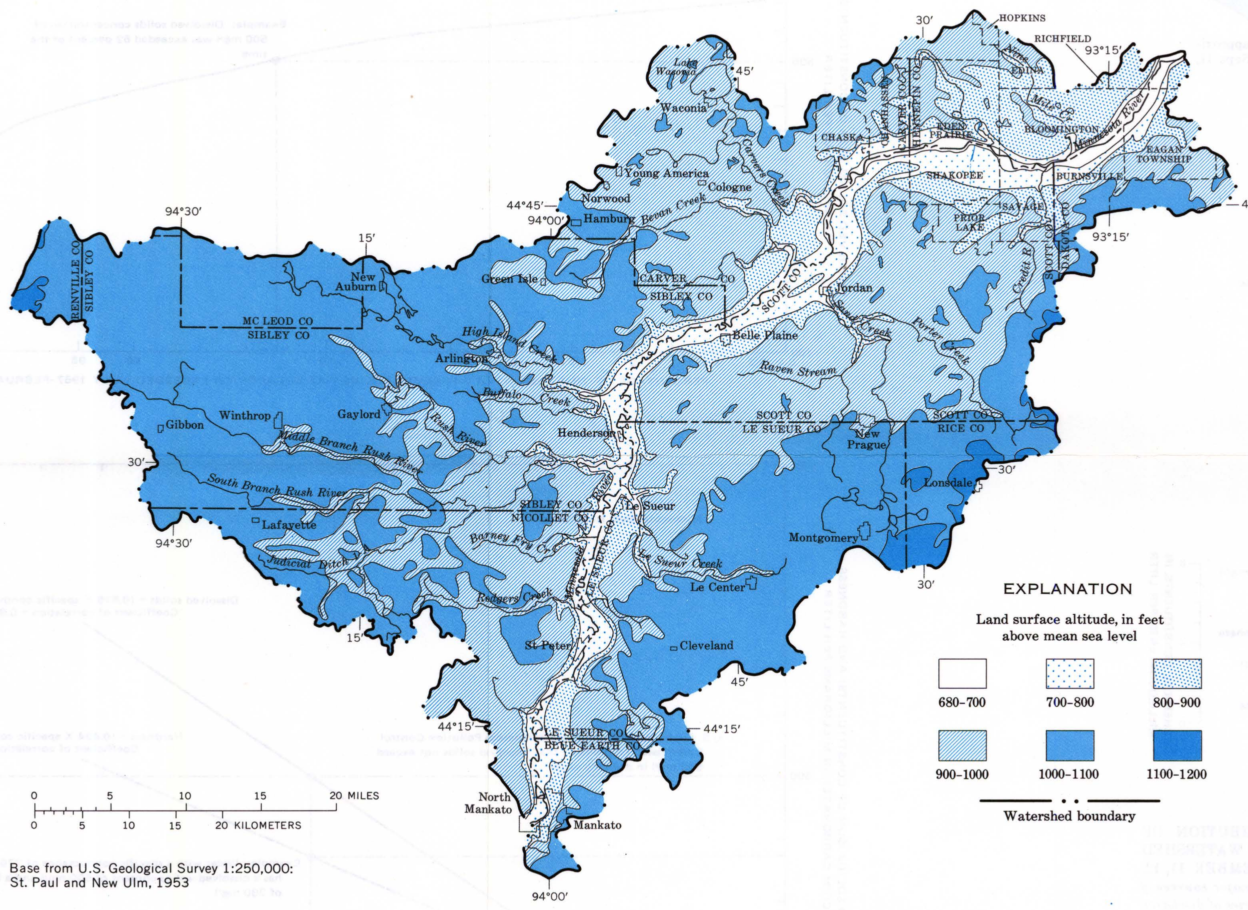
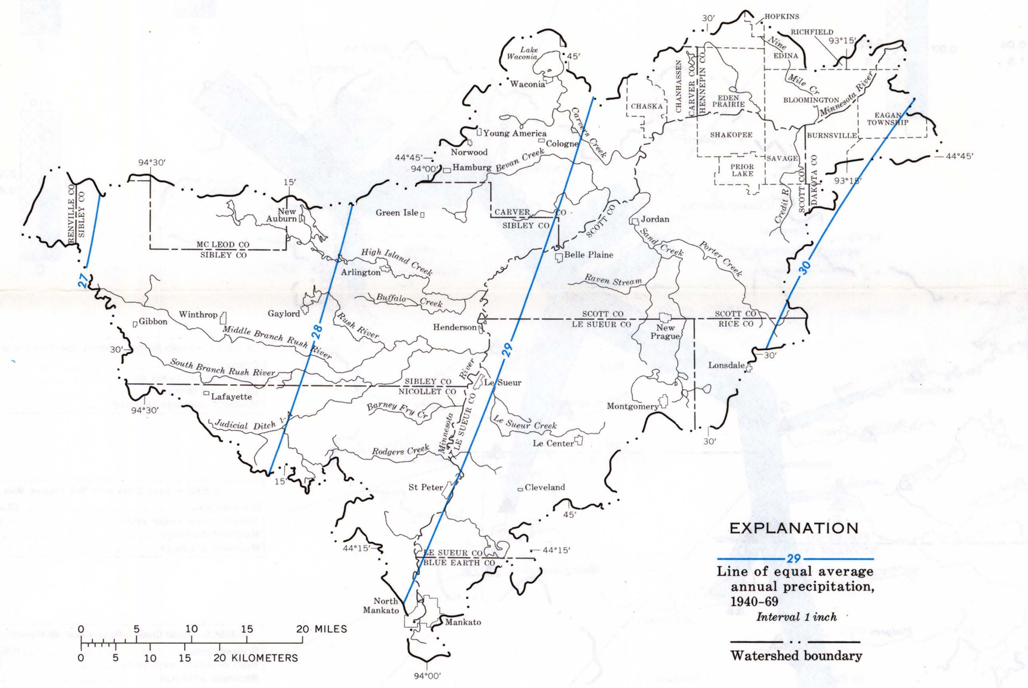
INTRODUCTION

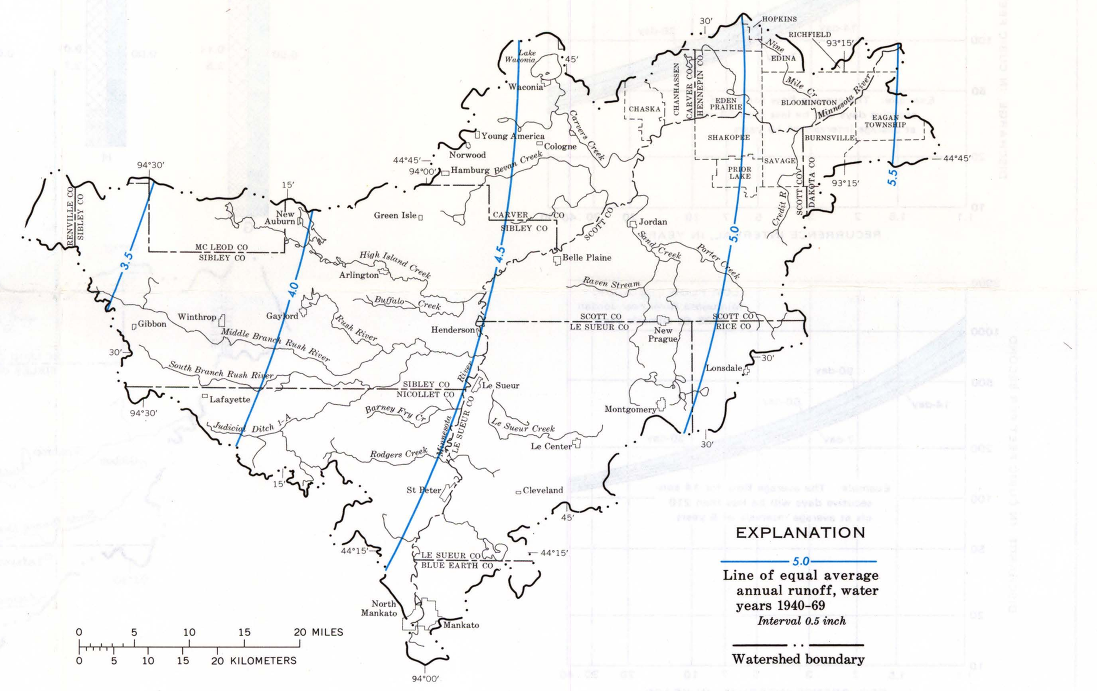


THE LOWER MINNESOTA RIVER WATERSHED, AN AREA OF 2,005 SQUARE MILES, IS FAIRLY FLAT WEST OF THE MINNESOTA RIVER, BUT RISES TO A HILLY RIDGE ALONG THE EAST SIDE OF THE WATERSHED—*Most of the area is covered by ground moraine cut deeply by the Minnesota River and less deeply by its tributaries. Surface drainage is toward the Minnesota River, which flows northeastward and discharges into the Mississippi River at the northeast corner of the watershed. The configuration of the water table, generally between 10 and 50 feet below land surface, is a subdued replica of the land surface. Shallow ground water moves generally toward local streams and then into the Minnesota River.*

WATER BUDGET

28.8 inches PRECIPITATION (Average annual, for 1940–69) = 4.5 inches RUNOFF (Average annual, from stream-gaging records for 1940–69) + 24.3 inches EVAPOTRANSPIRATION (Obtained by difference in water budget) ± 0 UNDERFLOW (The difference between ground-water flow into and out of the water shed is estimated to be less than 0.1 inch) ± 0 CHANGE IN STORAGE (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 THE 30 YEAR PERIOD, 1940–69, SHOWS 28.8 INCHES OF PRECIPITATION ENTERING THE SYSTEM, OF WHICH ALMOST 85 PERCENT RETURNS TO THE ATMOSPHERE AS EVAPOTRANSPIRATION—*The water budget shows the annual average balance between total water gains and losses. For ease of comparison, all water-quantity units are converted to inches per year. The equation states that water entering the area as precipitation is balanced by runoff and evapotranspiration; that is, inflow equals outflow plus or minus a change in storage. Ground-water recharge is assumed to be balanced (or canceled) by ground-water discharge. The difference between underflow into and out of the water shed is small, and changes in ground-water storage are insignificant.*

MUNICIPAL DATA

Municipality	Estimated population served (1970)	Water use: Annual industrial use (million gallons)	Annual domestic use (million gallons)	Total annual pumpage (million gallons)	Average daily pumpage (thousand gallons)	Per capita domestic use (gallons per day)	Aquifer: Name	Thickness – open to wells (feet)	Water system: Number of wells	Approximate well depth (feet)	Usual pumping rate (gallons per minute)	Specific capacity (gallons per minute per foot of drawdown)	Daily plant capacity (thousand gallons)	Representative quality (milligrams per liter): Iron (Fe)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids, calculated	Hardness as $CaCO_3$
Arlington	1,823	33	61	94	256	91	Franconia and Dresbach	171	2	670	800	21	------	0.75	140	1.6	591	430
Belle Plaine	2,328	------	56	56	155	67	Glacial sand and gravel	39	2	280	550	-----	1,152	1	120	25	640	380
Burnsville	19,940	.05	562	562	1,541	77	Jordan	100	5	400	1,200	18	5,801	.28	5.7	1	290	290
Chanhassen	928	------	32	32	89	95	Jordan	77	2	471	950	37	1,555	1.8	1	.5	295	300
Chaska	4,352	------	117	117	320	74	Franconia to Precambrian	366	1	566	250	10	1,800	1.3	110	1	485	430
							Glacial sand	35	2	112	500	23		2.1	12	1	346	340
Cleveland	492	------	20	20	54	109	Glacial gravel	20	2	383	250	28	720	.1	25	1	410	320
Cologne	518	------	10	10	28	54	Franconia	94	1	344	155	6.7	120	1.8	130	1.5	-----	540
							St. Lawrence to Precambrian	484	1	775	83	4.2		1.5	200	2.5	-----	560
Eagan Township	9,500	31	277	308	842	80	Jordan	96	4	450	600	30	3,322	.29	10	3.2	300	260
Edina	44,046	119	2,254	2,373	6,500	140	Jordan	90	12	500	1,000	28	21,240	.65	15	8	310	290
							Precambrian	112	3	1,000		12		.44	15	16	250	190
Gaylord	1,720	------	65	65	179	104	Glacial sand and gravel	30	3	425	430	29	1,858	1.4	180	3	737	494
Gibbon	877	------	29	29	78	89	Glacial sand and gravel	40	2	236	160	15	461	12	500	5.8	1000	670
Green Isle	363	12	8	20	53	59	Dresbach	352	1	802	150	15	288	.6	33	1	-----	410
Hamburg	377	------	10	10	27	71	Dresbach	319	1	745	100	33	144	1.3	30	1	-----	430
Henderson	728	------	10	10	27	37	Franconia and Dresbach	630	1	720	155	3.1	223	1.1	110	20	-----	370
Hopkins	13,428	343	514	857	2,348	98	Jordan to Dresbach	494	1	780	1,000	71	------	.31	5	2.3	290	260
							Jordan	70	3	500	2,300	90		.4	5	2.8	330	290
Jordan	1,836	------	57	57	155	85	Dresbach	300	4	550	710	30	2,621	.91	88	1	381	280
Lafayette	498	------	7	7	20	40	Glacial gravel	10	2	373	135	-----	324	5.7	460	7.9	1300	700
Le Center	1,890	------	46	46	127	67	Jordan to Dresbach	337	2	553	250	5	922	.2	60	1	500	360
Le Sueur	3,745	49	135	184	504	99	Glacial drift	30	4	250	670	30	64	.75	51	5	360	220
							Glacial drift to Dresbach	600	1	650	400	5.2		.6	73	54	460	280
Montgomery	2,281	------	82	82	225	99	Jordan to Dresbach	450	3	700	250	6.8	18	.02	98	1.2	520	290
New Prague	3,750	------	143	143	391	104	St. Lawrence to Dresbach	250	3	400	280	8	22	.37	120	1.7	564	430
North Mankato	7,347	------	210	210	576	78	Glacial sand and gravel	30	1	76	500	-----	77	4.3	180	3.7	-----	440
							Franconia and Dresbach	400	2	680	1,200	15		.8	190	4.3	-----	420
Norwood	1,058	------	35	35	96	91	Jordan to Dresbach	330	1	680	350	22	1,008	3.2	58	1	650	470
							Jordan	50	1	450	350	25		4.2	89	1.2	640	460
Prior Lake	1,114	------	40	40	110	99	Glacial sand and gravel	20	2	200	300	-----	576	.1	15	4	290	250
St. Peter	8,339	4	256	260	713	84	Jordan	30	2	81	500	-----	2,822	.24	36	5.5	280	280
							Jordan to Dresbach	547	2	700	650	-----		.8	30	4.8	640	390
Savage	3,611	.5	95	96	264	72	Jordan	97	1	250	600	40	864	1.9	5	1	-----	380
Shakopee	6,876	.2	237	237	650	95	Franconia and Dresbach	500	4	780	900	20	2,765	.05	11	1	310	290
Waconia	2,445	------	104	104	286	117	Glacial sand	----	2	400	700	-----	1,476	3	5	1	420	330
Winthrop	1,391	61	31	92	252	60	Glacial sand	24	2	335	500	23	1,440	3.4	410	9.1	900	530
Young America	611	------	14	14	38	62	Franconia and Dresbach	448	1	923	190	4.8	274	.6	130	1.8	-----	400
Total	148,212	653	5,517	6,170	16,904	102												

SUMMARY

EVALUATION OF WATER RESOURCES

Purpose	Considerations	Surface Water: Minnesota River	Large lakes	Small lakes and minor streams	Ground Water: Pleistocene: Glacial sand and gravel	Cretaceous: Sandstone and shale	Ordovician: St. Peter Sandstone	Prairie du Chien Group	Cambrian: Jordan Sandstone	St. Lawrence Formation and Franconia Sandstone	Dresbach Group	Precambrian: Crystalline rocks
Municipal and industrial supply	For a moderate supply, principal needs are: Quantity Minimum available surface water supply of 1 cfs or wells yielding 250 gpm. Quality Dissolved-solids content less than 500 mg/l. Hardness less than 180 mg/l.	Adequate supply. — Requires treatment.	Adequate supply from some lakes for limited use. — Requires treatment.	Many adequate with development of storage facilities. — Requires treatment.	Locally adequate supply. — Considerable local variation in yield. Very hard water. Iron, sulfate, and dissolved solids high.	Inadequate yield. Very hard water. Iron, sulfate, and dissolved solids high.	Generally adequate supply. — Locally low yields due to very fine sand. Very hard water. Iron high, sulfate and dissolved solids high locally.	Generally adequate supply from limestone and dolomite. Locally New Richmond Sandstone yields adequate supply. — Yield varies because of distribution of fractures. Susceptible to pollution where near the surface, requires treatment. Very hard water. Iron and dissolved solids high.	More than adequate supply throughout area of occurrence. — Very hard water. Iron and dissolved solids high, sulfate high locally.	Locally adequate supply from sandstone layers. — Very hard water. Iron, sulfate, and dissolved solids high.	Adequate supply from sandstone layers, especially Ironton-Galesville aquifer at the top and Mt. Simon at the base. — Very hard water. Iron, sulfate, and dissolved solids high.	Inadequate supply. Very hard water. Iron high, sulfate and dissolved solids very high.
Rural domestic and stock supply	For an adequate farm supply, needs are: Quantity Minimum of 5 gpm. Quality Dissolved-solids content less than 1,000 mg/l.	Adequate supply. — Available only to riparian lands. May require treatment.	Adequate supply. — Available only to riparian lands. May require treatment.	Adequate for stock. — Available only to riparian lands. May require treatment.	Adequate supply in most of watershed. — Thin or absent in some areas. Very hard water. Iron, sulfate, and dissolved solids generally high.	Adequate supply where present. — Very hard water. Iron, sulfate, and dissolved solids high.	Adequate supply throughout area of occurrence, generally acceptable quality. — Very hard water. Iron high, sulfate high locally.	Adequate supply, generally acceptable quality. — Very hard water. Iron high.	Adequate supply, generally acceptable quality. — Very hard water. Iron high, sulfate high locally.	Adequate supply, generally acceptable quality. — Very hard water. Iron and sulfate high.	Adequate supply, generally acceptable quality. — Very hard water. Iron and sulfate high.	Adequate supply in west end of watershed where Cambrian and Ordovician rocks are absent. — Very hard water. Iron high, sulfate and dissolved solids very high.
Irrigation supply	For an average farm, needs are: Quantity Minimum available surface water supply of 2 cfs during growing season or wells yielding 250 gpm. Quality Dissolved-solids content less than 2,000 mg/l. Suitability of water quality for irrigation as indicated by classification of U.S. Dept. of Agriculture.	Adequate supply. — Available only to riparian lands.	Adequate supply from some lakes. Limited use from others. — Available only to riparian lands.	Adequate supply for limited use from some. — Available only to riparian lands.	Locally adequate supply, generally acceptable quality. — Test drilling desirable because of local variation in yield.	Inadequate yield. Boron may be high.	Generally adequate supply, acceptable quality.	Adequate supply, acceptable quality.	Adequate supply, acceptable quality.	Locally adequate supply, acceptable quality.	Adequate supply, acceptable quality.	Inadequate yield.
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. — Fluctuating water level.	Excellent migratory waterfowl resting and feeding areas. Excellent wildlife habitat in marsh areas and along shores. Many suitable for fish.	Good migratory waterfowl resting and feeding areas. Excellent wildlife 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 and fishing. — Fluctuating water level.	Suitable for hunting, fishing, and water sports. Widely distributed.	Many suitable for hunting and trapping. Widely distributed. — Most are shallow and may go dry.								

EXPLANATION

Good / Fair / Poor — Overall evaluation for purpose and considerations indicated.

Adequate supply, generally acceptable quality. — Advantages

Very hard water. Iron high. — Disadvantages

WATER USE, 1970 (MILLIONS OF GALLONS)

	Ground water	Surface water	Total
Public supply			
Domestic (population 148, 212)	5,500	0	5,500
Industrial	650	0	650
Rural supply			
Domestic (population 47, 850)	1,300	0	1,300
Livestock	1,000	180	1,180
Irrigation	240	41	281
Self supplied			
Industrial	3,300	780	4,080
Thermoelectric power	32	97,000	97,032
Watershed total (population 196, 062)	12,022	98,001	110,023

SIGNIFICANT WATER FACTS

The main sources of water are precipitation and flow in the Minnesota River, which enters the watershed from the south.

All municipalities use ground-water supplies. Glacial sand and gravel are widely used aquifers in the west. The Dresbach, Jordan, and St. Peter aquifers are the most reliable and widely used in the central and eastern parts.

Most of the watershed is an area of ground-water recharge, as indicated by a decrease in hydraulic potential (head) with depth below land surface. Regional ground-water flow converges on the Minnesota River, where ground water discharges as base flow and as evapotranspiration.

The use of ground water is about 12,000 million gallons per year. This estimate represents 0.34 inch of water used compared with 28.8 inches of precipitation, 24.3 inches of evapotranspiration, and 4.5 inches of runoff. Considerably more water could be used without seriously depleting the amount of ground water in storage or affecting the water budget. However, carefully planned and supervised development is advisable, so that local areas are not overdeveloped or polluted.

Dissolved solids, sulfate, and bicarbonate concentrations in water from glacial deposits decrease generally from west to east. Dissolved solids range from 900 mg/l in water from areas of gray till to generally less than 400 mg/l in water from areas of red till and from outwash deposits. Water from bedrock is influenced by the overlying glacial deposits through which it percolates. Similar to the change in water quality in glacial deposits, dissolved solids in water from bedrock units tends to decrease from west to east.

Runoff is greatest in the spring and early summer, after the spring breakup. Runoff may be high locally in the summer after intense storms. Runoff recedes during late summer and fall to its lowest amount in late winter.

In many years, small tributary streams go dry during the fall and winter because of little natural stream storage and little base flow.

Generally, daily discharges are most uniform just before spring breakup and least uniform in the summer.

Surface water provides excellent year-round recreational facilities and fish and wildlife habitat.

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WATER RESOURCES OF THE LOWER MINNESOTA RIVER WATERSHED, SOUTH-CENTRAL MINNESOTA

By
H. W. Anderson, Jr., D. F. Farrell, and W. L. Broussard

1974

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