ordovician aquifers. Diagrams of estimated water use from the aquifers were generated using site-specific information contained in SWUDS. Aquifer data are not available for the agricultural and self-supplied domestic categories. Water use from the aquifers for these categories was estimated based on shallow bedrock aquifer maps and geographic population distributions.

Numerical data in this report were derived from several sources. It should be noted that numbers were rounded independently; thus the sums of individual rounded numbers may not equal the totals. The percentages were calculated from the unrounded "raw" numbers rather than the rounded numbers. Only values larger than 0.01 Mgal (million gallons) are shown on the tables and only county totals larger than 0.01 Mgal are shown on the maps.

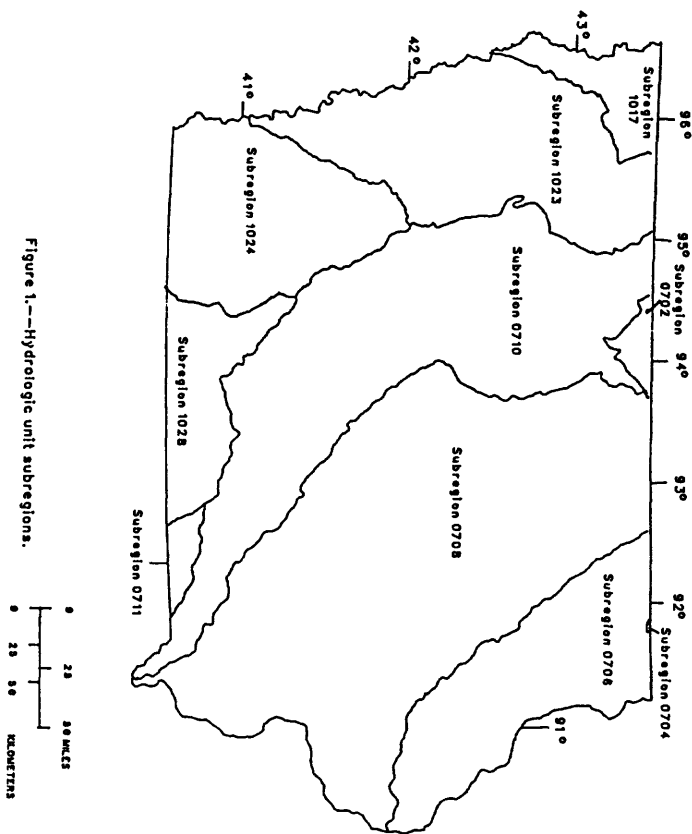


Table 1. Geologic and hydrogeologic units in Iowa

[Modified from Steinhilber and Horlick, 1970]

AGE	ROCK UNIT	DESCRIPTION	HYDROGEOLOGIC UNIT		WATER-BEARING CHARACTERISTICS
Quaternary	Alluvium	Sand, gravel, silt and clay	Surficial aquifers		Moderate to large yields
	Glacial drift (undifferentiated)	Predominantly glacial till containing scattered, irregular bodies of sand and gravel			Small yields
	Buried channel deposits	Sand, gravel, silt and clay			Small to large yields
Cretaceous	Turonian	Shale	Confining unit	Dakota aquifer	Does not yield water
	Cenomanian Albian	Shale	Confining unit		Does not yield water
		Sandstone and shale			Moderate to large yields
Pennsylvanian	Virgilian	Shale and limestone	Confining unit or local Pennsylvanian aquifer	Mississippian - Pennsylvanian aquifer	Small yields only from locally productive limestone and sandstone
	Missourian				
	Desmoinesian				
Mississippian	Meramecian	Limestone, sand	Mississippian aquifer		Small to moderate yields
	Osagean	Limestone and cherty dolomite			
	Kinderhookian	Oolitic limestone and cherty dolomite			
Devonian	Famennian Frasnian	Shale, limestone in lower part	Confining unit		Does not yield water
	Givetian Eifelian				
Silurian	Ludlovian	Dolomite, locally cherty	Silurian-Devonian aquifer		Moderate to large yields
	Wenlockian				
	Llandoverian				

Table 1. Geologic and hydrogeologic units in Iowa (cont.)

AGE	ROCK UNIT	DESCRIPTION	HYDROGEOLOGIC UNIT		WATER-BEARING CHARACTERISTICS
Ordovician	Richmondian	Shale and dolomite	Confining unit		Does not yield water, except locally
	Maysvillian				
	Edenian	Limestone and dolomite	Minor aquifer		Small yields
	Rocklandian-Kirkfieldian-Shermanian	Limestone and thin shale, some sandstone in southeast Iowa	Confining unit		Generally does not yield water; except locally
	Chazyan-Blackriveran	Sandstone	St. Peter aquifer		Used with underlying Jordan aquifer
Cambrian	Canadian	Dolomite, sandy and cherty	Prairie du Chien-Jordan aquifer	Cambrian - Ordovician aquifer	Large yields
	Jordan Sandstone	Sandstone			
	St. Lawrence Formation	Dolomite	Confining unit (wedges in northwest Iowa)		Does not yield water
	Franconia Sandstone	Sandstone and shale			
Precambrian	Dresbach Group	Sandstone	Dresbach aquifer		Large yields
	Sioux Quartzite	Quartzite	Base of ground-water reservoir		
	Undifferentiated	Coarse sandstone crystalline rocks			Does not generally yield water except at Manson cryptovolcanic area in northwest Iowa

The nomenclature and classification of rock units in this report are those of the Iowa Department of Natural Resources (Geological Survey Bureau), (Bill J. Bunker, written commun., 1988) and do not necessarily coincide with those accepted by the U.S. Geological Survey.

Aquifers in Iowa

Rocks and sediment, such as sand and gravel, sandstone, and fractured limestone, that store and transmit significant quantities of water to wells are called aquifers. Shale, unfractured limestone, glacial till, and clay generally restrict water movement and form confining units. Geologic and hydrogeologic units, including aquifers, are listed in table 1.

Surficial aquifers are unconsolidated deposits of sediment near the land surface. Alluvium consists of sand and gravel deposits that underlie the floodplains of the major rivers in Iowa. Some sand and gravel deposits interbedded with glacial till may contain small quantities of water accessible to wells. In some locations buried-channel deposits, which are ancient stream sediment overlain by glacial till, are significant aquifers.

Beneath these unconsolidated deposits are layers of sedimentary bedrock. For this report, the major bedrock aquifers are the Dakota, Mississippian-Pennsylvanian, Silurian-Devonian, and Cambrian-Ordovician aquifers. The Pennsylvanian and Mississippian aquifers are combined because the water withdrawn from the Pennsylvanian aquifer was always less than 10 percent of this combined total in each water-use category. The Cambrian-Ordovician aquifer includes the following aquifers for this report: Galena, St. Peter, Prairie du Chien-Jordan, and Dresbach. The Prairie du Chien-Jordan aquifer generally is the most productive and geographically the most used of the Cambrian-Ordovician aquifers. Therefore, most of the water withdrawn from the Cambrian-Ordovician aquifers probably is from the Prairie du Chien-Jordan aquifer.

Underlying the sedimentary rocks in Iowa are Precambrian metamorphic and igneous crystalline rocks. Specific hydrologic information is not known about these rocks and they are not considered to be significant sources of usable water.

Estimated Total Water Use

A total of 1,010,000 Mgal was estimated to have been withdrawn from Iowa's surface- and ground-water resources during 1985. Of this total, 764,000 Mgal, or about 76 percent, was from surface-water sources and 245,000 Mgal, or about 24 percent, was from ground-water sources.

The distribution of estimated total surface- and ground-water withdrawals by county is shown in figure 2. The estimated water use by category for each county is shown in table 2. The largest estimated total water use of 201,000 Mgal occurred in Woodbury County and accounted for about 20 percent of the State's total water use. About 95 percent of the water used in Woodbury County was for power generation. Pottawattamie County had the second largest estimated total water use with 182,000 Mgal. About 94 percent of this was for power generation. Other counties with large estimated total water-use quantities are: Allamakee, Muscatine, and Clinton. Power generation accounted for most of the water used in these counties.

The proportion of estimated total water use for each of the eight categories is shown in figure 3. About 66 percent of the estimated total water use was for power generation. Estimated total surface- and ground-water withdrawals by category are presented in figure 4 and figure 5.

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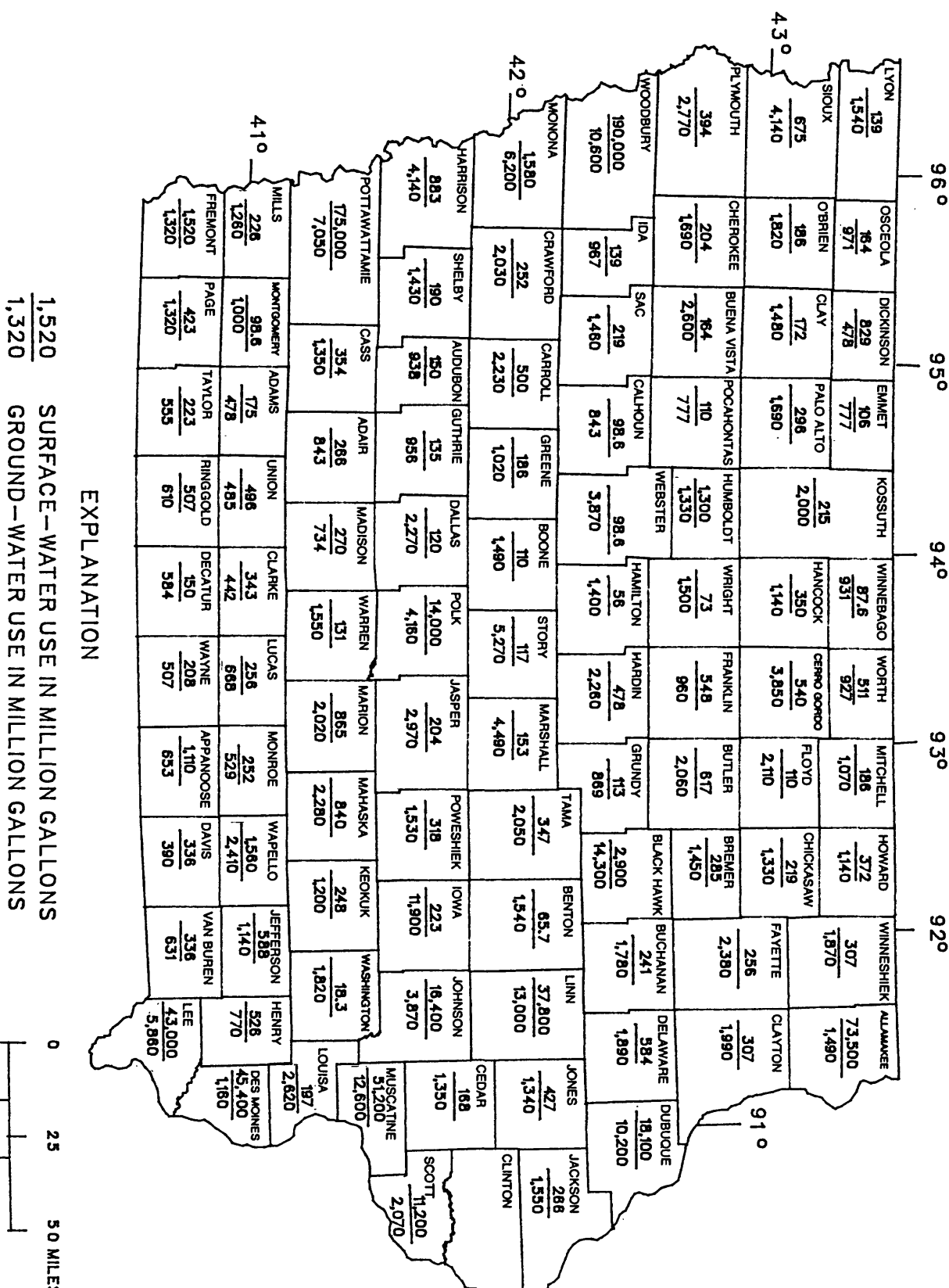


Figure 2.—Estimated total water use by county.

Table 2. Estimated total water use
(All values are in million gallons;--value less than 0.01 million gallons.)

County	WATER USE CATEGORY							Public-- water supply	Total
	Agricultural	Self-supplied domestic	Self-supplied commercial	Self-supplied industrial	Irrigation	Mining	Power		
Adair	745	150	--	--	--	40.2	--	175	1,110
Adams	394	98.6	--	--	--	51.1	--	110	654
Allamakee	912	256	--	117	--	--	73,200	453	74,900
Appanoose	303	266	--	--	--	21.9	--	1,170	1,760
Audubon	708	124	--	--	36.5	54.8	--	164	1,090
Benton	759	299	--	--	22.0	7.4	--	518	1,610
Black Hawk	460	270	3,670	3,440	190	2,760	285	6,240	17,300
Boone	460	266	3.7	--	7.3	--	--	861	1,600
Bremer	445	292	3.7	29.2	65.7	219	--	675	1,730
Buchanan	785	332	139	47.5	36.5	146	--	537	2,020
Buena Vista	756	190	--	--	98.6	14.6	--	1,700	2,760
Butler	678	230	475	--	94.9	840	--	358	2,660
Calhoun	417	146	--	--	54.8	3.7	--	321	943
Carroll	1,120	212	91.3	237	69.4	292	--	712	2,730
Cass	624	157	--	--	190	205	--	529	1,710
Cedar	792	256	--	11.0	3.7	58.4	--	398	1,710
Cerro Gordo	467	245	--	11.0	182	1,310	--	398	1,520
Cherokee	901	179	3.7	--	29.2	84.0	--	697	4,400
Chickasaw	540	226	--	76.7	285	14.6	--	409	1,890
Clarke	329	124	--	--	--	36.5	--	295	1,550
Clay	471	168	--	84.0	292	25.6	29.2	584	785
Clayton	1,380	336	--	183	--	14.6	--	376	1,650
Clinton	916	332	--	4,440	32.9	102	54,500	376	2,280
Crawford	974	230	--	237	69.4	69.4	--	2,000	62,300
Dallas	350	318	62.1	212	165	25.6	--	697	2,280
Davis	420	193	--	--	51.2	--	--	1,260	2,390
Decatur	376	142	--	--	--	54.8	--	62.1	726
Delaware	1,720	325	--	--	3.7	21.9	--	161	734
Des Moines	303	332	--	18.3	65.7	347	43,500	398	2,470
Dickinson	362	153	--	--	--	7.3	--	1,940	46,500
Dubuque	1,440	686	204	5,120	25.6	18.3	17,700	785	1,310
Emet	277	113	11.0	11.0	54.8	25.6	--	3,110	28,300
Fayette	1,070	307	11.0	47.5	76.7	518	--	391	883
Floyd	364	212	21.9	774	139	3.7	--	602	2,630
Franklin	554	179	--	--	117	424	--	701	2,220
Fremont	299	117	1,420	40.2	756	--	--	224	1,510
Greene	376	131	--	--	241	73.0	--	223	2,860
Grundy	529	186	--	--	--	--	--	383	1,200
Guthrie	555	153	--	--	--	--	--	266	981
Hamilton	595	146	139	7.3	80.4	--	--	303	1,080
Hancock	511	186	51.1	168	25.6	562	--	485	1,970
Hardin	822	215	--	588	102	172	--	303	1,490
Harrison	402	219	--	--	43.9	460	--	613	1,490
Henry	482	215	--	--	3,630	332	--	445	2,740
Howard	500	172	--	--	--	14.6	--	584	5,030
Humboldt	284	120	--	--	14.7	646	--	183	1,300
Ida	646	110	3.7	--	29.2	920	985	183	1,520
Iowa	865	256	11.0	--	32.9	69.4	--	295	2,630
Jackson	883	318	--	186	47.5	7.3	--	245	1,110
Jasper	825	387	--	21.9	14.7	76.7	--	507	12,100
			--	--	139	387	--	1,820	1,820
			--	--			--	1,440	3,180

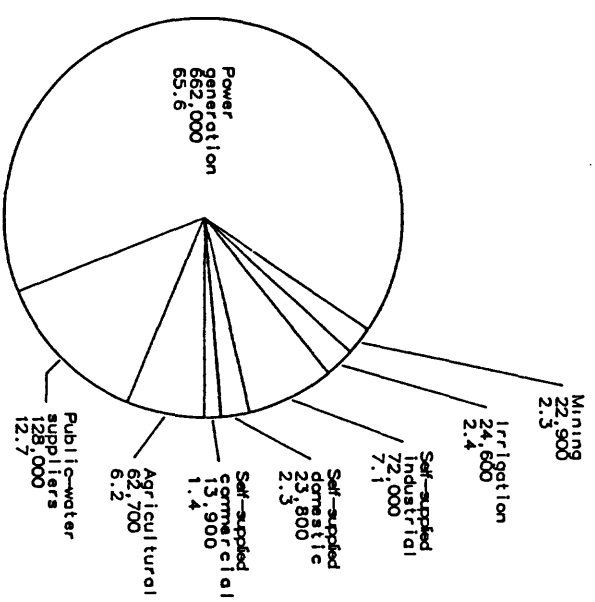
Table 2. Estimated total water use (cont.)
(All values are in million gallons;--value less than 0.01 million gallons.)

County	WATER USE CATEGORY							Public- water supply	Total
	Agricultural	Self-supplied domestic	Self-supplied commercial	Self-supplied industrial	Irrigation	Mining	Power		
Jefferson	417	186	--	--	62.1	551	--	510	1,730
Johnson	967	489	204	7.3	32.9	1,070	13,100	4,400	20,300
Jones	883	281	--	197	14.7	25.6	--	365	1,770
Keokuk	876	175	--	--	7.3	139	--	252	1,450
Kossuth	945	282	--	292	110	40.2	--	540	2,220
Lee	613	409	3.7	44,600	186	362	--	2,770	48,900
Linn	555	704	--	1,980	150	205	37,600	9,650	50,800
Louisa	284	197	--	128	511	25.6	1,480	186	2,810
Lucas	252	146	7.3	--	--	--	--	518	923
Lyon	821	193	--	--	310	7.3	--	343	1,670
Madison	522	212	--	--	32.9	58.5	--	179	1,000
Mahaska	993	277	40.2	--	54.8	496	--	1,260	3,120
Marion	686	292	485	--	32.9	317	--	1,070	2,880
Marshall	529	281	270	--	25.6	1,430	263	1,840	4,640
Mills	321	161	--	--	715	--	--	292	1,490
Mitchell	624	186	--	--	124	95.0	--	230	1,260
Monona	460	146	73.0	--	6,730	54.8	--	314	7,780
Monroe	402	150	--	51.1	--	14.7	--	164	782
Montgomery	445	124	--	--	--	11.0	--	522	1,100
Muscatine	457	343	--	4,140	438	657	51,100	6,750	63,900
O'Brien	891	172	--	--	69.4	365	--	511	2,010
Osceola	417	117	--	--	347	62.1	--	193	1,140
Page	610	161	--	--	216	135	--	625	1,750
Palo Alto	464	142	--	--	883	157	--	343	1,990
Plymouth	1,370	321	--	--	452	215	--	798	3,160
Pocahontas	445	164	--	--	29.2	18.3	--	230	887
Polk	193	730	51.2	270	259	890	1,210	14,500	18,100
Pottawattamie	866	526	5,080	325	646	135	171,000	3,350	182,000
Poweshiek	733	204	--	--	22.0	274	--	617	1,850
Ringgold	485	106	--	--	14.7	--	--	512	1,120
Sac	858	168	--	--	179	98.6	--	372	1,680
Scott	536	507	11.0	299	25.6	511	4,270	7,160	13,300
Shelby	818	193	--	29.2	58.5	68.4	--	456	1,620
Sioux	1,790	350	--	21.9	1,360	135	--	1,170	4,830
Story	398	241	98.6	91.3	153	832	--	3,570	5,380
Tama	686	256	391	628	--	--	--	442	2,400
Taylor	474	117	--	--	--	7.3	--	178	776
Union	427	131	--	--	--	11.0	--	412	981
Van Buren	376	168	--	11.0	--	282	--	131	968
Wapello	336	282	--	14.6	--	--	1,470	1,850	3,960
Warren	482	485	29.2	--	76.7	--	--	613	1,690
Washington	953	245	--	--	14.7	131	--	493	1,840
Wayne	430	139	7.3	--	--	--	--	139	715
Webster	417	310	--	650	58.5	464	--	2,070	3,970
Winnebago	262	124	91.3	--	80.4	--	--	460	1,020
Winneeshiek	1,250	248	--	18.3	22.0	47.5	--	496	2,180
Woodbury	1,040	318	--	2,040	2,420	110	190,000	4,420	201,000
Worth	208	146	--	--	73.0	873	--	139	1,440
Wright	314	135	405	142	36.5	18.3	--	518	1,570
Total	62,700	23,800	13,900	72,000	24,600	22,900	662,000	128,000	1,010,000

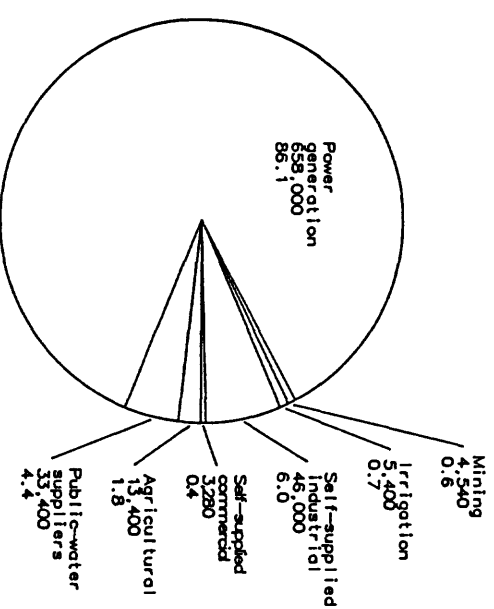
Consumptive water use includes the water that is no longer available for use because it has evaporated, transpired, been incorporated into products, consumed by people or livestock, or otherwise removed from the water environment. Estimated total consumptive water use during 1985 was 178,000 Mgal and is shown for each water-use category in figure 6. The water used for agriculture and irrigation was considered to be 100 percent consumed and accounted for 49 percent of the estimated total consumptive water use. Commercial and industrial consumptive use was estimated to be about 13 percent of withdrawals. About 3 percent of the water used for cooling purposes in thermoelectric power plants was estimated to be consumed through evaporation. Domestic users were estimated to consume 40 percent of withdrawals. Total consumptive use for the public-water supply category was estimated by applying the respective consumptive-use figures to the deliveries; losses in the distribution system also were included. The water consumed by mining processes is negligible.

Estimated total surface-water use for each hydrologic unit subregion is shown in figure 7. Over 96 percent of the total surface-water withdrawals were made in hydrologic unit subregions 0706, 0708, and 1023. Surface-water use in these areas, predominantly was for power generation.

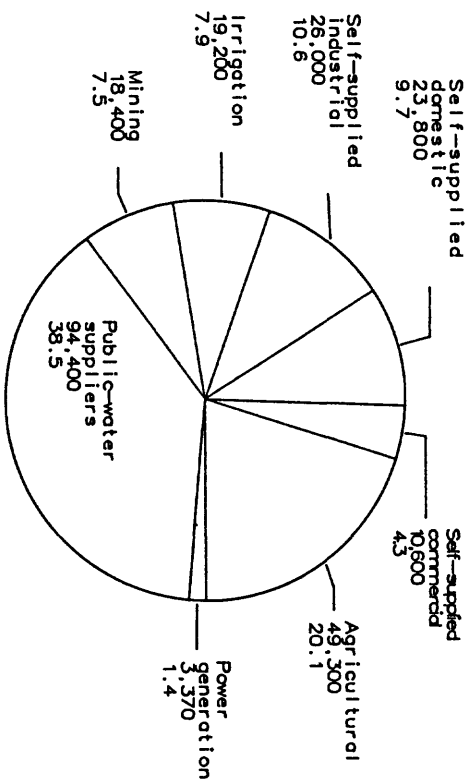
The proportion of the estimated total ground-water withdrawals by aquifer is shown in figure 8. Sixty percent of all ground-water withdrawals were from surficial aquifers.



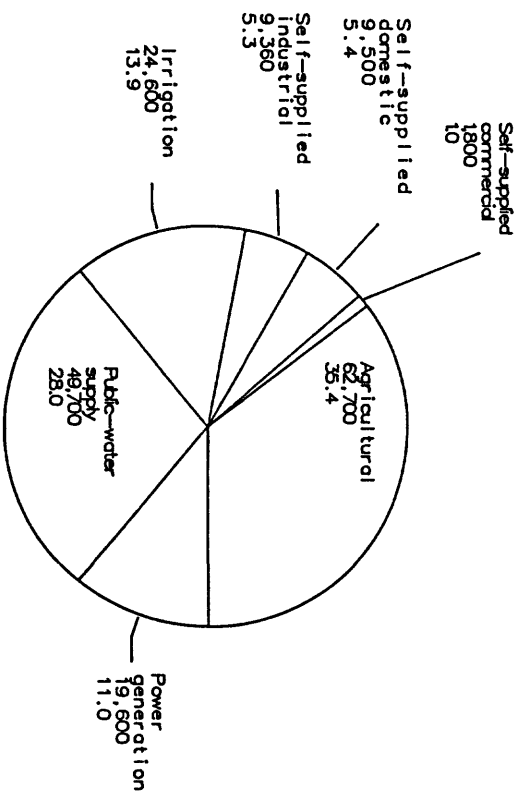
[Values are in million gallons and percent.]
Figure 3.—Estimated total water use by category.



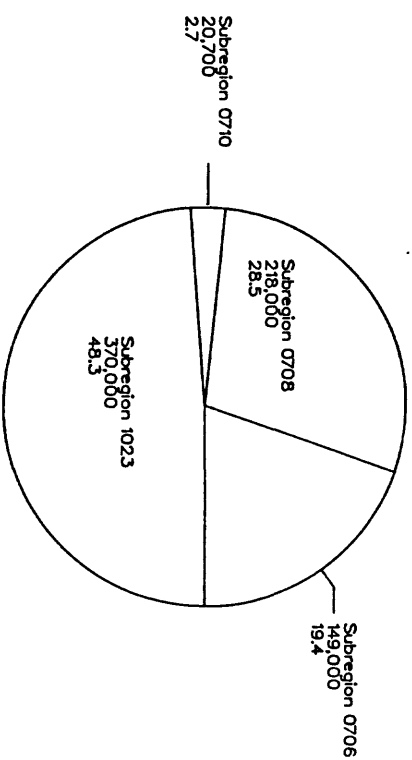
[All values are in million gallons and percent.]
Figure 4.—Estimated total surface-water use by category.



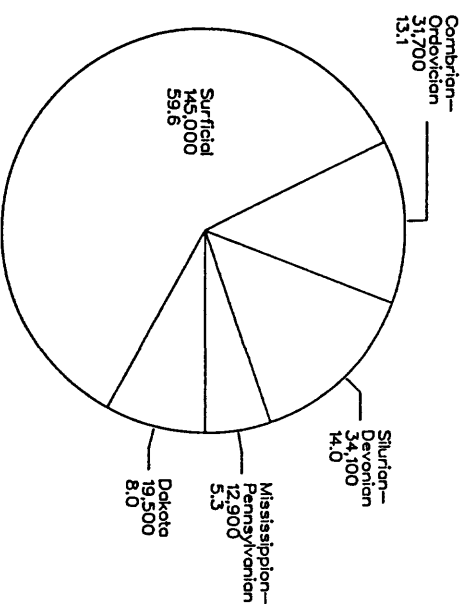
[All values are in million gallons and percent.]
Figure 5.—Estimated total ground-water use by category.



[All values are in million gallons and percent.]
Figure 6.—Estimated total consumptive water use by category.



[All values are in million gallons and percent; subregions with values less than 1.0 percent are not shown.]
Figure 7.—Estimated total surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent.]
Figure 8.—Estimated total ground-water use by aquifer.

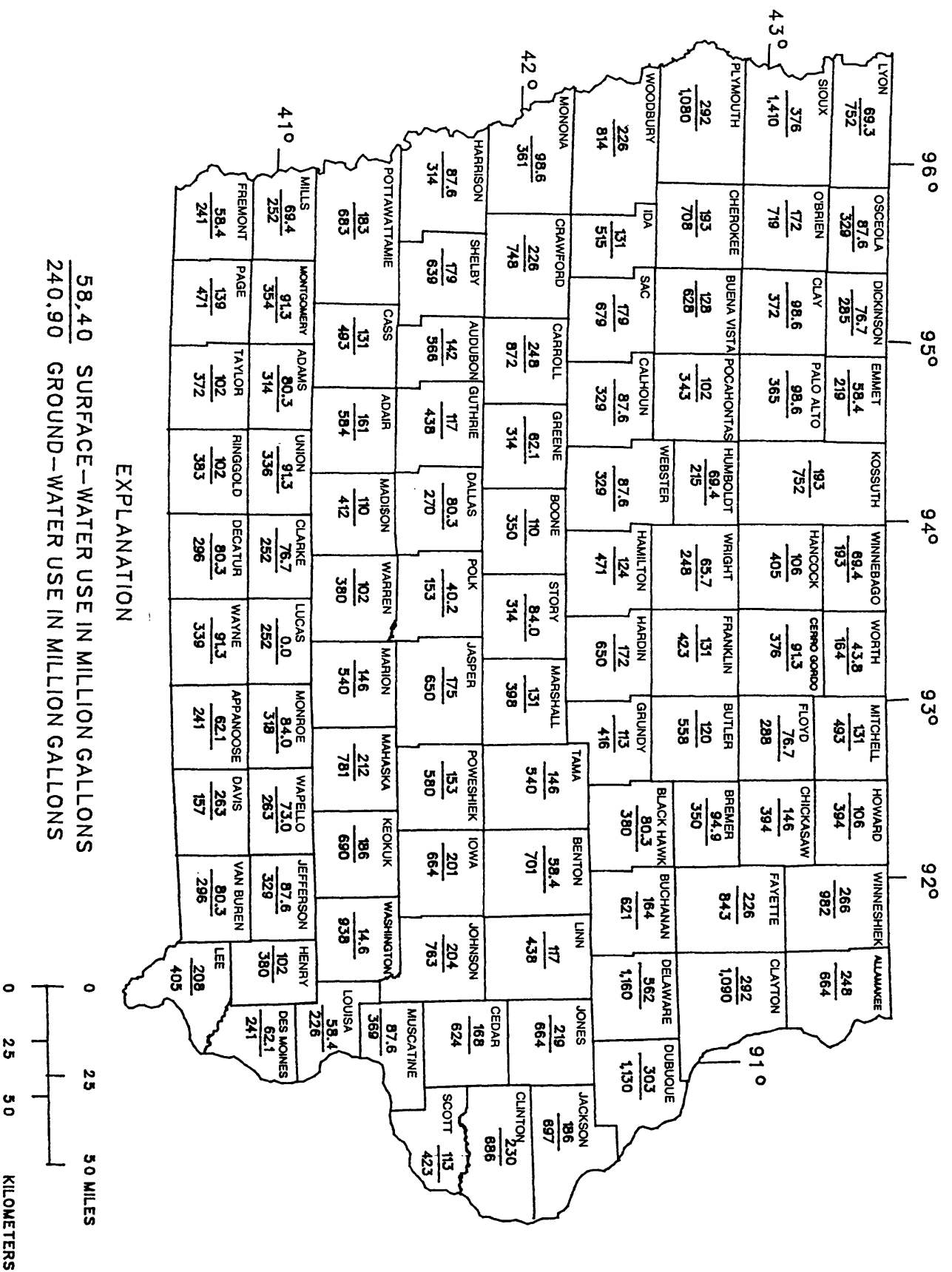


Figure 9.---Estimated agricultural water use by county.

Agricultural

Agricultural water use is defined as the water withdrawn for livestock feeding and upkeep and does not include irrigation withdrawals. The agricultural category accounted for 6 percent of the estimated total water use and more than 35 percent of the total consumptive water use.

Water withdrawals for agricultural activities were estimated to be 62,700 Mgal. Of this total, 79 percent, or 49,300 Mgal, was withdrawn from ground-water sources, and 13,400 Mgal was withdrawn from surface-water sources. The quantity of water withdrawn for agricultural water use in each county is shown in figure 9. Sioux County had the largest estimated agricultural water use with 1,790 Mgal. Surface-water withdrawals for each hydrologic unit subregion are shown in figure 10 and ground-water withdrawals for each aquifer are shown in figure 11. Surficial aquifers supplied 56 percent of the ground water used for agricultural purposes.

Water use by animal populations was as follows: hogs, 34,200 Mgal; cattle, 23,000 Mgal; milk cows, 4,410 Mgal; sheep, 318 Mgal; horses, 298 Mgal; chickens, 264 Mgal; and turkeys, 217 Mgal. All water used for livestock was considered to be consumed.

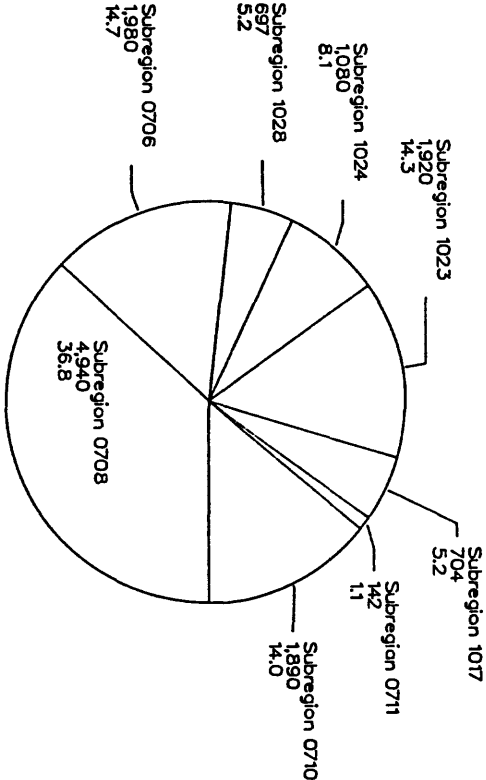
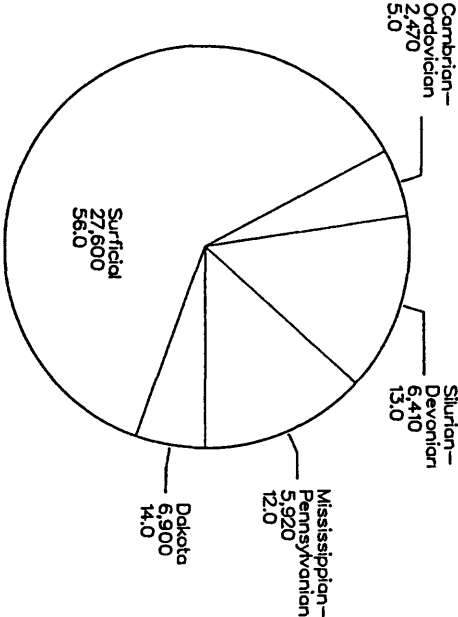


Figure 10.--Estimated agricultural surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent.]

Figure 11.--Estimated agricultural ground-water use by aquifer.

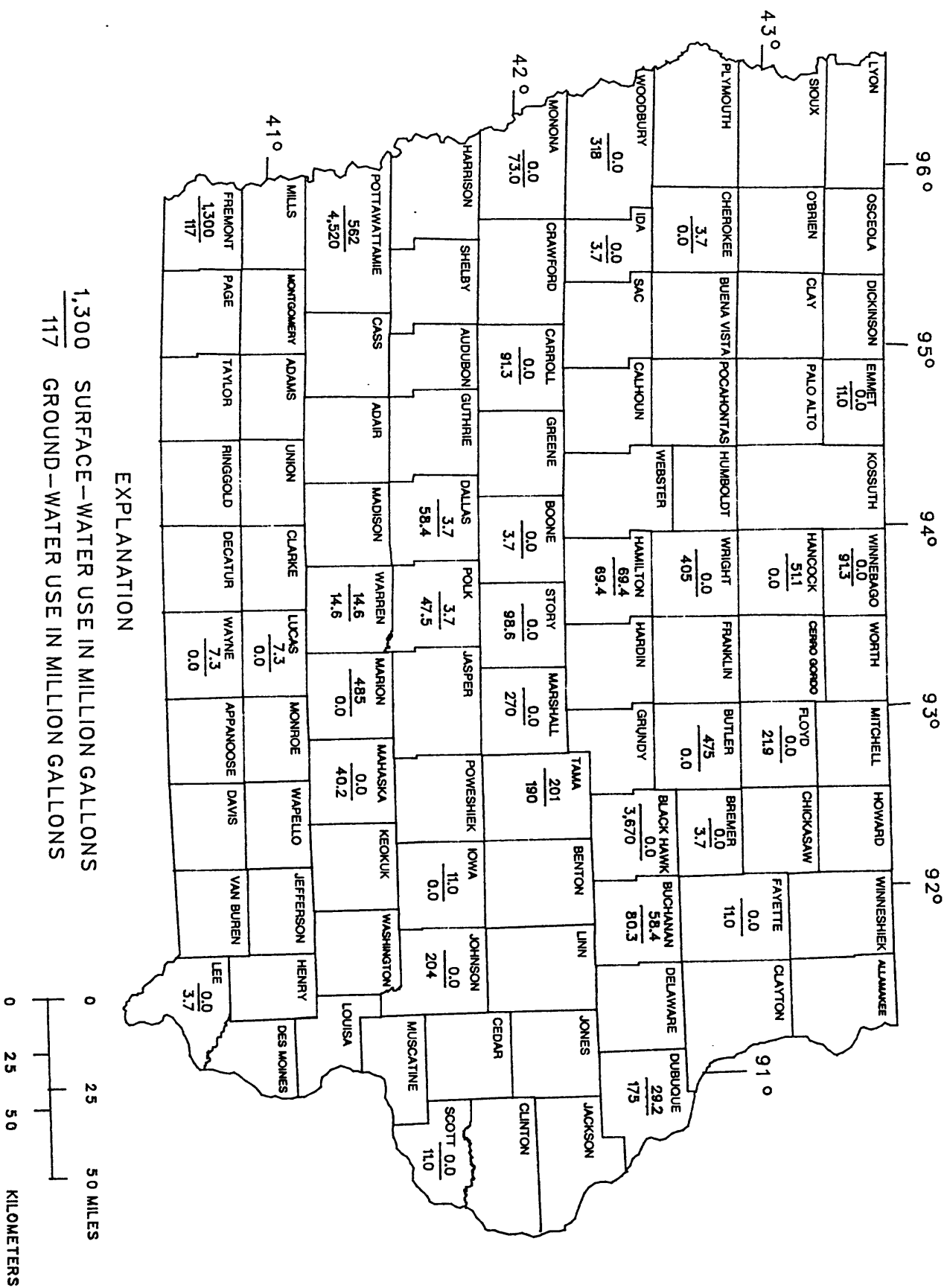


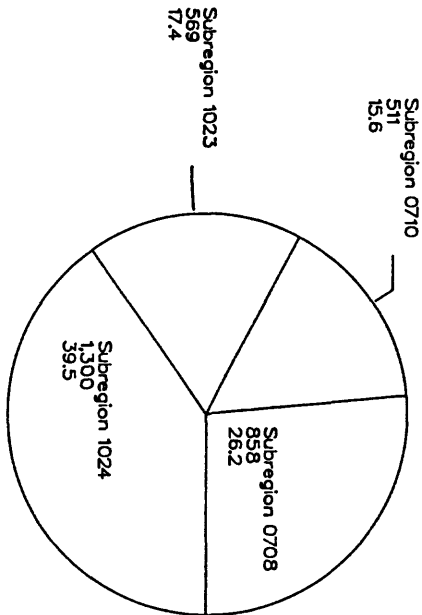
Figure 12.—Estimated self-supplied commercial water use by county.

Self-Supplied Commercial

The self-supplied commercial water-use category includes those users who made their own withdrawals from a surface- or ground-water source. Commercial users who purchase their water from public-water supplies are not included in this category. Uses of water in this category include air-conditioning, recreation, and services. Some examples of establishments in the self-supplied commercial category are hotels and other lodging places, recreational and amusement services, educational institutions, hospitals and governmental agencies.

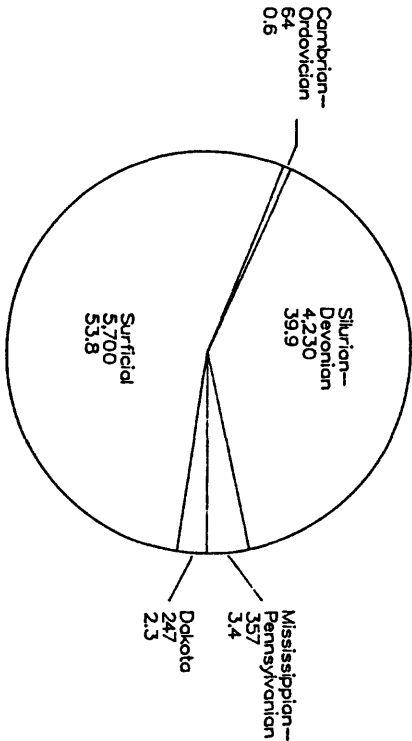
During 1985, there were about 110 permitted self-supplied commercial users in Iowa. A total of 13,900 Mgal was withdrawn, of which 76 percent was from ground-water sources and 24 percent was from surface-water sources. Withdrawal quantities for each county are illustrated in figure 12. Thirty-seven percent of the water withdrawn by self-supplied commercial users occurred in Pottawattamie County and 26 percent of the water withdrawn occurred in Black Hawk County.

Withdrawal quantities within each hydrologic unit subregion are shown in figure 13 and from each aquifer in figure 14. Of the total estimated ground water withdrawn for commercial use, about 54 percent was from surficial aquifers and 40 percent was from the Silurian-Devonian aquifer. Consumptive use was estimated to be 1,800 Mgal for the self-supplied commercial users.



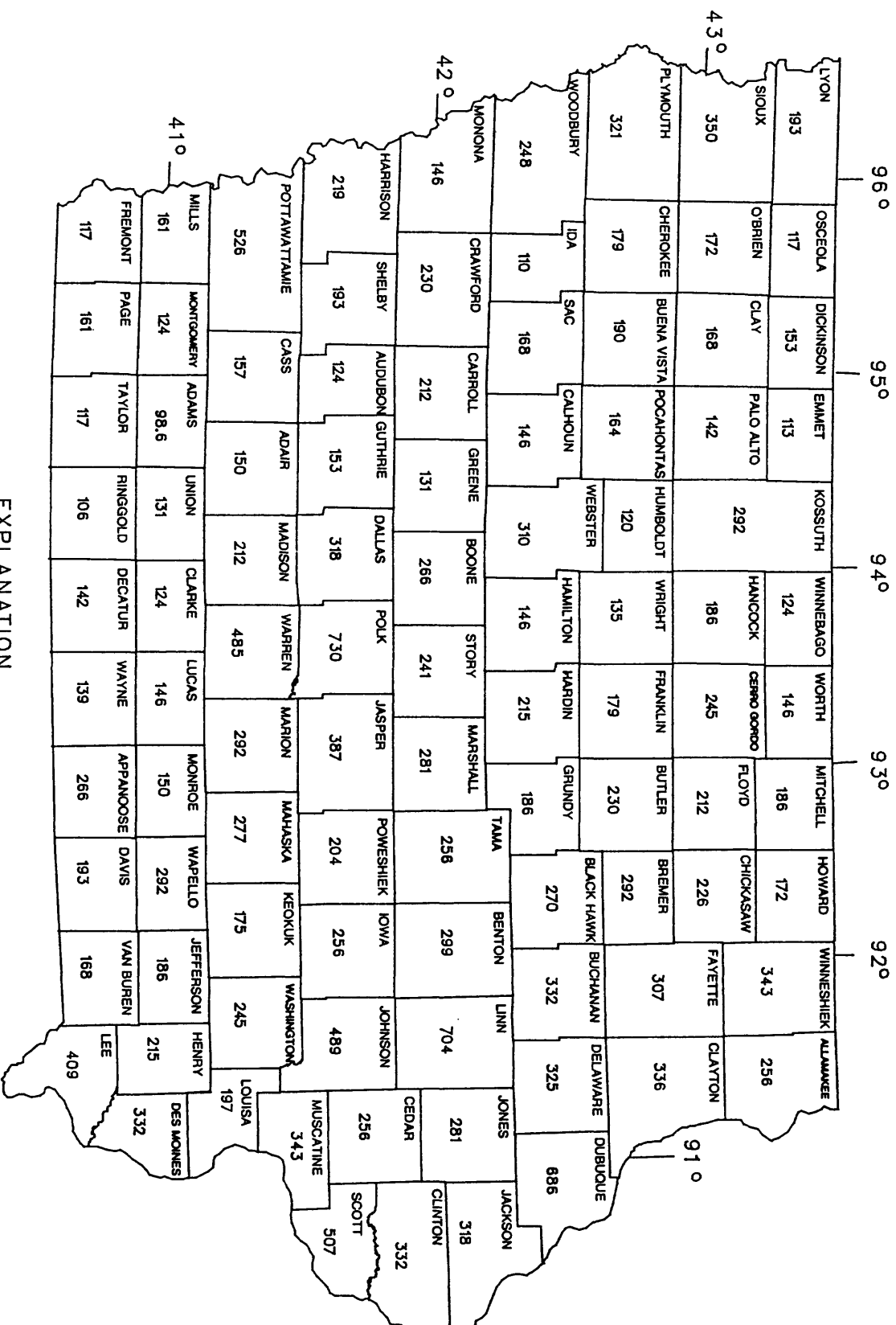
[All values are in millions of gallons and percent; subregions with values less than 1.0 percent are not shown.]

Figure 13.—Estimated self-supplied commercial surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent.]

Figure 14.—Estimated self-supplied commercial ground-water use by aquifer.



EXPLANATION

117 GROUND-WATER USE IN MILLION GALLONS

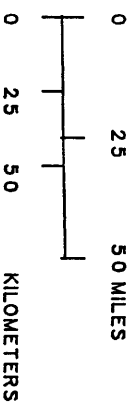


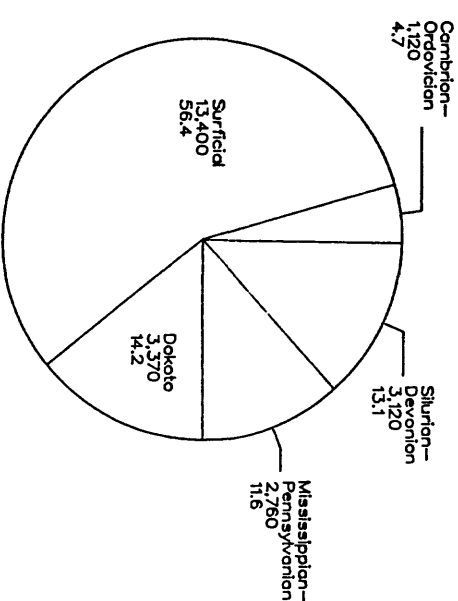
Figure 15.—Estimated self-supplied domestic water use by county.

Self-Supplied Domestic

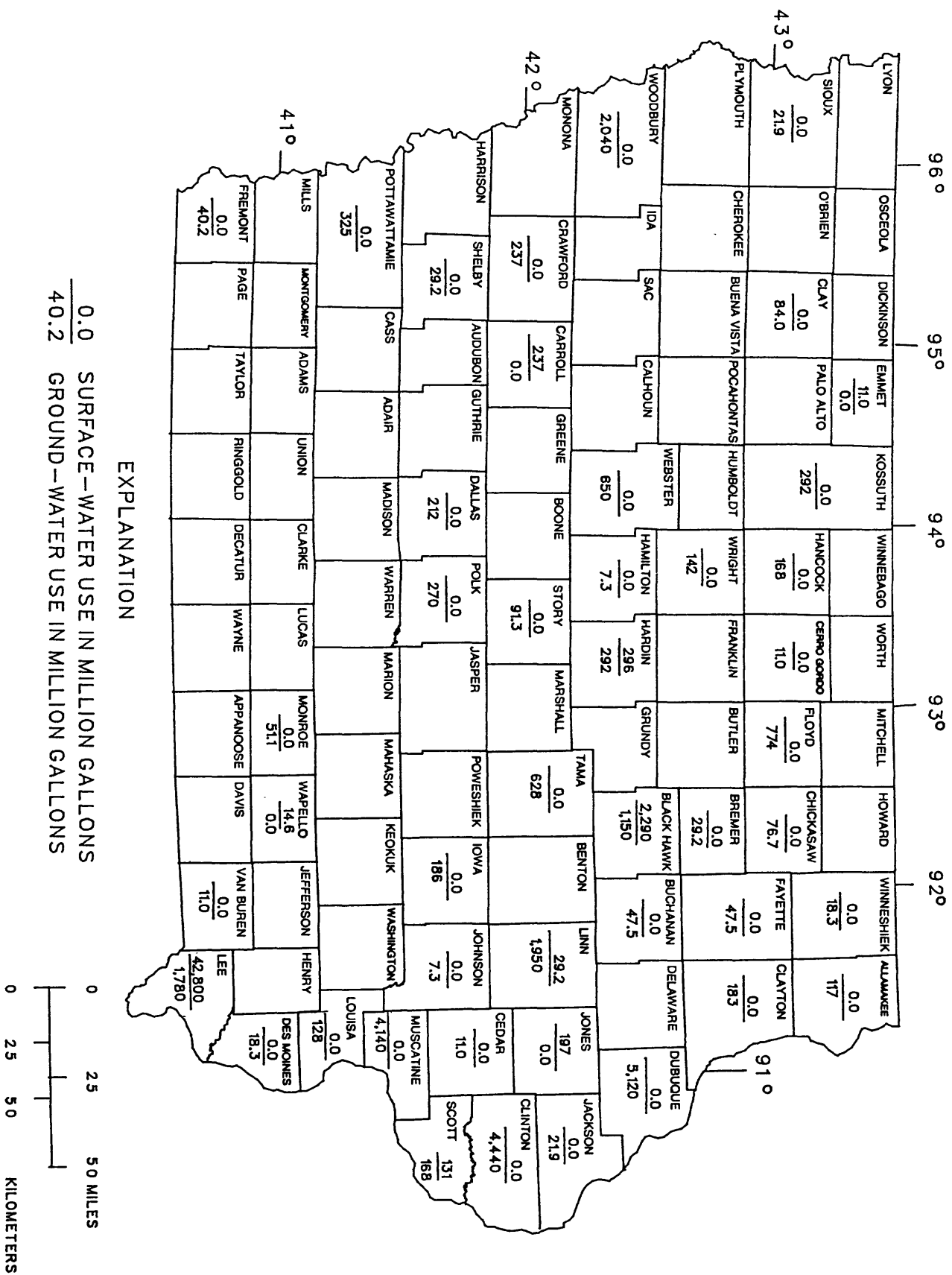
The self-supplied domestic water-use category includes water used for household activities such as drinking, food preparation, washing, and watering lawns. The self-supplied domestic users usually obtain water from privately owned wells. The number of people served by self-supplied systems was determined by subtracting the number of people served by public-water supplies from the total population. About 26 percent of the population uses self-supplied water. An average per capita water use of 85 gallons per day (Buchmiller and Karsten, 1983) was applied to the self-supplied domestic population.

In 1985, self-supplied domestic water use was 23,800 Mgal. Self-supplied domestic withdrawals for each county are shown in figure 15. Polk County had the largest self-supplied domestic water use of 730 Mgal. Linn County had the second largest self-supplied domestic withdrawals, 704 Mgal.

For this report, it was estimated that all withdrawals for self-supplied domestic water use were from ground-water sources. Therefore, a compilation of surface-water use in each hydrologic unit subregion was not prepared. Self-supplied domestic ground-water use by aquifer is shown in figure 16. Where available, surficial aquifers were used statewide because this water is the most inexpensive to access. Surficial aquifers accounted for about 56 percent of the self-supplied domestic withdrawals. In addition, self-supplied users in northwestern Iowa withdrew water from the Dakota aquifer, which is the bedrock aquifer that underlies the surficial deposits in that part of the State. The Silurian-Devonian aquifers were used in the northeastern and east-central section of Iowa and the Mississippian-Pennsylvanian aquifers were used in the central part of the State. In the extreme northeast where the younger rocks have been eroded, self-supplied domestic withdrawals included water from the Cambrian-Ordovician aquifers. Consumptive water use was 9,500 Mgal.



[All values are in million gallons and percent.]
 Figure 16.—Estimated self-supplied domestic ground-water use by aquifer.

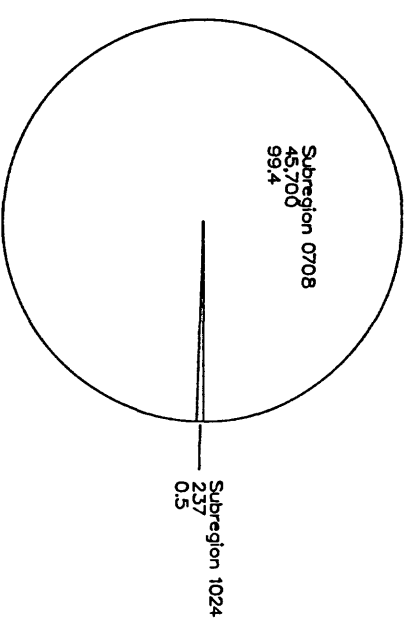


Self-Supplied Industrial

The self-supplied industrial category includes those industrial water users who made their own withdrawals from a surface- or ground-water source. Industrial users who purchased their water from public-water supplies are not included in this category. About 150 industries provided their own water supply in 1985. The industrial water-use category includes a variety of uses such as manufacturing, processing, washing, conveying, condenser cooling, air conditioning, and sanitation. Often industries required water for different processes and used a combination of water sources. For example, self-supplied surface water may have been used in cooling operations and water from public-water supplies used for sanitation purposes. Public-water supplies provided more than 15,000 Mgal to industries in 1985.

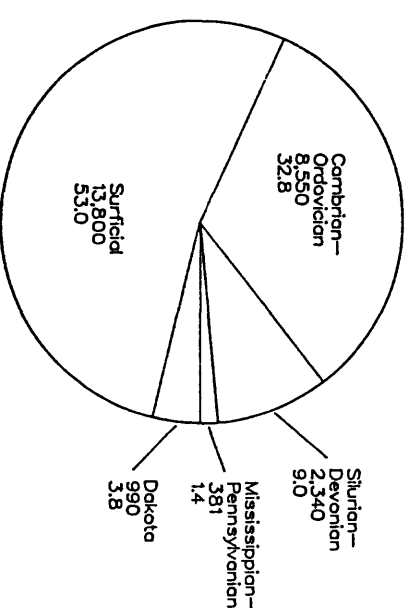
Of the 72,000 Mgal withdrawn by self-supplied industrial users, 64 percent was from surface-water sources and 36 percent was from ground-water sources. The distribution of estimated water use by county is shown in figure 17. About 140 permitted self-supplied industries were in 45 counties. A few major users accounted for most of the water withdrawn by self-supplied industries. One user in Lee County withdrew 93 percent of the surface-water withdrawals in the self-supplied industrial category.

Surface-water withdrawals within each hydrologic unit subregion are shown in figure 18. Ninety-nine percent of the self-supplied industrial surface-water withdrawals were from the Mississippi River. Ground-water withdrawals from each aquifer are shown in figure 19. Surficial aquifers were the source of 53 percent of the self-supplied industrial ground-water used. Consumptive use by self-supplied industries was estimated at 9,360 Mgal, an average of 13 percent of the withdrawals.



[All values are in million gallons and percent; subregions with values less than 0.1 percent are not shown.]

Figure 18.—Estimated self-supplied industrial surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent.]

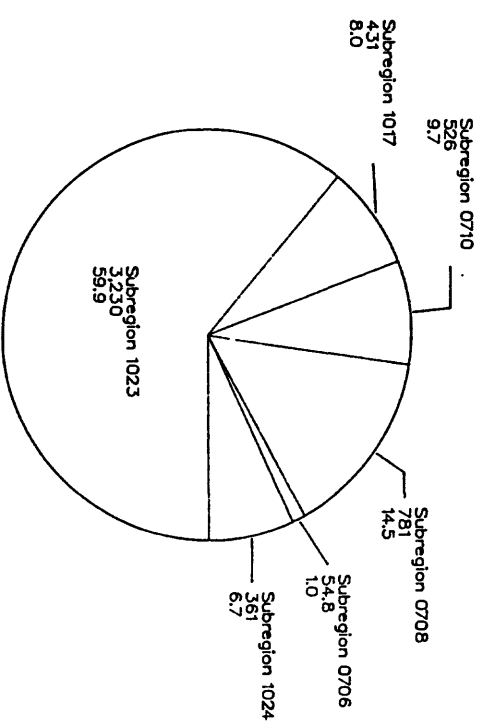
Figure 19.—Estimated self-supplied industrial ground-water use by aquifer.

Irrigation

The irrigation water-use category includes irrigation of farm crops, specialty crops, and golf courses. In 1985, a total of 24,600 Mgal was applied to 178,000 irrigated acres. Because the growing season occurred during warm and dry months, withdrawals during June, July, and August accounted for nearly 90 percent of the irrigation water use. Irrigation by spraying techniques, including center pivots, traveling guns, and sprinkler systems, was used on about 78 percent of the acres irrigated. The remaining acres were irrigated by flooding techniques.

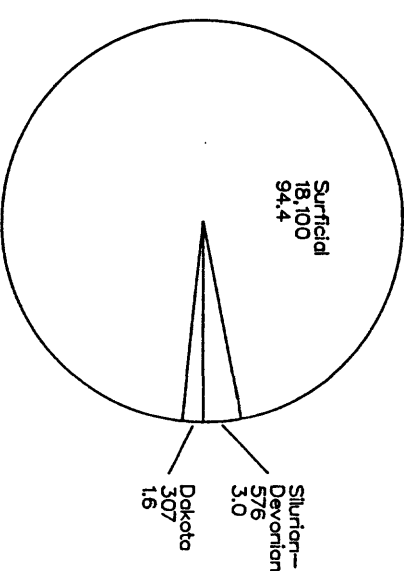
Of the total 24,600 Mgal withdrawn for irrigation purposes, 19,200 Mgal was obtained from ground-water sources and 5,400 Mgal from surface streams or ponds. Withdrawals by county are shown in figure 20. More than 69 percent of the State's irrigation withdrawals occurred in nine counties along the western border, where precipitation is less than the State average and sandy loam soils are present. The largest use of 6,730 Mgal occurred in Monona County followed by 3,630 Mgal and 2,420 Mgal in Harrison and Woodbury Counties. Withdrawals for irrigation are least in southern Iowa where sufficient shallow water sources required for irrigation generally are unavailable.

The distribution of surface-water withdrawals by hydrologic unit subregion are shown in figure 21. Surficial aquifers (fig. 22) were the source of 94 percent of the estimated irrigation ground-water use. Most of this water was easily accessed from wells completed in the alluvial deposits that underlie the flood plains of the Mississippi and Missouri Rivers. All the water used for irrigation was considered to be consumed by evapotranspiration and is about 14 percent of the total consumptive water use in Iowa.



[All values are in million gallons and percent; subregions with values less than 0.1 percent are not shown.]

Figure 21.—Estimated irrigation surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent; aquifers with values less than 1.0 percent are not shown.]

Figure 22.—Estimated irrigation ground-water use by aquifer.

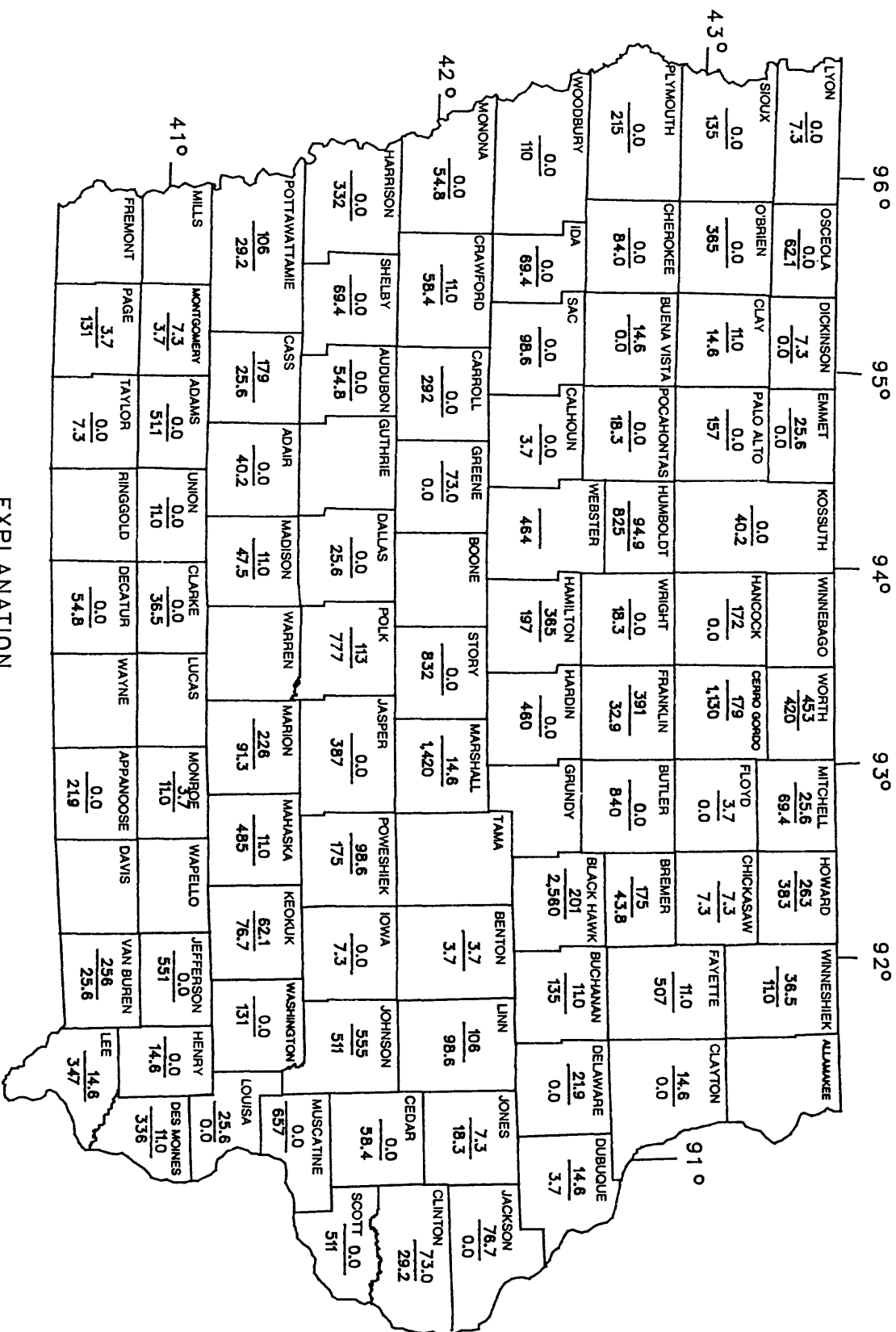
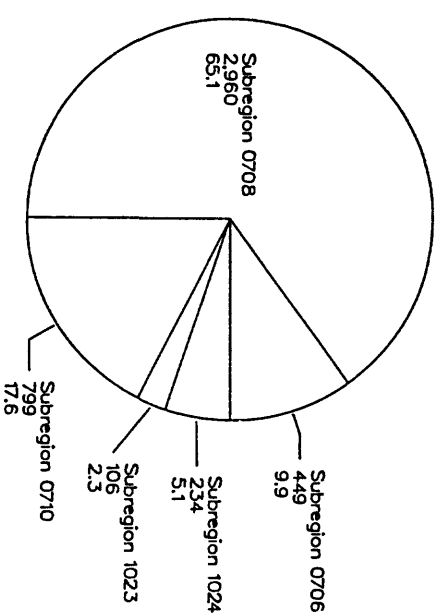


Figure 23.—Estimated mining water use by county.

Mining

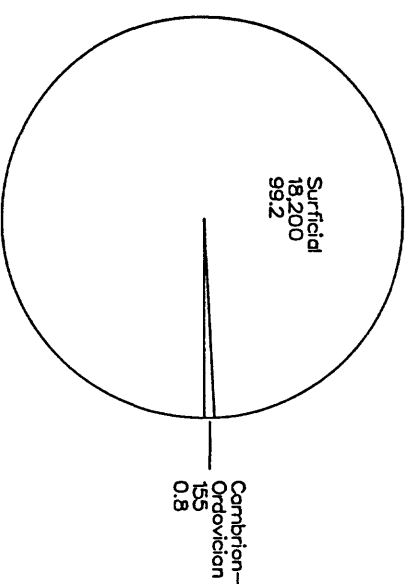
The mining water-use category is defined as that use associated with the extraction of naturally occurring minerals. The primary mining activities in Iowa include quarrying of limestone and the production of sand and gravel. Water use associated with construction sites also was included in the mining category. Mining operations in Iowa during 1985 accounted for 2 percent of the water used in the State. About 500 permits for mining activities have been issued in Iowa to more than 110 companies; 8 companies hold more than 200 of the permits. Over 40 percent of the permitted users reported no water use in 1985.

Water use for mining operations in Iowa was 22,900 Mgal. Surface- and ground-water withdrawals by county are shown in figure 23. Over 80 percent of the total water used in mining was from ground-water sources. Twelve percent of the total mining withdrawals occurred in Black Hawk County. Surface-water use within each hydrologic unit subregion is shown in figure 24. Mining operations were most intensive in the central part of the State where thick sand and gravel deposits are present. Surficial aquifers (fig. 25), most often accessed through open pits and quarries, were the source of nearly all the ground-water withdrawn. The water withdrawn for most mining operations was used for washing and dewatering. The water consumed by these processes is negligible.



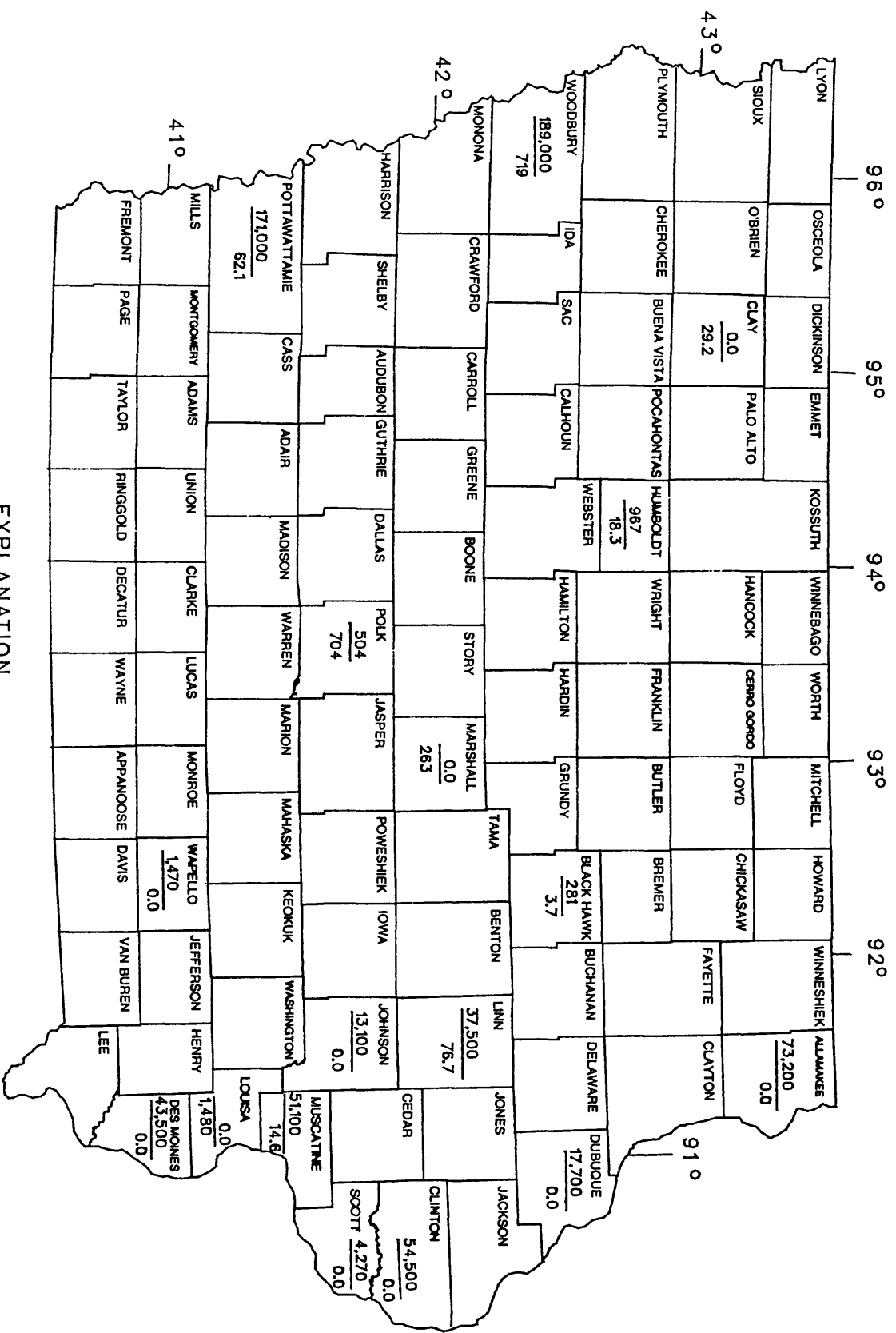
[All values are in million gallons and percent; subregions with values less than 0.1 percent are not shown.]

Figure 24.—Estimated mining surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent; aquifers with values less than 0.1 percent are not shown.]

Figure 25.—Estimated mining ground-water use by aquifer.



EXPLANATION

171,000 SURFACE-WATER USE IN MILLION GALLONS

62.1 GROUND-WATER USE IN MILLION GALLONS

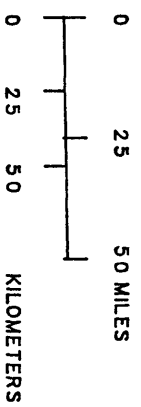


Figure 26.—Estimated power generation water use by county.

Power Generation

The power generation water-use category includes the water used by thermoelectric power generating facilities and is the category with the largest water use. Thermoelectric power generating facilities in Iowa include fossil-fuel and nuclear-powered plants. Most of the large thermoelectric power plants operate along the Mississippi and Missouri Rivers. The only nuclear power plant is located in Linn County. One percent of the water withdrawn for thermoelectric power generation was used at the nuclear power plant. During 1985, thermoelectric power plants generated 22,300 gigawatt-hours of electricity, of which the nuclear power plant produced 2,700 gigawatt-hours. Deliveries from public supplies were negligible.

Surface and ground water withdrawn by county for thermoelectric power generation plants in 1985 is shown in figure 26. Total power generation water use was 662,000 Mgal; surface-water withdrawals were 659,000 Mgal and ground-water withdrawals were 3,370 Mgal. The largest withdrawal of water was 190,000 Mgal in Woodbury County.

Withdrawals by hydrologic unit subregion are shown in figure 27 and withdrawals from aquifers are shown in figure 28. Surficial aquifers were the principal source of ground water. Nearly 3,320 Mgal was withdrawn from these aquifers. The main use of water in this category was for the production of steam and for cooling equipment (Buchmiller and Karsten, 1983). It was estimated that about 3 percent of the withdrawals, or 19,600 Mgal, was consumed by evaporation during these processes and the remaining 97 percent was available to downstream users.

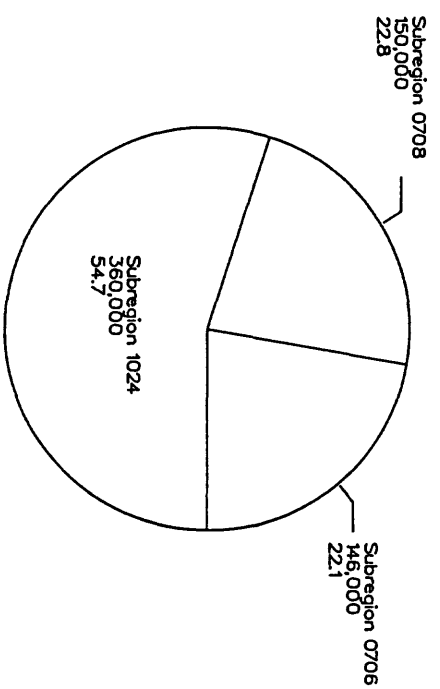


Figure 27.—Estimated power generation surface-water use by hydrologic unit subregion.

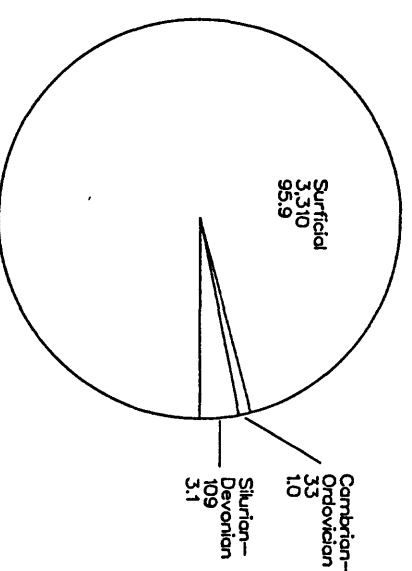


Figure 28.—Estimated power generation ground-water use by aquifer.

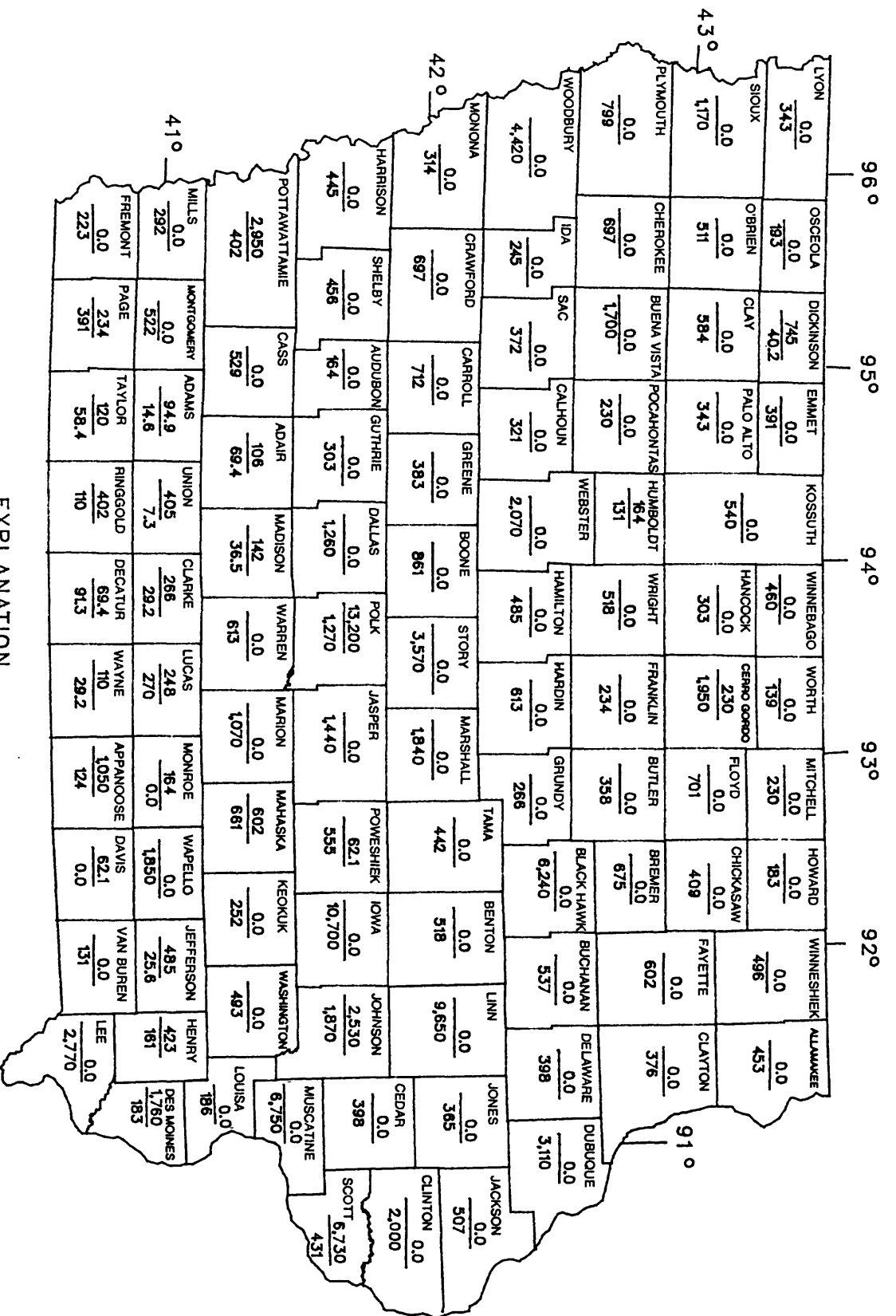


Figure 29.—Estimated public-water supply water use by county.

Public-Water Supply

The public-water supply category is the second largest use of water in Iowa. A public-water supplier is defined as an establishment primarily engaged in the distribution of water for sale for domestic, commercial, and industrial purposes. Some examples of public-water suppliers are cities, towns, mobile home parks, housing associations, and rural water associations. Water use was based on withdrawals by the public-suppliers rather than on metered customer usage. As a result, losses in the distribution system and other nonmetered uses are included in this section.

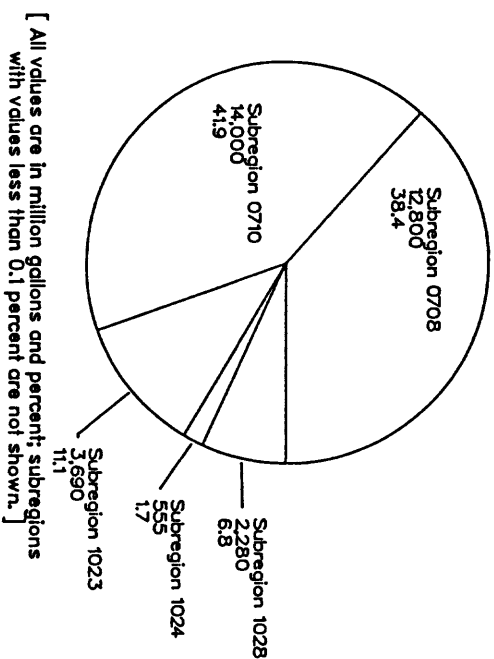
The quantity of surface and ground water used by public-water supplies in each county is shown in figure 29. The largest withdrawal was 14,500 Mgal in Polk County. In the northern two-thirds of the State, surface water is used as a source for public-water supplies in only 6 of the 68 counties because abundant ground water of suitable quality is available. In the southern one-third of the State, the quality of available ground-water is less desirable. The principle bedrock aquifer in this area is the Prairie du Chien-Jordan aquifer. However, its depth generally exceeds 1,000 feet below the land surface and the water is highly mineralized (Cagle and Heinitz, 1978, p. 45 and 78). Therefore, surface-water sources are more widely used by public-water suppliers in this area.

A total of 128,000 Mgal was estimated to have been withdrawn by public-water suppliers during 1985. Of this, 94,400 Mgal, or 74 percent was from ground-water sources, and 26 percent was from surface-water sources. Surface-water withdrawals within each hydrologic unit subregion are shown in figure 30. Ground-water withdrawals for each aquifer are shown in figure 31. All of the ground water was from wells, with over 48 percent from surficial aquifers. The Cambrian-Ordovician aquifer was the source of 20 percent of the ground-water withdrawals, and the Silurian-Devonian aquifer was the source of 18 percent.

Public-water suppliers delivered water to domestic, commercial, and industrial users. Domestic water use accounted for 86 percent, or 105,000 Mgal, of the public-water supply deliveries. Industrial users received 15,100 Mgal and commercial users received 1,520

Mgal. Total consumptive use for the public-water supply category was 49,700 Mgal. This included 42,200 Mgal consumed by domestic users; 1,960 Mgal consumed by industrial users; 198 Mgal consumed by commercial users and 5,380 Mgal were unmetered use or losses in the distribution system.

Figure 30.—Estimated public-water supply surface-water use by hydrologic unit subregion.



[All values are in million gallons and percent.]

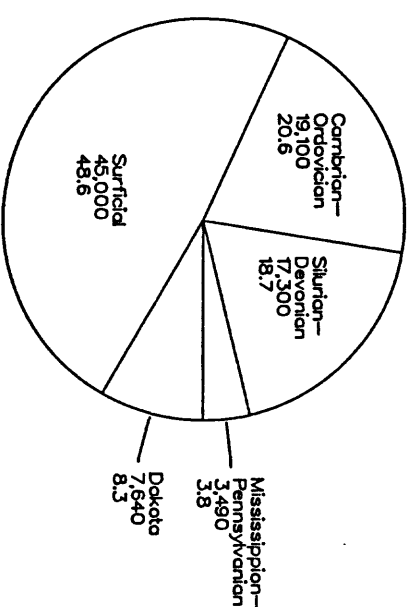


Figure 31.—Estimated public-water supply ground-water use by aquifer.

Summary

During 1985, total estimated water withdrawals in Iowa were 1,010,000 Mgal. Of this total, 764,000 Mgal were from surface-water sources and 245,000 Mgal were from ground-water sources. The power generation category was the largest user of water, withdrawing 662,000 Mgal; more than 99 percent of this was from surface-water sources. The second largest withdrawals were made by the public-water supply category, withdrawing 128,000 Mgal; 74 percent of this was from ground-water sources. If power generation is excluded from the total water use, public-water supply accounted for 37 percent of the total use. The self-supplied industrial water-use category was the third largest user of water, withdrawing 72,000 Mgal. The remaining water use by category was agricultural, 62,700 Mgal; self-supplied domestic, 23,800 Mgal; irrigation, 24,600 Mgal; mining, 22,900 Mgal; and self-supplied commercial, 13,900 Mgal. Nearly 58 percent of the total water use occurred in five counties that have thermoelectric power plants operating on the Mississippi or Missouri Rivers. More than 96 percent of the total surface-water withdrawals were made in hydrologic unit subregions 0706, 0708, and 1023. These subregions are bordered by the Mississippi and Missouri Rivers. Surficial aquifers were the source of 60 percent of the ground-water withdrawals. The remaining 40 percent was withdrawn from the following aquifers: Silurian-Devonian, 14 percent; Cambrian-Ordovician, 13 percent; Dakota, 8 percent; and Mississippian-Pennsylvanian, 5 percent. Total consumptive use was estimated to be 178,000 Mgal. Thirty-five percent of the water consumed was in the agricultural water-use category and 28 percent was in the public-water supply category. Irrigation accounted for 14 percent of the water consumed. The remaining consumptive water use was as follows: power generation, 11 percent; self-supplied industrial, 5 percent; self-supplied domestic, 5 percent; and self-supplied commercial, 1 percent.

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