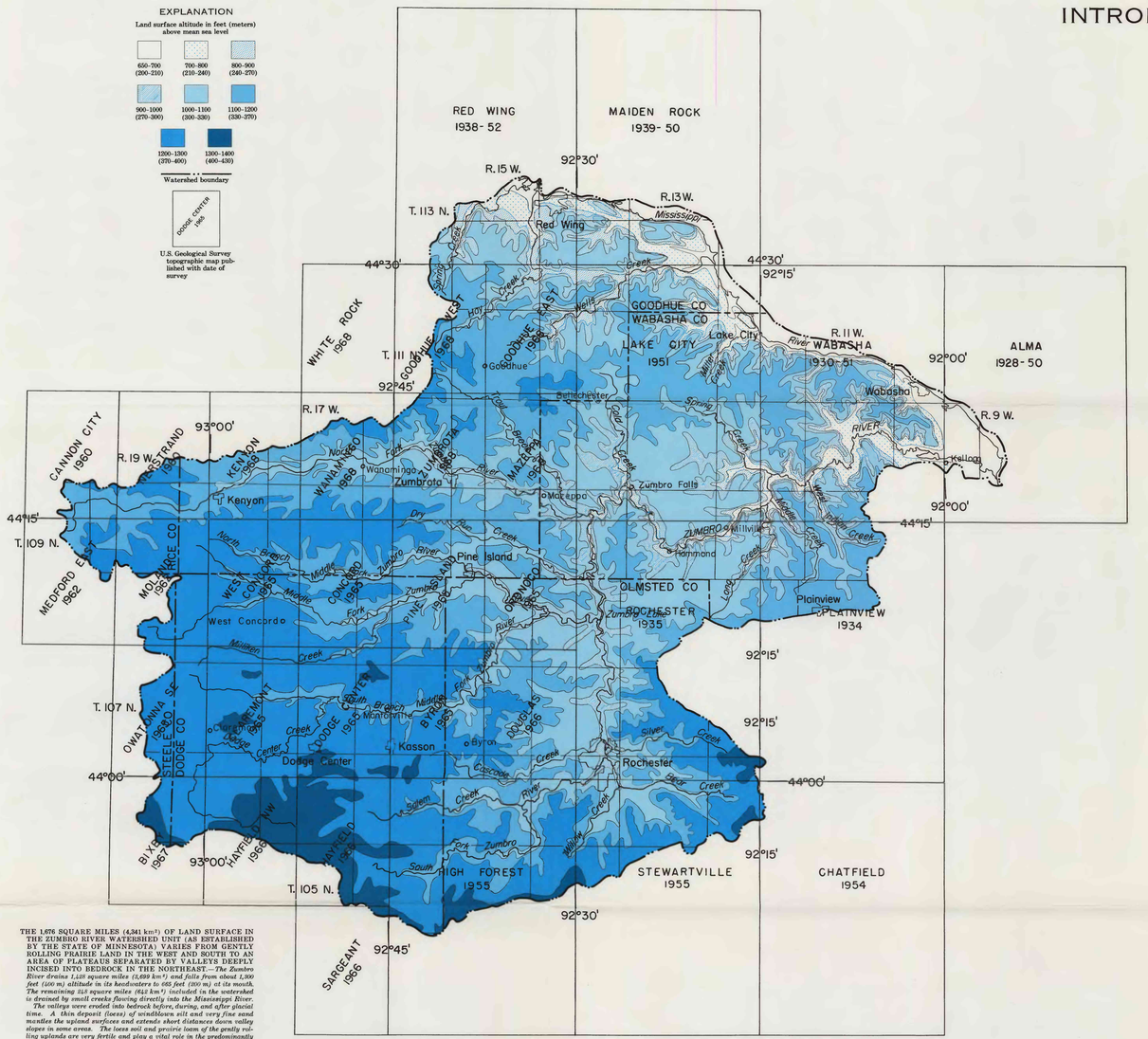
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-543 (SHEET 1 OF 3)

INTRODUCTION

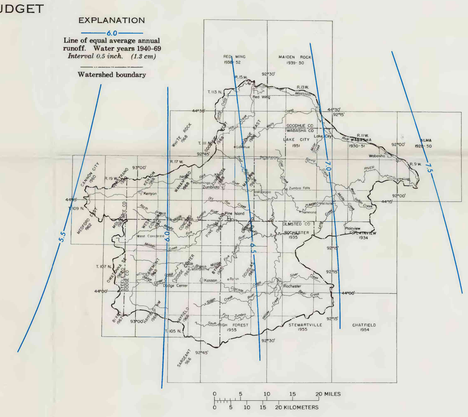


THE 1,676 SQUARE MILES (4,341 km²) OF LAND SURFACE IN THE ZUMBRO RIVER WATERSHED UNIT (AS ESTABLISHED BY THE STATE OF MINNESOTA) VARIES FROM GENTLY ROLLING PRAIRIE LAND IN THE WEST AND SOUTH TO AN AREA OF PLATEAUS SEPARATED BY VALLEYS DEEPLY INCISED INTO BEDROCK IN THE NORTHEAST.—*The Zumbro River drains 1,126 square miles (3,699 km²) and falls from about 1,300 feet (400 m) altitude in its headwaters to 665 feet (200 m) at its mouth. The remaining 515 square miles (643 km²) included in the watershed is drained by small creeks flowing directly into the Mississippi River.*

The valleys were eroded into bedrock before, during, and after glacial time. A thin deposit (loess) of windblown silt and very fine sand mantles the upland surfaces and extends short distances down valley slopes in some areas. The loess soil and prairie loam of the gently rolling uplands are very fertile and play a vital role in the predominantly agricultural economy.

Topographic quadrangle maps published by the U.S. Geological Survey are available for the entire watershed.

WATER BUDGET



28.2 inches (71.6 cm) PRECIPITATION	=	6.5 inches (16.5 cm) RUNOFF	+	21.7 inches (55.1 cm) EVAPOTRANSPIRATION	±	0 UNDERFLOW	±	0 CHANGE IN STORAGE
Average annual, for 1940–69		Average annual, from stream-gaging records for 1940–69		Obtained by difference in water budget		The difference between ground-water flow into and out of the watershed is estimated to be less than 0.1 inch (0.25 cm)		Long-term gains in ground-water, surface-water, and soil-moisture storage are assumed to be nearly balanced by losses

THE AVERAGE ANNUAL WATER BUDGET FOR 1940–69 SHOWS THAT PRECIPITATION ON THE WATERSHED IS APPROXIMATELY EQUAL TO SURFACE RUNOFF PLUS EVAPOTRANSPIRATION.—*The areal distribution of precipitation is fairly uniform despite wide daily variations in summer caused by local storms. The runoff increase from west to east is due in part to greater discharge of ground water to the deeply incised stream valleys in the downstream (east) end of the watershed. The runoff increase may also be related to greater relief in the east, resulting in more rapid runoff and allowing less time for evapotranspiration.*

SUMMARY

EVALUATION OF WATER RESOURCES

Purpose	Considerations	Surface water: Zumbro River	Surface water: Tributaries and minor streams	Ground water: Sand and gravel aquifers	Ground water: Cedar Valley–Maquoketa–Dubuque–Galena aquifer	Ground water: St. Peter aquifer	Ground water: Prairie du Chien aquifer	Ground water: Jordan aquifer	Ground water: Ironton–Galesville aquifer	Ground water: Mount Simon–Red clastics aquifer
Municipal and industrial supply	For a moderate supply, principal needs are: Quantity — Minimum available surface water supply of 1 cfs (0.03 m³/s) or wells yielding 250 gpm (16 l/s). Quality — Dissolved-solids content less than 500 mg/l. Hardness less than 180 mg/l.	Adequate supply. — Restricted areal distribution. Very hard water. Suspended solids and coliform high.	Many adequate with development of storage facilities. — Restricted areal distribution. Very hard water. Suspended solids and coliform high.	Very high yields possible in river alluvium. — Inadequate supply except in alluvium along Mississippi and Zumbro Rivers. Susceptible to contamination. Very hard water. Iron generally high. Locally high dissolved solids.	Adequate in southern and western part of watershed where present. — Very hard water. Iron and dissolved solids high. Susceptible to contamination, requires treatment. Yield varies areally because of distribution of fractures.	Generally adequate supply where deeply buried. — Locally low yields due to fineness of sand. Very hard water.	Generally adequate supply except near valley outcrops. — Yield varies areally because of distribution of fractures. Susceptible to contamination where near the surface, especially through sink holes; requires treatment. Very hard water.	Adequate supply except near valley outcrops. — Very hard water. Iron high.	Adequate supply throughout the watershed. — Very hard water. Iron high.	Adequate supply throughout the watershed. — Very hard water. Dissolved solids high. Deeply buried.
Rural domestic and stock supply	For an adequate farm supply, needs are: Quantity — Minimum of 5 gpm. (0.3 l/s). Quality — Dissolved-solids content less than 1,000 mg/l.	Adequate supply. — Available only to riparian lands. Suspended solids and coliform high.	Adequate for stock. — Available only to riparian lands. Suspended solids and coliform high.	Locally adequate supply in western and southern part, of watershed and in alluvium along the Mississippi and Zumbro Rivers. Generally acceptable quality. — Susceptible to contamination. Thin or absent in most areas. Very hard water. Iron generally high.	Adequate supply where present. Generally acceptable quality. — Susceptible to contamination. Very hard water. Iron high.	Generally adequate supply where present. Acceptable quality. — Very hard water.	Adequate supply. Generally acceptable quality. — Susceptible to contamination. Very hard water.	Adequate supply except near valley outcrops. Acceptable quality. — Very hard water. Iron high.	Adequate supply throughout the watershed. Acceptable quality. — Very hard water. Iron high. Deeply buried except along Mississippi River and adjoining valleys.	Adequate supply throughout the watershed. Acceptable quality. — Very hard water. Deeply buried.
Irrigation supply	For an average farm, needs are: Quantity — Minimum available surface water supply of 2 cfs (0.06 m³/s)during growing season or wells yielding 250 gpm (16 l/s). Quality — Dissolved-solids content less than 2,000 mg/l is desired. Suitability of water quality for irrigation as indicated by classification of U.S. Dept. of Agriculture. (Wilcox 1955).	Adequate supply. Excellent quality. — Available only to riparian lands.	Adequate supply for limited use from some. Excellent quality. — Available only to riparian lands.	Locally adequate supply in western and southern parts of watershed, and in alluvium along Mississippi and Zumbro Rivers. — Exploratory drilling would help to define aquifer locally.	Generally adequate supply where present. — Yield varies areally because of distribution of fractures.	Generally adequate supply where present.	Adequate supply except near valley outcrops. Acceptable quality. — Yield varies areally because of distribution of fractures.	Adequate supply except near valley outcrops. Acceptable quality.	Adequate supply throughout the watershed. Acceptable quality.	Adequate supply. — Deeply buried. Percent sodium high in Red clastics.
Fish and wildlife habitat	Adequate depth and quality of water for fish in lakes and streams. Adequate cover for wildlife habitat is provided by: Wetlands–lakes or potholes surrounded by marsh areas. Streams–marsh and woodland along banks.	Suitable wildlife habitat along banks. Suitable for fish. Acceptable quality. — Occasional high water.	Suitable habitat along shores and banks. — Fluctuating water stage.							
Recreation	Adequate access to lakes and streams. Availability of areas suitable for hunting, fishing and other water sports. Available resorts, lake cottages, and campgrounds. Esthetic values and absence of pollution.	Suitable for hunting, fishing, and canoeing. — Occasional high water. Coliform frequently high.	Many suitable for hunting and trapping. Trout present in Mazeppa Creek, Cold Spring Brook, and West Indian Creek. — Occasional high water. Coliform frequently high.							

EXPLANATION

Good | Fair | Poor

Adequate supply throughout the watershed. — Advantages

Very hard water. Iron high. — Disadvantages

Overall evaluation for purpose and considerations indicated.

WATER USAGE IS A VERY SMALL PART OF THE WATER BUDGET.—*Distribution of water use is about as follows: domestic—50 percent, farm (for irrigation and livestock)—16 percent, and industrial—34 percent. Total usage, in water-budget terms, is 0.24 inch (0.61 cm) over the entire watershed, or less than 1 percent of inflow (average annual precipitation). Total quantity of water, thus, is of lesser concern than local availability and quality of water.*

MUNICIPAL SUPPLIES

Municipality	Estimated population served (1970)	Water use: Annual industrial use (million gallons)	Water use: Annual domestic use (million gallons)	Water use: Total annual pumpage (million gallons)	Water use: Average daily pumpage (thousand gallons)	Water use: Per capita domestic use (gallons per day)	Aquifer: Name	Aquifer: Symbol	Aquifer: Thickness–open to wells (feet)	Water system: Number of wells	Water system: Approximate well depth (feet)	Water system: Usual pumping rate (gpm)	Water system: Specific-capacity of wells (gpm per foot of drawdown)	Water system: Daily plant capacity (thousand gallons)	Quality (milligrams per liter): Iron (Fe)	Quality: Sulfate (SO_4)	Quality: Chloride (Cl)	Quality: Dissolved solids, calculated	Quality: Hardness as $CaCO_3$
Bellechester	199	--	4	4	12	60	Prairie du Chien	Opc	--	1	175	--	--	--	--	--	--	--	--
Byron	1,419	--	53	53	144	102	St. Peter and Prairie du Chien	Osp Opc	310	1	510	190	6.5	1,440	0.74	15	< 0.5	--	280
							Jordan	€j	74	1	700	810	20		1.1	19	< 1.0	330	270
Claremont	520	5	26	31	85	138	Maquoketa-Dubuque-Galena	Omd-Og	100	2	240	165	--	--	1.5	< 5	1.8	360	320
Dodge Center	1,603	3	52	55	151	94	Jordan	€j	91	2	913	650	9.7	1,570	.02	19	< 1.0	300	260
Goodhue	539	--	19	19	51	94	Prairie du Chien-Jordan	Opc-€j	262	1	314	300	--	432	.02	12	17	320	290
Hammond	179	--	9	9	25	140	Prairie du Chien	Opc	--	1	100	90	--	130	.04	10	2.5	270	260
Kasson	1,883	21	85	106	290	123	Prairie du Chien-Jordan	Opc-€j	422	1	856	510	15	1,454	3.3	54	1.1	380	330
							Jordan	€j	103	1	857	500	--		.60	45	1.1	500	320
Kellogg	403	--	17	17	47	117	Alluvial sand and gravel	Q	15	1	145	300	61	420	.07	6.3	< 0.5	320	270
Kenyon	1,575	20	56	76	211	98	Prairie du Chien-Jordan	Opc-€j	410	1	635	250	25	1,354	1.8	67	< 1.0	--	280
							Jordan	€j	99	1	710	690	58		.59	39	< 1.0	250	280
Lake City	3,976	20	177	197	540	122	Alluvial sand and gravel	Q	30	2	160	550	54	18,720	.05	8.0	1.7	310	290
Mantorville	479	--	13	13	36	75	St. Peter	Osp	--	1	181	110	5.4	--	.18	62	1.4	380	320
							Jordan	€j	--	1	750	--	--		--	--	--	--	--
Mazeppa	498	--	12	12	32	64	Jordan	€j	100	2	260	265	4.4	598	.42	18	1.0	310	260
Millville	139	--	2	2	5	39	Prairie du Chien	Opc	--	1	186	60	--	144	.03	10	3.0	350	300
Pine Island	1,640	17	60	77	210	100	Jordan	€j	90	1	565	1,000	25	1,440	.23	13	1.9	300	300
Plainview	2,093	37	37	74	204	49	Jordan	€j	119	1	420	250	25	360	.28	12	3.3	350	240
Red Wing	12,539	--	360	360	987	79	Ironton-Galesville to Mount Simon	€ig-€m	300	3	530	1,250	20	3,407	.40	27	6.1	--	260
							Mount Simon-Red clastics	€m-pKr	385	1	770	1,350	15		.75	25	230	--	340
Rochester	53,766	920	1,380	2,300	6,300	70	Prairie du Chien-Jordan	Opc-€j	280	9	450	950	7.3	23,731	.14	25	3.6	260	310
							Jordan to Ironton-Galesville	€j to €ig	500	9	850	1,000	6.3		.24	11	4.0	280	270
Wabasha	2,371	--	111	111	303	128	Alluvial sand and gravel	Q	25	2	200	750	56	1,728	.03	10	1.5	340	300
Wanamingo	574	3	29	32	89	139	Jordan	€j	90	1	590	450	8.5	648	.63	23	< 1.0	330	270
West Concord	718	5	15	20	54	56	Jordan	€j	100	1	803	--	--	--	--	--	--	--	--
Zumbro Falls	203	--	4	4	12	59	Prairie du Chien	Opc	3	1	86	160	--	230	.02	5.2	34	340	250
Zumbrota	1,929	22	67	89	246	96	Jordan	€j	111	1	481	450	8.5	648	.35	19	2.0	270	270
Total	89,245	1,070	2,590	3,660	10,000	79													

WATER USE 1970
(million gallons)

	Ground water	Surface water	Total
Public supply			
Domestic (population 89,245)	2,590	0	2,590
Industrial	1,070	0	1,070
Rural supply			
Domestic (population 35,590)	974	0	974
Livestock	936	384	1,320
Irrigation	5	2	7
Self supplied			
Industrial	1,160	14	1,170
Thermoelectric power	21	4	25
Watershed total (population 124,835)	6,760	404	7,160

METRIC CONVERSION TABLE

1 in. (inch)	= 2.54 cm (centimeters)
1 ft (foot)	= 0.3048 m (meters)
1 mi² (square mile)	= 2.59 km² (square kilometers)
1 acre	= 0.405 ha (hectares)
1 ac-ft (acre-foot)	= 0.1234 ha-m (hectare-meters)
1 gal (gallon)	= 3.785 l (liters)
1 gpm (gallon per minute)	= 0.06308 l/s (litres per second)
1 gpm/ft (gallon per minute per foot)	= 0.207 l/s/m (litres per second per meter)
1 ft³/s (cubic foot per second)	= 0.0283 m³/s (cubic meters per second)
1 ft³/s/mi (cubic foot per second per mile)	= 0.0176 m³/s/km (cubic meters per second per kilometer)

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WATER RESOURCES OF THE ZUMBRO RIVER WATERSHED, SOUTHEASTERN MINNESOTA

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