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WISCONSIN GROUNDWATER OBSERVATION-WELL NETWORK, 1946–95

Alexander Zaporozec

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INTRODUCTION

Purpose of the observation network

Although much of Wisconsin has abundant supplies of good-quality groundwater, instances of overdevelopment and contamination illustrate the need for a comprehensive, statewide groundwater-management plan. An important, but often overlooked, component of such a plan is a systematic and continuous program for monitoring groundwater levels.

Effective management of groundwater in Wisconsin requires that up-to-date information relating to water levels be readily available for efficient design of wells, water-supply facilities, and waste-disposal facilities; for land-suitability assessment, drought preparedness, and water-quality studies; and for water-related planning and management decisions. Groundwater-level measurements and the history of water-level fluctuations also are fundamental to water-resource investigations. Potential users include well drillers, consultants, researchers, planners, managers, farmers, local and state agencies, legislators, and citizens who desire or require a working knowledge of fluctuations in groundwater levels.

To provide these data, the U.S. Geological Survey (USGS) and the Wisconsin Geological and Natural History Survey (WGNHS) jointly operate a statewide network of observation wells. This report has been prepared to commemorate the 50th anniversary of the statewide observation-well network in Wisconsin.

Network history

The beginnings of systematic groundwater-level measurements can be traced to 1934, when the U.S. Soil Conservation Service installed 13 observation wells in southwestern Wisconsin as a part of the National Soil Conservation Program (Zaporozec, 1982). All but three of these wells have since been discontinued. During the years 1935–37 nine more observation wells were added by the Wisconsin Conservation Department (predecessor of the Wisconsin Department of Natural Resources) in each if its forest-protection districts in northern and central Wisconsin. Of these, three wells have been in operation ever since. In 1946, the WGNHS, directed by the State Legislature, initiated, in cooperation with the USGS, a program to measure groundwater levels on a regular basis. At that time the statewide observation-well network included 112 observation wells (Zaporozec, 1982).

Network concept and evaluation

The observation network in Wisconsin was established without any formalized concept and evolved according to changing needs. Historically, wells have been discontinued or added to the network as they became available as a result of various groundwater studies. The number of observation wells rapidly increased to 270 between 1946 and 1954, stabilizing at approximately 200 between 1957 and 1987; since then, the number of wells has declined (fig. 1).

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Water Resources Division, Madison District Office
6417 Normandy Lane, Madison, Wisconsin 53719

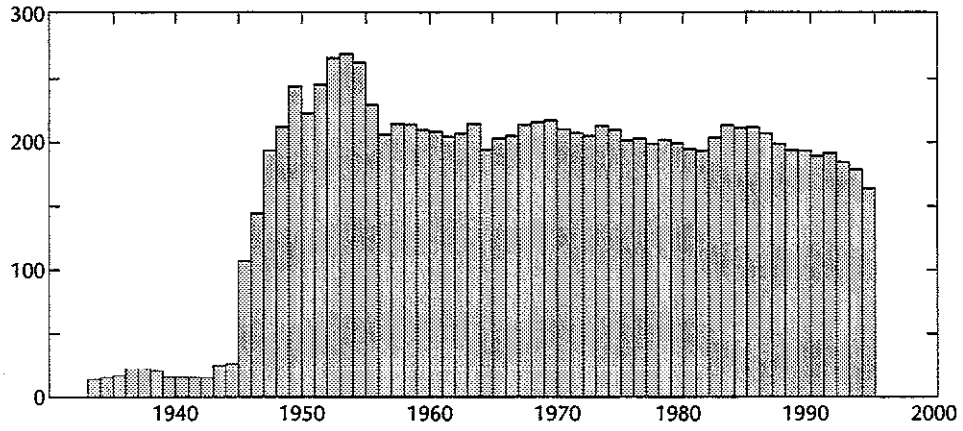

Figure 1. *Number of observation wells in Wisconsin, 1934–95.*

In April 1980 a USGS/WGNHS joint committee was formed to evaluate the observation-well network in Wisconsin and to recommend improvements. The committee established the concept and objectives of the network and criteria for network design: hydrogeologic setting, spatial distribution of wells, length, and continuity of record, frequency and accuracy of measurements, and well construction (Zaporozec, 1982); evaluated all wells according to the criteria; and recommended network revisions and future activities. The recommended revisions were carried out from 1982 to 1984.

The committee continues to meet on a regular basis to monitor the regularity and accuracy of water-level measurements and to re-evaluate and revise the network as necessary. In April 1994 the committee decided to take another look at the wells in the network to evaluate their usefulness in meeting the network goals and objectives. The evaluation concentrated on the quality of observation wells and cost of measurements. The main criteria, in addition to cost, were the availability of geologic data, good hydraulic connection of the wells with aquifers (response to recharge/drought events), and well construction (access to conduct hydraulic and/or geophysical measurements).

After the evaluation, the observation network was reduced in 1995 to 167 wells in 67 counties. The counties of Dunn, Eau Claire, Menominee, Ozaukee, and Washington currently do not have any observation wells. In addition, five piezometers were installed in deep wells in Grant and Vernon Counties. Well GR-29 has three piezometers: GR-132, GR-133, and GR-134; well VE-117 has two piezometers: VE-271 and VE-272. Locations of all observation wells are shown in figure 2 and the wells are listed in the appendix.

Recently, a two-year study, funded by the Wisconsin Department of Natural Resources from the Groundwater Account of the Environmental Fund, was completed to obtain hydraulic and geologic data for 37 of the 167 wells (Dunning and others, 1996). One of the findings of the study had direct implications for the observation network. Displacement/recovery tests (slug tests) were performed in 33 of the 37 wells. The tests provided reliable values of hydraulic conductivity for 21 wells, which indicated their good connection with aquifers. Two tests did not provide usable data. The remaining 10 wells exhibited slow recovery during the test, which indicated a poor connection with the aquifers and the need for restoration or replacement of the wells.

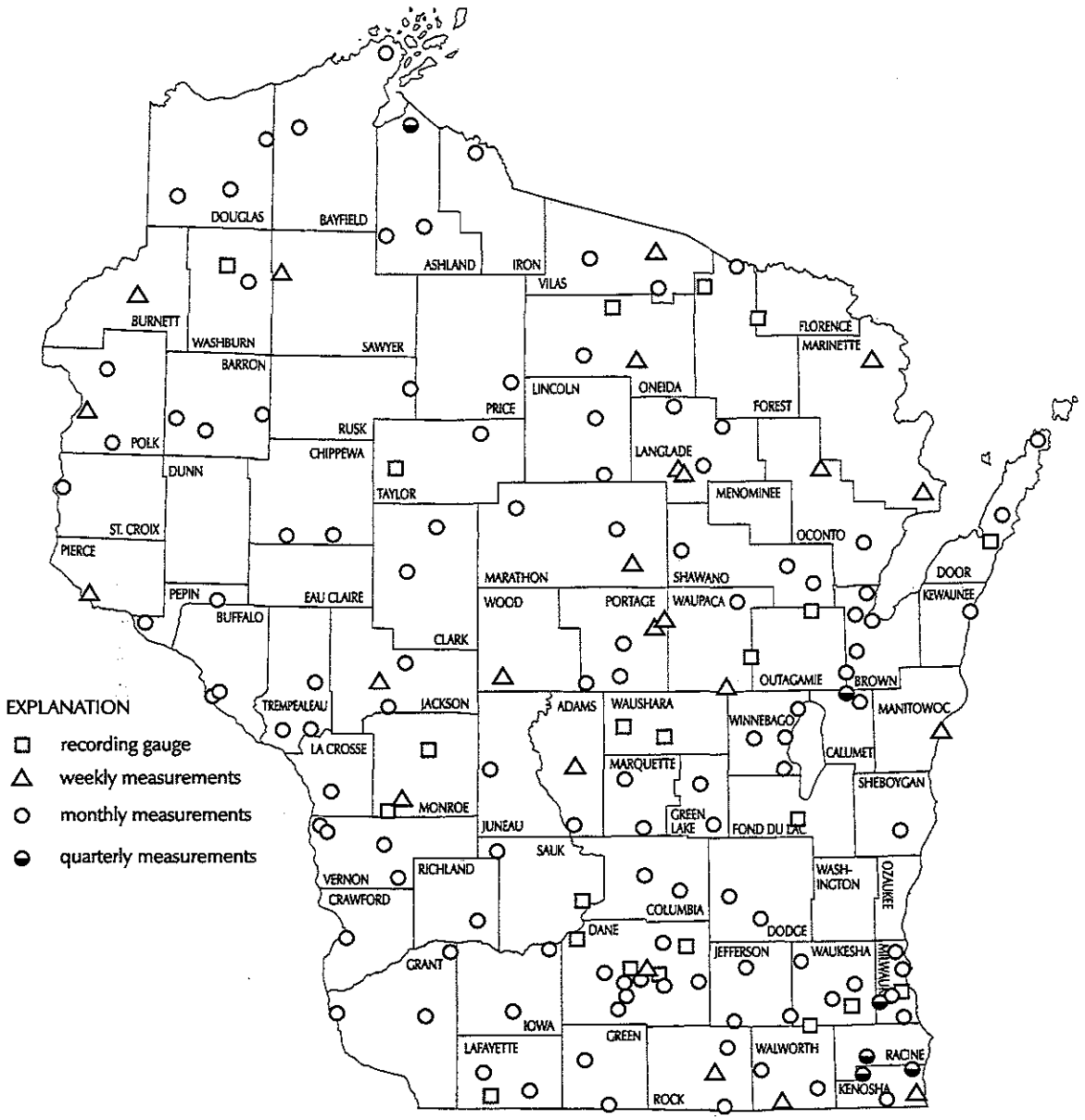

Figure 2. *Wisconsin observation-well network, 1995.*

Well-numbering system

Wells in the network are officially designated by a system of letters and numbers used by the USGS (for example, well WI-17/16E/15-0048 in fig. 3). The first two letters are abbreviations of the county name (table 1); the prefix "WI" indicates that the well is in Winnebago County. Wells are numbered according to the U.S. Bureau of Land Management system of land subdivision (fig. 3). The first set of digits indicates the township (17, fig. 3); the second set, the range either west or east of the Sixth Principal Meridian. The letter W following the range number indicates that the well is located west of the principal meridian; the letter E indicates location east of the principal meridian (16E, fig. 3). The third set of digits is the section of a township in which the well is situated (15, fig. 3). The last four numerals are the serial number of the well, assigned in the order in which the wells were inventoried in the county (0048 in fig. 3). In daily practice the well-numbering

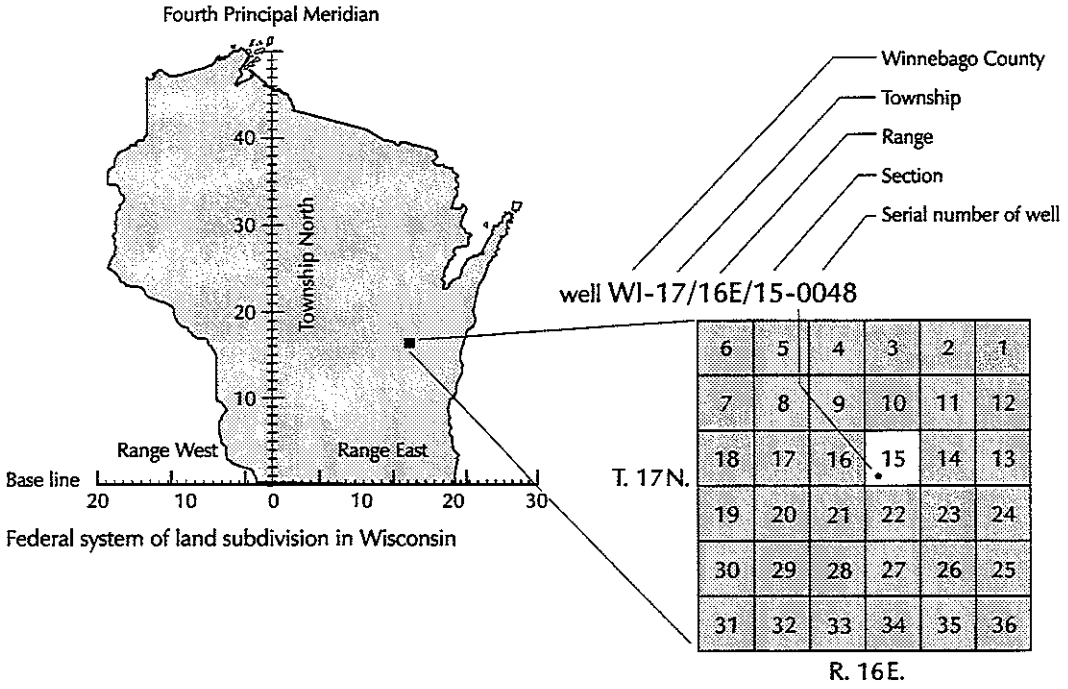

Figure 3. *Well-numbering system in Wisconsin (from Erickson and Cotter, 1983).*

system is simplified to the county abbreviation and the serial number: WI-48.

NETWORK DESIGN

Objectives of the network

The basic objectives of the Wisconsin observation-well network are

- to systematically study the natural regime of groundwater in various hydrogeologic conditions and to observe changes in the regime caused by human-related factors;
- to determine groundwater fluctuations and their causes, range, and trends; and
- to determine short-term changes and long-term trends in groundwater levels and to relate these determinations to precipitation and to changes in storage in the groundwater reservoirs.

Well locations and Wisconsin aquifers

Because it is not practical to monitor groundwater beneath all areas and within all water-bearing formations (aquifers) of the state to the same level of detail, it is necessary to establish observation wells in locations that are representative of the major Wisconsin aquifers. Therefore, observation wells are distributed areally and by aquifer to ensure uniform spatial coverage and proportional coverage of natural fluctuations in water-table and confined aquifers. Observation wells are also located in areas of heavy pumpage to monitor human-caused fluctuations and the gradual decline of water levels around major pumping centers.

The observation wells are located in all Wisconsin's principal aquifers, which have been grouped by the USGS into four major units: the unconsolidated sand and gravel aquifer and the three bedrock aquifers: the Silurian dolomite (formerly called Niagara) aquifer, the Ordovician Galena–Platteville aquifer, and the Cambrian–Ordovician sandstone aquifer (fig. 4). The Precambrian rocks, which underlie the principal aquifers, are important minor aquifers in some areas of the state.

Table 1. County name abbreviations used as prefixes in local well numbers

County	Prefix	County	Prefix	County	Prefix	County	Prefix
Adams	AD	Florence	FC	Marathon	MR	Rusk	RU
Ashland	AS	Fond du Lac	FL	Marinette	MT	St. Croix	SC
Barron	BR	Forest	FR	Marquette	MQ	Sauk	SK
Bayfield	BA	Grant	GR	Milwaukee	ML	Sawyer	SW
Brown	BN	Green	GN	Menominee	ME	Shawano	SH
Buffalo	BF	Green Lake	GL	Monroe	MO	Sheboygan	SB
Burnett	BT	Iowa	IW	Oconto	OC	Taylor	TA
Calumet	CA	Iron	IR	Oneida	ON	Trempealeau	TR
Chippewa	CH	Jackson	JA	Outagamie	OU	Vernon	VE
Clark	CK	Jefferson	JE	Ozaukee	OZ	Vilas	VI
Columbia	CO	Juneau	JU	Pepin	PP	Walworth	WW
Crawford	CR	Kenosha	KE	Pierce	PI	Washburn	WB
Dane	DN	Kewaunee	KW	Polk	PK	Washington	WN
Dodge	DG	La Crosse	LC	Portage	PT	Waukesha	WK
Door	DR	Lafayette	LF	Price	PR	Waupaca	WP
Douglas	DS	Langlade	LA	Racine	RA	Waushara	WS
Dunn	DU	Lincoln	LN	Richland	RI	Winnebago	WI
Eau Claire	EC	Manitowoc	MN	Rock	RO	Wood	WD

The sand and gravel aquifer is not a continuous unit. It consists of numerous layers and lenses deposited during the Pleistocene glaciation and of terraces and valley fillings of the Holocene Epoch spread throughout most of Wisconsin (fig. 4). The aquifer is mostly unconfined and its yields have a wide range. It is most productive in the Central Sand Plain of Wisconsin, where the highly permeable glacial outwash and alluvial sand and gravel may yield more than 1,000 gallons per minute.

The Silurian dolomite aquifer is present only east of Lake Winnebago in eastern Wisconsin (fig. 4), where it is the uppermost bedrock unit and the primary source of domestic water supplies. It was formerly called the Niagara aquifer after the main Silurian formation in Wisconsin. Wells tapping this aquifer yield from 10 to 500 gallons per minute and are commonly between 100 and 150 ft deep. Water in the aquifer may be locally confined where overlain by clayey till.

The Galena–Platteville is a locally important aquifer consisting of the Middle Ordovician dolomite with thin shale beds. It is an important source of water for domestic wells in the southern part of the state and along the Niagara escarpment, where it is the uppermost bedrock unit (fig. 4). The aquifer is commonly unconfined and yields about 100 gallons per minute.

The sandstone aquifer is composed of the thick sedimentary sequence of Cambrian and Ordovician sandstone and dolomite underlying the southern two-thirds of Wisconsin (fig. 4). Its thickness and water yields generally increase to the southeast. The yields may reach more than 1,000 gallons per minute in deep municipal wells. The aquifer is confined in eastern Wisconsin beneath the Maquoketa Formation. Additionally, it may be confined in places by the internal units or by overlying glacial deposits of low permeability.

The distribution of observation wells in the aquifers is summarized in table 2. Of the 167 observation wells in the network, more than 80 percent are located in the sandstone aquifer (72 wells) or the sand and gravel aquifer (64 wells). Locations of observation wells in the sand and gravel aquifer and in bedrock aquifers are shown in the appendix in figures A1 and A2, respectively.

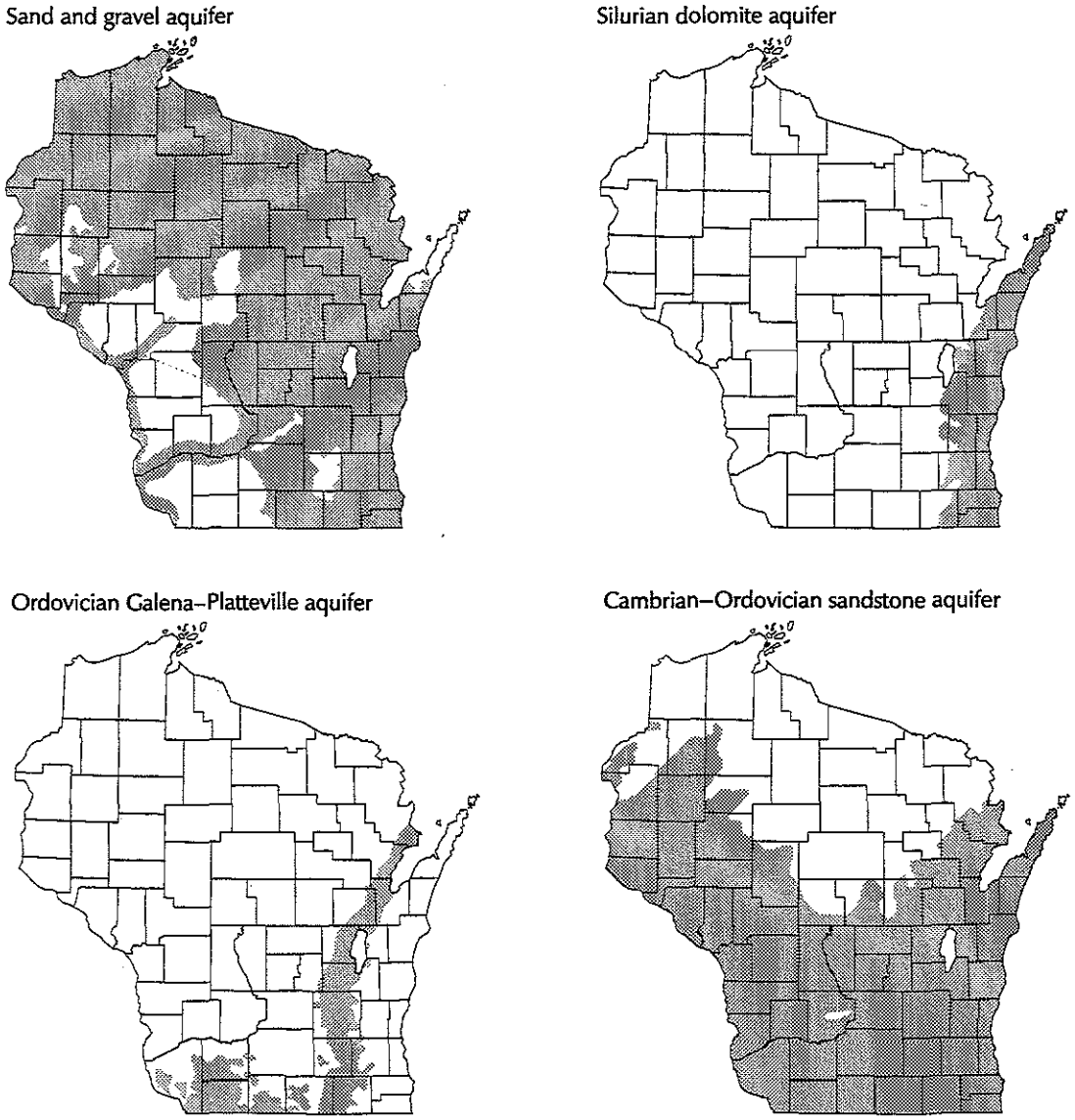

Figure 4. *Principal aquifers of Wisconsin (adapted from Erickson and Cotter, 1983).*

Frequency and accuracy of measurements

Most observation wells (121) are measured monthly (table 3). Some observation wells in key locations are measured more frequently (weekly or continuously) to obtain data suitable for reliable statistical analyses. Automatic recorders, which measure water levels continuously, are distributed proportionally to include all aquifers, especially those with frequent and rapid changes in water level. In addition to these permanently installed recorders, roving recorders are installed on selected new wells for a limited time period to determine the appropriate frequency of measurements.

All measurements are taken at regular intervals with accuracy to 0.01 ft.

DATA COLLECTION AND PROCESSING

Traditionally, the basic data collection in Wisconsin, including water-level measurements from observation wells, has been carried on as a cooperative state/federal program with a 50/50 cost sharing. The state (through WGNHS)

Table 2. Wisconsin observation wells 1995, by aquifer

Aquifer monitored	Beginning of record							Number of wells
	1934–40	1941–50	1951–60	1961–70	1971–80	1981–90	1991–95	
Sand and gravel	6	12	13	12	4	15	2	64
Silurian dolomite	–	5	–	2	3	1	–	11
Ordovician Galena–Platteville dolomite	–	4	2	6	2	1	–	15
Cambrian–Ordovician sandstone	1	14	7	22	13	13	2	72
Precambrian	–	–	–	1	–	4	–	5

Table 3. Period of record and frequency of measurements on Wisconsin observation wells as of December 31, 1995

First year of record	Frequency of measurements					Number of wells
	Continuous	Weekly	Monthly	Quarterly	Annually	
1934–40	1	4	2	–	–	7
1941–50	3	7	24	–	1	35
1951–60	6	–	15	1	–	22
1961–70	2	4	36	–	1	43
1971–80	4	1	17	–	–	22
1981–90	3	3	26	2	–	34
1991–95	3	–	1	–	–	4
Total	22	19	121	3	2	167

pledges its 50 percent of funding to the USGS and this federal unit matches the amount and provides the field staff. However, state support has not increased substantially since 1964.

Water levels in Wisconsin observation wells are measured by a group of federal, state, and local government employees and local volunteer observers. About 50 percent of wells are serviced by the USGS staff; 25 percent of wells are measured by state, county, or city employees free of charge; and the remaining 25 percent are measured by local observers, either at no charge or for a small fee.

The incoming data are checked for completeness and accuracy, and possible erroneous values are corrected before being entered into a computer. Water-level measurements and associated geologic and well constructor's reports are stored in a computer database; these data are available to the public upon request. Data can be retrieved either in a tabular or a graphical form. Requests for data are most frequently made by well drillers, developers, consultants, and staff of state agencies. The number of requests (especially by media representatives and the public) dramatically increases either in periods of drought, when a number of shallow wells usually run out of water, or in periods of above-normal precipitation, when the water table rises and causes flooding of basements and low-lying areas.

Many publications relating to groundwater

levels in Wisconsin are available (see Bibliography). Originally, hydrographs of individual wells were periodically published in WGNHS publications (Audini and others, 1959; Devaul, 1967; Erickson, 1972; Erickson and Cotter, 1983). Now, hydrographs are generated by computer upon request. Several county summaries of water-level fluctuations have been published in a popular form (Lippelt and Zaporozec, 1982, 1985; Zaporozec, 1980c, 1981). The character and causes of fluctuations and their relation to the hydrologic cycle have been explained in a popular form (Patterson and Zaporozec, 1985) and in technical publications (Patterson and Zaporozec, 1987; Zaporozec, 1980a, 1980b).

Summaries of collected data are published in several periodical series issued annually, quarterly, or monthly (see Bibliography). Selected water-level measurements are available and updated monthly on the World Wide Web by the USGS (http://wwwdwimdn.er.usgs.gov/gw/).

SUMMARY

The Wisconsin water-level observation program has a long tradition and is somewhat unique because systematic measurements for a statewide network of observation wells for a long period of time (in this case, 50 years) are not common in the United States. The program is a result of successful collaboration of a state (WGNHS) and a federal (USGS) agency and has been a valuable source of information for its many users. Requests for data primarily come from consultants, regulatory and planning agencies, well drillers, and the media. Summaries of water-level measurements are distributed by the WGNHS and USGS on a regular basis.

The WGNHS and USGS strive to maintain the quality and improve the efficiency of the network by continuous supervision and evaluation of the network function. A standing WGNHS/USGS joint committee regularly meets to monitor network operations and to recommend revisions as needed. Recently completed hydraulic testing of 37 observation wells, which showed that the hydraulic connection of wells with surrounding aquifers is poor, indicated the need for periodic testing of all accessible network wells to ensure reliable information about water levels for regulatory agencies and citizens of all Wisconsin counties.

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Zaporozec A., 1982, Groundwater level monitoring program in Wisconsin: Wisconsin Geological and Natural History Survey Educational Series 24, 9 p.

Periodical water-level-data publications

Groundwater levels in Wisconsin. Annual summaries, published since 1981 by Wisconsin Geological and Natural History Survey in Educational Series 15, 4-p. pamphlets.

Groundwater levels in Wisconsin. Monthly hydrographs from 16 observation wells, published since 1991 by U.S. Geological Survey, 4-p. pamphlets.

Water conditions in Wisconsin. Quarterly reviews of five key observation wells, published since 1980 by U.S. Geological Survey, 4-p. pamphlets.

Water resource data, Wisconsin. Annual water-data report containing, among other, water-level data for 60 selected observation wells, published by U.S. Geological Survey for each water year since 1977.

APPENDIX

Table A1. Wisconsin groundwater observation-well network, 1995 (source: U.S. Geological Survey, 1996).

Site ID	Local well ID	Meas. freq.	Aquifer	Well depth	Begin year
4357590894900	AD-17/06E/08-0076	W	SDGV	21.0	1969
4340140894712	AD-14/06E/21-0128	M	SNDS	80.0	1969
4609360905317	AS-43/04W/32-0006	M	SDGV	89.0	1957
4611090903730	AS-43/02W/21-0054	M	SDGV	73.0	1967
4636310904158	AS-48/03W/26-0178	Q	SDGV	137.0	1984
4633520912314	BA-47/08W/08-0124	M	SDGV	300.0	1968
4652200904920	BA-51/04W/26-0262	M	PCMB	205.0	1986
4413230914934	BF-20/12W/09-0119	M	SDGV	80.0	1984
4412570914959	BF-20/12W/16-0120	M	SDGV	15.5	1986
4433250880717	BN-24/20E/18-0013	M	GLPV	250.0	1947
4432280880031	BN-24/20E/24-0076	M	SNDS	500.0	1950
4424380880813	BN-22/19E/01-0154	M	GLPV	190.0	1966
4438330880218	BN-25/20E/14-0890	M	GLPV	56.0	1983
4515140915821	BR-33/13W/21-0046	M	SNDS	65.0	1956
4522040920817	BR-33/14W/06-0048	M	SNDS	204.0	1969
4524300913532	BR-34/10W/22-0153	M	SNDS	132.0	1964
4552240922156	BT-39/16W/17-0002	W	SDGV	46.0	1937
4413590881204	CA-20/19E/02-0006	Q	SNDS	1050.0	1952
4411380880613	CA-20/20E/22-0062	M	GLPV	345.0	1974
4453060912530	CH-28/09W/25-0120	M	SDGV	99.5	1964
4454390911557	CH-28/07W/17-0142	M	SNDS	60.0	1968
4445250904432	CK-26/03W/04-0001	M	SNDS	150.0	1953
4456190903352	CK-28/02W/01-0509	M	SDGV	40.0	1983
4325040891148	CO-11/11E/16-0134	M	SNDS	71.0	1974
4329210892459	CO-12/09E/27-0620	M	SNDS	80.0	1974
4313320910434	CR-09/06W/27-0059	M	SNDS	113.0	1966
4324150885526	DG-11/13E/22-0081	M	SNDS	125.0	1964
4317250884413	DG-10/15E/32-0109	M	GLPV	215.0	1965
4304270892300	DN-07/09E/23-0005	W	SNDS	347.0	1946
4304270892849	DN-07/09E/19-0064	C	SNDS	300.0	1977
4313220894758	DN-09/06E/29-0083	C	SDGV	146.0	1953
4304560891906	DN-07/10E/09-0105	C	SNDS	378.0	1974
4303430891847	DN-07/10E/21-0146	M	SNDS	457.0	1977
4312310891921	DN-09/10E/33-0441	M	SNDS	105.0	1959
4301060890303	DN-06/12E/02-0880	M	SNDS	235.0	1970
4256290893539	DN-05/08E/06-0927	M	SNDS	340.0	1984
4303080892943	DN-07/08E/25-1134	M	SNDS	85.0	1976
4306380893531	DN-07/08E/06-1136	M	SNDS	325.0	1980
4259580893216	DN-06/08E/15-1289	M	SNDS	182.0	1986
4304060892329	DN-07/09E/23-1297	M	SDGV	68.0	1978
4312330891032	DN-09/11E/34-1355	C	SNDS	70.0	1990
4457570871517	DR-29/27E/30-0007	M	SLRN	111.0	1946
4450550872139	DR-27/26E/05-0265	C	SLRN	442.0	1971
4515180870426	DR-32/28E/15-0317	M	SLRN	155.0	1983
4631170913428	DS-47/10W/23-0001	M	SDGV	40.0	1937
4619210914842	DS-44/12W/01-0327	M	SDGV	148.0	1968
4618110920910	DS-44/14W/08-0329	M	PCMB	60.0	1968
4548360883949	FC-39/15E/31-0004	C	SDGV	53.0	1967
4342310883118	FL-14/17E/06-0659	C	SNDS	506.0	1995
4601520884749	FR-41/14E/18-0002	M	SDGV	18.0	1948
4556060885930	FR-40/12E/21-0087	C	SDGV	102.0	1967
4342380885925	GL-14/13E/06-0032	M	SNDS	400.0	1983
4350110890457	GL-16/12E/21-0047	M	SNDS	65.0	1974
4244270894947	GN-03/06E/18-0002	M	SNDS	150.0	1946
4230590893952	GN-01/07E/33-0074	M	SNDS	201.0	1979
4255510903913	GR-05/02W/06-0005	M	SNDS	35.0	1946
4252460910421	GR-05/06W/27-0029	M	SNDS	1428.0	1982
4310420902915	GR-08/01W/10-0072	M	SDGV	18.0	1963
4252460910421	GR-05/06W/27-0132[1]	Q	SNDS	1430.0	1982
4252460910421	GR-05/06W/27-0133[1]	Q	SNDS	1240.0	1982
4252460910421	GR-05/06W/27-0134[1]	Q	SNDS	665.0	1982
4629420902246	IR-46/01E/04-0121	M	PCMB	300.0	1983
4256440901019	IW-06/03E/32-0032	M	GLPV	92.0	1957
4309430895626	IW-08/05E/18-0110	M	SNDS	188.0	1968
4410460904729	JA-20/03W/30-0005	M	SNDS	190.0	1953
4418100904840	JA-21/04W/13-0038	W	SDGV	80.0	1981
4424200904618	JA-22/03W/08-0085	M	PCMB	85.0	1983
4305110884920	JE-07/14E/10-0144	M	SNDS	378.0	1965
4251410885401	JE-05/13E/25-0303	M	SNDS	150.0	1970
4253320883522	JE-05/16E/15-0849	M	SNDS	122.0	1984
4355150901529	JU-17/02E/28-0098	M	SNDS	71.0	1969
4239070875217	KE-02/22E/11-0006	Y	SNDS	1751.0	1946
4238190880903	KE-02/20E/17-0021	Y	SNDS	1908.0	1961
4232140875038	KE-01/22E/13-0046	W	SLRN	135.0	1963
4230550880203	KE-01/21E/29-0288	M	SDGV	232.0	1972
4434000872700	KW-24/25E/10-0030	M	SLRN	203.0	1974
4511220890145	LA-31/12E/08-0027	M	SDGV	93.0	1952
4509330890848	LA-31/11E/20-0064	W	SDGV	20.0	1948
4508470890851	LA-31/11E/29-0200	W	SDGV	15.0	1949
4520130885338	LA-33/13E/17-0334	M	SDGV	48.5	1968
4526030891116	LA-34/10E/13-0537	M	SDGV	97.0	1983
4351380911054	LC-16/07W/14-0076	M	SNDS	325.0	1986
4240040902206	LF-02/01E/04-0011	M	GLPV	64.0	1947
4231130901611	LF-01/02E/33-0057	C	GLPV	265.0	1952
4234550900433	LF-01/03E/01-0294	M	GLPV	200.0	1970
4523180894025	LN-34/06E/36-0060	M	SDGV	21.8	1944
4508400893728	LN-31/07E/28-0092	M	SDGV	86.0	1983
4258190875512	ML-06/22E/20-0085	C	SNDS	1834.0	1974
4256100880154	ML-06/21E/32-0094	M	SNDS	1845.0	1946
4307060875836	ML-08/21E/35-0118	M	SLRN	136.0	1946

[1] Piezometers on well GR-29

Frequency of measurement
C = continuous
W = weekly
M = monthly
Q = quarterly
Y = annually

Aquifer monitored
SDGV = Pleistocene sand and gravel
SLRN = Silurian dolomite
GLPV = Ordovician Galena–Platteville dolomite
SNDS = Cambrian–Ordovician sandstone
PCMB = Precambrian

Site ID	Local well ID	Meas. freq.	Aquifer	Well depth	Begin year
4304120875458	ML-07/22E/17-0120	M	SLRN	400.0	1946
4256130880143	ML-06/21E/32-0148	M	SLRN	180.0	1946
4252020875634	ML-05/22E/30-0540	M	SNDS	1846.0	1974
4404300874204	MN-19/23E/35-0028	M	SLRN	147.0	1968
4343420904956	MO-15/04W/34-0002	C	SNDS	44.0	1934
4348400904613	MO-15/03W/05-0010	W	SDGV	16.7	1934
4400260903901	MO-18/02W/29-0017	C	SNDS	192.0	1950
4352440892934	MQ-16/08E/12-0009	M	SNDS	274.0	1949
4339560892756	MQ-14/09E/30-0026	M	SNDS	170.0	1965
4458450900544	MR-29/03E/24-0027	M	SDGV	41.9	1944
4447090892653	MR-27/09E/31-0028	W	SDGV	27.0	1944
4459130893745	MR-29/07E/24-0100	M	SDGV	104.0	1984
4538160875901	MT-37/20E/34-0007	W	SDGV	33.0	1939
4503560874139	MT-30/23E/15-0031	W	GLPV	395.0	1970
4450540880252	OC-27/20E/03-0020	M	SNDS	100.0	1968
4508190882639	OC-31/16E/25-0179	W	SDGV	46.0	1983
4552130893235	ON-39/08E/18-0022	C	SDGV	27.1	1944
4540260894253	ON-37/06E/27-0023	M	SDGV	37.0	1944
4537390892200	ON-36/09E/09-0024	W	SDGV	33.0	1944
4418400881150	OU-21/19E/04-0326	M	GLPV	280.0	1969
4430290883304	OU-24/18E/34-0380	M	SNDS	277.0	1983
4433530881942	OU-24/18E/08-0416	C	SNDS	740.0	1995
4438450923645	PI-25/18W/18-0151	W	SDGV	77.0	1985
4530130923146	PK-35/17W/08-0040	M	SDGV	52.0	1957
4516240923148	PK-32/17W/07-0075	M	SNDS	96.0	1957
4523520923320	PK-34/18W/26-0093	W	SDGV	64.0	1966
4431380921740	PP-24/16W/26-0039	M	SNDS	140.0	1969
4436240915124	PP-25/12W/32-0040	M	SNDS	160.0	1968
4533110900653	PR-35/03E/04-0065	M	SDGV	118.0	1986
4431270891741	PT-24/10E/28-0015	M	SDGV	52.0	1950
4418330893156	PT-21/08E/10-0036	M	SDGV	12.0	1950
4414540894328	PT-21/07E/31-0059	M	SDGV	15.3	1951
4428100891945	PT-23/10E/18-0276	M	SDGV	17.4	1958
4426230893027	PT-23/08E/25-0376	M	SDGV	36.4	1960
4241190880818	RA-03/20E/28-0062	Q	SDGV	104.0	1985
4318400902032	RI-10/01E/26-0023	M	SNDS	160.0	1965
4239560890223	RO-02/12E/02-0003	W	SNDS	470.0	1947
4246230885619	RO-04/13E/27-0008	M	SNDS	722.0	1952
4230220885902	RO-01/13E/32-0491	M	GLPV	230.0	1979
4531070904201	RU-35/03W/14-0089	M	SDGV	25.0	1957
4340000875624	SB-14/21E/24-0084	M	SLRN	162.0	1974
4505360924550	SC-30/20W/14-0013	M	SNDS	230.0	1983
4442030882146	SH-26/18E/30-0001	M	SNDS	132.0	1947
4446270883214	SH-27/16E/34-0027	M	SNDS	95.0	1974
4450450891005	SH-27/11E/04-0078	M	SDGV	51.0	1983
4321000894400	SK-10/06E/02-0003	C	SNDS	451.0	1989
4336050901337	SK-13/02E/14-0230	M	SNDS	160.0	1984
4600050912918	SW-41/09W/28-0007	W	SDGV	25.0	1937
4509470904839	TA-31/04W/13-0001	C	SDGV	24.0	1957
4519140901725	TA-33/02E/30-0009	M	SDGV	160.0	1965
4404220911829	TR-19/08W/35-0001	M	SNDS	195.0	1947
4404140912704	TR-19/09W/33-0009	M	SDGV	71.0	1953
4417430911531	TR-21/07W/17-0071	M	SNDS	83.0	1979
4339280911025	VE-14/07W/26-0008	M	SDGV	53.0	1934
4328420904944	VE-12/04W/34-0052	M	SNDS	100.0	1966
4336300905316	VE-13/04W/17-0071	M	SNDS	180.0	1966
4339210911321	VE-14/07W/28-0117	M	SNDS	198.0	1982
4339210911321	VE-14/07W/28-0271[2]	Q	SNDS	633.0	1982
4339210911321	VE-14/07W/28-0272[2]	Q	SNDS	524.0	1982
4603160891521	VI-41/10E/09-0003	M	SDGV	19.5	1948
4555170891440	VI-40/10E/28-0033	M	SDGV	37.0	1965
4559110894134	VI-41/06E/36-0959	M	SDGV	68.0	1980
4558200913947	WB-40/11W/01-0042	M	SNDS	140.0	1968
4600390915001	WB-41/12W/26-0048	C	SDGV	87.0	1982
4418270900750	WD-21/03E/10-0066	M	SDGV	73.0	1981
4411250882922	WI-20/17E/20-0001	M	SNDS	340.0	1946
4401220883246	WI-18/16E/23-0006	M	GLPV	200.0	1950
4356240883454	WI-17/16E/15-0048	M	GLPV	180.0	1967
4403470884736	WI-18/14E/02-0594	M	SNDS	200.0	1983
4300520881335	WK-06/19E/02-0006	M	SNDS	1785.0	1970
4306080883104	WK-07/17E/05-0020	M	SNDS	773.0	1946
4255350881317	WK-05/19E/02-0031	C	SLRN	508.0	1947
4256070881730	WK-06/19E/31-1301	M	SDGV	237.5	1992
4415450885229	WP-21/13E/25-0002	W	SNDS	205.0	1950
4423550884438	WP-22/14E/12-0013	C	SDGV	203.0	1958
4438210884908	WP-25/14E/17-0771	M	PCMB	146.0	1983
4407130893208	WS-19/08E/15-0008	C	SDGV	18.0	1951
4403450891517	WS-18/10E/01-0105	C	SDGV	14.0	1956
4240040884406	WW-03/15E/33-0009	M	GLPV	287.0	1947
4235320882546	WW-02/17E/36-0037	M	SNDS	820.0	1963
4233150883503	WW-01/16E/10-0083	W	SDGV	150.0	1980
4250060882715	WW-04/17E/02-0908	C	SDGV	85.0	1995

[2] Piezometers on well VE-117

Frequency of measurement
- C = continuous
- W = weekly
- M = monthly
- Q = quarterly
- Y = annually

Aquifer monitored
- SDGV = Pleistocene sand and gravel
- SLRN = Silurian dolomite
- GLPV = Ordovician Galena–Platteville dolomite
- SNDS = Cambrian–Ordovician sandstone
- PCMB = Precambrian

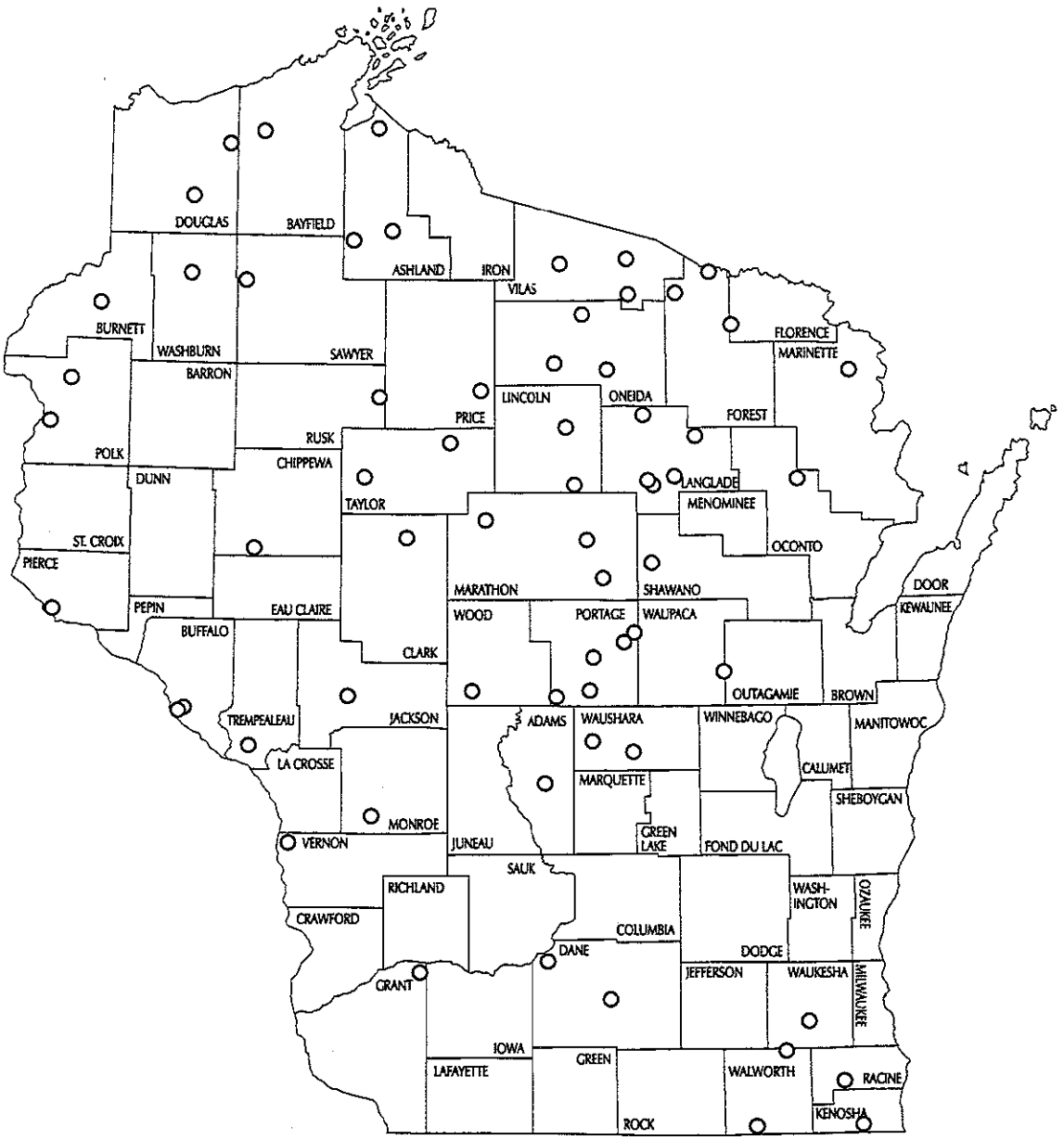

Figure A1. *Wisconsin observation wells in the sand and gravel aquifer.*

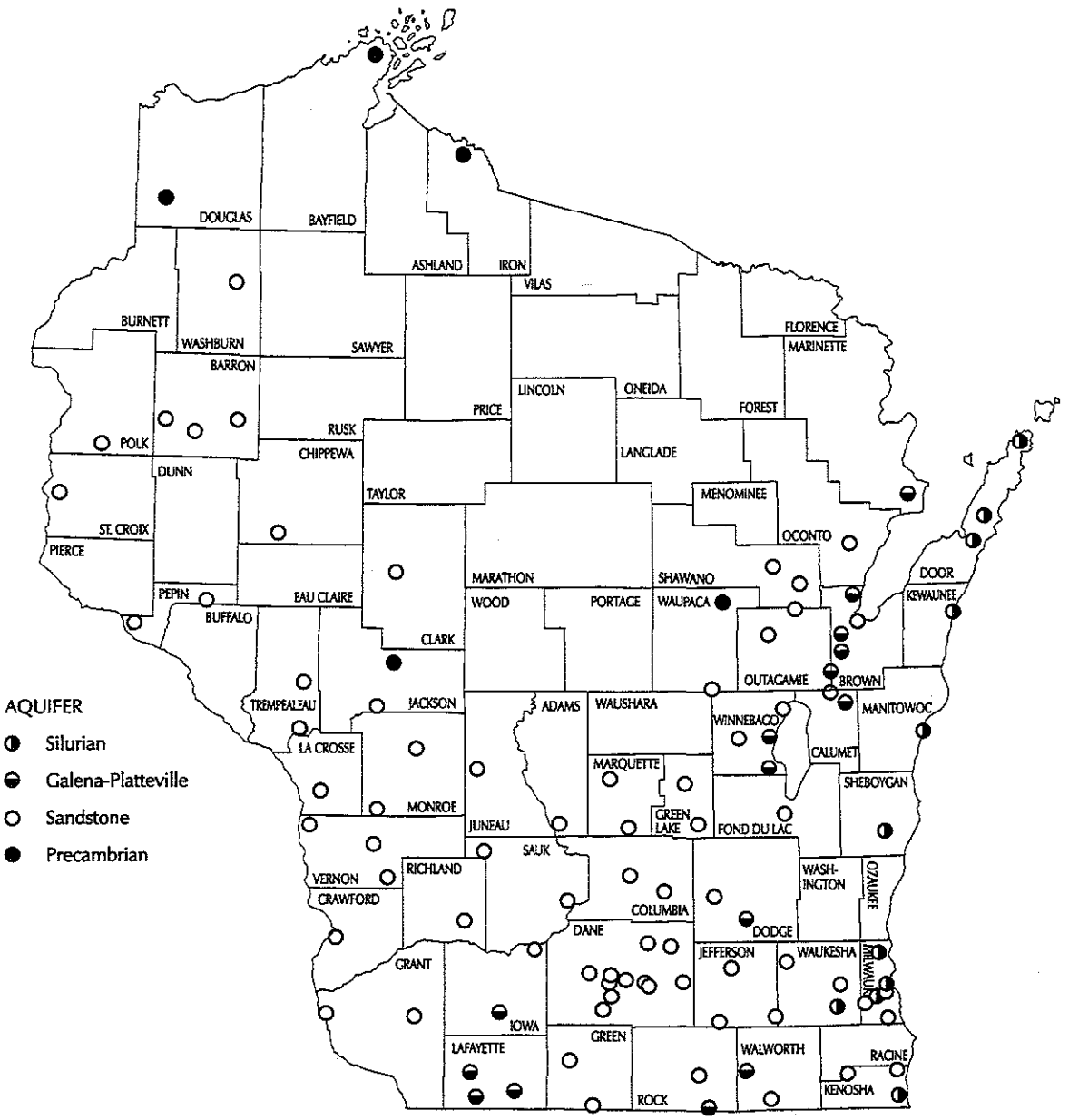

Figure A2. *Wisconsin observation wells in bedrock aquifers.*

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James M. Robertson, *Director and State Geologist*

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