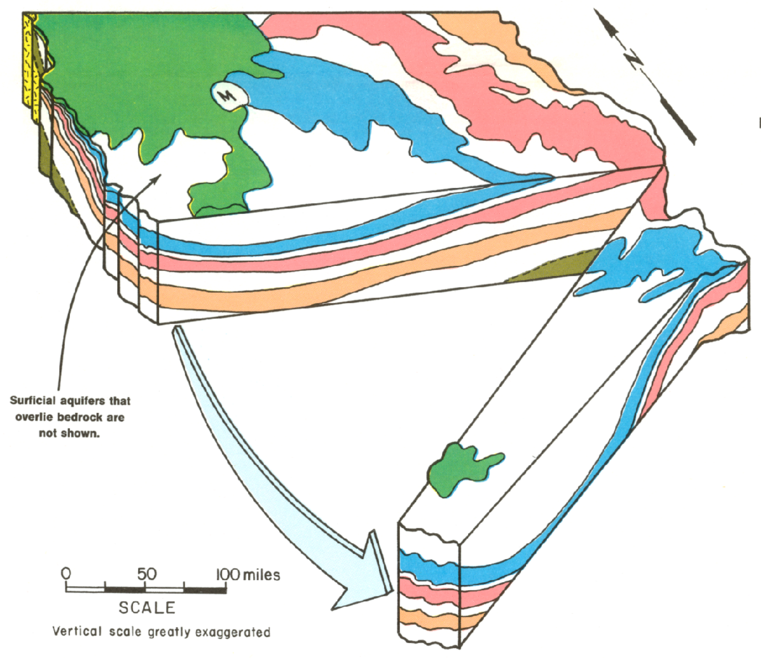
# INTRODUCTION

To protect and improve the environment and to satisfy the demand society places on the natural resources within the environment requires proper development and management of our land and water. These objectives can be adequately accomplished through long-range planning that is based on a solid foundation of basic water and water-related data. Basic hydrologic data, to be of optimum aid to the water developer and to local, regional, or state planners and managers, must be presented in a readily usable form. One such format is a hydrologic atlas, in which synthesized data can be presented on maps of usable scale. Accordingly, the Iowa Geological Survey in cooperation with the U.S. Geological Survey is publishing a series of hydrologic atlases that will describe and evaluate the availability and chemical quality of the water resources, and evaluate the potential pollution hazard to water sources from various land-use practices. Initial atlases present information on the discrete aquifers in the State's ground-water reservoir — a reservoir that produces 75 percent of the water used in Iowa, excluding that used for power generation.




### IOWA IS UNDERLAIN BY FIVE PRINCIPAL BEDROCK AQUIFERS, OVERLYING THESE ARE THE LESS EXTENSIVE GLACIOFLUVIAL AND ALLUVIAL AQUIFERS, COLLECTIVELY CALLED THE SURFICIAL AQUIFER. SEPARATING THE PRINCIPAL AQUIFERS ARE WIDESPREAD CONFINING BEDS THAT PREVENT OR RETARD INTERAQUIFER MOVEMENT OF WATER. ALL THESE ROCKS COMPRISE A VAST GROUND-WATER RESERVOIR THAT CONTAINS AN IMMENSE QUANTITY OF WATER IN STORAGE (MODIFIED FROM STEINHILBER AND HORICK, 1970)

The bottom of the ground-water reservoir is the Precambrian crystalline complex, which occurs at a depth of about 5,200 feet in southwestern Iowa and rises to the surface in extreme northwestern Iowa and to within 800 feet of the surface in northeastern Iowa. Overlying these basement rocks is a succession of consolidated sedimentary strata of Paleozoic age that are dominantly sandstones and dolomites in the lower part, and shales, dolomites and limestones in the upper part. These strata have been downwarped into a broad trough, known as the Iowa basin. The surface of the dipping Paleozoic rocks was beveled by erosion, thus exposing older Paleozoic strata in the northeastern and northwestern parts of the State and forming extensive recharge areas of the Paleozoic aquifers in northeastern Iowa. The beveled Paleozoic rocks in northwestern Iowa are unconformably overlain by nearly flat-lying shales and sandstones of Cretaceous age. The surface of both the Paleozoic and Cretaceous rocks has been modified considerably by pre-Pleistocene erosion, and nearly everywhere is mantled by glacial drift and loess of variable thicknesses.
The water-bearing bedrock units in the ground-water reservoir are the porous, permeable sandstones of Cretaceous and Paleozoic ages and the fissured, cavernous limestones and dolomites of Paleozoic age. This atlas is concerned with one of the Paleozoic units — the Mississippian. The other units will be discussed in subsequent atlases.

### PURPOSE AND SCOPE

The purpose of this atlas is to present information on the occurrence, movement, availability, use, and chemical quality of water from the Mississippian aquifer in Iowa. Included is a brief description of the physical characteristics and spatial relations of the rocks that contain the water. Also discussed and evaluated are the areas of high pollution hazard to this and underlying aquifers. The information presented in this atlas is based on water-well data collected over many years, initially by the Iowa Geological Survey and later in cooperation with the U.S. Geological Survey.

### METHOD OF PRESENTATION

The synthesized data presented in this atlas have been divided into three subject headings — geology, hydrology, and chemical quality of water. Although each subject is treated on a separate atlas sheet, some deviation in map presentation was required.
The geologic nomenclature and classification of rock units in this report are those of the Iowa Geological Survey and do not necessarily coincide with those used by the U.S. Geological Survey. The units used in mapping the geology of the Mississippian aquifer are series terms, because of the complexity of Mississippian stratigraphy. However, many drillers and ground-water consultants are more familiar with formation and group names; therefore these have been shown on the stratigraphic chart and are used in the report.

### ACKNOWLEDGEMENTS

Appreciation is expressed to past and present personnel of the Iowa and U.S. Geological Surveys, whose geologic studies have provided the basis for this report. The cooperation of the well drillers who work in Iowa also is acknowledged. Their efforts in carefully collecting drill cuttings and recording water data provided the basic data foundation for this study.
Private well owners and municipal water superintendents provided data on water use and allowed collection of water samples. The chemical analyses of water used in this atlas were made by the State Hygienic Laboratory. Special thanks are due Ray Anderson and Diana Gilmore for drafting all maps and illustrations.

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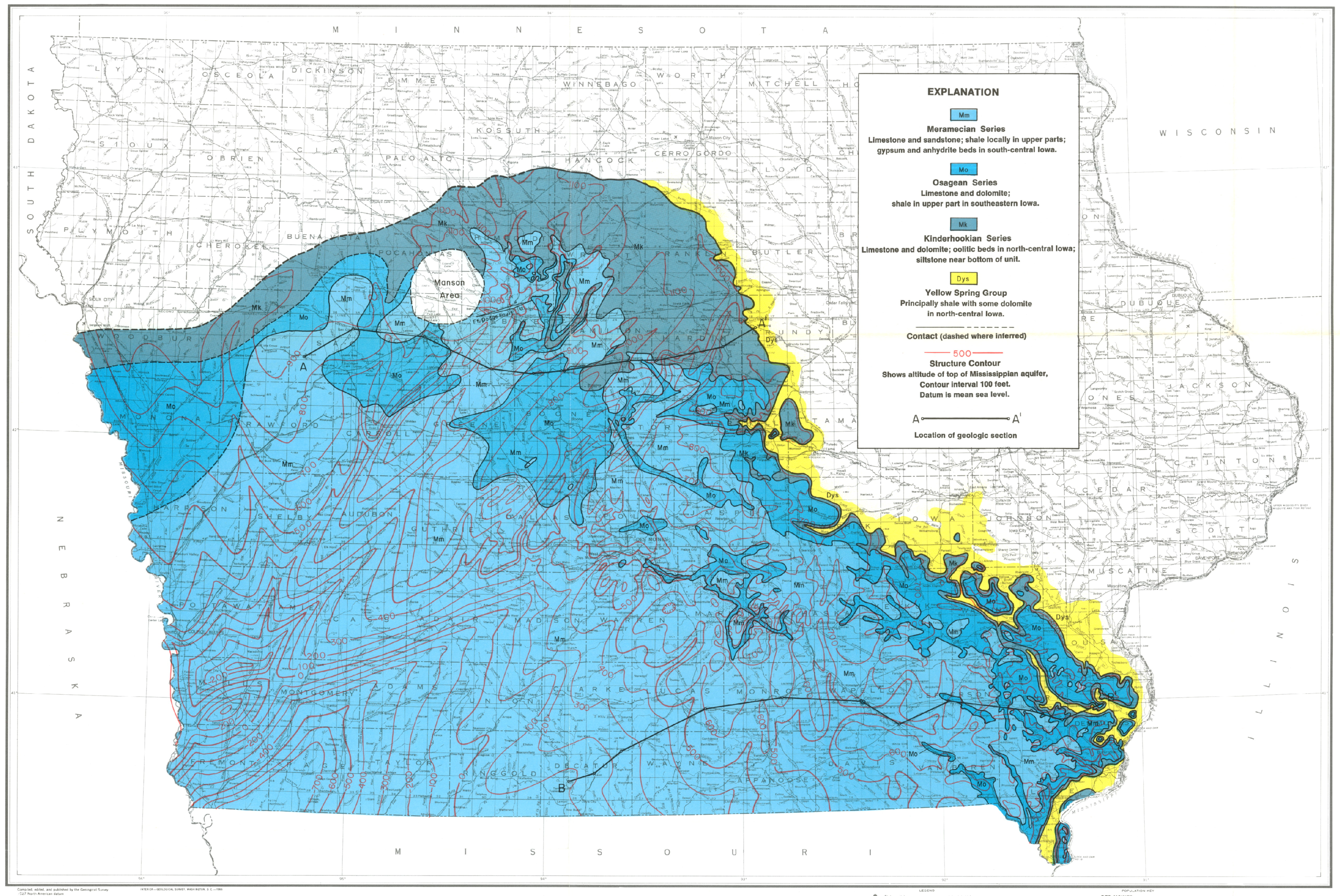
# GEOLOGY




### GEOLOGIC UNITS OF THE MISSISSIPPIAN AQUIFER AND OVERLYING AND UNDERLYING STRATA①

| System | Series | Group / Formation | Formation: North-central Iowa | Formation: Southeastern Iowa | Thickness (ft) | Physical Character: North-central Iowa | Physical Character: Southeastern Iowa |
|---|---|---|---|---|---|---|---|
| CRETACEOUS | | | Undifferentiated | | 0-300 | Sandstone and shale. | |
| PENNSYLVANIAN | | | Undifferentiated | | 0-1500+ | Principally shale, limestone, and siltstone in upper part; mostly carbonaceous shale and thin limestone and coal beds in lower part. | |
| MISSISSIPPIAN | Meramecian | | Ste. Genevieve | | 0-85 | Red, green and gray calcareous shales; minor limestones, dense and fossiliferous. | Limestone and greenish-gray shale; the limestone may be very dense locally. Commonly fossiliferous. |
| MISSISSIPPIAN | Meramecian | | St. Louis | | 0-135 | Limestone, very dense in some zones, and dolomite, usually sandy; commonly much sandstone; minor chert, locally thin shale. | Upper part limestone and sandstone; limestone commonly very dense. Lower part dolomite, sandy, minor chert; also gypsum-anhydrite beds in parts of Dallas, Marion, Mahaska, Monroe, Appanoose, Davis, and Van Buren Counties. |
| MISSISSIPPIAN | Meramecian | | Spergen | | | | |
| MISSISSIPPIAN | Osagean | | Warsaw | | 0-75 | Dolomite and limestone with much chert; locally contains shale in upper part; glauconite near top and base of Burlington. Many beds consist largely of fossil fragments. | Dolomite and shale; usually small amount of chert and chalcedony; geode zone locally at base. |
| MISSISSIPPIAN | Osagean | | Keokuk | | 0-125 | | Limestone and dolomite containing much chert; glauconite usually at top and near base of Burlington. Many beds consist largely of fossil fragments. Upper part of Keokuk contains a thin shale unit locally. |
| MISSISSIPPIAN | Osagean | | Burlington | | 0-140 | | |
| MISSISSIPPIAN | Kinderhookian | | Gilmore City | | 0-160 | Limestone, generally partly oolitic, but may be nearly all oolitic in some places; locally some beds consist predominately of fossil fragments; commonly very dense at top. | |
| MISSISSIPPIAN | Kinderhookian | Hampton Formation | Iowa Falls | | 0-160 | Dolomite, often calcareous; generally dense, may be saccharoidal. | |
| MISSISSIPPIAN | Kinderhookian | Hampton Formation | Eagle City | | | Limestone, partly oolitic and very dense. | |
| MISSISSIPPIAN | Kinderhookian | Hampton Formation | Maynes Creek | Wassonville | 0-130 | Dolomite, calcareous; usually contains considerable chert in lower part. | Dolomite, calcareous; or dolomite and limestone, cherty; thin oolite locally at top in northwest part of this district; usually minor chert in lower part. |
| MISSISSIPPIAN | Kinderhookian | North Hill Group | Chapin | Starrs Cave | 0-90 | Limestone and dolomite, partly oolitic. | Limestone, locally oolitic, especially at base; commonly fossil fragments. |
| MISSISSIPPIAN | Kinderhookian | North Hill Group | Prospect Hill | | 0-95 | Siltstone, dolomitic, and becoming more dolomitic toward the north. | Siltstone, dolomitic; some shale. |
| MISSISSIPPIAN | Kinderhookian | North Hill Group | | McCraney | 0-70 | | Limestone to dolomite, locally very dense. |
| DEVONIAN | Upper Devonian | Yellow Spring Group | | English River | 0-30 | | Siltstone, dolomitic. |
| DEVONIAN | Upper Devonian | Yellow Spring Group | Maple Mill | | 0-310 | Shale, slightly calcareous or dolomitic locally, green-gray. Thins to north. | Shale, may be dolomitic, green-gray; spore-bearing in lower part. |
| DEVONIAN | Upper Devonian | Yellow Spring Group | Aplington | | 0-40 | Dolomite with minor shale and limestone near base; some chert in upper part. | |
| DEVONIAN | Upper Devonian | Yellow Spring Group | Sheffield | | 0-200 | Shale, green-gray. | Shale, dark olive gray to yellowish-brown. |

① The nomenclature and classification of rock units in this report are those of the Iowa Geological Survey and do not necessarily coincide with those accepted by the U.S. Geological Survey.

### THE MISSISSIPPIAN AQUIFER, WHICH UNDERLIES ABOUT SIXTY PER CENT OF THE STATE, CONSISTS PRINCIPALLY OF LIMESTONE AND DOLOMITE STRATA THAT ARE GROUPED INTO THREE MAPPABLE UNITS — THE KINDERHOOKIAN, OSAGEAN, AND MERAMECIAN SERIES OF THE MISSISSIPPIAN SYSTEM

The Kinderhookian strata are chiefly limestone and cherty dolomite, with some siltstone near the basal part of the unit. In north-central Iowa, the unit is characterized by oolitic limestone beds that thin and become discontinuous to the south and southeast. The Osagean strata are chiefly dolomite and limestone with an abundance of chert; however, the only shale (Warsaw Shale) of any consequence in the Mississippian rocks occurs in this unit in southeastern Iowa. The Meramecian rocks are mainly sandy limestone and sandstone with some dense dolomite beds near the base and shale locally near the top. The unit in south-central Iowa contains beds of gypsum and anhydrite.

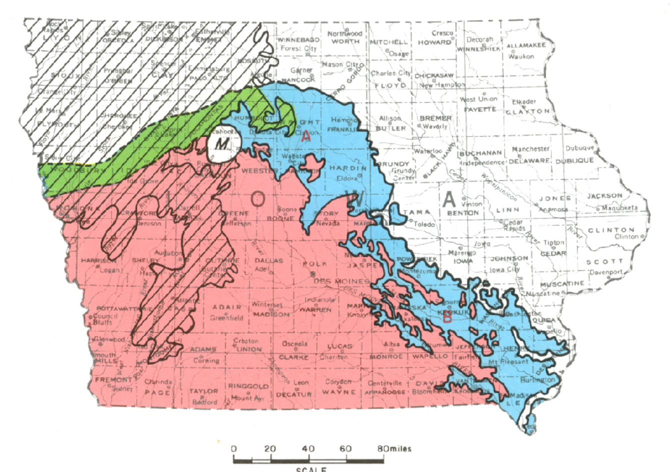
### THE MAXIMUM THICKNESS OF THE MISSISSIPPIAN AQUIFER IS ABOUT 600 FEET; HOWEVER, IN THE OUTCROP* AREA, THE THICKNESS GENERALLY IS BETWEEN 100 AND 300 FEET

The thickness at any site can be determined directly from the map on sheet 2 of this atlas.

*Use of outcrop and subcrop in this atlas follows usage in AGI Glossary, and allows for more convenient reference to the two areas of the aquifer's occurrence.

### THROUGHOUT THE GREATER PART OF ITS AREAL EXTENT, THE MISSISSIPPIAN AQUIFER OCCURS BETWEEN TWO REGIONAL CONFINING BEDS

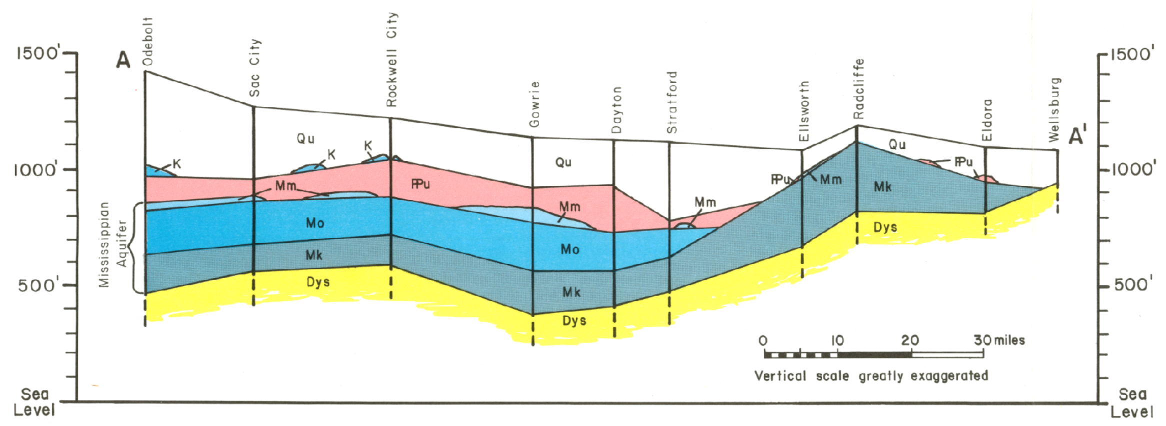
Underlying the aquifer and separating it from the Silurian-Devonian aquifer, are impermeable shale units of Devonian age. In southern and southeastern Iowa these shales are very thick, but in north-central Iowa they are thin and patchy in occurrence. Overlying the aquifer in most of the subcrop area are impermeable shales of Pennsylvanian age. However, in northwest Iowa, the subcrop in places is overlain by permeable sandstones of Cretaceous age. In the outcrop area in north-central and southeastern Iowa the aquifer is overlain directly by semi-permeable glacial drift and locally by permeable, water-bearing alluvium.



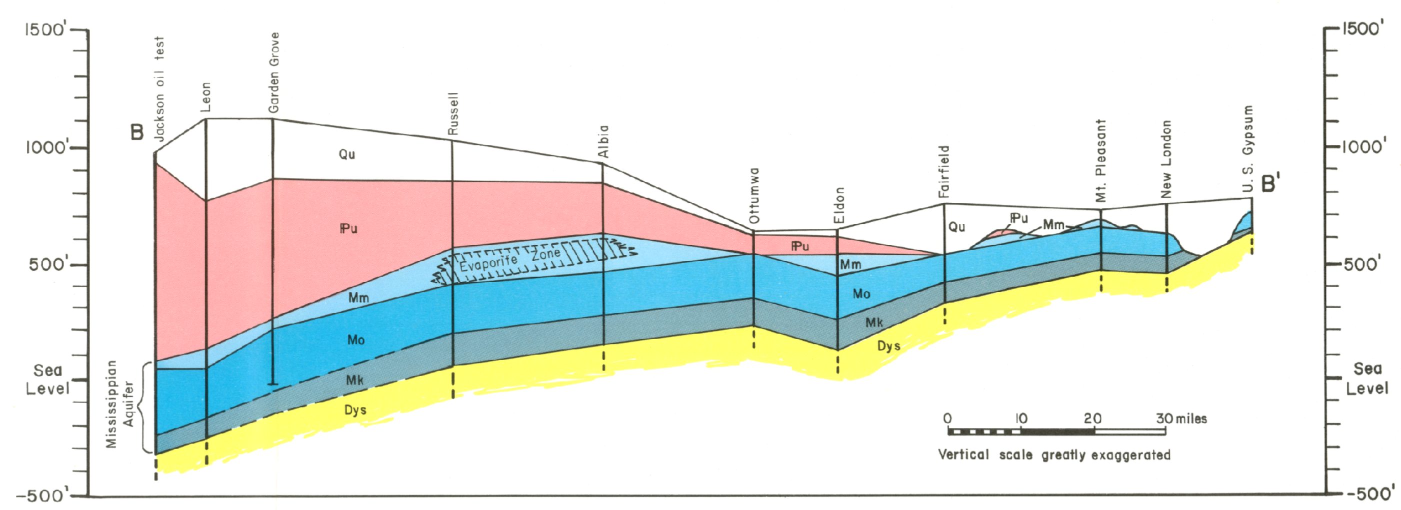

OUTCROP AND SUBCROP AREAS OF THE MISSISSIPPIAN AQUIFER

### THE MISSISSIPPIAN AQUIFER HAS A GENTLE SOUTHWESTWARD SLOPE FROM THE OUTCROP AREA AND A STEEP SOUTHWARD SLOPE FROM IOWA'S WESTERN BORDER, SO THAT IT IS DEEPLY BURIED UNDER PENNSYLVANIAN ROCKS IN THE DEEPEST PART OF THE IOWA BASIN

Local variations in the aquifer's altitude are considerable and are caused by structural flexures and erosion of the aquifer's surface. Erosional features are particularly prominent in southeast Iowa, where preglacial and interglacial streams have cut deep channels in the aquifer. Some of these were cut deep enough to completely breach and isolate segments of the aquifer.
The depth to the aquifer at any site or locality can be determined from the altitude shown on the above map and a topographic map. To illustrate: if the altitude of a site is 700 feet above sea level and the altitude of the aquifer at that site is 600 feet above sea level, the depth would be 100 feet. This figure would be equivalent also to the thickness of material overlying the aquifer. In the outcrop area the depth would be the thickness of glacial drift; in the subcrop area it would be the thickness of glacial drift plus the consolidated rocks above the aquifer.




Qu Quaternary, chiefly glacial till
K Cretaceous System
IPu Pennsylvanian System, undifferentiated
Mm Meramecian Series
Mo Osagean Series
Mk Kinderhookian Series
Dys Yellow Spring Group
Evaporite Zone — Beds of gypsum and anhydrite (extent shown on sulfate concentration map of sheet 3)
Contact (dashed where inferred)
well or test hole — bottom of well; well completed at lower horizon




# MISSISSIPPIAN AQUIFER OF IOWA

By
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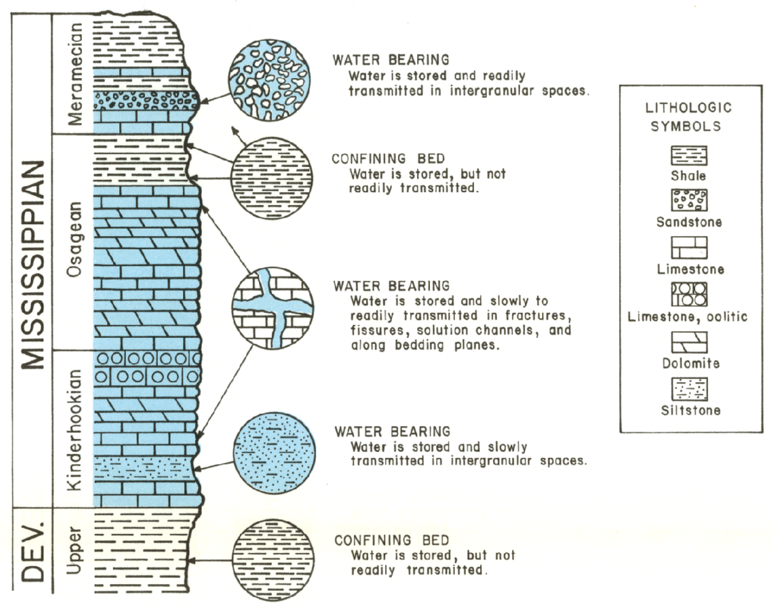
Iowa Geological Survey
and
W. L. Steinhilber
U.S. Geological Survey
1973

# HYDROLOGY

## OCCURRENCE OF WATER




### WATER IN THE AQUIFER OCCURS PRINCIPALLY IN SECONDARY OPENINGS IN THE PREDOMINANTLY CARBONATE-TYPE ROCKS OF THE MISSISSIPPIAN SYSTEM

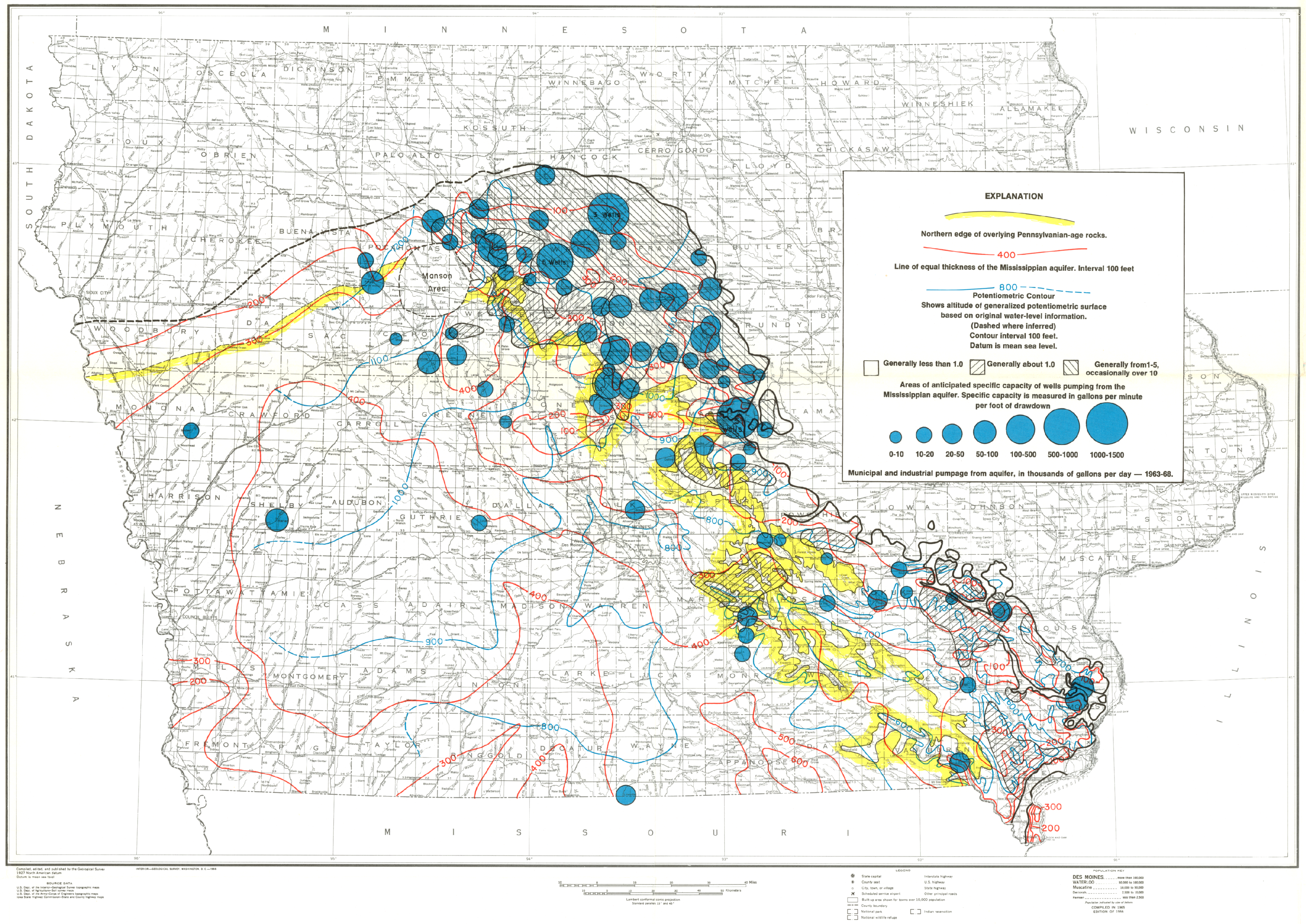
The carbonate rocks are dense, crystalline, lithographic, or tightly cemented fragmental limestones and dolomites, whose intrinsic porosities for the most part are exceedingly low. However, secondary openings occur in the form of fractures, joints, and bedding planes, many of which have been enlarged by solution activity. These openings are random in occurrence, irregular in distribution, and variable in size and extent. Therefore, the storage and transmission characteristics of the Mississippian carbonate rocks are extremely variable from place to place. In southeastern Iowa, inspection of quarry faces reveals that most water flows along the contacts between various rock units where abrupt changes in lithology occur. These are interconnected by a vertical joint system. Locally in north-central Iowa, where drillers report highly creviced and cavernous conditions in the Kinderhookian strata, the storage and transmission characteristics of the aquifer are unusually high.

### WATER OCCURS ALSO IN TWO ROCK UNITS THAT HAVE A PRIMARY POROSITY

These are the St. Louis Sandstone in the Meramecian Series and the Prospect Hill Siltstone in the Kinderhookian Series. Of the two, the St. Louis Sandstone has the greater hydrologic significance. It is of widespread occurrence and is the principal water-bearing rock above the Warsaw Formation. In southeastern and parts of south-central Iowa, the Warsaw is a shale unit that retards movement of water between the St. Louis and the underlying carbonate rocks of the Osagean and Kinderhookian.

### WATER OCCURS UNDER BOTH ARTESIAN AND WATER-TABLE CONDITIONS

Artesian conditions predominate, even in the outcrop area where the aquifer is confined by glacial till. However, in many localities in the outcrop area, the artesian pressure is quickly depleted in the vicinity of pumping wells. Under these conditions, the aquifer is being dewatered.




## RECHARGE, MOVEMENT, AND DISCHARGE

### WATER FROM THE AQUIFER CONTRIBUTES TO THE BASE FLOW OF THE PRINCIPAL STREAMS IN THE OUTCROP AREA

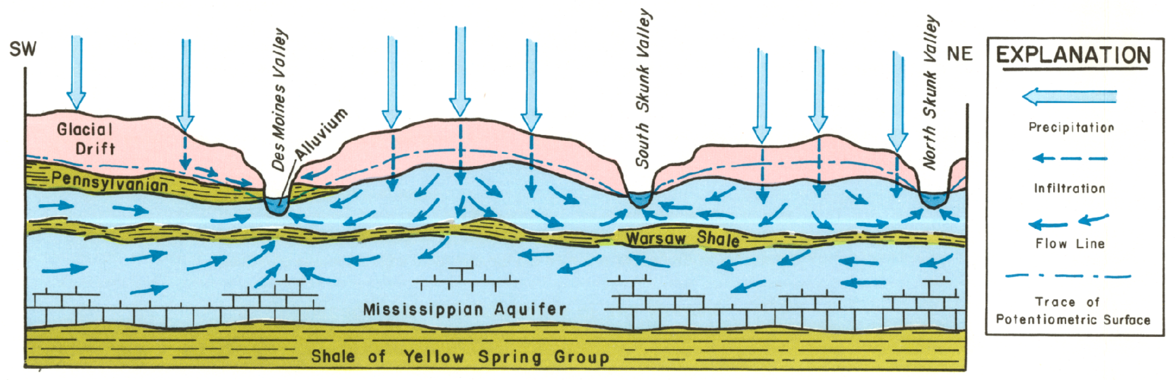
The potentiometric contours, corroborated by more detailed potentiometric mapping in southeast Iowa (Coble, 1971, p. 54) and in central Iowa (Twenter and Coble, 1965, p. 60), clearly show that the Des Moines River valley is the principal discharge area for the aquifer. Other important discharge areas are the valleys of the Iowa, Skunk, North Skunk, and South Skunk Rivers.

### RECHARGE, MOVEMENT, AND DISCHARGE RELATIONS ARE SIGNIFICANTLY DIFFERENT IN THE SUBCROP AND OUTCROP AREAS OF THE AQUIFER

Recharge characteristics inferred from the adjacent hydrographs, discharge characteristics and general movement shown by the potentiometric contours, and inferences drawn from geologic and chemical quality data all lead to the conclusions that follow:

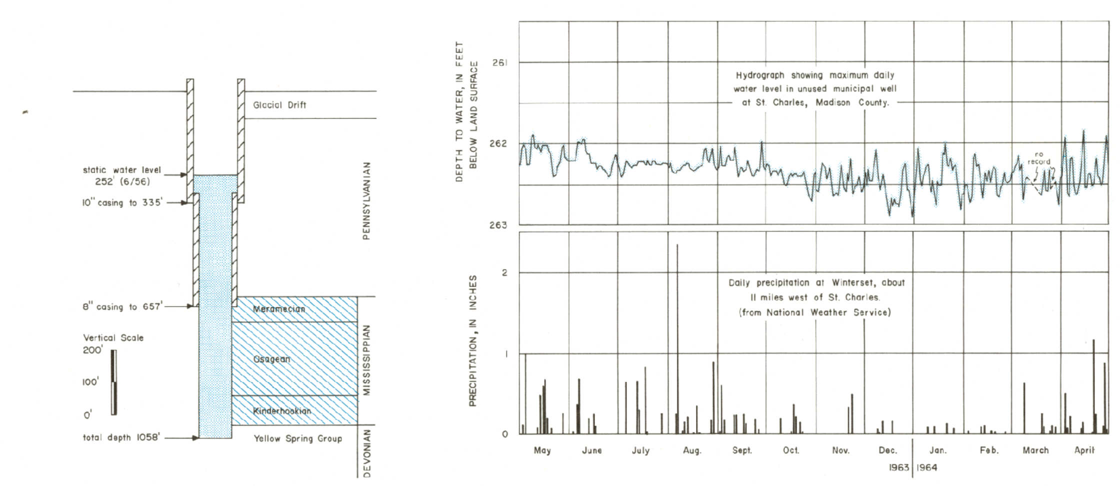
**Subcrop Area:** The aquifer is recharged along its northwestern periphery by downward seepage of water from the sandstones of the Cretaceous System. The water moves through the aquifer, which is confined by overlying and underlying confining beds, in a southerly and southeasterly direction. Some water moves into Missouri as underflow, but a large part is discharged into the Des Moines River. Movement through the subcrop area probably is extremely slow, because the transmissivity of the aquifer in this area is considered to be very low.

**Outcrop Area:** The inferred hydrologic relations for the southeastern part are summarized in the diagram below. In the north-central part, however, the flow system is not believed to be separated, because the Warsaw Shale is not present. Thus, in that area, water enters the system under the upland areas and moves toward and discharges into the nearby principal streams. Movement through the outcrop area, particularly in the north-central part, would be much faster than through the subcrop area, because transmissivities are considered to be much higher.



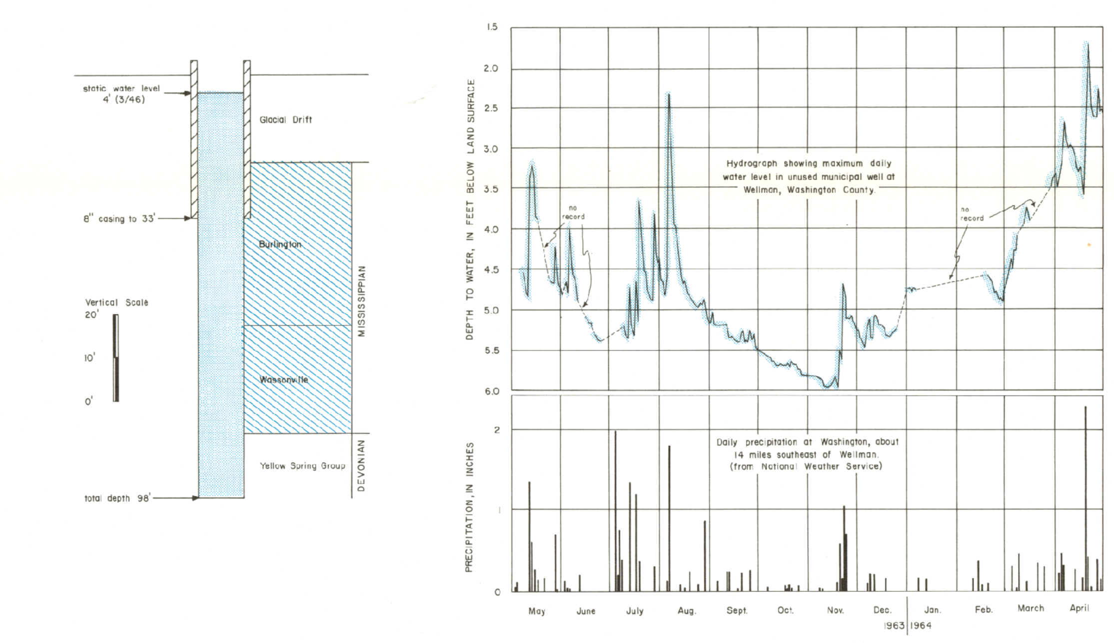

IDEALIZED HYDROLOGIC SECTION OF MISSISSIPPIAN AQUIFER IN MAHASKA COUNTY

The hypothesis of separate circulation zones, shown in idealized form, is supported by chemical-quality data in southeastern Iowa (Coble, 1971, p. 71-72).




### IN THE SUBCROP AREA WHERE THE AQUIFER IS CONFINED BY THICK PENNSYLVANIAN STRATA, THE AQUIFER RECEIVES NO RECHARGE FROM LOCAL PRECIPITATION

The fluctuations shown are attributed to withdrawals from nearby farm wells and variations in barometric pressure.




### IN THE OUTCROP AREA WHERE THE AQUIFER IS COVERED BY GLACIAL DRIFT, THE AQUIFER IS RECHARGED BY LOCAL PRECIPITATION

Infiltration to the aquifer is rapid in localities where the drift is thin or sandy. Where the drift is thick or clayey, however, infiltration is slow.

## WITHDRAWALS

### THE TOTAL OF ALL WITHDRAWALS OF WATER FROM THE MISSISSIPPIAN AQUIFER DURING THE PERIOD 1963-68, AVERAGED ABOUT 17 MGD (MILLION GALLONS PER DAY), WITH ABOUT 70 PERCENT OF THE WITHDRAWALS CONCENTRATED IN AND ADJACENT TO THE NORTH-CENTRAL OUTCROP AREA

Withdrawals by municipalities and industries totaled about 7.5 mgd. The magnitude and location of the known withdrawals, shown on the above map, are considered to represent at least 90 percent of all principal withdrawals from the aquifer. Hence, total municipal and industrial pumpage is conservatively estimated to be about 8 mgd.

Rural withdrawals are more difficult to estimate, because the total number of rural wells that pump water from the aquifer are not known. The fact that this aquifer is the best available source in some counties and the only source in others leads to a conservative estimate that 20,000 rural wells withdraw approximately 9 mgd from the aquifer for domestic and livestock supplies.

SOME MUNICIPAL AND INDUSTRIAL WELLS PUMPING FROM THE MISSISSIPPIAN AQUIFER

| Well location | Well name | Year drilled | Altitude of land surface (feet) | Depth of well below land surface (feet) | Diameter of well (inches) | Depth cased (feet) | Principal water-bearing bed: Depth to top (feet) | Thickness (feet) | Rock type | Geologic unit | Water level: Depth to water below land surface (feet) | Date of measurement | Yield: Rate (gpm) | Date of measurement | Drawdown (feet) | Specific capacity (gpm/ft) | Use of water | Average daily pumpage (gallons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calhoun County SW SW sec. 13, T. 86N., R. 32W. | Lohrville No. 3 | 1958 | 1145 | 645 | 8 & 6¾ | 676 | 676 | 70 | Limestone & dolomite | Burlington Gilmore City | 88 | May 1959 | 360 | May 1959 | 32 | 9.4 | Municipal | 51,700 |
| Dallas County NE NW sec. 18, T. 79N., R. 26W. | Linden | 1954 | 1124 | 700 | 8 & 6 | 688 | 688 | 112 | Limestone & dolomite sandy | St. Louis through Keokuk | 295 | April 1970 | 65 | April 1970 | 65 | 1.0 | Municipal | 14,000 |
| Des Moines County SE NE sec. 26, T. 72N., R. 3W. | Mediapolis | 1966 | 770 | 130 | 10 | 42 | 42 | 70 | Dolomite & limestone | Burlington through McCraney | 42 | Sept. 1966 | 30 | Sept. 1966 | 0 | — | Municipal | 60,300 |
| Hancock County NW NW sec. 6, T. 94N., R. 26W. | Corwith No. 2 | 1953 | 1174 | 128 | 8 | 92 | 89 | 36 | Dolomite | Maynes Creek Chapin | 38 | July 1962 | 200 | July 1962 | 30 | 6.7 | Municipal | 35,000 |
| Hardin County NW NE sec. 33, T. 87N., R. 21W. | Hubbard No. 2 | 1945 | 1094 | 480 | 10 | 246 | 245 | 235 | Limestone, dolomite, minor sand | St. Louis through Maynes Creek | 27 | Nov. 1945 | 112 | Nov. 1945 | 83 | 1.3 | Municipal | 19,000 |
| Hardin County NE NW sec. 13, T. 88N., R. 21W. | Iowa Falls No. 5 | 1957 | 1151 | 232 | 12 | 56 | 60 | 165 | Dolomite & siltstone | Maynes Creek Prospect Hill | 12 | Sept. 1957 | 200 | Sept. 1957 | 126 | 1.6 | Municipal | 71,000 |
| Humboldt County SW SW sec. 6, T. 91N., R. 29W. | Gilmore City No. 2 | 1957 | 1217 | 207 | 16 | 62 | 62 | 145 | Limestone & dolomite | Gilmore City Maynes Creek | 72 | Oct. 1957 | 466 | Oct. 1957 | 6 | 77 | Municipal | 21,000 |
| Jasper County NE NW sec. 17, T. 78N., R. 17W. | Lynnville No. 2 | 1956 | 880 | 386 | 8 | 107 | 107 | 273 | Limestone & dolomite | St. Louis through Hampton | 130 | Aug. 1956 | 60 | Aug. 1956 | 60 | 0.7 | Municipal | 7,300 |
| Marshall County SW NE sec. 13, T. 85N., R. 19W. | Liscomb | 1949 | 1008 | 276 | 8 & 6 | 159 | 99 | 175 | Limestone, dolomite, siltstone | Burlington through Prospect Hill | 38 | Aug. 1949 | 15 | Aug. 1949 | 59 | 0.3 | Municipal | 7,100 |
| Marshall County NE SW sec. 25, T. 84N., R. 18W. | Swift Packing Co. | 1934 | 890 | 177 | 10 | 55 | 55 | 122 | Limestone & dolomite | Undifferentiated | 25 | June 1934? | 500 | June 1934? | 15 | 33 | Industrial | 923,000 |
| Monona County NE SW sec. 19, T. 83N., R. 42W. | Soldier No. 3 | 1962 | 1153 | 800 | 12 & 8 | 485 | 485 | 315 | Limestone & dolomite | Keokuk through Hampton | 110 | Oct. 1962 | 151 | Oct. 1962 | 126 | 1.2 | Municipal | 14,600 |
| Monroe County SE SE sec. 10, T. 73N., R. 18W. | Lovilia No. 1 | 1934 | 921 | 397.5 | 8 & 6 | 368 | 368 | 29.5 | Sandstone & limestone | Pennsylvanian and St. Louis | 195 | Nov. 1934 | 42± | Nov. 1934 | 137 | 0.3 | Municipal | 20,400 |
| Pocahontas County NE NW sec. 27, T. 90N., R. 34W. | Fonda No. 2 | 1939 | 1231 | 302 | 10 | 282 | 282 | 20 | Dolomite | St. Louis or Warsaw | 28 | April 1939 | 210 | July 1962 | — | — | Municipal | 51,700 |
| Polk County SW NW sec. 31, T. 80N., R. 25W. | Bondurant | 1951 | 971 | 650 | 8 | 350 | 350 | 285 | Limestone & dolomite | Warsaw through Starrs Cave | 160 | April 1951 | 36 | April 1951 | 132 | 0.3 | Municipal | 21,800 |
| Shelby County NE NW sec. 19, T. 79N., R. 38W. | Harlan No. 2 | 1957 | 1181.5 | 1040 | 8 | 972 | 972 | 68 | Limestone & dolomite | Gilmore City Hampton | 250 | Jan. 1957 | 80 | Sept. 1980 | — | — | Municipal | 57,600 |
| Story County NW SE sec. 12, T. 85N., R. 24 W. | Story City No. 2 | 1945 | 971 | 261 | 12 | 132 | 132 | 129 | Limestone & dolomite | Burlington Gilmore City | 20 | Oct. 1945 | 647 | Oct. 1945 | 48.5 | 14 | Municipal | 215,000 |
| Van Buren County sec. 8, T. 69N., R. 9W. | Bonaparte | 1957 | 584 | 136 | 10 | 19 | 19 | 117 | Limestone & dolomite | Keokuk through Starrs Cave | 28 | Oct. 1957 | 25 | Oct. 1957 | 66 | 0.3 | Municipal | 34,600 |
| Washington County SE SE sec. 31, T. 76N., R. 8W. | West Chester No. 2 | 1957 | 767 | 243 | 8 | 135 | 130 | 102 | Dolomite, cherty | Burlington Wassonville | 47 | Aug. 1957 | — | — | — | — | Municipal | 6,500 |
| Webster County SE NW sec. 8, T. 89N., R. 28W. | Johnston Clay Works | 1956 | 886 | 300 | 6¼ | 129 | 129 | 171 | Dolomite & limestone | Keokuk through Hampton | +2 | Sept. 1959 | 20 | Sept. 1959 | — | — | Industrial | 2,800 |
| Wright County SE SW sec. 18, T. 92N., R. 23W. | Belmond No. 2 | 1956 | 1186 | 208 | 12 & 10 | 206 | 106 | 102 | Dolomite | Maynes Creek Chapin | 30 | Jan. 1956 | 880 | Jan. 1956 | 60 | 9.2 | Municipal | 143,000 |
| Wright County SE NW sec. 27, T. 91N., R. 24W. | Eagle Grove No. 4 | 1957 | 1112 | 450 | 16 | 170 | 150 | 285 | Limestone & dolomite | Gilmore City through Prospect Hill | 5 | Aug. 1957 | 882 | Aug. 1957 | 87.5 | 10 | Municipal | 290,000 |
| Wright County NE NW sec. 25, T. 91N., R. 24W. | General Mills, Inc. | 1951 | 1188 | 215 | 20 & 18 | 92 | 90 | 125 | Limestone & dolomite | Maynes Creek Chapin | 20 | July 1951 | 440 | July 1951 | 12 | 37 | Industrial | 634,000 |

## SPECIFIC CAPACITY AND YIELD OF WELLS

### THE SPECIFIC CAPACITIES OF WELLS IN THE NORTH-CENTRAL PART OF THE OUTCROP AREA ARE CONSISTENTLY HIGHER THAN ELSEWHERE

In the subcrop area, specific capacities generally are much less than 1 gpm/foot (gallon per minute per foot of drawdown). However, because more room for drawdown generally is available in the deeper wells penetrating the aquifer in the subcrop area, yields of as much as 50 gpm may be obtained. The specific capacity data shown on the map serves also as a rough transmissivity map of the aquifer. Highest transmissivities occur in north-central Iowa where specific capacities are highest. Lowest transmissivities occur in the subcrop area where specific capacities are lowest.

| SYSTEM | SERIES | WELL YIELDS: NORTH-CENTRAL OUTCROP AREA | WELL YIELDS: SOUTHEASTERN OUTCROP AREA |
|---|---|---|---|
| MISSISSIPPIAN | MERAMECIAN | Generally yields 3 to 10 gpm (gallons per minute) and occasionally 10 to 25 gpm to domestic wells. Municipal supplies of 40 to 50 gpm have been developed locally. | |
| | OSAGEAN | Yields 5 to 15 gpm to domestic wells. Local yields of 25 to 35 gpm are possible. | Yields 5 to 15 gpm to domestic wells; however, supplies of only 3 gpm or less may be expected at some places. Municipal supplies of 20 to 40 gpm have been developed. |
| | KINDERHOOKIAN | The Gilmore City Limestone generally yields 5 to 20 gpm to domestic wells; however, local yields are as much as 50 gpm. Yields of several hundred gallons per minute have been reported from crevices in the formation at Story City and Roland. Yields from the combined Gilmore City and the underlying Hampton are as much as 400 to 880 gpm at Eagle Grove, Belmond, Iowa Falls, and Marshalltown; equivalent yields probably are available throughout that area. | Generally yields only 1 to 3 gpm to wells. Local yields of 10 to 30 gpm have been reported. The North Hill Group may yield small supplies to wells. |

### HIGH YIELDS ARE OBTAINED MOST CONSISTENTLY FROM THE KINDERHOOKIAN SERIES IN THE NORTH-CENTRAL OUTCROP AREA

Elsewhere in the outcrop area yields of 50 gpm or more can be obtained only locally. In the subcrop area, yields of 50 gpm have been obtained locally from wells that fully penetrate the aquifer. The Meramecian Series, because of its widespread occurrence and fairly consistant yield of 3 to 10 gpm, is an important source for rural supplies in both outcrop and subcrop areas.

## AVAILABILITY OF WATER

Availability is defined here as the amount of water that can be developed from the aquifer without significantly depleting total storage. An upper limit on this amount would be the recharge to the aquifer; a lower limit would be the amount that natural discharge could be reduced. Quantitative studies on aquifer characteristics and magnitudes of recharge and discharge are needed to determine the maximum amount of water that can be withdrawn from the aquifer on a sustained basis. In the absence of such definitive data, some gross calculations are presented to indicate that large supplies of water are available for development in north-central Iowa and small to moderate supplies elsewhere.

### NORTH-CENTRAL OUTCROP AREA

Average recharge to the aquifer in this area, assuming that 3 percent of average annual precipitation infiltrates to the aquifer, is estimated to be at least 45,000 gallons per day per square mile or a total of 360 mgd (million gallons per day) for the area. This amount is on the conservative side of the recharge determined for a similar drift-covered carbonate aquifer in Illinois (Walton, 1962, p. 51). Therefore, the amount of water entering the aquifer is believed to be at least 30 times the current withdrawal rate of about 12 mgd. Greater withdrawals could be sustained even through prolonged periods of reduced recharge, because the amount of water in storage in the aquifer (estimated to be 7.5 to 15 trillion gallons①) is tremendously greater than the average annual amount of recharge.

### SOUTHEAST OUTCROP AREA

The tighter nature of the Mississippian rocks in most of this area precludes the development of major water supplies from the aquifer. However, moderate supplies are available locally where larger rock openings exist and where recharge is available. Recharge in this area, in general, is significantly less than in the north-central area, because the glacial drift is very clayey.

### SUBCROP AREA

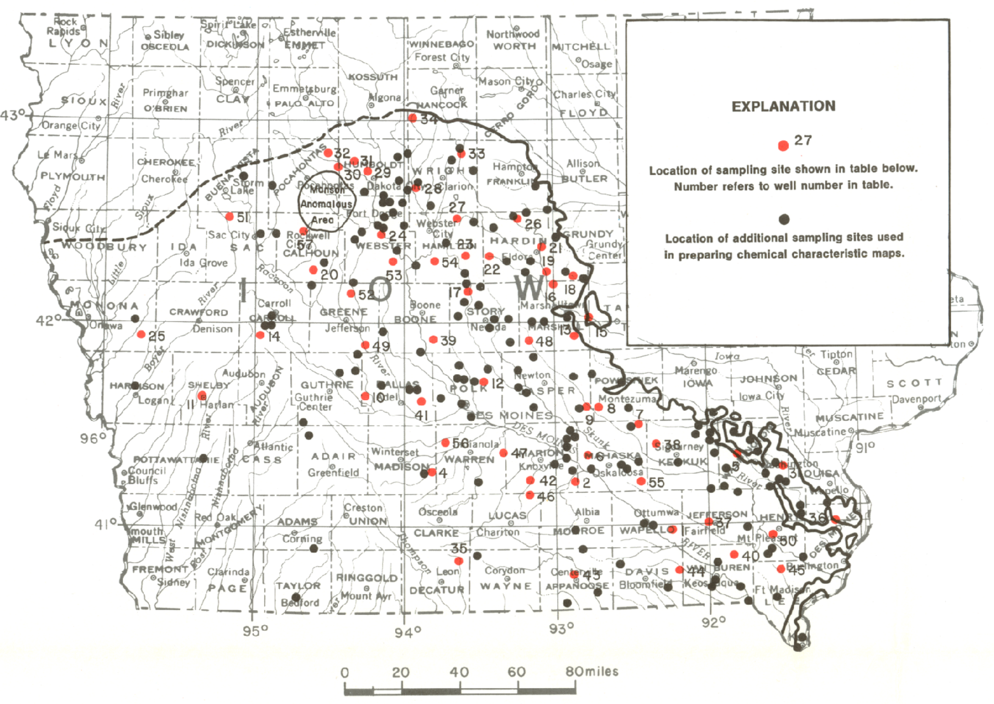
The amount of water available for development in this artesian system, where recharge and discharge areas are far apart, is limited largely by the amount of water moving through the aquifer. Because this rate of movement is considered to be very slow, withdrawals from the aquifer are dependent on decreasing the artesian head. Withdrawals of 10 to possibly 50 gpm probably can be sustained in most places without excessive water-level declines if the wells are adequately spaced and if leakage from the Pennsylvanian strata can be induced.

① The maximum estimate is based on the assumption that the volume of rock openings in the Mississippian strata (joints, bedding planes, and occasional solution tubules) observed in quarries in north-central Iowa are constant for the whole aquifer throughout the area. The minimum estimate is based on the assumption that the openings observed were representative of only the upper half of the aquifer.

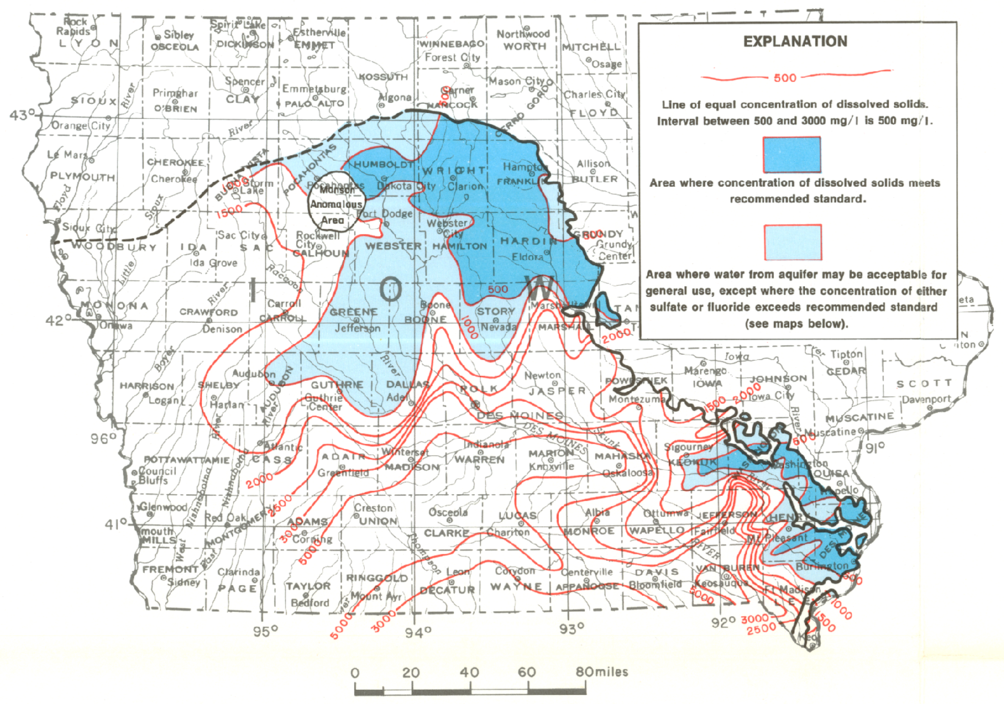
# MISSISSIPPIAN AQUIFER OF IOWA

By
P. J. Horick
Iowa Geological Survey
and
W. L. Steinhilber
U.S. Geological Survey
1973

# QUALITY OF WATER




WELL LOCATION MAP

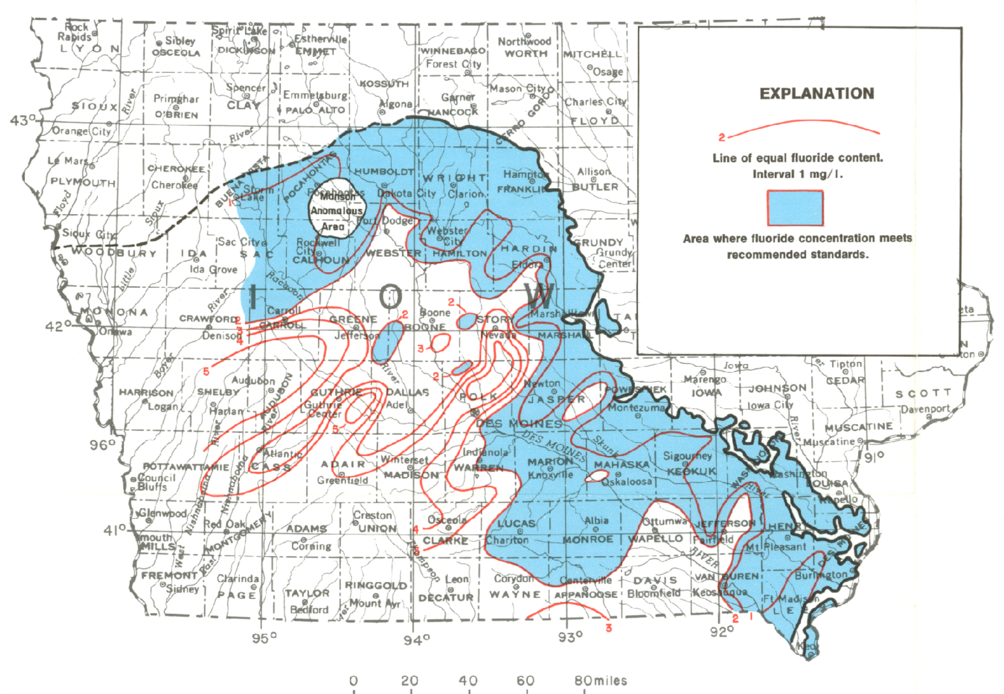



THE DISSOLVED-SOLIDS CONTENT OF WATER FROM THE MISSISSIPPIAN AQUIFER MEETS THE RECOMMENDED STANDARD IN ONLY 15 PER CENT OF THE AQUIFER'S AREA OF OCCURRENCE

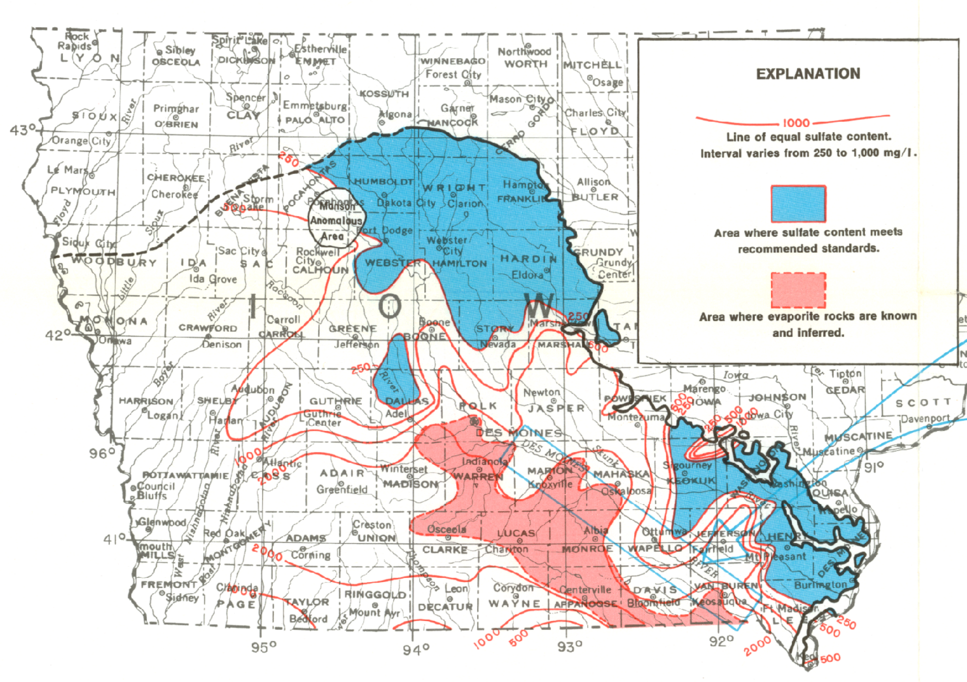
The water may be acceptable for general use in an additional 15 percent of the area.

REPRESENTATIVE CHEMICAL ANALYSES OF WATER FROM THE MISSISSIPPIAN AQUIFER
(Dissolved constituents and hardness in milligrams per liter. Analyses made by Iowa State Hygienic Laboratory.)

| Map Number | Well location | Well name | Year drilled | Geologic unit | Date of collection | Depth of well (feet) | Temperature (°C) | Dissolved solids | Iron (Fe) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Carbonate (CO3) | Bicarbonate (HCO3) | Sulfate (SO4) | Chloride (Cl) | Fluoride (F) | Nitrate (NO3) | Hardness as CaCO3: Total | Hardness as CaCO3: Carbonate | Hardness as CaCO3: Non-carbonate | pH | Specific conductance (micromhos at 25°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wapello County SE NW sec. 36, T. 72N., R. 13W. | Agency No. 5 | 1958 | St. Louis-Spergen | 6-8-62 | 350 | 13 | 676 | .24 | .05 | 47 | 20 | 9.8 | 190 | 0 | 499 | 167 | 10 | 1.2 | 1.0 | 199 | 199 | 0 | 7.5 | 1080 |
| 2 | Marion County NE sec. 24, T. 74N., R. 18W. | Bussey No. 1 | 1936 | Pennsylvanian and St. Louis | 1-7-62 | 290 | | 3689 | 3.5 | .05 | 440 | 63 | 12 | 620 | 0 | 283 | 2210 | 20 | 1.1 | 0.7 | 1360 | 232 | 1128 | 7.2 | 4000 |
| 3 | Washington County NW NE sec. 21, T. 76N., R. 8W. | Ainsworth | 1962 | Burlington-Wassonville | 6-25-62 | 189 | 13 | 366 | .20 | .05 | 77 | 32 | 3.4 | 72 | 0 | 501 | 49 | 8 | .45 | 0.1 | 323 | 323 | 0 | 8.0 | 620 |
| 4 | Madison County NE NE sec. 23, T. 75N., R. 26W. | St. Charles | 1956 | St. Louis through Starrs Cave | 2-17-56 | 867 | 17 | 8030 | 2.9 | .12 | 322 | 77 | 20 | 2130 | 0 | 307 | 4420 | 686 | 3.7 | 0.1 | 1122 | 252 | 870 | 7.4 | 9060 |
| 5 | Washington County SE SE sec. 31, T. 75N., R. 8W. | West Chester No. 2 | 1957 | Burlington-Wassonville | 8-57 | 243 | | 434 | 1.6 | .05 | 69 | 42 | 2.5 | 46 | 0 | 427 | 61 | 3.0 | 0.3 | 7.6 | 347 | 347 | 0 | 7.8 | 670 |
| 6 | Mahaska County SE SW sec. 35, T. 76N., R. 17W. | Leighton | 1958 | St. Louis | 1-20-60 | 210 | | 473 | .12 | .05 | 108 | 28 | 3.1 | 30 | 0 | 573 | 5.6 | 0.1 | 0.7 | 0.2 | 365 | 365 | 0 | 7.9 | 820 |
| 7 | Mahaska County NW NW sec. 3, T. 77N., R. 14W. | Barnes | 1957 | St. Louis-Warsaw | 12-10-62 | 230 | 14 | 1649 | 3.2 | .05 | 224 | 106 | 11 | 73 | 0 | 259 | 916 | 2 | 0.5 | 0.1 | 996 | 212 | 783 | 7.4 | 1870 |
| 8 | Poweshiek County SE SE sec. 9, T. 78N., R. 16W. | Searsboro | 1956 | Keokuk-Burlington | 1-7-60 | 290 | | 1365 | .80 | .25 | 203 | 93 | 9.3 | 116 | 0 | 196 | 839 | 7.0 | 0.8 | 1.3 | 848 | 160 | 688 | 7.4 | 1760 |
| 9 | Jasper County NE NW sec. 11, T. 78N., R. 17W. | Lynnville No. 2 | 1957 | St. Louis through Starrs Cave | 1-23-59 | 388 | | 1002 | .34 | .05 | 155 | 49 | 8.3 | 90 | 0 | 308 | 427 | 7 | 1.6 | 8.0 | 589 | 300 | 289 | 7.1 | 1310 |
| 10 | Dallas County NE NE sec. 18, T. 79N., R. 29W. | Linden | 1954 | St. Louis through Keokuk | 11-9-60 | 700 | | 628 | .10 | .05 | 12 | 7.4 | 3.2 | 196 | 0 | 312 | 192 | 32 | 5.5 | 0.1 | 59 | 59 | 0 | 8.1 | 1020 |
| 11 | Shelby County SE NW sec. 18, T. 79N., R. 38W. | Harlan No. 2 | 1957 | Gilmore City-Hampton | 8-14-60 | 1048 | | 1481 | .24 | .05 | 24 | 16 | 12 | 442 | 4.8 | 394 | 622 | 101 | 8.8 | 0.4 | 148 | 148 | 0 | 8.1 | 2240 |
| 12 | Polk County SW NW sec. 31, T. 80N., R. 22W. | Bondurant | 1951 | Warsaw through Starrs Cave | 5-28-58 | 650 | | 1016 | 14 | .43 | 57 | 39 | 11 | 436 | 0 | 403 | 794 | 42 | 3.0 | 3.1 | 303 | 303 | 0 | 7.7 | 2240 |
| 13 | Marshall County SE SE sec. 6, T. 82N., R. 17W. | Ferguson No. 1 | 1955 | Gilmore City through Starrs Cave | 11-30-60 | 185 | | 581 | .25 | .05 | 165 | 59 | 3.7 | 61 | 0 | 371 | 409 | 7 | 0.6 | 3.6 | 650 | 304 | 352 | 7.1 | 1300 |
| 14 | Carroll County SE SW sec. 8, T. 82N., R. 35W. | Templeton | 1956 | St. Louis-Burlington | 12-31-59 | 920 | | 1314 | 1.2 | .05 | 45 | 18 | 18 | 320 | 0 | 361 | 499 | 84 | 5.7 | 2.8 | 187 | 187 | 0 | 7.9 | 1850 |
| 15 | Marshall County NW NW sec. 13, T. 83N., R. 17W. | LeGrand No. 2 | 1955 | Starrs Cave-Prospect Hill-McCraney | 8-25-59 | 98 | 12 | 649 | .16 | .05 | 116 | 36 | 0.9 | 21 | 0 | 265 | 130 | 29 | 0.2 | 58 | 438 | 234 | 204 | 7.5 | 900 |
| 16 | Marshall County SW NE sec. 12, T. 83N., R. 18W. | Liscomb | 1949 | Burlington through Prospect Hill | 4-8-59 | 278 | | 410 | .46 | .16 | 92 | 33 | 1.8 | 11 | 0 | 353 | 72 | 0.5 | 0.4 | 0.2 | 341 | 289 | 52 | 7.3 | 690 |
| 17 | Story County NW SE sec. 12, T. 83N., R. 24W. | Story City No. 2 | 1949 | Burlington-Gilmore City | 4-25-62 | 261 | 10 | 373 | .12 | .05 | 84 | 33 | 2.6 | 16 | 0 | 459 | 15 | 0.5 | 1.8 | 0.1 | 340 | 340 | 0 | 7.1 | 690 |
| 18 | Grundy County NE NE sec. 25, T. 86N., R. 17W. | Conrad No. 3 | 1962 | Hampton through Prospect Hill | 3-20-62 | 120 | | 443 | .16 | .05 | 84 | 31 | 1.3 | 9.9 | 0 | 283 | 68 | 14 | .25 | 7.2 | 337 | 232 | 105 | 7.6 | 660 |
| 19 | Hardin County NE SE sec. 21, T. 88N., R. 19W. | Union | 1946 | Hampton through Chapin | 5-6-60 | 195 | | 406 | .02 | .05 | 61 | 26 | 5.1 | 8.6 | 0 | 249 | 68 | 10 | 0.2 | 9.6 | 308 | 204 | 104 | 7.4 | 600 |
| 20 | Calhoun County SW SW sec. 13, T. 86N., R. 32W. | Lohrville No. 3 | 1959 | Burlington-Gilmore City | 2-4-61 | 645 | 11 | 1115 | 2.3 | .29 | 204 | 67 | 6.0 | 53 | 0 | 503 | 461 | 0.5 | 0.6 | 0.1 | 784 | 412 | 372 | 7.0 | 1440 |
| 21 | Hardin County SW NE sec. 4, T. 87N., R. 19W. | Pine Lake Country Club | 1960 | Maynes Creek-Prospect Hill | 4-20-60 | 240 | | 240 | .04 | .05 | 48 | 30 | 0.9 | 3.2 | 7.2 | 276 | 17 | 2.0 | 0.2 | 0.1 | 243 | 238 | 5 | 8.5 | 450 |
| 22 | Hamilton County SE NE sec. 29, T. 87N., R. 22W. | Radcliffe | 1957 | Gilmore City through Prospect Hill | 3-26-62 | 395 | | 361 | .20 | .05 | 86 | 28 | 0.0 | 19 | 0 | 437 | 10 | 1 | .45 | 0.1 | 332 | 332 | 0 | 7.1 | 660 |
| 23 | Hamilton County SW SE sec. 13, T. 87N., R. 23W. | Ellsworth | 1953 | Burlington through Maynes Creek | 1-6-63 | 365 | | 402 | 1.1 | .05 | 51 | 39 | 4.9 | 40 | 0 | 459 | 18 | 0.5 | 0.1 | 0.1 | 288 | 288 | 0 | 7.7 | 700 |
| 24 | Webster County SW NE sec. 19, T. 88N., R. 26W. | Otho | 1955 | Burlington through Prospect Hill | 6-7-56 | 616 | | 619 | .83 | .05 | 105 | 50 | 12 | 36 | 0 | 466 | 143 | 7.0 | 2.2 | 0.1 | 468 | 382 | 86 | 7.6 | [illegible] |
| 25 | Monona County SE NE sec. 19, T. 83N., R. 42W. | Soldier No. 3 | 1962 | Keokuk through Hampton | 10-19-62 | 600 | | 1682 | 0.9 | 0.5 | 261 | 76 | 36 | 160 | 0 | 325 | 763 | 190 | 1.9 | 0.1 | 963 | 266 | 697 | 7.1 | 2260 |
| 26 | Hardin County NE NW sec. 13, T. 89N., R. 21W. | Iowa Falls No. 5 | 1957 | Maynes Creek-Prospect Hill | 1-11-60 | 232 | 10 | 383 | 1.3 | .08 | 83 | 29 | 1.9 | 6.9 | 0 | 417 | 5.8 | 2.0 | 0.3 | .89 | 342 | 342 | 0 | 7.4 | 600 |
| 27 | Hamilton County NW SE sec. 35, T. 89N., R. 24W. | Blairsburg | 1938 | Gilmore City-Hampton | 12-4-62 | 261 | | 547 | .48 | .05 | 69 | 45 | 3.8 | 41 | 0 | 476 | 41 | 0.5 | 1.3 | 0.1 | 356 | 356 | 0 | 7.3 | 780 |
| 28 | Wright County SE NW sec. 27, T. 91N., R. 26W. | Eagle Grove No. 4 | 1957 | Gilmore City through Prospect Hill | 1-25-60 | 450 | 10 | 415 | 1.1 | .28 | 101 | 29 | 3.0 | 11 | 0 | 456 | 21 | 0.5 | 0.4 | 0.1 | 372 | 372 | 0 | 7.2 | 690 |
| 29 | Humboldt County SE NW sec. 1, T. 91N., R. 29W. | Humboldt | | Gilmore City | 10-5-60 | Springs | 10 | 232 | .13 | .06 | 92 | 21 | 2.3 | 4.8 | 0 | 342 | 33 | 5 | .25 | 3.3 | 316 | 280 | 36 | 7.2 | 590 |
| 30 | Humboldt County NE NW sec. 6, T. 91N., R. 30W. | Gilmore City No. 2 | 1957 | Gilmore City-Maynes Creek | 10-31-61 | 207 | | 415 | .02 | .05 | 93 | 28 | 1.4 | 4.8 | 0 | 334 | 49 | 11 | .25 | 3.3 | 348 | 274 | 74 | 7.4 | 660 |
| 31 | Humboldt County SE NE sec. 20, T. 92N., R. 29W. | Rutland | 1948 | Gilmore City | 1-12-60 | 75 | 11 | 398 | .02 | .05 | 94 | 29 | 2.4 | 5.7 | 0 | 393 | 23 | 2.0 | .35 | 1.3 | 354 | 322 | 32 | 7.3 | 640 |
| 32 | Pocahontas County SE NE sec. 33, T. 93N., R. 31W. | Rolfe | 1947 | Gilmore City through Prospect Hill | 3-3-58 | 185 | | 757 | 2.0 | .32 | 139 | 57 | 3.1 | 43 | 0 | 532 | 227 | 1.5 | 0.5 | 1.6 | 582 | 436 | 146 | 7.2 | 980 |
| 33 | Wright County NE SE sec. 15, T. 93N., R. 25W. | General Mills, Inc. | 1951 | Maynes Creek-Chapin | 10-15-57 | 210 | 12 | 372 | .87 | .05 | 90 | 32 | 2.9 | 7.5 | 0 | 420 | 20 | 4.0 | .15 | 0.1 | 356 | 344 | 12 | 7.4 | 640 |
| 34 | Hancock County NW NE sec. 6, T. 94N., R. 24W. | Corwith No. 2 | 1958 | Maynes Creek-Chapin | 8-24-59 | 126 | 10 | 852 | 1.9 | .05 | 99 | 32 | 4.4 | 92 | 0 | 515 | 172 | 0.5 | 0.3 | 0.1 | 379 | 379 | 0 | 7.4 | 1000 |
| 35 | Decatur County NE NE sec. 33, T. 70N., R. 24W. | Garden Grove | 1959 | Keokuk-Burlington | 9-14-60 | 1140 | | 4596 | 1.5 | .05 | 277 | 80 | 2.9 | 952 | 0 | 361 | 2560 | 160 | 2.6 | 0.1 | 1020 | 296 | 724 | 7.5 | 6230 |
| 36 | Des Moines County SE SW sec. 33, T. 70N., R. 3W. | Mediapolis | 1956 | Burlington through McCraney | 1-16-59 | 130 | | 366 | 1.2 | .47 | 91 | 25 | 1.2 | 19 | 0 | 410 | 31 | 4 | 0.5 | 1.1 | 332 | 332 | 0 | 7.1 | 650 |
| 37 | Jefferson County SE SW sec. 27, T. 72N., R. 10W. | Barnett Nursery | 1962 | Keokuk | 7-15-63 | 305 | | 2402 | .20 | .25 | 144 | 80 | 13 | 508 | 0 | 564 | 1230 | 19 | .95 | 0.1 | 692 | 462 | 230 | 7.7 | 3070 |
| 38 | Keokuk County SW SW sec. 10, T. 76N., R. 12W. | What Cheer No. 3 | 1939 | Burlington through Starrs Cave | 11-16-57 | 287 | | 1490 | 1.5 | .10 | 108 | 59 | 12 | 265 | 0 | 400 | 701 | 48 | 1.8 | 4.0 | 513 | 328 | 185 | 7.3 | 1920 |
| 39 | Boone County SE sec. 18, T. 82N., R. 25W. | Agr. Exp. Coop.— Iowa State Univ. farm | 1959 | Keokuk through Prospect Hill | 3-27-64 | 830 | | 1742 | 1.5 | .05 | 152 | 79 | 16 | 254 | 0 | 295 | 869 | 59 | 3.0 | 0.1 | 705 | 242 | 463 | 7.7 | 2270 |
| 40 | Van Buren County NE NW sec. 19, T. 70N., R. 9W. | Stockport | 1948 | St. Louis through Prospect Hill | 12-15-49 | 448 | 13 | 2560 | — | .13 | 60 | 22 | 787 | | 17 | 306 | 1260 | 214 | 0.5 | 0 | 282 | 282 | 0 | 8.2 | 3490 |
| 41 | Dallas County NW sec. 27, T. 79N., R. 26W. | Waukee No. 2 | 1958 | St. Louis through Prospect Hill | 7-24-63 | 865 | | 3245 | 6.9 | .11 | 302 | 54 | 15 | 832 | 0 | 318 | 1740 | 110 | 3.4 | 0.5 | 1097 | 259 | 838 | 7.3 | 3650 |
| 42 | Marion County NW SW sec. 11, T. 74N., R. 20W. | J. C. Rinehart | 1958 | St. Louis-Spergen | 1-22-65 | 256 | 15 | 4323 | 2.2 | .05 | 405 | 60 | 11 | 726 | 0 | 305 | 2360 | 38 | 2.2 | 0.9 | 1260 | 250 | 1010 | 7.2 | 4530 |
| 43 | Appanoose County SW NE sec. 30, T. 69N., R. 17W. | Steele Packing Co. | 1952 | St. Louis | 4-17-57 | 440 | | 4693 | 1.1 | .07 | 330 | 74 | 22 | 1060 | 0 | 305 | 2550 | 166 | 2.0 | 0.3 | 1129 | 246 | 883 | 7.1 | 5250 |
| 44 | Davis County SE NW sec. 5, T. 69N., R. 12W. | S. C. Rodgers | 1958 | Keokuk | 3-29-67 | 490 | 13 | 2930 | .28 | .05 | 209 | 69 | 15 | 560 | 0 | 251 | 1600 | 110 | 2.0 | 2.7 | 873 | 206 | 667 | 7.5 | 3600 |
| 45 | Lee County NW SW sec. 9, T. 68N., R. 6W. | Ed. Schinstock | 1956 | Keokuk-Burlington | 4-26-67 | 282 | 12 | 1050 | 1.6 | .05 | 74 | 37 | 6.0 | 240 | 0 | 515 | 390 | 49 | 1.4 | 0.4 | 338 | 338 | 0 | 7.6 | 1700 |
| 46 | Lucas County NW NE sec. 11, T. 73N., R. 20W. | Gerald James | 1944 | St. Louis-Spergen | 5-8-68 | 270 | 12 | 2110 | .05 | .34 | 261 | 63 | 45 | 610 | 0 | 357 | 1700 | 79 | 1.1 | 150 | 1160 | 326 | 835 | 7.3 | 3700 |
| 47 | Warren County NW NW sec. 24, T. 76N., R. 22W. | Ned L. Spurgin | 1955 | St. Louis | 8-13-68 | 380 | 11 | 5540 | 2.6 | .05 | 304 | 97 | 17 | 1700 | 0 | 327 | 4000 | 309 | 2.2 | 1.1 | 1160 | 276 | 884 | 7.5 | 6050 |
| 48 | Marshall County sec. 6, T. 82N., R. 19W. | Melbourne No. 2 | 1966 | Burlington through Maynes Creek | 5-7-67 | 330 | 16 | 2460 | .10 | .05 | 212 | 100 | 15 | 360 | 0 | 259 | 1400 | 30 | 2.4 | 2.5 | 940 | 212 | 728 | 7.4 | 2900 |
| 49 | Greene County NE NE sec. 29, T. 82N., R. 29W. | John Grow | 1962 | Keokuk | 6-15-64 | 385 | 13 | 890 | 5.2 | .05 | 96 | 56 | 16 | 117 | 0 | 346 | 387 | 17 | 1.1 | 0.1 | 472 | 284 | 188 | 7.6 | 1210 |
| 50 | Henry County NW SE sec. 12, T. 71N., R. 7W. | Jim Kauffman | 1964 | Warsaw through Starrs Cave | 6-21-67 | 251 | 12 | 410 | .04 | .05 | 79 | 39 | 1.2 | 18 | 0 | 437 | 11 | 5.5 | .25 | 6.4 | 356 | 356 | 0 | 7.3 | 710 |
| 51 | Sac County NE NE sec. 13, T.89N., R. 37W. | Robert Hensel | 1966 | Keokuk through Hampton | 3-6-68 | 700 | 13 | 2100 | 2.2 | .09 | 260 | 73 | 12 | 280 | 0 | 314 | 1200 | 22 | 1.6 | 1.1 | 950 | 257 | 693 | 7.3 | 2500 |
| 52 | Greene County NW NE sec. 8, T. 83N., R. 30W. | Robert Mace | 1960 | St. Louis-Warsaw | 6-17-64 | 415 | 13 | 737 | 5.1 | .05 | 89 | 49 | 23 | 71 | 0 | 346 | 267 | 17 | 2.4 | 0.1 | 424 | 284 | 140 | 7.6 | 1100 |
| 53 | Webster County SE SW sec. 2, T. 86N., R. 28W. | Kate Gabrielson | 1947 | St. Louis through Hampton | 8-20-61 | 120 | 11 | 600 | 3.5 | 0 | 87 | 41 | 123 | | 0 | 408 | 284 | 12 | 2.2 | 0 | 387 | 334 | 53 | 7.5 | 1070 |
| 54 | Hamilton County SW NW sec. 8, T. 86N., R. 25W. | Stanhope No. 4 | 1949 | St. Louis through Hampton | 6-4-64 | 385 | | 658 | .04 | .05 | 92 | 53 | 5.6 | 52 | 0 | 437 | 169 | 0.5 | 1.2 | 0.1 | 448 | 358 | 90 | 7.7 | 1090 |
| 55 | Mahaska County NE NE sec. 21, T. 74N., R. 14W. | Floyd Brown | 1962 | St. Louis | 3-30-67 | 210 | 11 | 545 | .16 | .05 | 82 | 28 | 6.4 | 69 | 0 | 561 | 85 | 0.6 | .75 | 0.2 | 318 | 318 | 0 | 7.6 | 940 |
| 56 | Warren County NW NW sec. 31, T. 77N., R. 25W. | Ralph Butler | 1966 | St. Louis through Hampton | 9-13-69 | 625 | 16 | 5780 | .13 | .12 | 264 | 78 | 14 | 1300 | 0 | 339 | 3160 | 340 | 3.1 | 0.7 | 992 | 276 | 702 | 7.5 | 7000 |
| 57 | Calhoun County sec. 34, T. 89N., R. 33W. | Jolley School | 1953 | St. Louis through Starrs Cave | 10-11-58 | 401 | | 1351 | 11 | .05 | 200 | 53 | 6.7 | 85 | 0 | 462 | 563 | 1 | 1.2 | 0.1 | 682 | 295 | 487 | 7.3 | 1620 |




FLUORIDE CONCENTRATIONS LIMIT THE ACCEPTABILITY OF THE WATER FOR DOMESTIC PURPOSES




SULFATE CONCENTRATIONS ALSO LIMIT THE ACCEPTABILITY OF THE WATER FOR DOMESTIC PURPOSES

Concentrations often exceed 4,000 mg/l in the area where gypsum and anhydrite deposits are known to be present.

SIGNIFICANCE OF MINERAL CONSTITUENTS AND PROPERTIES OF WATER①

| Constituent or Property | Maximum Recommended Concentration (Milligrams per liter) | Significance |
|---|---|---|
| Iron (Fe) | 0.3 | Objectionable as it causes red and brown staining of clothing and porcelain. High concentrations affect the color and taste of beverages. |
| Manganese (Mn) | 0.05 | Objectionable for the same reasons as iron. When both iron and manganese are present, it is recommended that the total concentration not exceed 0.3 mg/l. |
| Calcium (Ca) and Magnesium (Mg) | - a - | Principal causes for hardness and scale-forming properties of water. They reduce the lathering ability of soap. |
| Sodium (Na) and Potassium (K) | - a - | Impart a salty or brackish taste when combined with chloride. Sodium salts cause foaming in boilers. |
| Sulfate ($SO_4$) | 250 | Commonly has a laxative effect when the concentration is 600 to 1,000 mg/l, particularly when combined with magnesium or sodium. The effect is much less when combined with calcium. This laxative effect is commonly noted by newcomers, but they become acclimated to the water in a short time. The effect is noticeable in almost all persons when concentrations exceed 750 mg/l. Sulfate combined with calcium forms a hard scale in boilers and water heaters. |
| Chloride (Cl) | 250 | Large amounts combined with sodium impart a salty taste. |
| Fluoride (F) | 2.0 | In the area of the aquifer's occurrence, concentrations of 0.8 to 1.3 mg/l are considered to play a part in the reduction of tooth decay. However, concentrations over 2.0 mg/l will cause the mottling of the enamel of children's teeth. |
| Nitrate ($NO_3$) | 45 | Waters with high nitrate content should not be used for infant feeding as it may cause methemoglobinemia or cyanosis. High concentrations suggest organic pollution from sewage, decayed organic matter, nitrate in the soil, or chemical fertilizer. |
| Dissolved Solids | 500 | This refers to all of the material in water that is in solution. It affects the chemical and physical properties of water for many uses. Amounts over 2,000 mg/l will have a laxative effect on most persons. Amounts up to 1,000 mg/l are generally considered acceptable for drinking purposes if no other water is available. |
| Hardness (as $CaCO_3$) | - a - | This affects the lathering ability of soap. It is generally produced by calcium and magnesium. Hardness is expressed in milligrams per liter equivalent to $CaCO_3$ as if all the hardness were caused by this compound. Water becomes objectionable for domestic use when the hardness is above 100 mg/l; however, it can be treated readily by softening. |
| Temperature | - a - | Affects the desirability and economy of water use, especially for industrial cooling and air conditioning. Most users want a water supply with a low and constant temperature. |

① See U.S. Public Health Service Publication No. 956 (revised 1962) and Hem, 1959 for further discussion.

a. No maximum recommended concentration.

The chemical constituents and properties shown in the above table are the ones that are usually determined in routine water analyses. They form the basis for the chemical characteristic maps and text presented on this atlas sheet. Comments regarding the acceptability of water are based on the U.S. Public Health Service drinking-water standards shown in the above table. These standards are mandatory for interstate carriers, but are recommended for drinking-water supplies in general. Moreover, the American Water Works Association supports these standards as minimum standards for municipal supplies.

The maximum recommended concentrations of some constituents are often exceeded without obvious ill effects, although the water may be unpalatable. However, concentrations of consituents that affect the health of the user should not be exceeded. It should also be recognized that standards for uses other than drinking water are usually different than those listed above. For these reasons, the concentrations of some constituents and properties of water from the aquifer are shown on maps so that the water user can decide if the water meets his particular requirements or desires. Comments regarding acceptability are presented to point out the areas where the aquifer contains the most desirable quality water.

The data presented on this sheet are based on analyses of water from many wells — some that penetrate the aquifer and some that are completed in the upper part. This is of particular significance in southeastern and south-central Iowa, where the flow system is separated by the Warsaw Shale. Work in southeastern Iowa (Coble, 1971, p. 71) and data in south-central Iowa indicate that less mineralized water is available from the Meramecian rocks. Even in and near the area of evaporite deposits, small quantities of much less mineralized water can be obtained from the St. Louis Sandstone (see well No. 6 in adjoining table). For this reason, emphasis in drawing the maps was placed on water analyses of wells that penetrated the thickest section of the aquifer.

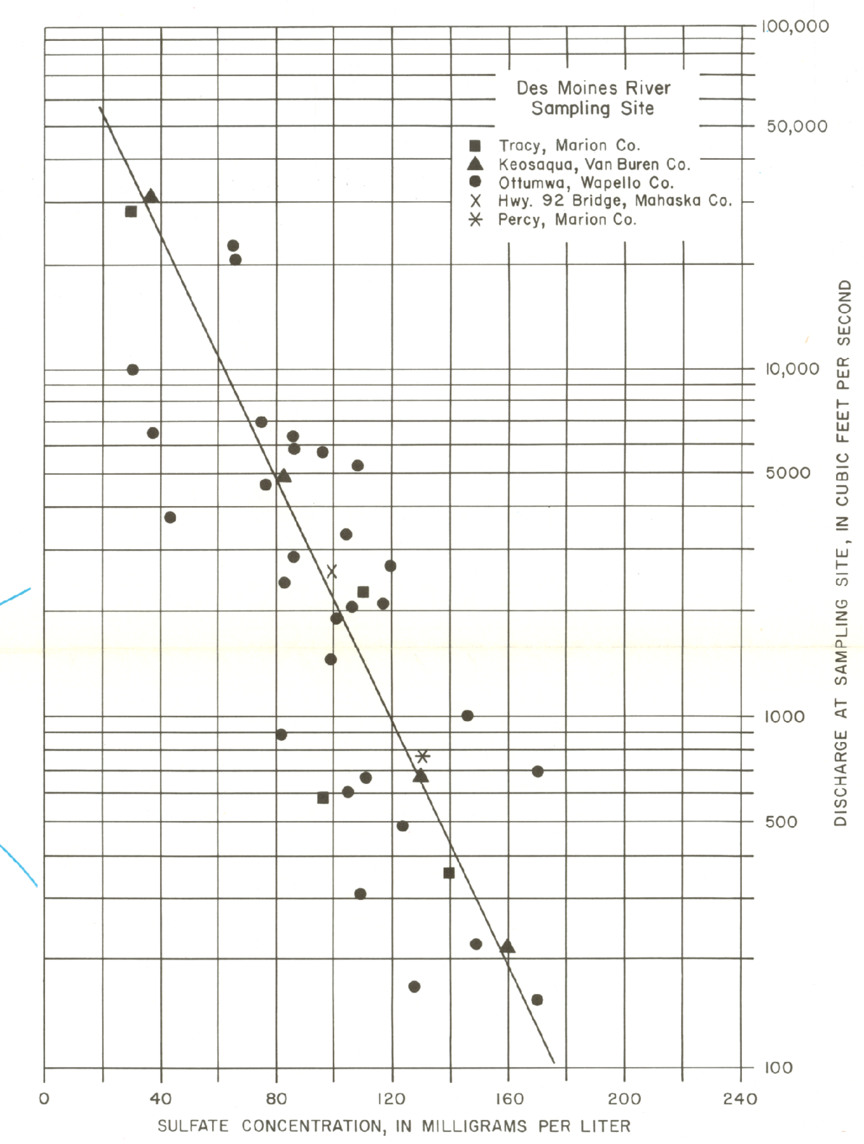
## DATA NOT PRESENTED ON MAPS

CHLORIDE content generally is less than 20 mg/l (milligrams per liter) in the outcrop area of the aquifer and less than 80 mg/l elsewhere. Unusually high concentrations occur locally in southern Iowa. These high concentrations are always associated with very high sodium concentrations, but not all water with high sodium content has a high chloride content.

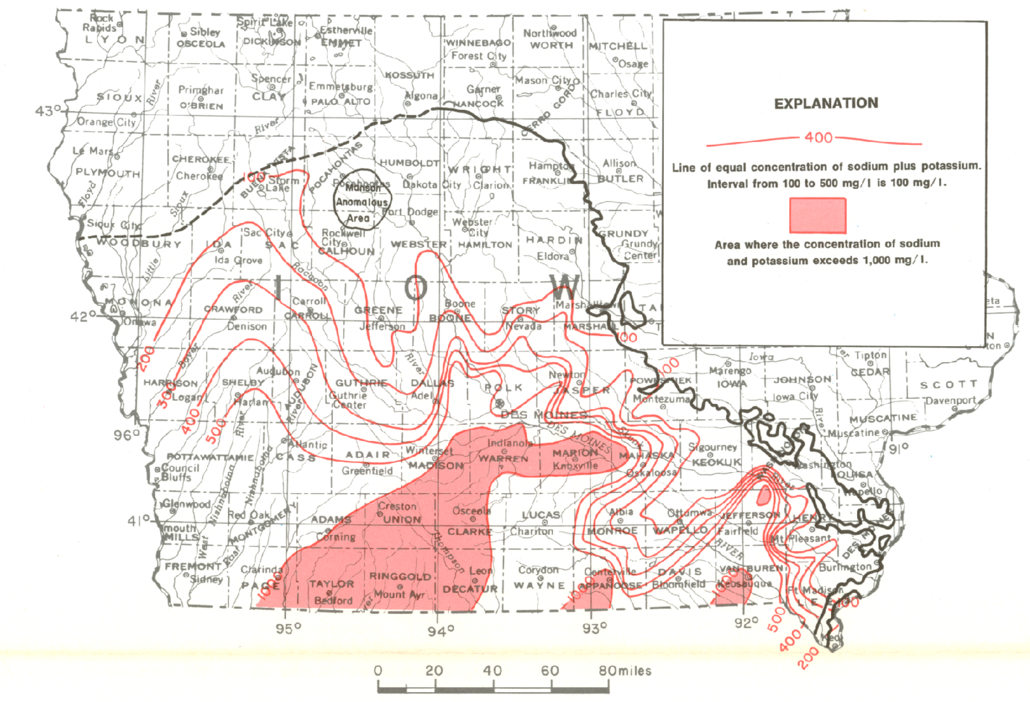
NITRATE content generally is less than 5 mg/l, because the Mississippian rocks contain very little nitrogenous material. Water with an unusually high concentration of nitrate, such as from well number 46, is a good indication that the well is polluted.

IRON and MANGANESE content are difficult to assess. The concentrations of both can be affected by microorganisms. Both oxidize and precipitate readily in the presence of air; therefore, unless special sampling precautions are used, the reported concentration can be quite different than the actual concentration. Moreover, iron dissolved from casings, pipes, and pumps can increase the iron content of the water. Analyses on hand indicate both constituents vary considerably. Iron concentrations exceed the recommended standard in 40 percent of the samples. Manganese concentrations exceed the recommended standard in 32 percent of the samples. Both constituents, however, are readily removed by treatment.

TEMPERATURE of the water usually ranges between 10-13°C, but temperatures as high as 18°C have been recorded from the deeper zones of the aquifer. The temperature is dependent on the latitude and depth of the well withdrawing water from the aquifer.

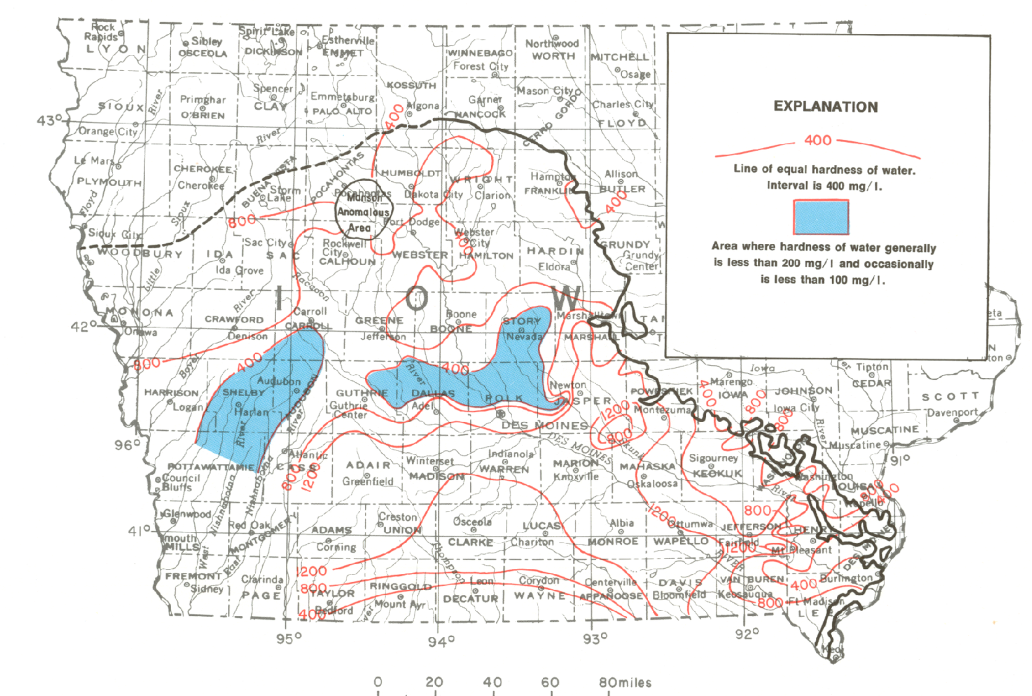



HIGH-SULFATE WATER FROM THE AQUIFER THAT DISCHARGES INTO THE LOWER DES MOINES RIVER IS ESPECIALLY NOTICEABLE DURING LOW-FLOW PERIODS




PEOPLE RESTRICTED TO A LOW SODIUM DIET SHOULD BE AWARE THAT WATER FROM THIS AQUIFER IN SOUTHERN IOWA CONTAINS AN EXTREMELY HIGH SODIUM CONTENT

The concentrations of sodium and potassium are combined as a mapping parameter, because prior to 1952 most analyses did not report the two constituents separately. Based on later analyses, however, the potassium content of water from the aquifer is known to seldom exceed 20 mg/l. Therefore, the map is considered a valid portrayal of the sodium content.




WATER FROM THE AQUIFER, WITH FEW EXCEPTIONS, IS EXTREMELY HARD

The exceptions occur in a small area through Central Iowa. High concentrations of fluoride are invariably associated with the low-hardness water.

# CONCLUSIONS

## WATER SUPPLY

The Mississippian aquifer underlies about 60 percent of the State, but in only about 15 percent of this area can the aquifer be considered a major source of potable water. This area comprises all or parts of 10 counties in the north-central part of the Mississippian outcrop, where the aquifer will yield moderate to large supplies of good to excellent quality water to wells. Estimates of recharge and storage in that region indicate that many times the current withdrawal rate of about 12 mgd can be developed from the aquifer. Determination of the actual amount available will require definitive studies of recharge, discharge, and storage. The location and spacing of the withdrawal sites to recover the optimum amount of water will require the acquisition of quantitative data on the aquifer characteristics. These studies should be initiated before a greater stress is imposed on the system.

Elsewhere, the aquifer yields either small quantities of moderately to highly mineralized water (subcrop area), or small to moderate quantities of fair to good quality water (southeast outcrop area). Additional supplies probably can be developed in both areas. At places in the subcrop area, the aquifer probably will be developed for many more rural supplies when home demineralizing units become economically feasible. Because the aquifer in these two areas is not considered a major source of water, additional definitive studies at this time are not recommended.

## PROTECTION OF MISSISSIPPIAN AQUIFER

A potential pollution hazard to the Mississippian aquifer exists in its outcrop area. The aquifer here is recharged through the glacial drift; therefore, any deleterious material introduced into the surficial flow system eventually will reach the Mississippian aquifer. Deleterious materials may be in the form of farm chemicals that are over-applied and infiltrate the ground or may be downward percolating leachates produced from waste-disposal sites. Waste-disposal sites in the outcrop area of the aquifer would be best located where the glacial drift is thick or has very low permeability. The map on sheet 1 of this atlas will enable land-use planners to determine the thickness of the glacial drift in the outcrop area. Determinations of permeability will require additional study.

## PROTECTION OF UNDERLYING CAMBRIAN-ORDOVICIAN AQUIFER

A potential contamination hazard to the underlying Cambrian-Ordovician aquifer exists in the subcrop area of the Mississippian aquifer. In that area the Mississippian aquifer contains highly mineralized water, whereas the Cambrian-Ordovician aquifer contains fair-to-good-quality water (Coble, 1970). Moreover, the potentiometric surface of the Mississippian aquifer in the subcrop area generally is at least 100 feet higher than that of the Cambrian-Ordovician aquifer (Steinhilber and Horick, 1970). Therefore, it is imperative that wells drilled to the deeper aquifer be properly cased and completely cement grouted, in order to prevent downward borehole movement of mineralized water from the Mississippian. Also, when deep wells are no longer in use, they should not merely be abandoned. The wells should be properly plugged (Van Eck, 1971), because casing failures eventually occur — even when cement grouted.

# MISSISSIPPIAN AQUIFER OF IOWA

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