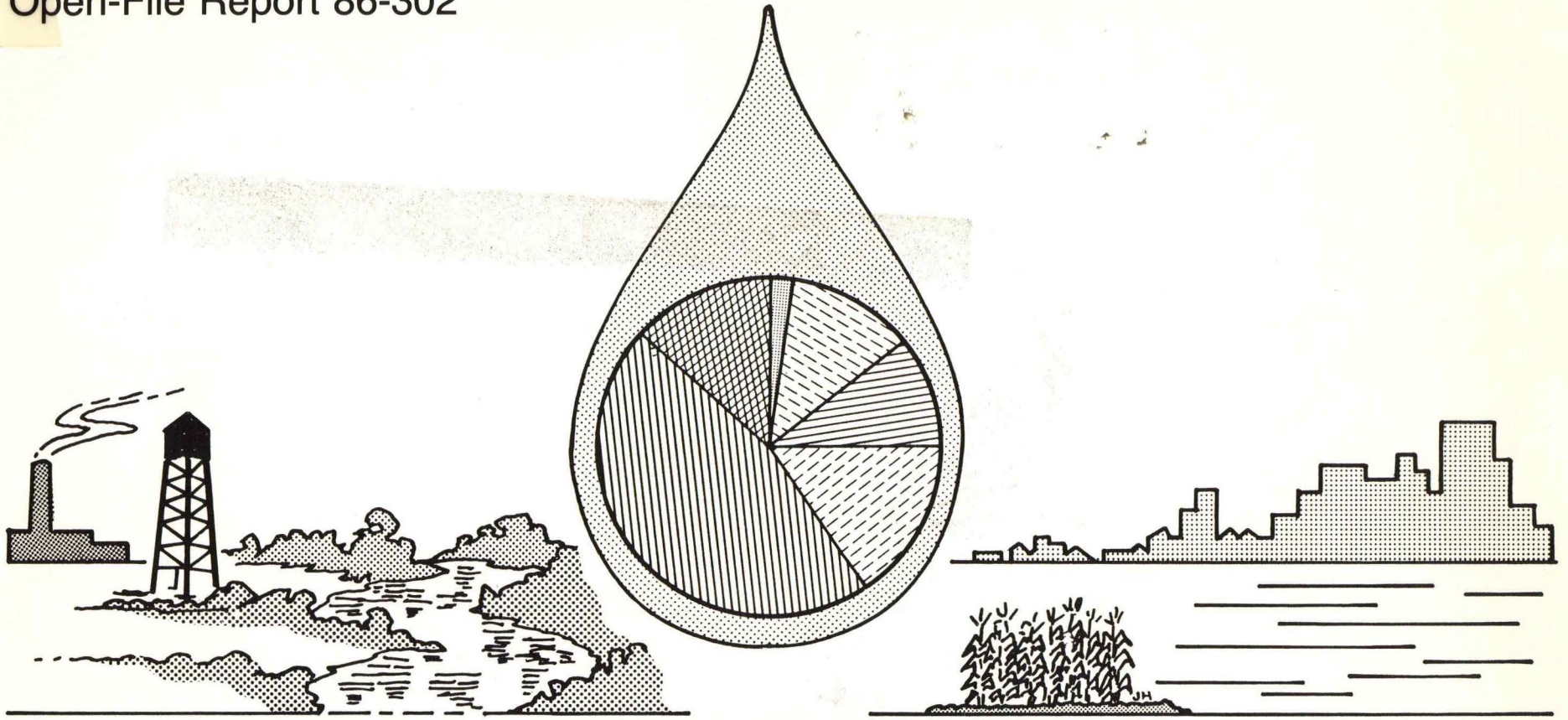


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# PERMITTED WATER USE IN IOWA, 1985

U.S. GEOLOGICAL SURVEY  
Open-File Report 86-302



Prepared in cooperation with  
IOWA DEPARTMENT OF WATER, AIR AND WASTE MANAGEMENT and the  
IOWA GEOLOGICAL SURVEY

# **PERMITTED WATER USE IN IOWA, 1985**

By D. L. Runkle, J. L. Newman and E. M. Shields

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**IOWA DEPARTMENT OF WATER, AIR AND WASTE MANAGEMENT** and the  
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Iowa City, Iowa  
1985

**UNITED STATES DEPARTMENT OF THE INTERIOR**

DONALD PAUL HODEL, *SECRETARY*

**GEOLOGICAL SURVEY**

Dallas L. Peck, *Director*

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## CONTENTS

Abstract .....	1
Introduction.....	1
Acknowledgements .....	1
Explanation of data .....	2
Aquifers in Iowa .....	2
Total permitted water use .....	4
Agricultural (non-irrigational) .....	7
Self-supplied commercial.....	9
Self-supplied industrial.....	11
Irrigation .....	13
Mining .....	15
Power generation .....	17
Public water suppliers .....	19
Summary.....	24
Selected references.....	24

## FIGURES

1. Total permitted water use in Iowa Counties, 1985 .....	3
2. Total permitted water use by category .....	4
3. Total permitted surface-water use by category.....	4
4. Total permitted ground-water use by category.....	5
5. Total permitted surface-water use by source .....	5
6. Total permitted ground-water use by source .....	5
7. Total permitted ground-water use by aquifer .....	5
8. Permitted agricultural (non-irrigation) water use in Iowa Counties, 1985 .....	6
9. Permitted agricultural (non-irrigation) surface-water use by source.....	7
10. Permitted agricultural (non-irrigation) ground-water use by aquifer.....	7
11. Permitted self-supplied commercial water use in Iowa Counties, 1985 .....	8

12. Permitted self-supplied commercial surface-water use by source .....	9
13. Permitted self-supplied commercial ground-water use by source .....	9
14. Permitted self-supplied commercial ground-water use by aquifer .....	9
15. Permitted self-supplied industrial water use in Iowa Counties, 1985 .....	10
16. Permitted self-supplied industrial surface-water use by source .....	11
17. Permitted self-supplied industrial ground-water use by aquifer .....	11
18. Permitted irrigation water use in Iowa Counties, 1985 .....	12
19. Permitted irrigation surface-water use by source .....	13
20. Permitted irrigation ground-water use by source .....	13
21. Permitted irrigation ground-water use by aquifer .....	13
22. Permitted mining water use in Iowa Counties, 1985.....	14
23. Permitted mining surface-water use by source.....	15
24. Permitted mining ground-water use by source.....	15
25. Permitted mining ground-water use by aquifer.....	15
26. Permitted power water use in Iowa Counties, 1985 .....	16
27. Permitted power surface-water use by source .....	17
28. Permitted power ground-water use by aquifer .....	17
29. Permitted public water supplier water use in Iowa Counties, 1985 .....	18
30. Permitted public water supplier surface-water use by source .....	19
31. Permitted public water supplier ground-water use by aquifer .....	19

## TABLES

1. Total permitted water use, in million gallons per year, by category for each county .....	20
2. Aquifers in Iowa .....	22

# Permitted Water Use in Iowa, 1985

by D. L. Runkle, J. L. Newman and E. M. Shields

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## Abstract

This report summarizes where, how much and for what purpose water is allocated for use in Iowa with permits issued by the Department of Water, Air and Waste Management. In Iowa, from a total permitted water use of 855,175.45 million gallons per year, about 58 percent is from surface-water sources and about 42 percent is from ground-water sources. Streams are 80.5 percent of the total surface-water use and wells make up 80.1 percent of the total ground-water use, with 65.4 percent of ground water coming from surficial aquifers. Power generation is the use category that is permitted the largest amount of total water use, 46.6 percent, with surface water being the source of 96.7 percent and 77.9 percent of the surface water is from streams. The public water suppliers' category is the next largest use type with 15.7 percent of the total permitted water. Ground water constitutes 74.4 percent of the public water supplier category with 51.7 percent from surficial aquifers. Surface water makes up 25.6 percent of this category with 83.0 percent of the surface water withdrawn from streams. Mining comprises 13.4 percent of the total water use and is the third largest water-use category. Ground water is the source of 63.3 percent of permitted mining water use with 94.3 percent of this from quarries and sand and gravel pits. Surface water is the source of 36.7 percent of the permitted mining water use with 97.6 percent from streams. Irrigation is the fourth largest permitted use type using 12.0 percent of the total water use. Eighty-eight percent of irrigation is from ground-water sources where surficial aquifers account for 94.7 percent. Streams are 81.1 percent of irrigational surface-water use. Self-supplied industrial users are permitted 10.6 percent of the total permitted water use with 85.5 percent of this from ground-water sources and 14.5 percent from surface-water sources. Of the self-supplied industrial ground-water use, 47.9 percent comes from surficial aquifers and of the self-supplied industrial surface-water use 86.1 percent is from streams. Self-supplied commercial use is allocated 1.5 percent of the total permitted water. Surface-water is the source of 37.7 percent of this and 62.3 percent is from ground-water sources. Agricultural (non-irrigation) use is 0.3 per-

cent of the total permitted water with 73.3 percent from ground-water sources and 26.7 percent from surface-water sources. The areas that are allocated the most water permits are east-central Iowa and west-central Iowa.

## Introduction

The information presented in this report was compiled to summarize the amount of water allocated through the Department of Water, Air and Waste Management's (DWAWM) water permit system. The data used in this report includes all active permits that were issued by DWAWM prior to July 26, 1985. This data represents maximum permitted withdrawals and not necessarily actual use.

As part of an amendment to the 1957 Iowa Water Law, beginning July 1, 1985, all water users who use more than 25,000 gallons per day (gpd) have one year to obtain a water withdrawal permit from DWAWM. Prior to this, municipal water users and self-supplied water users, within city limits, in existence before 1957, were not required to apply for permits if they did not increase withdrawal amounts or change the source from which they withdrew water. Also with this amendment, water users withdrawing more than 25,000 gpd from the Mississippi, Missouri and the segments of the Big Sioux River and the Des Moines River that make up the State border between Lee County and Missouri will be required to obtain a permit. With this new legislation, it is expected that many new water withdrawal permits will be issued to longstanding water users in Iowa.

## Acknowledgements

The authors would like to extend thanks to the Department of Water, Air and Waste Management for collecting water-use information over the years and providing the permitted water-use data for this report. A special thanks to James Wiegand, of the Department of Water, Air and Waste Management, for lending his expertise to the subject, supplying the data, and providing a thorough and helpful review of the report.

## Explanation of data

A water use permit is issued to a water user for an area of land. Water is allocated from three major sources: wells, reservoirs, and streams. For this report, reservoirs are divided into 7 types: natural lakes, artificial lakes, farm ponds, main-stem reservoirs (dams constructed across a major drainage way), and lagoons are surface-water types of reservoirs. Sand or gravel pits and quarries are considered ground-water reservoirs.

Some assumptions concerning the data were made for this report. When the same amount of water is allocated from different sources (wells, reservoirs, or streams) within the same permit, the amount allocated is divided equally between the sources. For example, if 52.1 million gallons per year (mgy) is allocated from both wells and streams then it is assumed that 26.05 mgy is allocated from wells and 26.05 mgy from streams. When water is permitted from several different aquifers it is assumed, for this report, that all the water is allocated from the primary aquifer.

For this report, the total permitted water use and the permitted water for each of the seven water-use categories is divided into surface water and ground water and presented on the State map for each County along with the number of permits issued. Pie diagrams illustrate the distribution of surface-water, ground-water, and total water use by water-use category. For each water-use category, pie diagrams are used, when appropriate, to illustrate the amount of water permitted from different surface-water and ground-water sources. Bar diagrams are used to represent the amount of water allocated from ground-water aquifers.

## Aquifers in Iowa

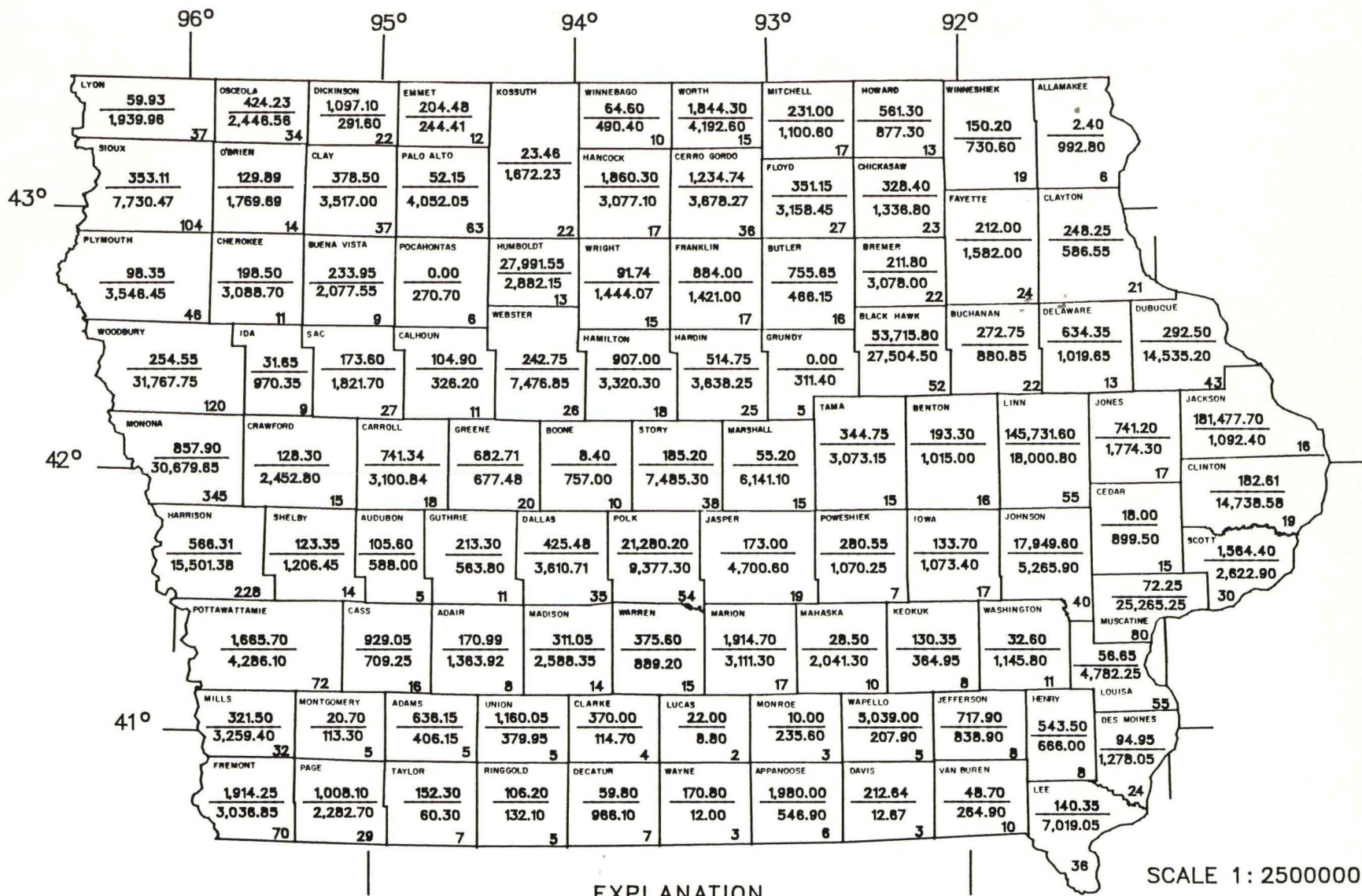
Rocks and sediments, such as sand and gravel, sandstone, and fractured limestone, that store and transmit significant quantities of water to wells are called aquifers. Shale, unfractured limestone, glacial till, and clay generally restrict water movement and form confining units. Table 2 describes the geologic and hydrogeologic units in Iowa. The commonly discussed aquifers in Iowa are listed under the hydrogeologic unit column in table 2.

Surficial aquifers are unconsolidated deposits of sediment near the land surface. Alluvium consists of sand and gravel deposits that are located underneath the floodplains of the major rivers in Iowa. Some sand and gravel deposits interbedded with glacial till may contain small amounts of water accessible to wells. Locally, buried channel deposits, which are ancient stream sediments overlain by glacial till, are important aquifers.

Beneath these unconsolidated deposits are layers of consolidated sedimentary rocks called bedrock. The five major bedrock aquifers in Iowa are the Dakota, Mississippian, Silurian-Devonian, Prairie du Chien-Jordan, and Dresbach aquifers. Two other aquifers are the Pennsylvanian, which is used in parts of western Iowa, and the St. Peter, which is used with the underlying Jordan aquifer. Some aquifers are separated from one another by confining beds in certain parts of Iowa.

For this report, the water permitted from the Pennsylvanian and Mississippian aquifers was combined in the aquifer bar diagrams because the water allocated 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. In Iowa, the Prairie du Chien-Jordan aquifer is generally the most productive and the most used of the Cambrian-Ordovician aquifers. Therefore, most of the water allocated from the Cambrian-Ordovician aquifers is probably from the Prairie du Chien-Jordan aquifer.

Underlying the sedimentary rocks in Iowa are metamorphic and igneous crystalline rocks of Precambrian age. These rocks form the base of the ground-water reservoir in Iowa.



1,914.25 surface-water use in million gallons per year  
3,036.85 ground-water use in million gallons per year  
 70 the number of permits issued

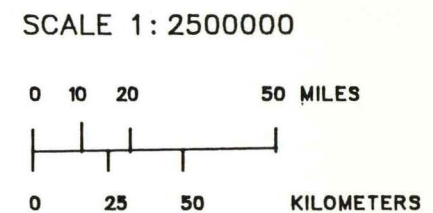


Figure 1. Total permitted water use.

## Total permitted water use

A total of 855,175.45 mgy is permitted to be withdrawn from Iowa's surface-water and ground-water resources. Of this total, 492,001.66 mgy, or 57.5 percent, is permitted from surface-water sources and 363,173.79 mgy, or 42.5 percent, from ground-water sources.

The distribution of permitted water use and number of permits issued by county is shown in figure 1. Table 1 shows the total permitted water use by category for each county. The largest permitted water use is 182,570.10 mgy in Jackson County. More than 99.2 percent of this total is permitted for power generation. Linn County has the next largest permitted water use with 163,732.40 mgy. About 84.7 percent of the total permitted amount is for power generation. Other counties with large total permitted water-use amounts are: Black Hawk, Woodbury, Monona, Humboldt, Polk and Muscatine. About 58.5 percent of Black Hawk County's water use is permitted to power generation. For Woodbury and Monona, the largest permitted water use is for irrigation purposes. Almost all of the water permitted in Humboldt is for mining purposes. Over half of Polk County's permitted water use is to public water suppliers and 49.0 percent of Muscatine County's permitted water use is to self-supplied industrial use.

Total permitted amounts in million gallons per year for each of the seven water-use categories are shown in figure 2. The distribution of surface-water use among the water-use categories is shown in figure 3 and ground-water use in figure 4.

More than 80.5 percent of the permitted surface-water use is from streams, as shown in figure 5. Figure 6 illustrates that wells are the major source of permitted ground-water use. More than 65.4 percent of the permitted ground-water use from wells is from surficial aquifers as shown in figure 7.

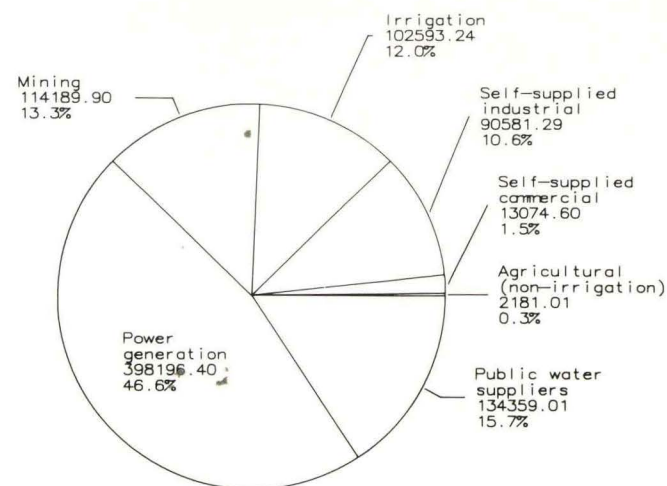


Figure 2. Total permitted water use, by category, in million gallons per year and percent

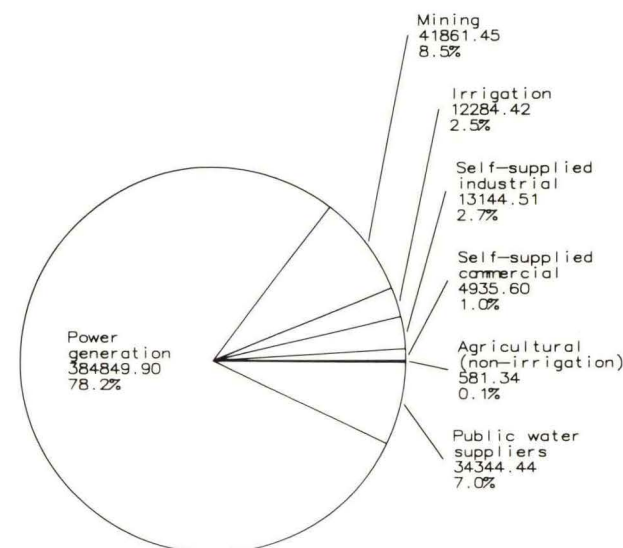


Figure 3. Total permitted surface-water use, by category, in million gallons per year and percent



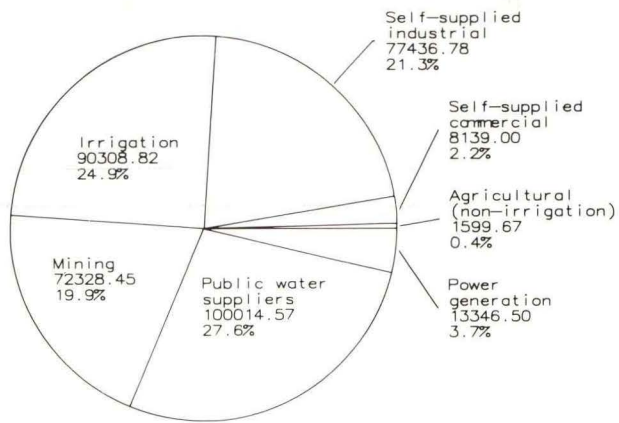


Figure 4. Total permitted ground-water use, by category, in million gallons per year and percent

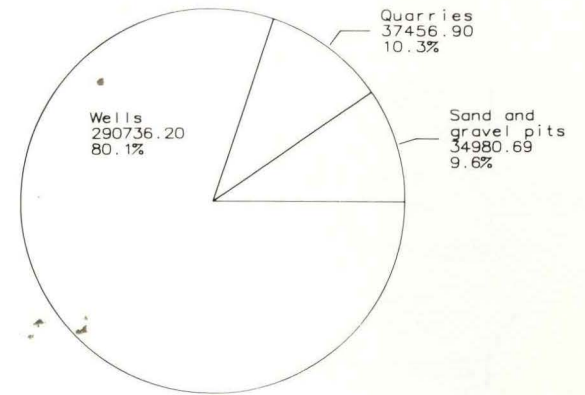


Figure 6. Total permitted ground-water use, by source, in million gallons per year and percent

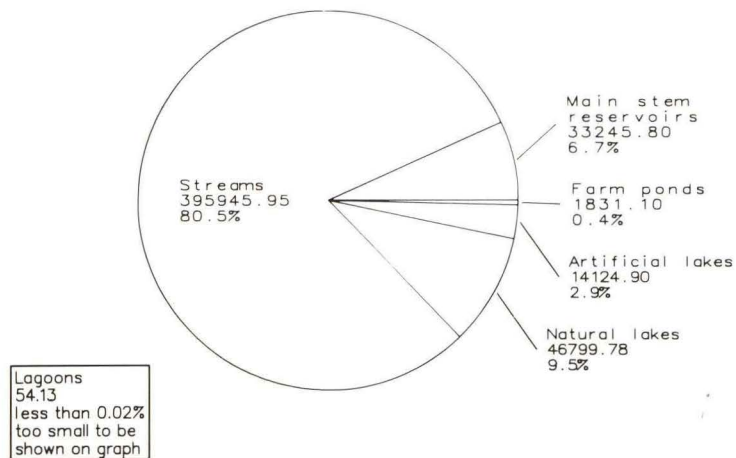


Figure 5. Total permitted surface-water use, by source, in million gallons per year and percent

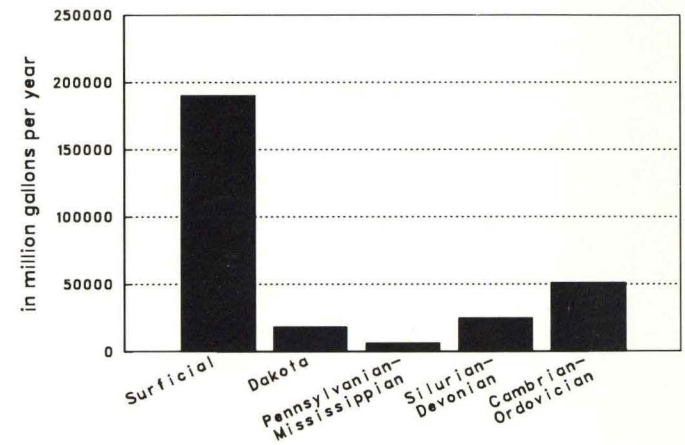


Figure 7. Total permitted ground-water use by aquifer

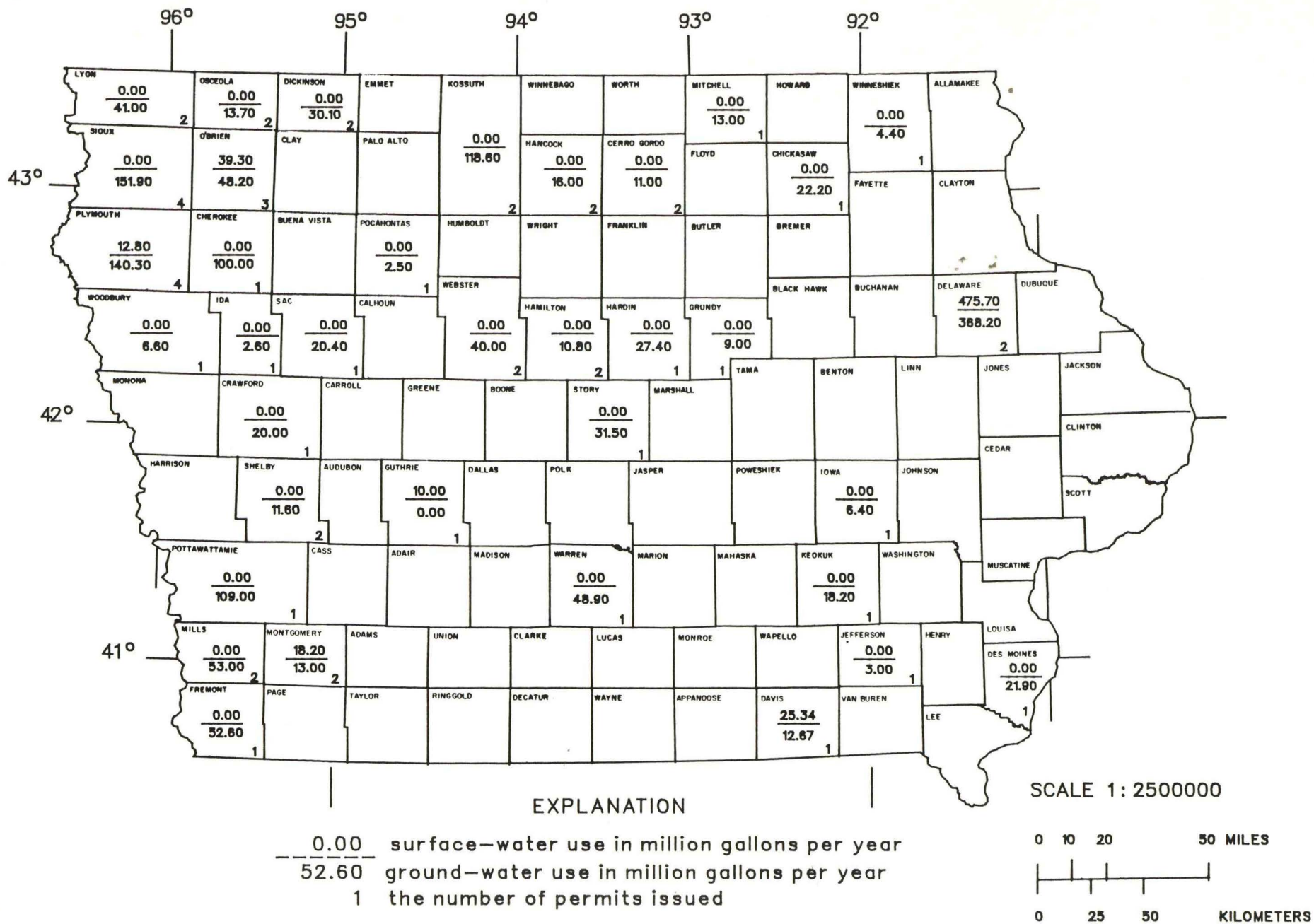


Figure 8. Permitted agricultural (non-irrigation) water use.

### Agricultural (non-irrigation)

Agricultural (non-irrigation) water use is defined in this report as the water used for animal production and commercial feedlots. The agricultural (non-irrigation) water-use category has the smallest permitted use of the seven water-use categories. The use permitted by county is shown in figure 8. Some of the agricultural water users receive their water from town and rural water supplies and therefore are included under the public water suppliers' category.

A total of 56 water-use permits have been issued in 36 of Iowa's 99 counties with 2,181.01 mgy allocated to agricultural (non-irrigation) use. Of this total, 581.34 mgy, or 26.7 percent, is permitted from surface-water sources, and 1,599.67 mgy from ground-water sources. The amount of water allocated from surface-water sources is shown in figure 9. All permitted ground-water use is from wells with over half allocated from surficial aquifers and a third from the Dakota aquifer (figure 10). Delaware County in northeastern Iowa has the largest permitted agricultural (non-irrigation) water use of 843.90 mgy.

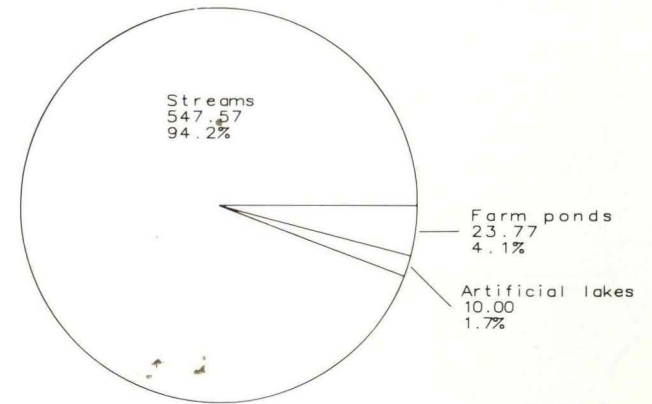


Figure 9. Permitted agricultural (non-irrigation) surface-water use, by source, in million gallons per year and percent

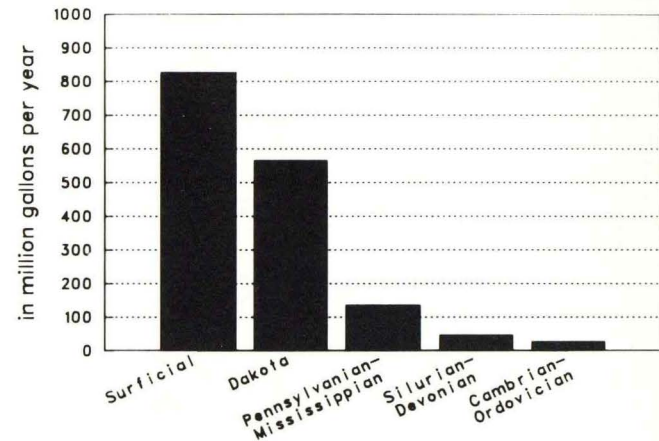


Figure 10. Permitted agricultural (non-irrigation) ground-water use by aquifer

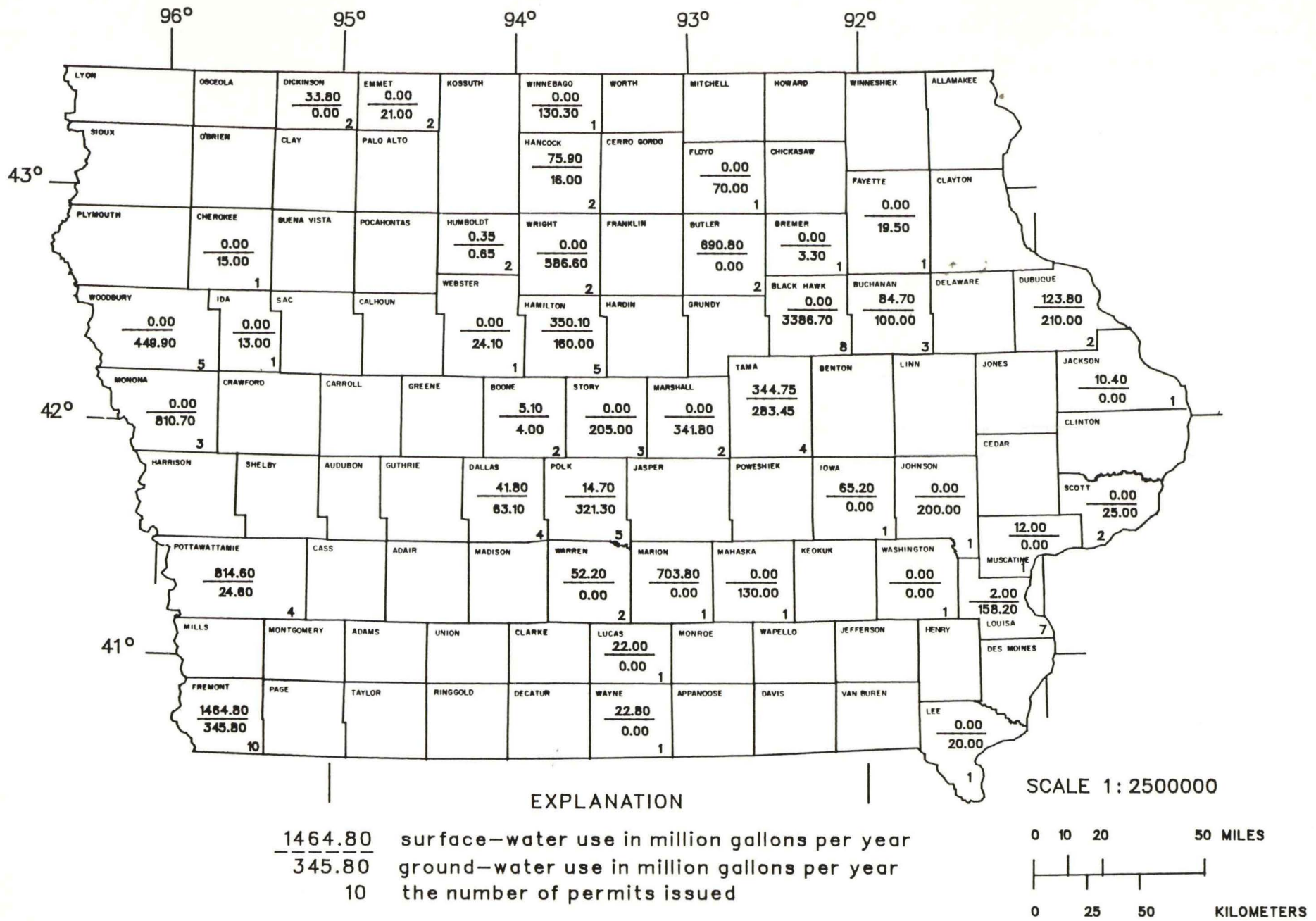


Figure 11. Permitted self-supplied commercial water use.

## Self-supplied commercial

The self-supplied commercial water-use category includes a wide variety of water uses for businesses, government establishments, and other organizations. Some examples of establishments in the self-supplied commercial category are: hotels and other lodging places, recreational and amusement services, educational institutions, hospitals, and government agencies. Only self-supplied commercial water users are permitted. Most self-supplied commercial water users located in or near towns receive water from public-water supplies and so are included under the public water suppliers' category. The distribution of self-supplied commercial water use in Iowa by county is shown in figure 11. Black Hawk County has the largest permitted self-supplied commercial water use of 3,386.70 mgy. Fremont County in southwestern Iowa has the most number of permits issued with ten.

One hundred water-use permits have been issued and 13,074.60 mgy have been permitted for self-supplied commercial use in 40 counties in Iowa. About 37.7 percent of this total is permitted from surface-water sources and almost all of that is permitted from streams (figure 12). A total of 8,139.00 mgy is permitted from ground-water sources and nearly all of this is permitted from wells (figure 13). More than 50 percent of the water permitted from wells is from the Silurian-Devonian aquifer and 34.9 percent from surficial aquifers (figure 14).

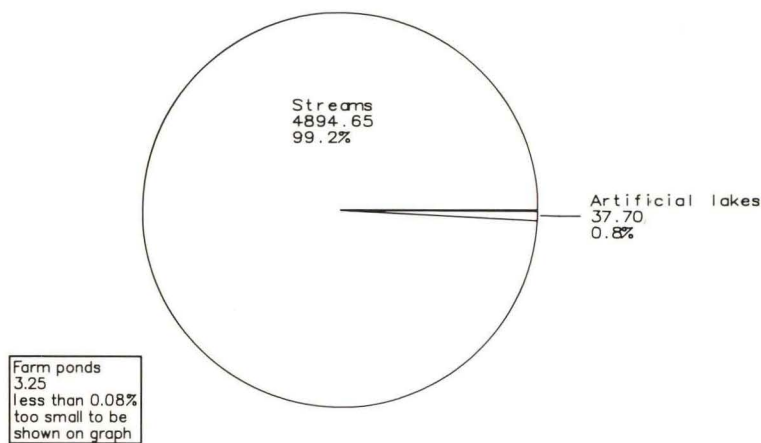


Figure 12. Permitted self-supplied commercial surface-water use, by source, in million gallons per year and percent

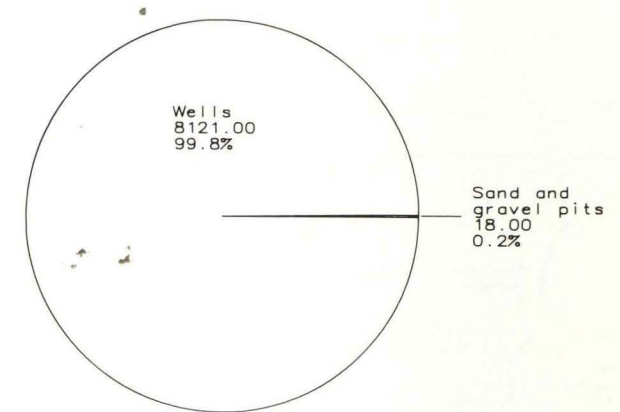


Figure 13. Permitted self-supplied commercial ground-water use, by source, in million gallons per year and percent

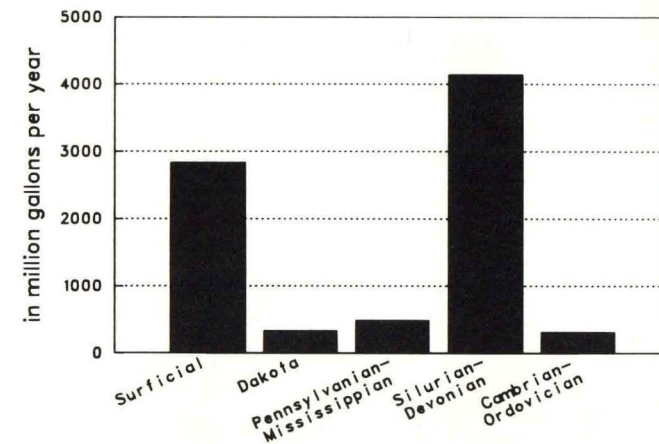


Figure 14. Permitted self-supplied commercial ground-water use by aquifer

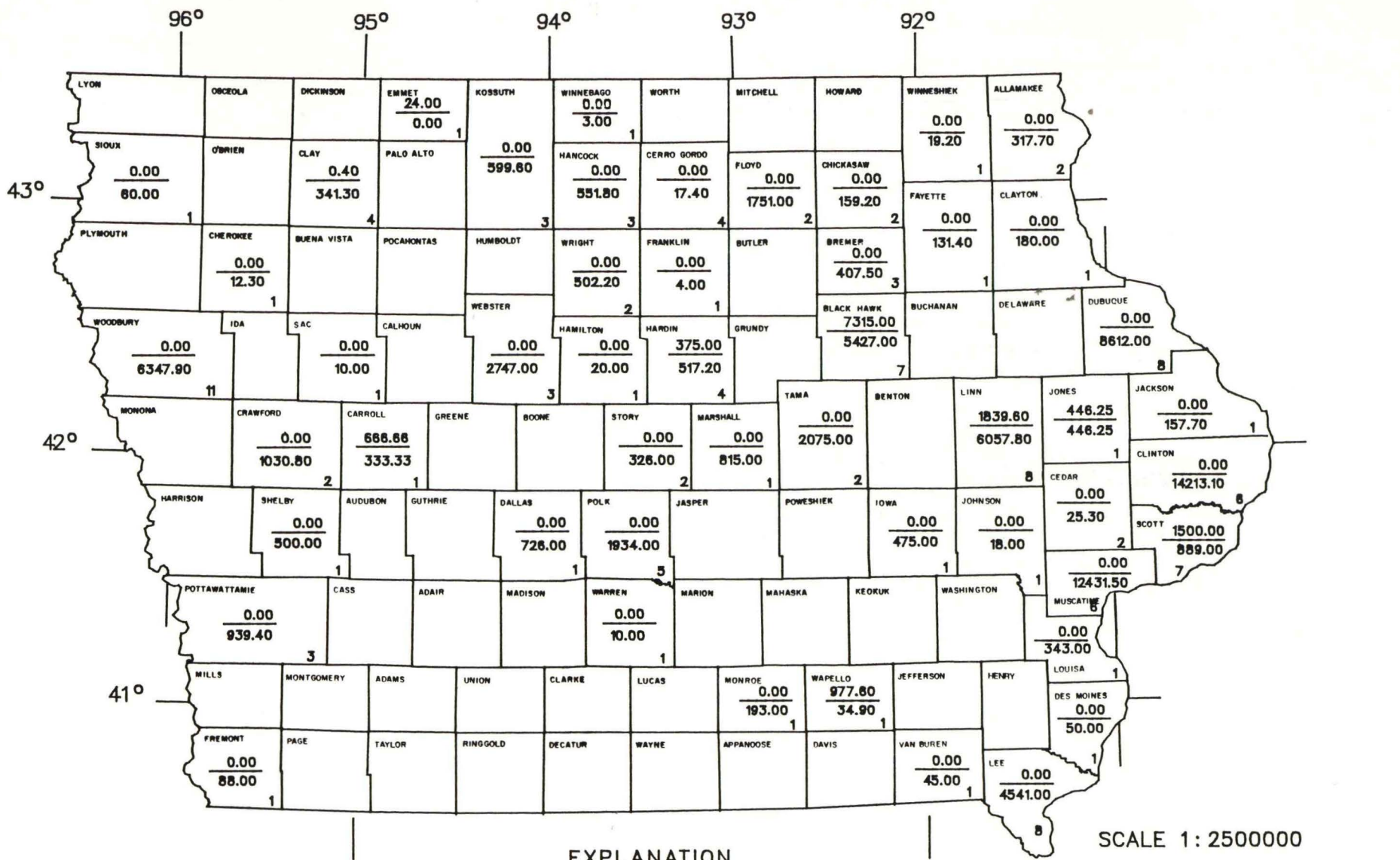


Figure 15. Permitted self-supplied industrial water use.

## Self-supplied industrial

The industrial water-use category includes a variety of uses such as manufacturing, processing, cooling, housekeeping, and drinking water. Only the self-supplied industrial water users are permitted. Some self-supplied industrial water users receive water from public-water supplies and are therefore included under the public water suppliers' category.

Figure 15 shows the distribution for permitted self-supplied industrial water use. The largest permitted amount to self-supplied industries is 14,213.10 mgy in Clinton County. Other counties with large permitted amounts are Black Hawk (12,742.00 mgy), Muscatine (12,431.50 mgy), Dubuque (8,612.00 mgy), Linn (7,897.40 mgy), and Woodbury (6,347.90 mgy). Woodbury County has the most self-supplied industrial permits issued with eleven.

A total of 134 water-use permits and 90,581.29 mgy have been allocated to self-supplied industrial water users in 50 counties in Iowa. Of this total, 13,144.51 mgy are permitted from surface-water (figure 16) and 85.5 percent from ground-water sources. About 47.9 percent of the ground water permitted for self-supplied industrial water use is from surficial aquifers and 36 percent from the Cambrian-Ordovician aquifer (figure 17).

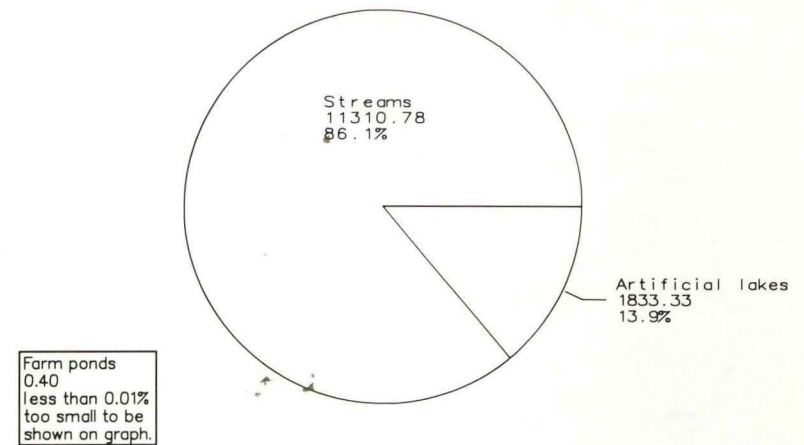


Figure 16. Permitted self-supplied industrial surface water use, by source, in million gallons per year and percent

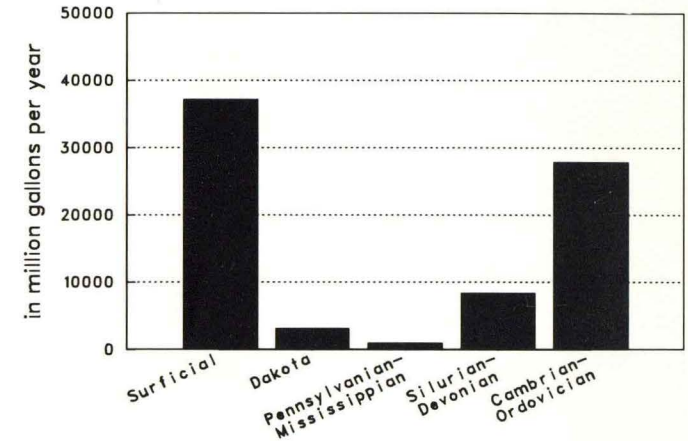


Figure 17. Permitted self-supplied industrial ground-water use by aquifer

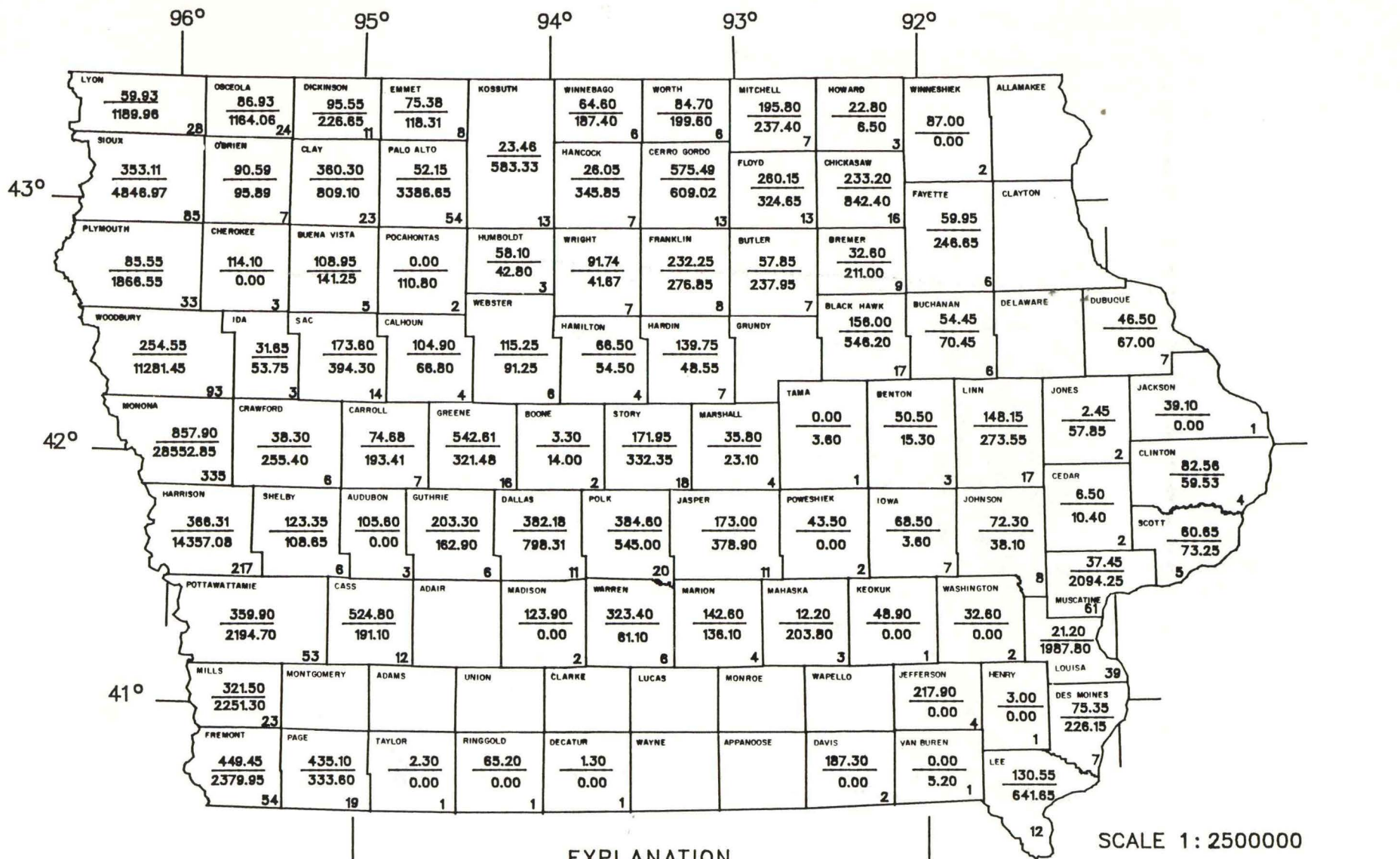


Figure 18. Permitted irrigation water use.



## Irrigation

The irrigation water-use category includes the irrigation of farm crops, specialty crops, and golf courses. A total of 1,593 water-use permits have been issued in 85 of Iowa's 99 counties. Most of the counties not having any irrigation permits are located in southern Iowa where sufficient water sources required for irrigation are unavailable (figure 18).

A total of 102,593.24 mgy has been permitted for irrigation water use with 11.9 percent from surface-water sources. Streams account for the largest part of surface-water permitted irrigation use, 81.1 percent, and farm ponds are second with 13.3 percent (figure 19). About 88.0 percent, or 90,308.82 mgy, of the water permitted is from ground-water sources. Wells are the most typical ground-water source permitted for irrigation use (figure 20). Surficial aquifers account for 94.7 percent of the ground water permitted from wells. Most of the water allocated from surficial aquifers is from alluvial aquifers that underlie the floodplains of the Missouri and the Mississippi Rivers.

Monona County has the largest permitted use of water for irrigation, 29,410.75 mgy. Other counties with greater than 10,000 mgy permitted are Harrison (14,723.39 mgy) and Woodbury (11,536.00 mgy). Counties with greater than 2,000 mgy are: Louisa (2,009.00 mgy) and Muscatine (2,131.70 mgy) located along the Mississippi alluvial aquifer, Pottawattamie (2,554.60 mgy), Mills (2,572.80 mgy), Fremont (2,829.40 mgy), and Sioux (5,200.08 mgy), all located along the Missouri alluvial aquifer.

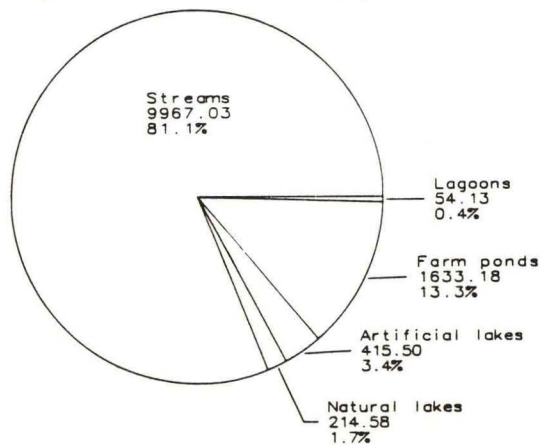


Figure 19. Permitted irrigation surface-water use, by source, in million gallons per year and percent

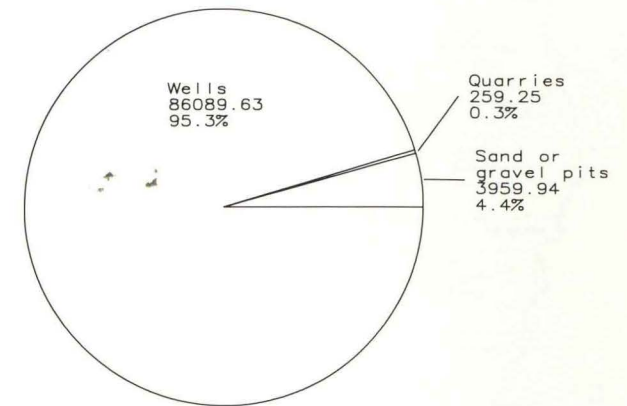


Figure 20. Permitted irrigation ground-water use, by source, in million gallons per year and percent

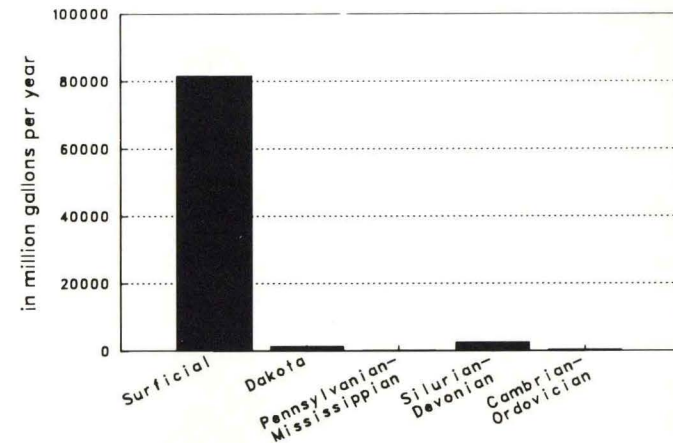


Figure 21. Permitted irrigation ground-water use by aquifer

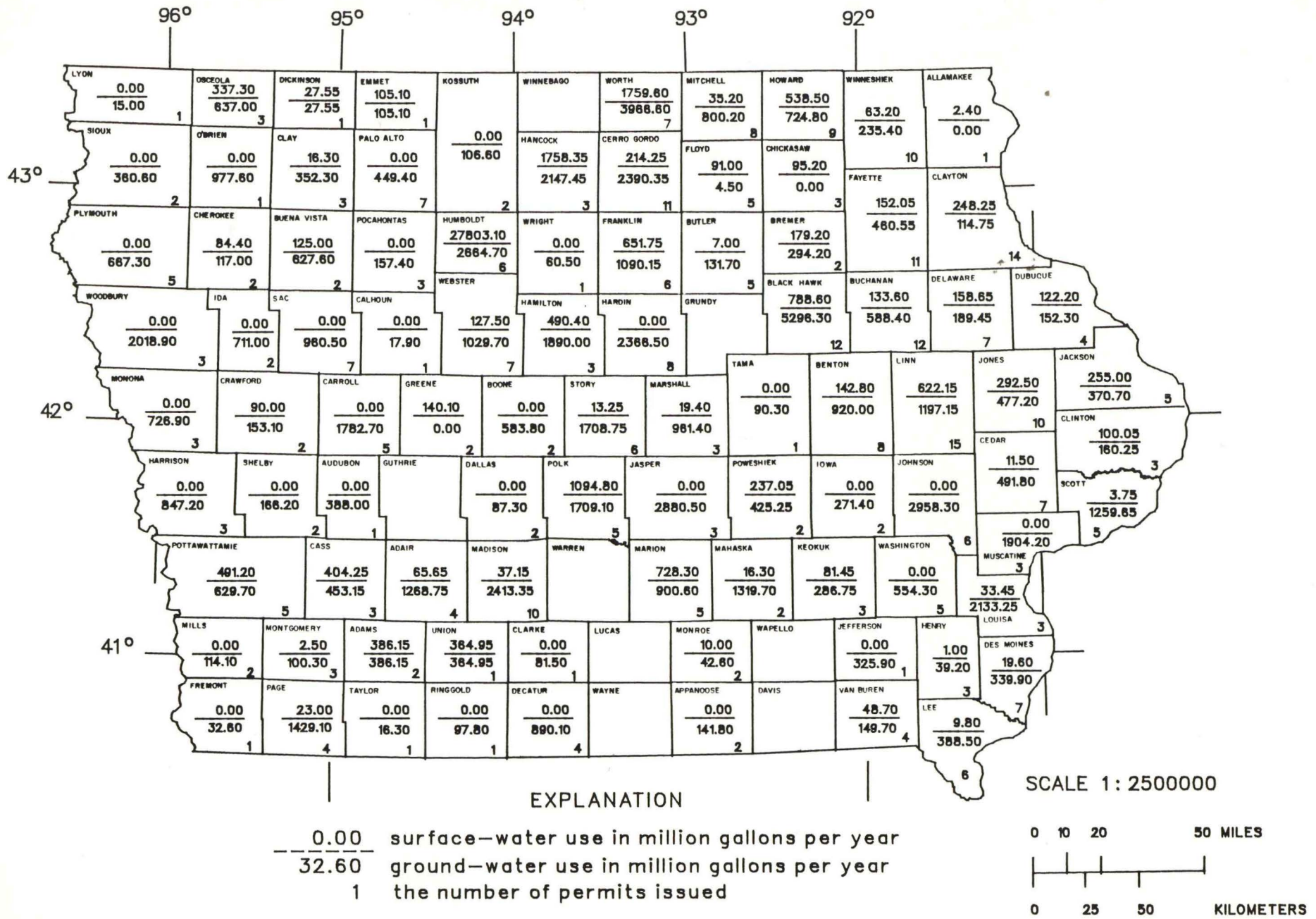


Figure 22. Permitted mining water use.

## Mining

The mining water-use category is defined as that associated with the extraction of naturally occurring minerals. Mining, in Iowa, includes quarrying, sand and gravel pit operations, milling (crunching, screening, and washing) and other processes customarily done at the mine site, or as part of mining activity. The primary mining activities in Iowa involve quarrying of limestone and the production of sand and gravel.

A total of 392 water-use permits for mining activities have been issued in 91 Iowa counties. A total amount of 114,189.90 mgy has been permitted to the mining water-use category with 41,861.45 mgy permitted from surface-water sources and 63.3 percent from ground-water sources. The distribution of permitted mining water use is shown in figure 22. About 97.6 percent of the permitted mining water from surface-water sources is from streams, and the remainder is from artificial lakes, natural lakes, farm ponds, and main-stem reservoirs (figure 23). Of the ground-water sources, about 51.4 percent is allocated from quarries, about 42.9 percent from sand and gravel pits, and about 5.7 percent from wells (figure 24). Of the amount allocated from wells, about 78.7 percent is permitted from surficial aquifers (figure 25).

The largest permitted amount for the mining category is 30,467.80 mgy for Humboldt County in north-central Iowa. Some other Counties with greater than 5,000 mgy permitted amounts are Black Hawk (6,084.90 mgy), and Worth (5,726.20 mgy).

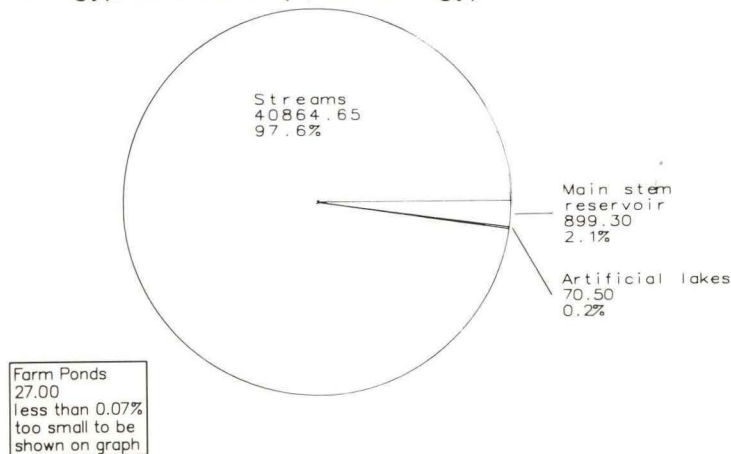


Figure 23. Permitted mining surface-water use, by source, in million gallons per year and percent

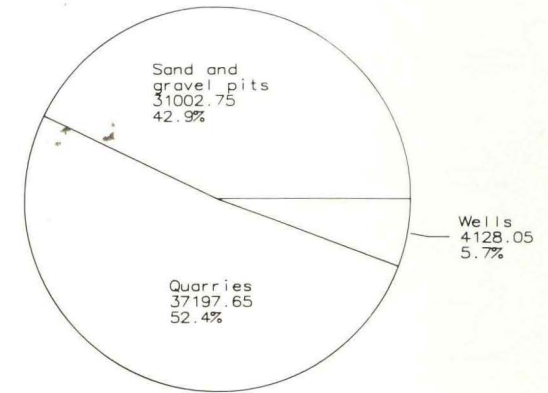


Figure 24. Permitted mining ground-water use, by source, in million gallons per year and percent

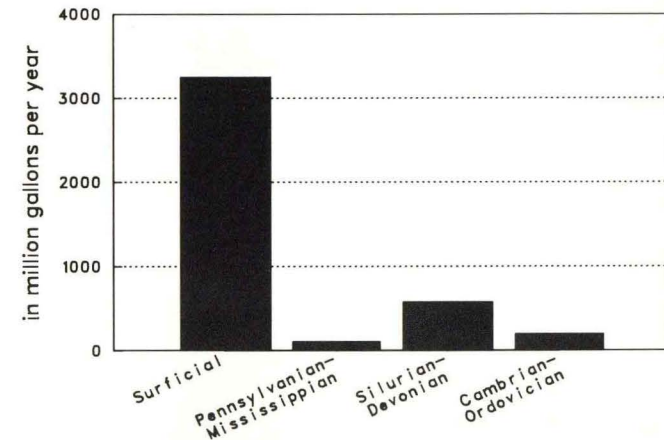


Figure 25. Permitted mining ground-water use by aquifer

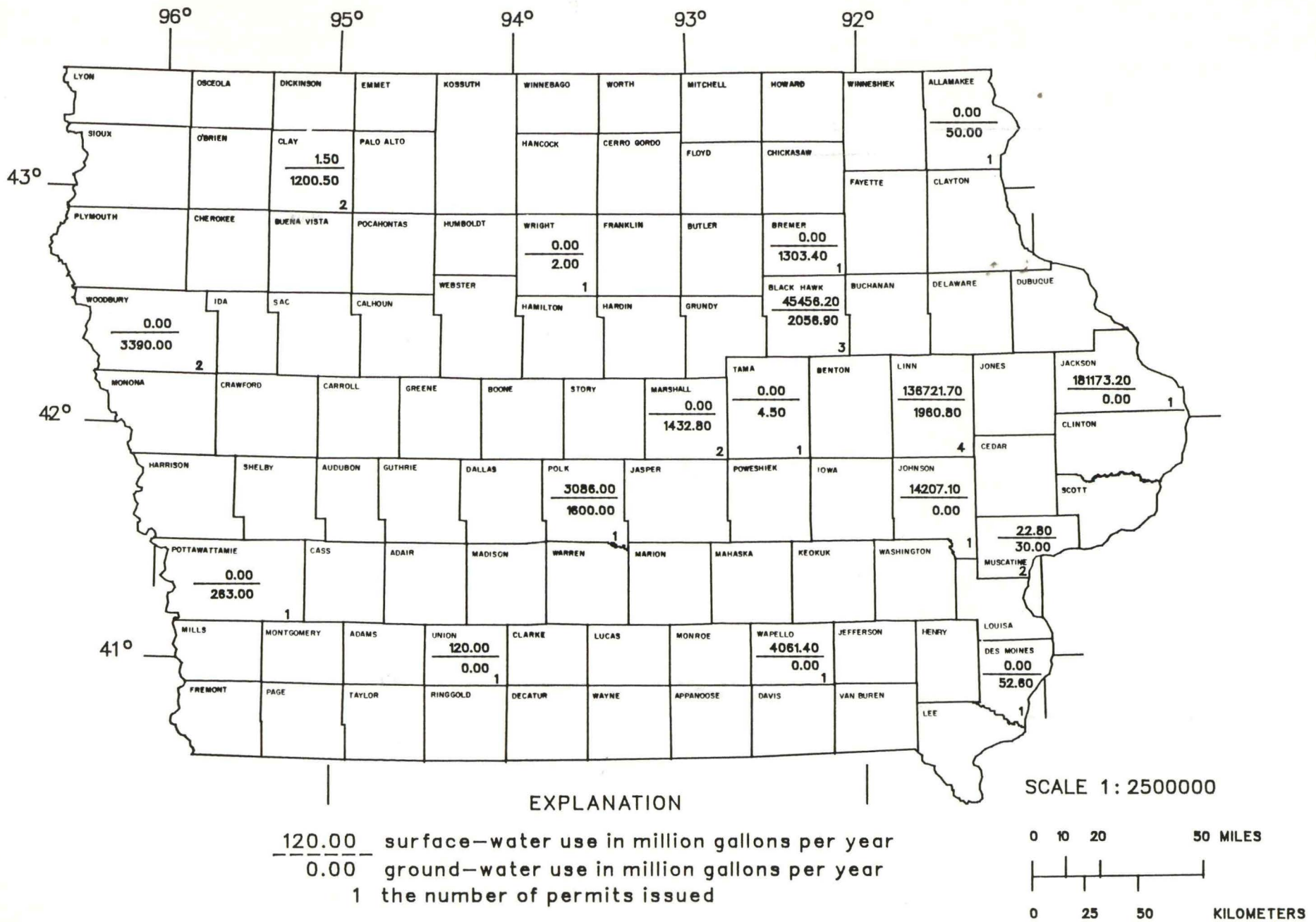


Figure 26. Permitted power water use.

## Power generation

The power water-use category includes the water permitted to power generating facilities. Until recently, many power facilities on the border rivers were not required to apply for permits, because they were unregulated. Although this water-use category has large allocation, in reality it consumes a small percent of withdrawn water since most is used for flow through cooling and returned to the stream. The largest total permitted amounts for power generation are 181,173.20 mgy in Jackson County and 138,682.50 mgy in Linn County (figure 26).

There are 26 permits issued to power generation facilities in 17 counties in Iowa. Power has the largest water use allocated of the seven water-use categories. A total of 398,196.40 mgy is permitted for power generation with 96.7 percent allocated from surface-water sources. Of the surface-water sources, about 77.9 percent is allocated from streams, about 11.7 percent from natural lakes, about 8.4 percent from main-stem reservoirs, and the remainder is allocated from artificial lakes and farm ponds (figure 27). All permitted ground water used for power generation is from wells, and more than 96.5 percent of that is from surficial aquifers (figure 28).

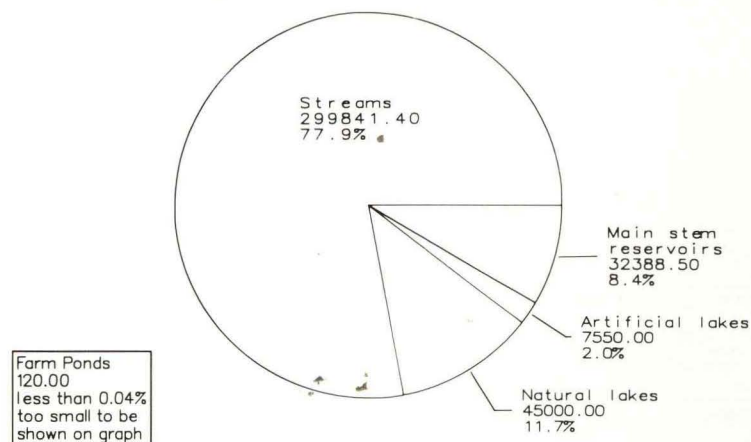


Figure 27. Permitted power surface-water use, by source, in million gallons per year and percent

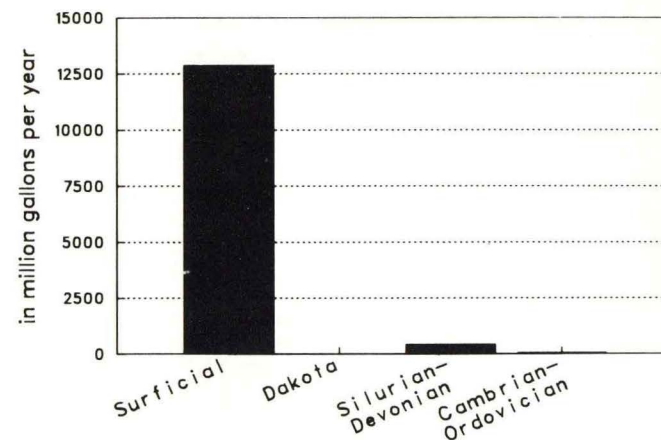


Figure 28. Permitted power ground-water use by aquifer

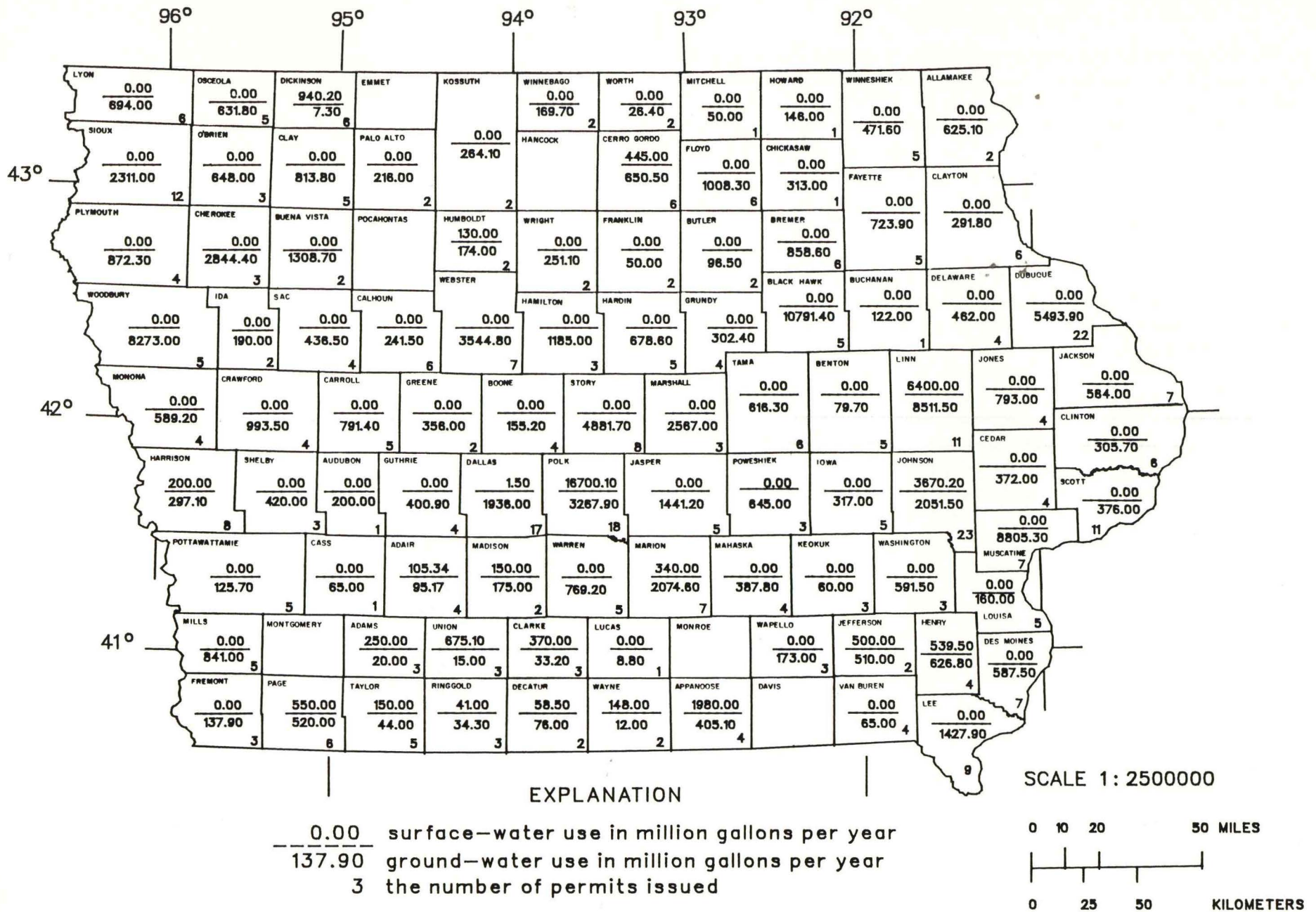


Figure 29. Permitted public water supplier water use.

## Public water suppliers

Public water suppliers are the largest permitted water-use category, if the power generation water-use category is excluded from the total. 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 in Iowa are cities, towns, mobile home parks, housing associations, and rural water associations.

The largest amount allocated in this category is 19,968.00 mgd in Polk County. Other counties with large permitted amounts are Linn (14,911.50 mgd) and Black Hawk (10,791.40 mgd). The permitted ground-water and surface-water use for public water suppliers is shown by county in figure 29. Four hundred and fifty-five permits have been issued in 93 counties.

A total of 134,359.01 mgd has been permitted for public water supplier use, with 25.6 percent allocated from surface-water sources and 100,014.57 mgd from ground-water sources. Of the surface-water sources, 83.0 percent is allocated from streams, about 12.3 percent from artificial lakes and about 4.6 percent from natural lakes (figure 30). All of the ground water is allocated from wells and about 51.7 percent is allocated from surficial aquifers, 22.1 percent from the Cambrian-Ordovician aquifer and 12.8 percent from the Dakota aquifer (figure 31).

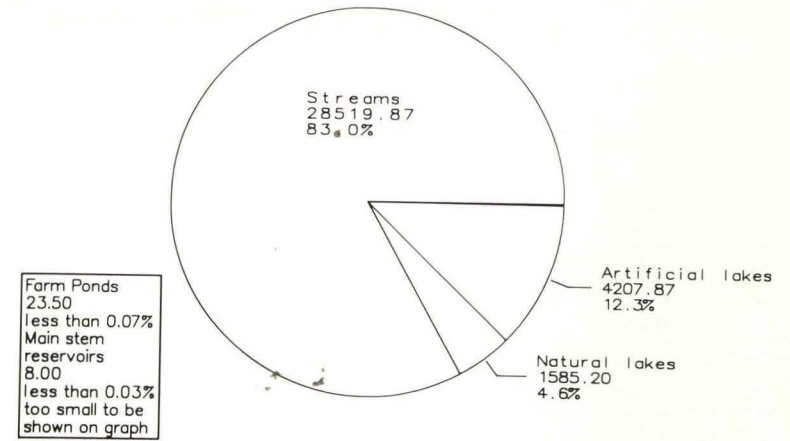


Figure 30. Permitted public water suppliers surface-water use, by source, in million gallons per year and percent

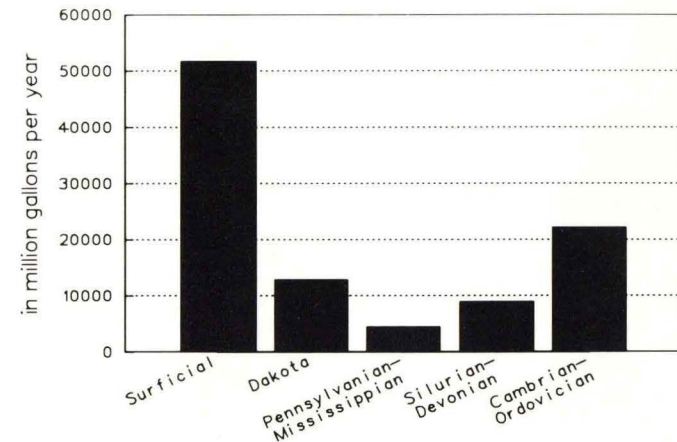


Figure 31. Permitted public water suppliers ground-water use by aquifer

Table 1. Total permitted water use, in million gallons per year, by category for each county

WATER USE CATEGORIES								
County	Agricultural (non-irrigation)	Self-Supplied Commercial	Self-Supplied Industrial	Irrigation	Mining	Power	Public Water Suppliers	Total per county
ADAIR					1334.40		200.51	1,534.91
ADAMS					772.30		270.00	1,042.30
ALLAMAKEE			317.70		2.40	50.00	625.10	995.20
APPANOOSE					141.80		2385.10	2,526.90
AUDUBON				105.60	388.00		200.00	693.60
BENTON				65.80	1062.80		79.70	1,208.30
BLACK HAWK		3386.70	12742.00	702.20	6084.90	47513.10	10791.40	81,220.30
BOONE		9.10		17.30	583.80		155.20	765.40
BREMER		3.30	407.50	243.60	473.40	1303.40	858.60	3,289.80
BUCHANAN		184.70		124.90	722.00		122.00	1,153.60
BUENA VISTA				250.20	752.60		1308.70	2,311.50
BUTLER		690.80		295.80	138.70		96.50	1,221.80
CALHOUN				171.70	17.90		241.50	431.10
CARROLL			999.99	268.09	1782.70		791.40	3,842.18
CASS				715.90	857.40		65.00	1,638.30
CEDAR			25.30	16.90	503.30		372.00	917.50
CERRO GORDO	11.00		17.40	1184.51	2604.60		1095.50	4,913.01
CHEROKEE	100.00	15.00	12.30	114.10	201.40		2844.40	3,287.20
CHICKASAW	22.20		159.20	1075.60	95.20		313.00	1,665.20
CLARKE					81.50		403.20	484.70
CLAY			341.70	1169.40	368.60	1202.00	813.80	3,895.50
CLAYTON			180.00		363.00		291.80	834.80
CLINTON			14213.10	142.09	260.30		305.70	14,921.19
CRAWFORD	20.00		1030.80	293.70	243.10		993.50	2,581.10
DALLAS		104.90	726.00	1180.49	87.30		1937.50	4,036.19
DAVIS	38.01			187.30				225.31
DECATUR				1.30	890.10		134.50	1,025.90
DELAWARE	843.90				348.10		462.00	1,654.00
DES MOINES	21.90		50.00	301.50	359.50	52.60	587.50	1,373.00
DICKINSON	30.10	33.80		322.20	55.10		947.50	1,388.70
DUBUQUE		333.80	8612.00	113.50	274.50		5493.90	14,827.70
EMMET		21.00	24.00	193.69	210.20			448.89
FAYETTE		19.50	131.40	306.60	612.60		723.90	1,794.00
FLOYD		70.00	1751.00	584.80	95.50		1008.30	3,509.60
FRANKLIN			4.00	509.10	1741.90		50.00	2,305.00
FREMONT	52.60	1810.60	88.00	2829.40	32.60		137.90	4,951.10
GREENE				864.09	140.10		356.00	1,360.19
GRUNDY	9.00						302.40	311.40
GUTHRIE	10.00			366.20			400.90	777.10
HAMILTON	10.80	510.10	20.00	121.00	2380.40		1185.00	4,227.30
HANCOCK	16.00	91.90	551.80	371.90	3905.80			4,937.40
HARDIN	27.40		892.20	188.30	2366.50		678.60	4,153.00
HARRISON				14723.39	847.20		497.10	16,067.69
HENRY				3.00	40.20		1166.30	1,209.50
HOWARD				29.30	1263.30		146.00	1,438.60
HUMBOLDT		1.00		100.90	30467.80		304.00	30,873.70
IDA	2.60	13.00		85.40	711.00		190.00	1,002.00
IOWA	6.40	65.20	475.00	72.10	271.40		317.00	1,207.10
JACKSON		10.40	157.70	39.10	625.70	181173.20	564.00	182,570.10
JASPER				551.90	2880.50		1441.20	4,873.60



Table 1. Total permitted water use, in million gallons per year, by category for each county (cont.)

County	Agricultural (non-irrigation)	Self-Supplied Commercial	Self-Supplied Industrial	Irrigation	Mining	Power	Public Water Suppliers	Total per county
JEFFERSON	3.00			217.90	325.90		1010.00	1,556.80
JOHNSON		200.00	18.00	110.40	2958.30	14207.10	5721.70	23,215.50
JONES			892.50	60.30	769.70		793.00	2,515.50
KEOKUK	18.20			48.90	368.20		60.00	495.30
KOSSUTH	118.60		599.60	606.79	106.60		264.10	1,695.69
LEE		20.00	4541.00	772.20	398.30		1427.90	7,159.40
LINN			7897.40	421.70	1819.30	138682.50	14911.50	163,732.40
LOUISA		160.20	343.00	2009.00	2166.70		160.00	4,838.90
LUCAS		22.00					8.80	30.80
LYON	41.00			1249.89	15.00		694.00	1,999.89
MADISON				123.90	2450.50		325.00	2,899.40
MAHASKA		130.00		216.00	1336.00		387.80	2,069.80
MARION		703.80		278.70	1628.90		2414.60	5,026.00
MARSHALL		341.80	815.00	58.90	980.80	1432.80	2567.00	6,196.30
MILLS	53.00			2572.80	114.10		841.00	3,580.90
MITCHELL	13.00			433.20	835.40		50.00	1,331.60
MONONA		810.70		29410.75	726.90		589.20	31,537.55
MONROE			193.00		52.60			245.60
MONTGOMERY	31.20				102.80			134.00
MUSCATINE		12.00	12431.50	2131.70	1904.20	52.80	8805.30	25,337.50
O'BRIEN	87.50			186.48	977.60		648.00	1,899.58
OSCEOLA					974.30		631.80	2,870.79
PAGE				768.70	1452.10		1070.00	3,290.80
PALO ALTO	13.70			3438.80	449.40		216.00	4,104.20
PLYMOUTH	153.10			1952.10	667.30		872.30	3,644.80
POCAHONTAS	2.50			110.80	157.40			270.70
POLK		336.00	1934.00	929.60	2803.90	4686.00	19968.00	30,657.50
POTTAWATTAMIE	109.00	839.20	939.40	2554.60	1120.90	263.00	125.70	5,951.80
POWESHIEK				43.50	662.30		645.00	1,350.80
RINGGOLD				65.20	97.80		75.30	238.30
SAC	20.40		10.00	567.90	960.50		436.50	1,995.30
SCOTT		25.00	2389.00	133.90	1263.40		376.00	4,187.30
SHELBY	11.60		500.00	232.00	166.20		420.00	1,329.80
SIOUX	151.90		60.00	5200.08	360.60		2311.00	8,083.58
STORY	31.50	205.00	326.00	504.30	1722.00		4881.70	7,670.50
TAMA		628.20	2075.00	3.60	90.30	4.50	616.30	3,417.90
TAYLOR				2.30	16.30		194.00	212.60
UNION					729.90	120.00	690.10	1,540.00
VAN BUREN			45.00	5.20	198.40		65.00	313.60
WAPELLO			1012.50			4061.40	173.00	5,246.90
WARREN	48.90	52.20	10.00	384.50			769.20	1,264.80
WASHINGTON		0.00		32.60	554.30		591.50	1,178.40
WAYNE		22.80					160.00	182.80
WEBSTER	40.00	24.10	2747.00	206.50	1157.20		3544.80	7,719.60
WINNEBAGO		130.30	3.00	252.00			169.70	555.00
WINNESHIEK	4.40		19.20	87.00	298.60		471.60	880.80
WOODBURY	6.60	449.90	6347.90	11536.00	2018.90	3390.00	8273.00	32,022.30
WORTH				284.30	5726.20		26.40	6,036.90
WRIGHT		586.60	502.20	133.40	60.50	2.00	251.10	1,535.81
TOTAL	2,181.01	13,074.60	90,581.29	102,593.24	114,189.90	398,196.40	134,359.01	855,175.45

Table 2. Geologic and hydrogeologic units in Iowa

[Adapted from Steinhilber and Horick, 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 till containing scattered irregular bodies of sand and gravel			Small yields	
	Buried channel deposits	Sand, gravel, silt and clay			Small to large yields	
Cretaceous	Carlile Formation Graneros Formation	Shale	Confining unit		Does not yield water	
	Dakota Group	Sandstone and shale	Dakota aquifer		Moderate to large yields	
Pennsylvanian	Virgil Series	Shale and limestone	Confining unit or local Pennsylvanian aquifer	Mississippian - Pennsylvanian aquifer	Very small yields only from locally productive limestone and sandstone	
	Missouri Series					
	Des Moines Series	Shale; sandstones, mostly thin				
Mississippian	Meramec Series	Limestone, sand	Mississippian aquifer		Mississippian - Pennsylvanian aquifer	Small to moderate yields
	Osage Series	Limestone and cherty dolomite				
	Kinderhook Series	Oolitic limestone and cherty dolomite				
Devonian	Maple Mill Shale Sheffield Formation Lime Creek Formation	Shale, limestone in lower part	Confining unit			Does not yield water
	Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolomite; contains evaporites in southern half of Iowa	Silurian-Devonian aquifer			Moderate to large yields
Silurian	Niagaran Series Alexandrian Series	Dolomite, locally cherty				

Table 2. Geologic and hydrogeologic units in Iowa (cont.)

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

## Summary

In Iowa, total withdrawals of 855,175.45 mgy were permitted from ground-water and surface-water sources prior to July 26, 1985. Of this total, 492,001.66 mgy is permitted from surface-water sources and 363,173.79 mgy is permitted from ground-water sources. The counties with the largest allocations are Jackson County (182,570.10 mgy), Linn County (163,732.40 mgy) and Black Hawk County (81,220.30 mgy). Power generation is the largest permitted water category (398,196.40 mgy) with public water suppliers as the second largest permitted water category (134,359.01 mgy). Mining is permitted 114,189.90 mgy and irrigation is permitted 102,593.24 mgy. Following these water-use categories are: self-supplied industrial (90,581.29 mgy), self-supplied commercial (13,074.60 mgy) and agricultural (non-irrigation) with 2,181.01 mgy. Of the agricultural (non-irrigation) water use, 1,599.67 mgy is from ground-water sources and 581.34 mgy is from surface-water sources. Delaware County is permitted the largest amount of water, 843.90 mgy, for agricultural (non-irrigation) purposes. For the self-supplied commercial water-use category, 4,935.60 mgy is permitted from surface-water sources and 8,139.00 mgy is from ground-water sources. Black Hawk County has the largest permitted self-supplied commercial water use of 3,386.70 mgy. Self-supplied industrial permitted water use contains 77,436.78 mgy from ground-water sources and 13,144.51 mgy from surface-water sources. The county that has the largest amount of permitted self-supplied industrial water is Clinton County with 14,213.10 mgy. Ground water accounts for 90,308.82 mgy and surface water accounts for 12,284.42 mgy of irrigational use. Monona County is the county with the largest permitted irrigation water use with 29,410.75 mgy. The mining water-use category is permitted 41,861.45 mgy from surface-water sources and 72,328.45 mgy from ground-water sources. The county that has the largest amount permitted for mining is Humboldt County with 30,467.80 mgy. For the power generation category, 384,899.90 mgy is allocated from surface water and 13,346.50 mgy is allocated from ground water. The county with the dominant power water-use is Jackson County with 181,173.20 mgy. Ground water accounts for 100,014.57 mgy and surface water accounts for 34,344.44 mgy of public water suppliers. Polk County is the county that has the most water permitted in the public water suppliers' category with 19,968.00 mgy.

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