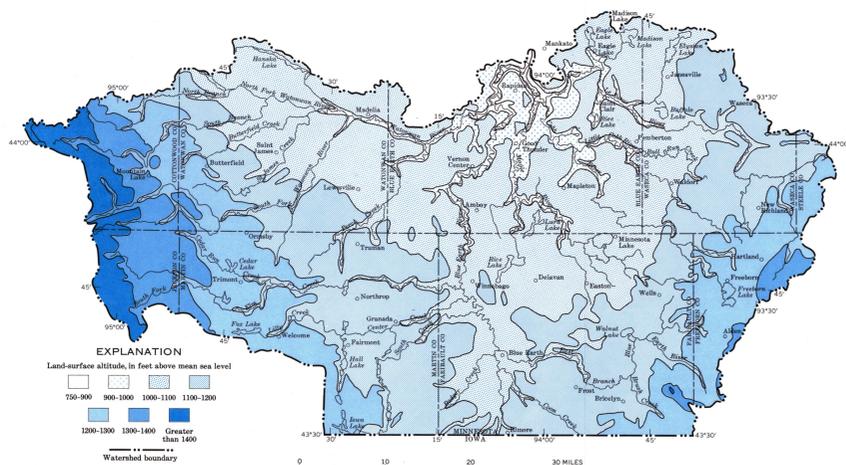
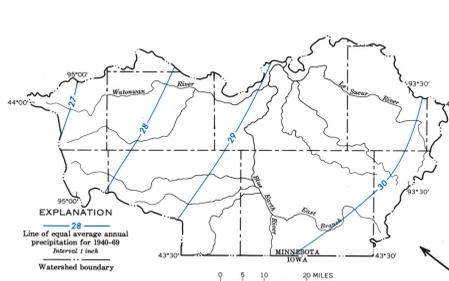


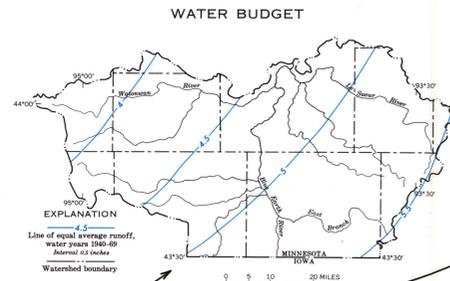
# INTRODUCTION



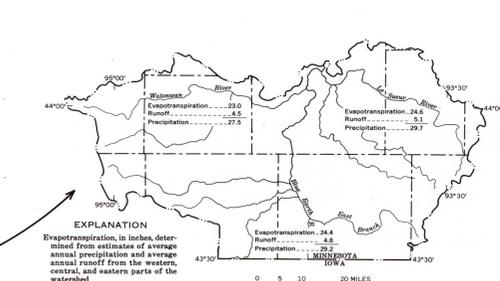
THE BLUE EARTH RIVER WATERSHED IN MINNESOTA INCLUDES 3,106 SQUARE MILES OF LAND SURFACE, WHICH VARIES FROM FAIRLY FLAT TO GENTLY ROLLING. The drainage area extends south to include an additional 140 square miles in Iowa. The western, southern, and eastern boundaries are and sources formed by Pleistocene glacial. Major streams have eroded channels up to 75 feet deep in headwater regions and 100 to 200 feet deep near the mouth of the Blue Earth River at Mankato. In their lower reaches major streams have cut through glacial deposits and into underlying bedrock (described on ground-water sheets).



EXPLANATION  
Line of equal average annual precipitation for 1940-69  
Watershed boundary



EXPLANATION  
Line of equal average annual runoff for 1940-69  
Watershed boundary



EXPLANATION  
Evapotranspiration, in inches, determined from estimates of average annual precipitation and average annual runoff from the western, central, and eastern parts of the watershed

$$29.2 \text{ inches PRECIPITATION} = 4.8 \text{ inches RUNOFF} + 24.4 \text{ inches EVAPOTRANSPIRATION} \pm \text{UNDERFLOW}$$

The difference between ground-water flow into and out of the watershed is estimated to be less than 0.1 inch

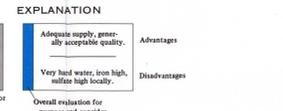
THE AMOUNT OF WATER ENTERING THE WATERSHED AS PRECIPITATION IS APPROXIMATELY EQUAL TO SURFACE RUNOFF PLUS EVAPOTRANSPIRATION; UNDERFLOW AND CHANGES IN STORAGE OF GROUND WATER AND SURFACE WATER ARE RELATIVELY SMALL. Precipitation is the source of virtually all recharge in the water budget. The amount of precipitation increases from west to east across the watershed. About 16 percent of the water leaves the watershed as runoff in streams. The amount of runoff also increases from west to east. Almost all the remaining 84 percent of the water is taken up by evaporation and by transpiration from plants. A small amount leaves the watershed as underflow moving through the ground toward the north, less moving toward the southwest. The underflow that leaves the watershed is estimated to be only slightly more than the underflow that enters from the west and southeast. No areas of ground-water decline are known; therefore, any net change in the amount of ground-water in storage during the period of record (1940-69) is assumed to be insignificant.

# SUMMARY

| Municipality    | Water use                          |   |                                       |  |  |                                  | Aquifer               |                  |                 |                               |                     |  | Water system                            |            |               |                               |                            |                            | Representative quality (micrograms per liter) |  |  |  |  |  |
|-----------------|------------------------------------|---|---------------------------------------|--|--|----------------------------------|-----------------------|------------------|-----------------|-------------------------------|---------------------|--|---|------------|---------------|-------------------------------|----------------------------|----------------------------|---|--|--|--|--|--|
|                 | Estimated population served (1970) | Annual industrial use (million gallons) | Annual domestic use (million gallons) | Total annual average (million gallons) | Average daily average (thousand gallons) | Per capita use (gallons per day) | Name                  | Thickness (feet) | Number of wells | Approximate well depth (feet) | Flow per well (gpm) | Specific capacity (gpm per foot of drawdown) | Daily yield capacity (thousand gallons) | Iron (ppm) | Chloride (CT) | Hardness as CaCO <sub>3</sub> | Dissolved solids, combined | Sulfate (SO <sub>4</sub> ) |   |  |  |  |  |  |
| Alden           | 680                                | None                                    | 18                                    | 18                                     | 49                                       | 72                               | Galena ls.            | 108              | 2               | 412                           | 200                 | 40   | 2.2                                     | 2.5        | 200           | 460                           | 38                         |                            |   |  |  |  |  |  |
| Amboy           | 615                                | None                                    | 19                                    | 19                                     | 54                                       | 87                               | Jordan ls.            | 46               | 1               | 638                           | 250                 | 1.9  | 1.6                                     | 3.3        | 590           | 811                           | 340                        |                            |   |  |  |  |  |  |
| Blue Earth      | 4,500                              | 5                                       | 167                                   | 172                                    | 472                                      | 102                              | Jordan ls.            | 78               | 173             | 1,100                         | 1,000               | 33   | 2.3                                     | 1.1        | 580           | 779                           | 320                        |                            |   |  |  |  |  |  |
| Brainerd        | 542                                | <1                                      | 15                                    | 15                                     | 41                                       | 74                               | Jordan ls.            | 89               | 1               | 650                           | 600                 | 13   | 3.0                                     | 3.0        | 602           | 880                           | 296                        |                            |   |  |  |  |  |  |
| Butterfield     | 601                                | None                                    | 10                                    | 10                                     | 28                                       | 47                               | Glacial gravel        | 98               | 1               | 284                           | 150                 | 1  | 0.1                                     | <1         | 260           | 500                           | 62                         |                            |   |  |  |  |  |  |
| Delavan         | 322                                | 11                                      | 11                                    | 22                                     | 61                                       | 94                               | St. Peter ss.         | 202              | 1               | 280                           | 280                 | 1  | 1.2                                     | 1.5        | 340           | 417                           | 64                         |                            |   |  |  |  |  |  |
| Eagle Lake      | 610                                | None                                    | 18                                    | 18                                     | 49                                       | 81                               | St. Peter ss.         | 273              | 1               | 473                           | 200                 | 1  | 2.5                                     | 1          | 390           | 493                           | 82                         |                            |   |  |  |  |  |  |
| Easton          | 423                                | None                                    | 20                                    | 20                                     | 54                                       | 128                              | Jordan ls.            | 69               | 1               | 399                           | 170                 | 1  | 245                                     | 83         | 300           | 376                           | 23                         |                            |   |  |  |  |  |  |
| Elmore          | 1,078                              | 3                                       | 31                                    | 34                                     | 92                                       | 78                               | Platteville ls.       | 20               | 1               | 140                           | 35                  | 1  | 144                                     | 50         | <1            | 320                           | 500                        | 27                         |   |  |  |  |  |  |
| Fairmont        | 12,000                             | 130                                     | 303                                   | 433                                    | 1,506                                    | 69                               | Galena ls.            | 20               | 2               | 124                           | 160                 | 10   | 432                                     | 1.3        | 0             | 350                           | 431                        | 91                         |   |  |  |  |  |  |
| Freeborn        | 314                                | None                                    | 10                                    | 10                                     | 29                                       | 91                               | Water from Budd Lake  | -----            | -----           | -----                         | -----               | 4,300  | .05                                     | 1          | 310           | 339                           | 50                         |                            |   |  |  |  |  |  |
| Frost           | 370                                | 1                                       | 11                                    | 12                                     | 32                                       | 79                               | Platteville ls.       | 6                | 1               | 354                           | 225                 | 7.5  | 324                                     | 1.5        | 5.0           | 350                           | 470                        | 49                         |   |  |  |  |  |  |
| Good Thunder    | 468                                | None                                    | 9                                     | 9                                      | 26                                       | 55                               | Galena ls.            | 123              | 2               | 216                           | 235                 | 8  | 367                                     | 1.0        | 0.5           | 230                           | 667                        | 150                        |   |  |  |  |  |  |
| Grenada         | 418                                | None                                    | 7                                     | 7                                      | 18                                       | 44                               | Prairie du Chien ls.  | 114              | 1               | 224                           | 250                 | 1  | 4.3                                     | 8.0        | 450           | 472                           | 82                         |                            |   |  |  |  |  |  |
| Harland         | 300                                | None                                    | 5                                     | 5                                      | 14                                       | 48                               | Glacial gravel        | 11               | 1               | 131                           | 50                  | 5  | 72                                      | 1.8        | 4.0           | 790                           | 1,160                      | 550                        |   |  |  |  |  |  |
| Janesville      | 1,500                              | None                                    | 95                                    | 95                                     | 261                                      | 174                              | St. Peter ss.         | 49               | 1               | 597                           | 100                 | 1  | 144                                     | .76        | 2.0           | 400                           | 578                        | 140                        |   |  |  |  |  |  |
| Leveaux         | 375                                | None                                    | 11                                    | 11                                     | 29                                       | 78                               | Jordan ls.            | 110              | 1               | 310                           | 100                 | 1  | 576                                     | 2.1        | 0             | 350                           | 502                        | 76                         |   |  |  |  |  |  |
| Madrid          | 2,500                              | 248                                     | 83                                    | 331                                    | 918                                      | 91                               | Prairie du Chien ls.  | 110              | 1               | 310                           | 100                 | 1  | 576                                     | 2.1        | 0             | 350                           | 502                        | 76                         |   |  |  |  |  |  |
| Maple Lake      | 600                                | None                                    | 21                                    | 21                                     | 58                                       | 97                               | Cambrian ss.          | 200              | 4               | 510                           | 500                 | 10-15  | 2,880                                   | 2.1        | 5             | 520                           | 609                        | 190                        |   |  |  |  |  |  |
| Mankato         | 23,795                             | 376                                     | 916                                   | 1,292                                  | 3,539                                    | 105                              | Jordan ls.            | 45               | 1               | 385                           | 150                 | 7.7  | 310                                     | -----      | -----         | -----                         | -----                      | -----                      |   |  |  |  |  |  |
| Mapleton        | 1,107                              | None                                    | 31                                    | 31                                     | 86                                       | 77                               | Glacial gravel        | 45               | 1               | 385                           | 150                 | 7.7  | 310                                     | -----      | -----         | -----                         | -----                      | -----                      |   |  |  |  |  |  |
| Minnetonka Lake | 700                                | 2                                       | 20                                    | 22                                     | 60                                       | 77                               | Cambrian ss.          | 400              | 3               | 700                           | 1,000               | 16   | 6,000                                   | 0.7        | 24            | 416                           | 630                        | 281                        |   |  |  |  |  |  |
| Mountain Lake   | 2,250                              | None                                    | 65                                    | 65                                     | 178                                      | 79                               | Glacial gravel        | 35               | 4               | 65                            | 700                 | 1  | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| New Richmond    | 1,046                              | None                                    | 26                                    | 26                                     | 71                                       | 68                               | Glacial gravel        | 35               | 4               | 65                            | 700                 | 1  | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| Northrop        | 189                                | None                                    | 3                                     | 3                                      | 9  | 47                               | Glacial gravel        | 35               | 4               | 65                            | 700                 | 1  | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| Oronhy          | 225                                | None                                    | 6                                     | 6                                      | 17                                       | 75                               | Glacial gravel        | 35               | 4               | 65                            | 700                 | 1  | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| Pemberton       | 160                                | None                                    | 3                                     | 3                                      | 8  | 48                               | Glacial gravel        | 8                | 3               | 62                            | 100                 | 14   | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| Rapidan         | 160                                | None                                    | 2                                     | 2                                      | 5  | 32                               | Glacial gravel        | 8                | 3               | 62                            | 100                 | 14   | -----                                   | -----      | -----         | -----                         | -----                      |                            |   |  |  |  |  |  |
| St. Clair       | 400                                | None                                    | 13                                    | 13                                     | 37                                       | 94                               | Prairie du Chien ls.  | 70               | 2               | 320                           | 100                 | 5.6  | 288                                     | 9.5        | 2.6           | 220                           | 530                        | 70                         |   |  |  |  |  |  |
| St. James       | 4,175                              | 135                                     | 77                                    | 212                                    | 580                                      | 50                               | Glacial gravel        | 4                | 3               | 40                            | 150                 | 22   | 1,407                                   | 1.8        | 27            | 674                           | 902                        | 380                        |   |  |  |  |  |  |
| Tinneton        | 800                                | None                                    | 19                                    | 19                                     | 52                                       | 65                               | Cretaceous sand       | 25               | 2               | 180                           | 150                 | 11   | 1,407                                   | 1.8        | 2.8           | 1,080                         | 1,370                      | 885                        |   |  |  |  |  |  |
| Truman          | 1,256                              | 1                                       | 49                                    | 50                                     | 225                                      | 107                              | Glacial gravel        | 10               | 2               | 95                            | 135                 | -----  | 360                                     | 3.4        | 0             | 460                           | 578                        | 89                         |   |  |  |  |  |  |
| Vernon Center   | 333                                | 4                                       | 9                                     | 13                                     | 35                                       | 74                               | Drebach ss.           | 102              | 1               | 292                           | 250                 | 6.2  | 360                                     | 7.1        | 4.3           | 470                           | 940                        | 390                        |   |  |  |  |  |  |
| Waldorf         | 272                                | 15                                      | 15                                    | 30                                     | 82                                       | 149                              | St. Lawrence dolomite | 10               | 1               | 295                           | 120                 | -----  | 173                                     | 3.7        | 1.5           | 370                           | -----                      | 150                        |   |  |  |  |  |  |
| Waconia         | 6,200                              | 42                                      | 382                                   | 424                                    | 1,179                                    | 170                              | St. Peter ss.         | 106              | 1               | 310                           | 225                 | 10   | 324                                     | 3.2        | 2.5           | 410                           | -----                      | 100                        |   |  |  |  |  |  |
| Welcome         | 750                                | None                                    | 20                                    | 20                                     | 54                                       | 71                               | Jordan ls.            | 80               | 3               | 750                           | 1,400               | 62   | 5,560                                   | .72        | 1             | 320                           | 455                        | 50                         |   |  |  |  |  |  |
| Wells           | 3,000                              | 220                                     | 84                                    | 304                                    | 800                                      | 77                               | Glacial gravel        | 20               | 2               | 200                           | 100                 | 16   | 252                                     | 3.6        | 0             | 760                           | 1,350                      | 800                        |   |  |  |  |  |  |
| Winnebago       | 2,020                              | None                                    | 44                                    | 44                                     | 112                                      | 56                               | Prairie du Chien ls.  | 250              | 3               | 700                           | 1,000               | 50   | 3,600                                   | 0.9        | 2.8           | 510                           | 712                        | 290                        |   |  |  |  |  |  |
| Total Urban     | 77,000                             | 1,193                                   | 2,648                                 | 3,841                                  | 10,920                                   | 94                               | Glacial gravel        | 150              | 1               | 362                           | 500                 | -----  | 432                                     | 1.8        | 1.0           | 630                           | 967                        | 440                        |   |  |  |  |  |  |

## EVALUATION OF WATER RESOURCES

| Purpose                         | Consideration   | Surface water                           |   |   | Ground water   |  |  |  |  |  |  |  |  |  |
|---------------------------------|---|---|---|---|--|--|--|--|--|--|--|--|--|--|
|                                 |   | Blue Earth, Le Sueur, and Watwan Rivers | Large lakes   | Small lakes and minor streams   | Pleistocene  | Cretaceous                                     | Ordovician                                     | St. Peter Sandstone                            | Prairie du Chien Group   | Jordan Sandstone   | St. Lawrence and Franconia Formations and Dresbach Group | Cambrian                                       | Precambrian                                    |  |
| Municipal and industrial supply | For a moderate supply, principal needs are:<br>Quantity<br>Minimum available surface water supply of 1 cfs or less yielding 250 gpm.<br>Quality<br>Dissolved solids content less than 500 mg/l.<br>Hardness less than 180 mg/l.   | Adequate supply.                        | Adequate supply from some lakes for restricted use.   | Many adequate with development of storage facilities.                                 | Locally adequate supply.                               | Generally adequate supply.                     | Generally adequate supply.                     | Generally adequate supply.                     | Generally adequate supply.   | More than adequate supply throughout area of occurrence. | Adequate supply from sandstone layers.                   | -----  | -----  |  |
| Rural domestic and stock supply | For an adequate farm supply, needs are:<br>Quantity<br>Minimum of 5 gpm.<br>Quality<br>Dissolved solids content less than 1,000 mg/l.   | Adequate supply.                        | Adequate supply.  | Adequate for stock.   | Adequate supply in most of watershed.                  | Adequate supply where present.                 | Adequate supply, generally acceptable quality. | Adequate supply locally.                       | Adequate supply throughout area of occurrence, generally acceptable quality. | Adequate supply, generally acceptable quality.           | Adequate supply, generally acceptable quality.           | Adequate supply, generally acceptable quality. | Adequate supply, generally acceptable quality. |  |
| Irrigation supply               | For an average farm needs are:<br>Quantity<br>Minimum available surface water supply of 2 cfs during growing season on well yielding 250 gpm.<br>Quality<br>Dissolved solids content less than 2,000 mg/l.<br>Satisfiability of water quality for irrigation as indicated by classification of U.S. Dept. of Agriculture (Wilcox, 1955) | Adequate supply.                        | Adequate supply from some lakes restricted use from others.   | Adequate supply for restricted use from some.   | Locally adequate supply, generally acceptable quality. | Generally adequate supply, acceptable quality. | Generally adequate supply, acceptable quality. | Generally adequate supply, acceptable quality. | Adequate supply, acceptable quality.   | Adequate supply, acceptable quality.                     | Adequate supply, acceptable quality.                     | Adequate supply, acceptable quality.           | Adequate supply, acceptable quality.           |  |
| Fish and wildlife habitat       | Adequate depth and quality of water for fish in lakes and streams.<br>Adequate cover for wildlife habitat is provided by:<br>Wetlands - lake or pool areas surrounded by marsh areas.<br>Streams - marsh and woodland along banks.  | Suitable for hunting and fishing.       | Excellent migratory waterfowl nesting and feeding areas. Excellent wildlife habitats in marsh areas and along shores. Some suitable for fish. | Good migratory waterfowl nesting and feeding areas and habitat for fish and wildlife. | -----  | -----  | -----  | -----  | -----  | -----  | -----  | -----  | -----  |  |
| Recreation                      | Adequate access to lakes and streams.<br>Availability of areas suitable for hunting, fishing, and other water sports.<br>Availability of camps, cabins, and campgrounds.<br>Absence of pollution.   | Suitable for hunting and fishing.       | Suitable for hunting, fishing, and water sports widely distributed.   | Many suitable for hunting and trapping widely distributed.                            | -----  | -----  | -----  | -----  | -----  | -----  | -----  | -----  | -----  |  |



## USEFUL WATER FACTS

Water supplies are obtained from wells tapping Pleistocene glacial deposits, Ordovician and Cambrian sedimentary rocks, and Precambrian crystalline rocks. In the western part of the watershed, glacial sand and gravel (generally buried) form the most accessible and widely used aquifers. Toward the east, increasing numbers of wells obtain water from Ordovician and Cambrian rocks. The Jordan, St. Peter, and Galena Formations are the most reliable and widely used aquifers in the central and eastern parts of the watershed. Most of the Blue Earth River watershed is an area of ground-water recharge, indicated by a decrease in hydraulic potential as depth below land surface increases. Ground-water discharge to surface runoff and to evapotranspiration is generally localized near streams. Dominant regional ground-water flow converges on Mankato, where the surface flow also discharges from the Blue Earth River into the Minnesota River. In the higher areas along the edge of the watershed there is also significant downward flow. Some of this downward flow in the east and southeast moves out of the watershed. The use of ground water in the watershed is estimated at 6,628 million gallons per year. This represents 0.12 inch over the entire basin, compared with 29.2 inches precipitation, 24.4 inches of evapotranspiration, and 4.8 inches runoff. This indicates that only a small percentage of the water is being used; however, much of the water is not available for use.

## SELECTED REFERENCES

Austin, G. S., Grant, J. A., Isola, R. J., and Sims, P. K., 1970, Geologic map of Minnesota, New Ulm sheet. Minnesota Geol. Survey.  
Leverett, Frank, 1922, Quaternary geology of Minnesota and parts of adjacent States: U.S. Geol. Survey Prof. Paper 161, 149 p.  
Patterson, J. L., and Gamble, C. R., 1968, Magnitude and frequency of floods in the United States, part 5, Hudson River and upper Mississippi River basins: U.S. Geol. Survey Water-Supply Paper 1678, 546 p.  
Shan, R. E., and Austin, G. S., 1966, Geologic map of Minnesota, St. Paul sheet: Minnesota Geol. Survey.  
Thiel, G. A., 1944, The geology and underground waters of southern Minnesota: Minnesota Geol. Survey Bull. 31, 606 p.  
U.S. Department of Commerce, Weather Bureau, 1969, Technical Paper No. 37, Evaporation maps for United States: Washington, D. C., U.S. Govt. Printing Office, 12 p.  
Wilcox, L. V., 1955, Classification and use of irrigation waters: U.S. Dept. of Agr. Circ. 969, 19 p.

## ACKNOWLEDGMENTS

The authors gratefully acknowledge the contribution of data for this report by well owners and drillers in the area. Some well logs were obtained from the Minnesota Geological Survey. Water analyses by Minnesota Department of Health, and soil maps by U.S. Soil Conservation Service, assisted the interpretation of water quality.