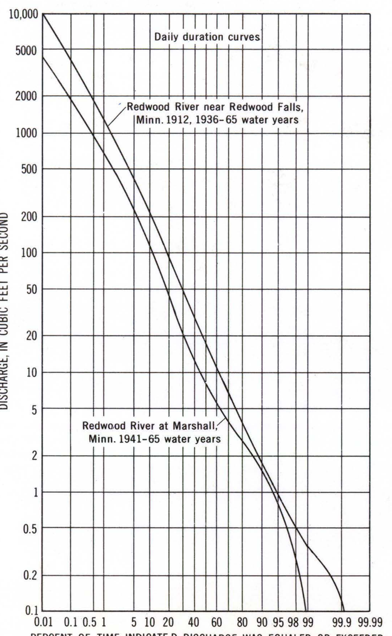
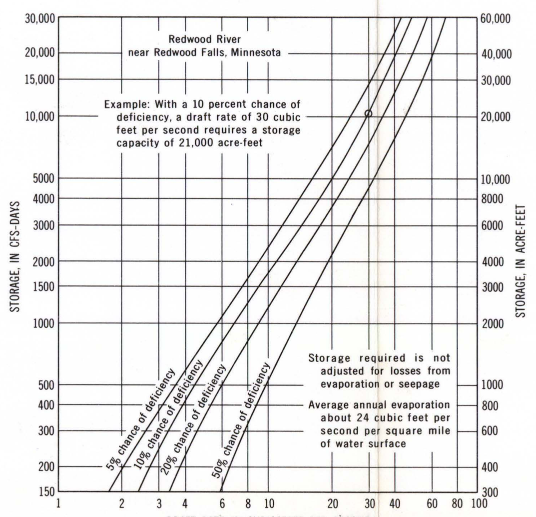
PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS, SOILS, AND MINERALS

SURFACE WATER

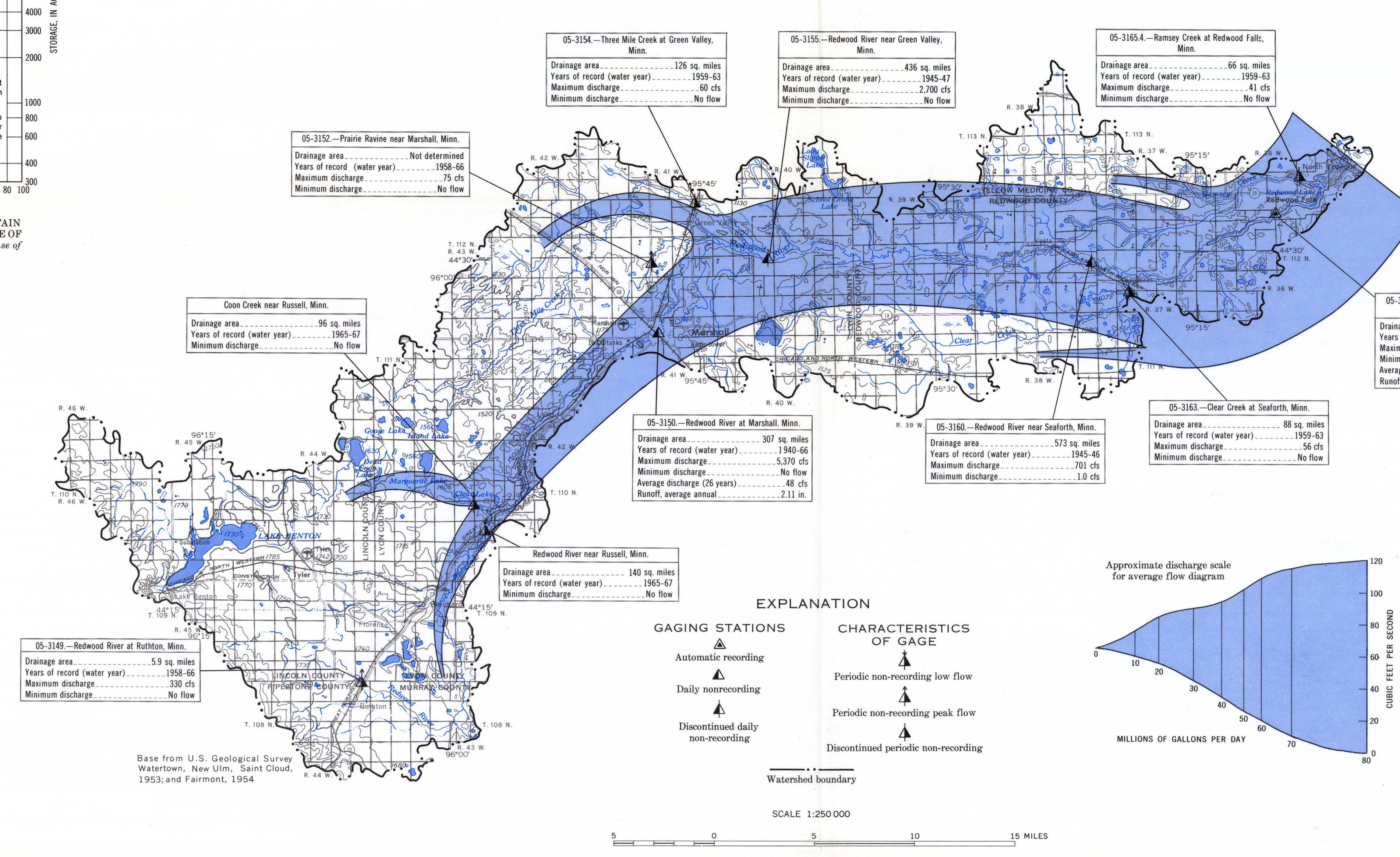
Variations of streamflow affect the suitability and quantity of water available for various uses. Consideration of magnitude, frequency and time of occurrence, effects of streamflow upon quality, and the duration of streamflow variations are necessary for the evaluation of surface-water resources.



HIGH FLOWS ARE CLOSELY RELATED TO THE SIZE OF THE DRAINAGE BASIN.—*For magnitude of flow higher than that equaled or exceeded 70 percent of the time, discharge near Redwood Falls (drainage area, 697 sq mi) is about twice that at Marshall (drainage area, 307 sq mi). Lower flows are mainly ground-water discharge and are not directly dependent on drainage area.*

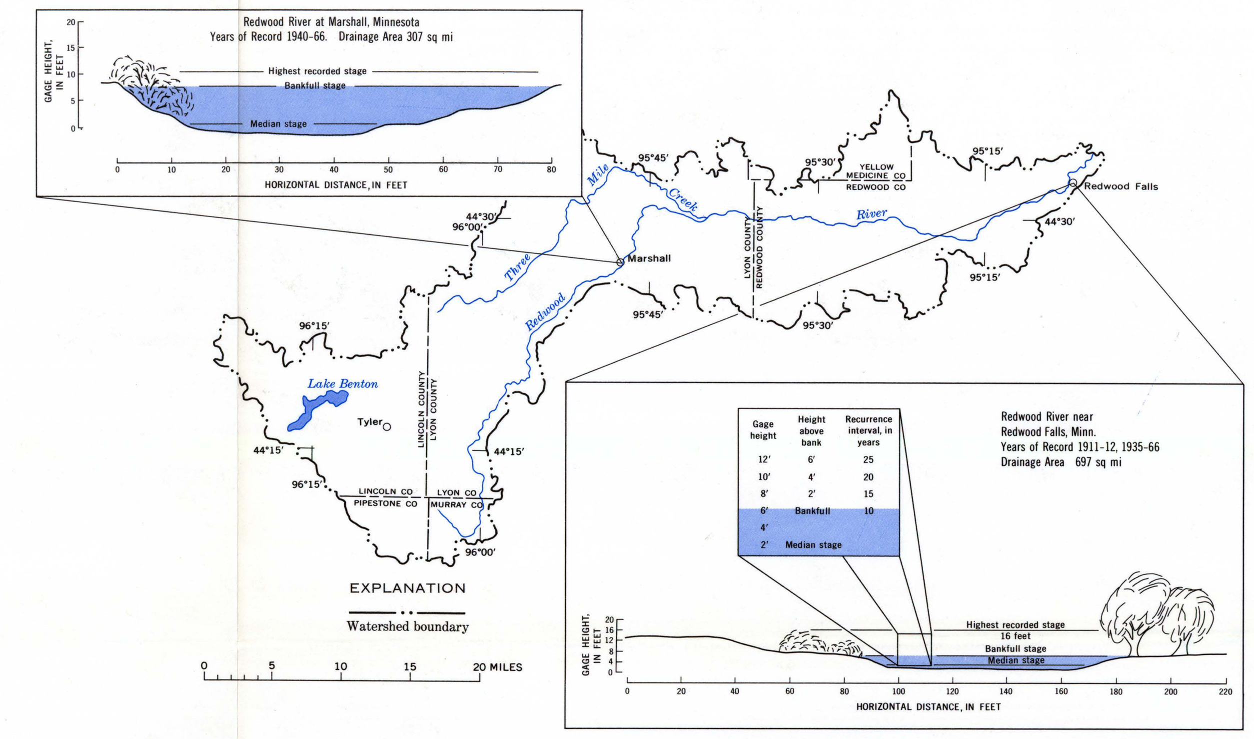


STORAGE OF STREAMFLOW IS REQUIRED TO MAINTAIN SPECIFIED DRAFT RATES WITH A SELECTED CHANCE OF DEFICIENCY.—*Low streamflow would be augmented by use of water stored during periods of high flow.*



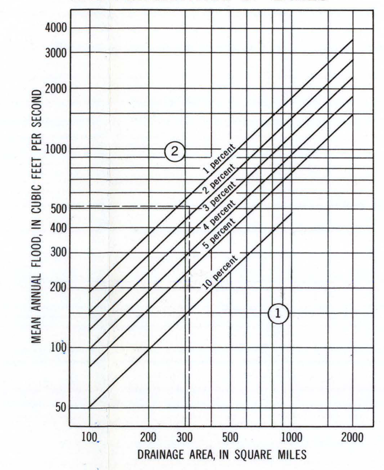
THE AVERAGE DISCHARGE IS THE THEORETICAL MAXIMUM RATE OF WATER USAGE WHICH THE STREAM COULD SUSTAIN.

To obtain a constant supply, high flows must be stored to provide water for release during periods of low runoff. The actual supply available for use would be less than average flow because of losses through evaporation and ground-water recharge, and because adequate reservoir capacity is not available.

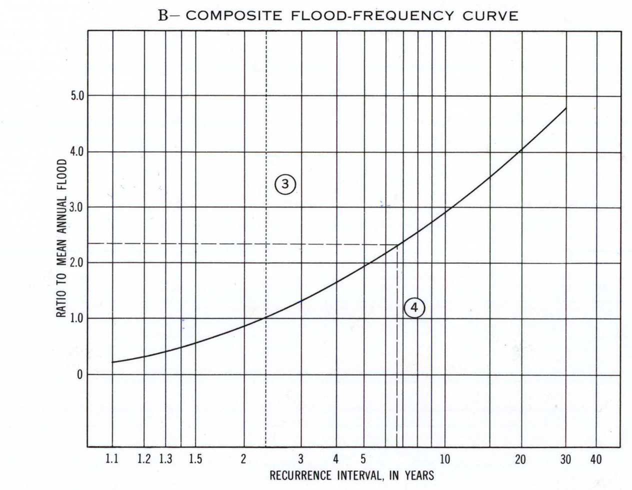


BANKFULL STAGE IS REACHED WHEN THE RIVER FIRST OVERFLOWS ITS NATURAL BANKS.—*At the gaging station near Redwood Falls, the Redwood River is deeply incised and reaches bankfull stage, on the average, once in every 10 years. At Marshall, where floods have caused damage, a diversion channel to carry excess flow was constructed in 1963 by the U.S. Army Corps of Engineers.*

A—RELATION CURVES BETWEEN MEAN ANNUAL FLOOD, DRAINAGE AREA, AND PERCENTAGE OF LAKES



B—COMPOSITE FLOOD-FREQUENCY CURVE

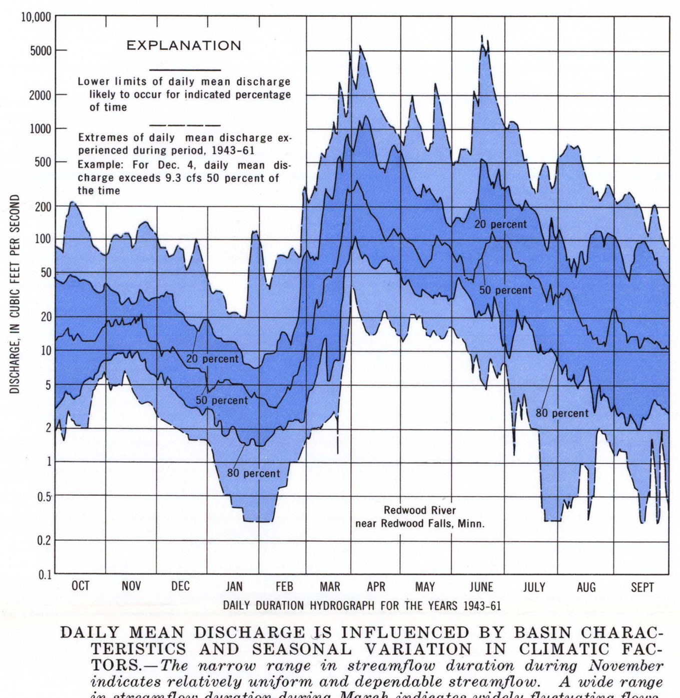


Example: Find the recurrence interval of a 1200 cfs flood for the drainage area above Marshall. Lakes comprise 1.7 percent of that area.

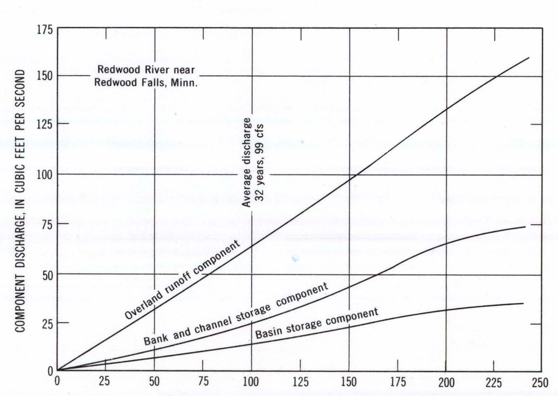
1. Determine drainage area at selected site. (Drainage areas at stream gaging sites, shown on average discharge map, may be used as a guide). .... D.A.=307 sq mi
2. Determine magnitude of mean annual flood from relation curve (A), using drainage area size and percentage of the basin in lakes. .... Lake=1.7 percent, M.A.F.=510 cfs
3. Compute ratio to mean annual flood. .... 1200/510=2.35
4. From flood-frequency curve (B), determine recurrence interval of flood of selected magnitude or magnitude of flood at specified recurrence interval. .... R.I.=6.7 yrs

FREQUENCY AND MAGNITUDE OF FLOODING IS RELATED TO DRAINAGE AREA AND PERCENTAGE OF BASIN IN LAKES

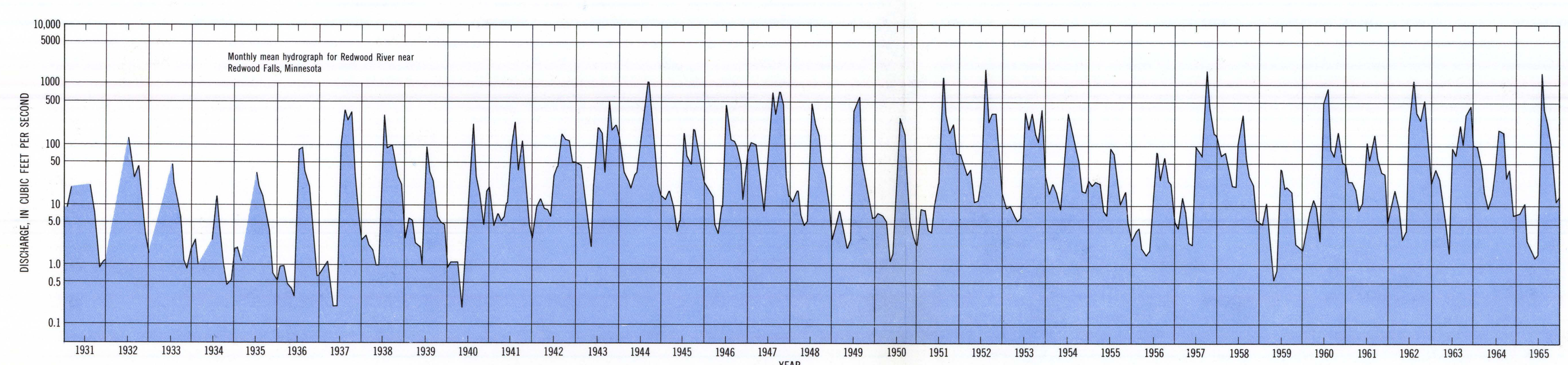
Small drainage basins with little surface storage allow rapid runoff, resulting in peak flows per square mile of high magnitude and short duration. Larger basins with greater storage provided by lakes and swamps retard surface runoff, resulting in peak flows per square mile of lower magnitude and longer duration. Curves from Prior and Hess (1961).



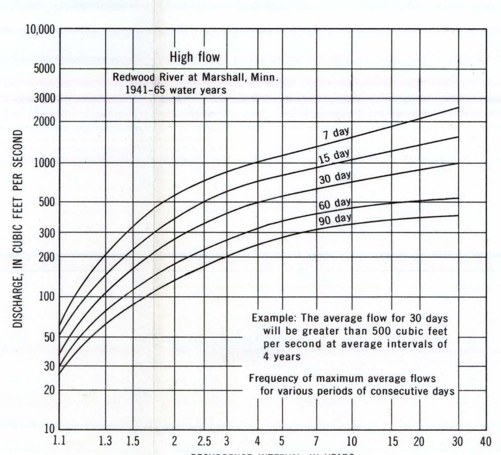
DAILY MEAN DISCHARGE IS INFLUENCED BY BASIN CHARACTERISTICS AND SEASONAL VARIATION IN CLIMATIC FACTORS.—*The narrow range in streamflow duration during November indicates relatively uniform and dependable streamflow. A wide range in streamflow duration during March indicates widely fluctuating flows.*

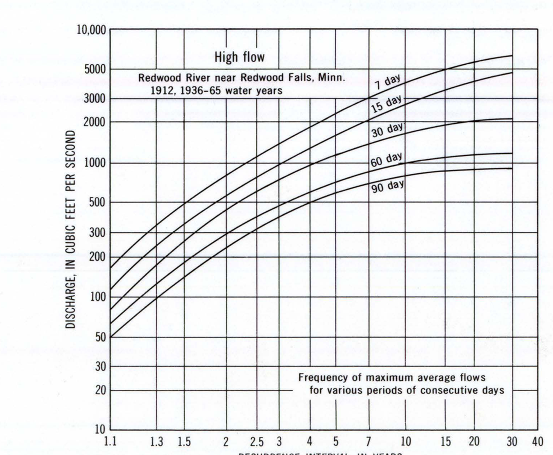


DIRECT OVERLAND RUNOFF IS THE MAJOR COMPONENT OF STREAMFLOW, AND IS MOST SIGNIFICANT AT HIGHER DISCHARGES.—*The percentage of flow from storage in the river banks and adjacent flood plain decreases as discharge increases, indicating that bank-storage capacity is limited. Discharge from basin storage, a relatively constant percentage within the normal range of annual discharge, becomes more significant at extreme low flows when it may comprise the total streamflow. The curves presented are valid only in the vicinity of the gaging station, and reflect the net effect of ground-water surface-water interchange occurring upstream.*

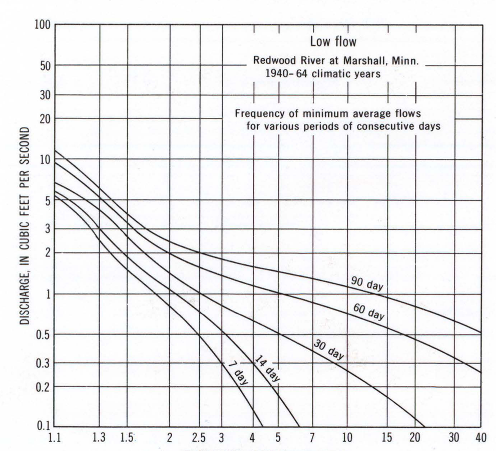


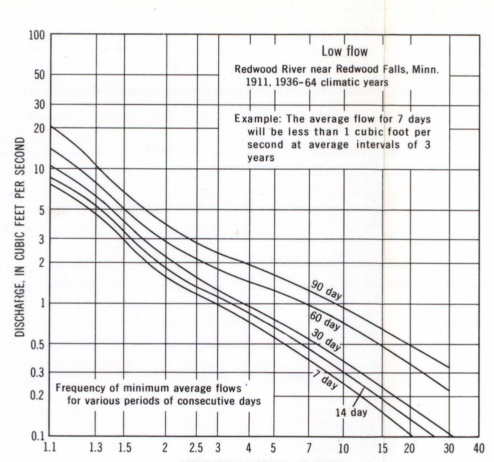
FLUCTUATIONS IN STREAMFLOW ARE CAUSED BY VARIATIONS IN PRECIPITATION AND TEMPERATURE.—*The highest flows usually occur in the spring as a result of snowmelt. Low flows occur during extended periods of subfreezing weather or deficient rainfall. The variability of flow indicates the need for storage to insure more uniform supplies greater than 5 cubic feet per second.*



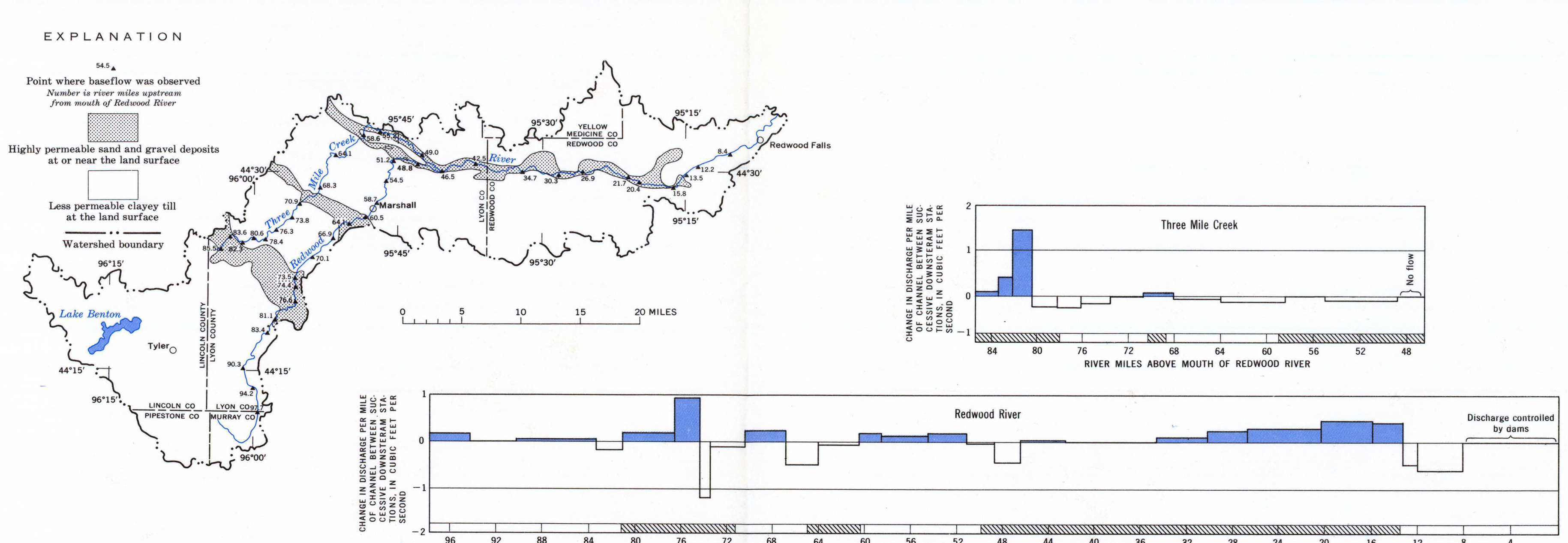


HIGH FLOWS ARE INFLUENCED BY PHYSIOGRAPHIC AND CLIMATIC FACTORS.—*High flows at the gaging stations near Redwood Falls and at Marshall have similar frequency-duration relationships. This is because the Redwood River watershed has a uniform climate and physiography. Difference in drainage area above the two stations is the main reason for the different magnitudes of high flow.*



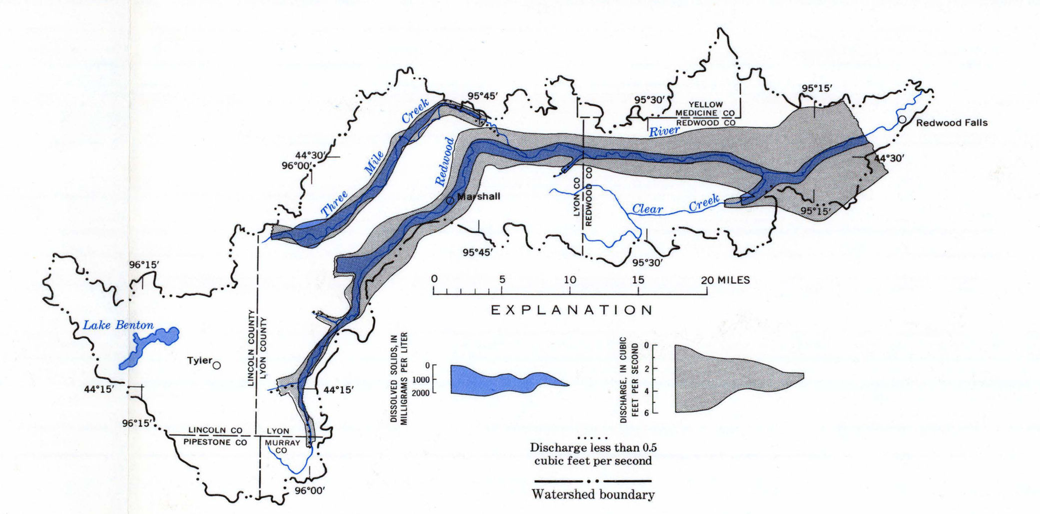


LOW FLOWS ARE LARGELY DISCHARGE FROM THE GROUND-WATER SYSTEM.—*Low flows at the gaging station at Marshall are more variable in frequency and duration than those at the gaging station near Redwood Falls. The extensive outwash deposits downstream from Marshall store water during periods of high flow and release it to the river during periods of low flow. Permeable materials along the channel upstream from Marshall have in part the same effect but ground-water discharge is more variable.*

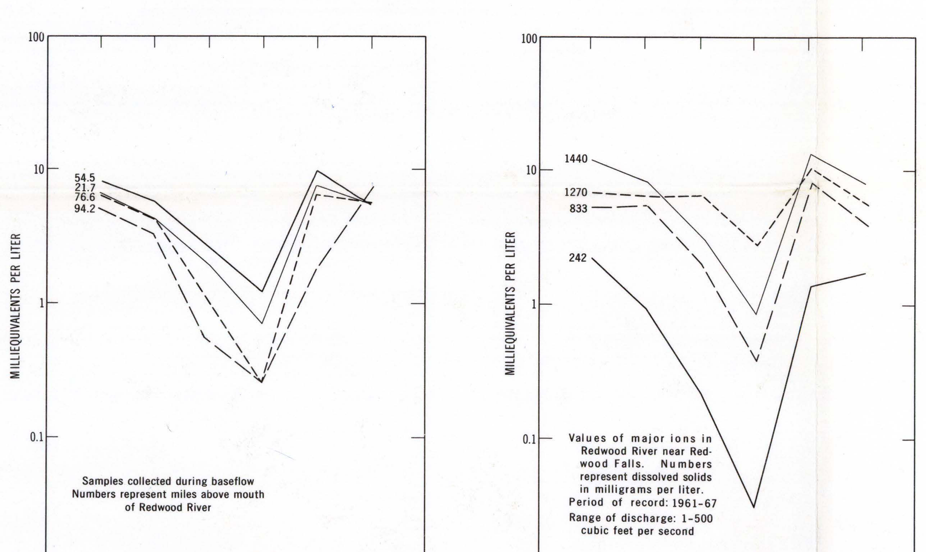


BASE FLOW IS STRONGLY AFFECTED BY SURFICIAL GEOLOGY

The more permeable the geologic materials along the water courses, the more effective the hydraulic connection between the streams and the ground-water system. Surficial sand and gravel deposits in southwestern Lyon County allow significant increases in base flow in Three Mile Creek and in the Redwood River. Sand and gravel deposits near the center of Lyon County allow a slight increase in base flow in Three Mile Creek and a significant loss in the Redwood River. The relatively permeable deposits along the Redwood River in the eastern half of the basin have a dual effect on base flow. At their upstream end, streamflow discharges to the ground-water system; toward their downstream end, ground water discharges to the river. Downstream from the sand and gravel deposits, the river loses significant amounts of base flow, probably because evapotranspirative demands are greater than ground-water discharge through the poorly permeable till.



DISSOLVED-SOLIDS CONCENTRATIONS ARE HIGH DURING BASE FLOW IN MOST WATER COURSES.—*Highly mineralized ground water, discharging from the glacial drift, makes up most of the base flow. In streams draining lakes and marshes base flow contains lower concentrations of dissolved solids.*



THE QUALITY OF WATER IN THE REDWOOD RIVER IS INFLUENCED BY GEOLOGIC CONDITIONS, BIOLOGIC ENVIRONMENT, PRECIPITATION, INFLOW OF WASTES AND NUTRIENTS, AND VARIATIONS IN DISCHARGE.—*The surface water quality is similar to that of water in the glacial drift during periods of base flow and throughout a wide range of discharge. In the marshy headwaters area (94.2 miles above the mouth) sulfate concentrations are low because of reducing conditions, common in stagnant waters. The maximum dilution of surface water occurs during periods of snowmelt (dissolved solids 242). Increases in sodium and chloride concentrations occur after periods of heavy rainfall and recharge to the ground-water system, which flushes sodium chloride water from sedimentary-rock aquifers (dissolved solids 1270).*

INDIVIDUAL CHEMICAL CONSTITUENTS SHOW CHANGES WHICH ARE RELATED TO THE REDWOOD RIVER ENVIRONMENT AND DISCHARGE

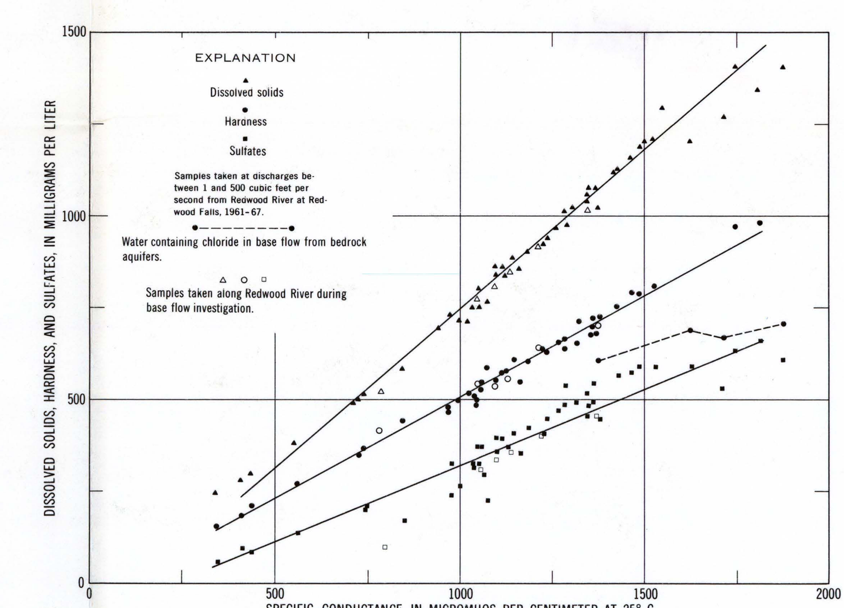
Concentrations of total dissolved solids and of most major ions in the river are slightly less than in ground water because of dilution from overland runoff and snowmelt. Water is very hard most of the time, and may require treatment to render it suitable for domestic uses. Iron and manganese are precipitated from ground water upon exposure to air, so concentrations in surface water are smaller. The difference in percentages of iron and manganese precipitated is controlled by pH.

Silica concentrations greater than 20 milligrams per liter are generally related to discharges less than 10 cubic feet per second, which are primarily from ground water. Boron concentrations also vary inversely with discharge.

Water color, which results from vegetative decay, is generally higher when storm flow flushes swampy areas. Municipal wastes and farming areas with barnyards and fertilized fields contribute nitrates and phosphates to surface runoff. Nitrates and phosphates in water are nutrients for algae and rooted plants.

Chemical constituents in milligrams per liter, pH, and color found in 42 water samples from Redwood River near Redwood Falls, 1961-1967. Range of discharge: 1-500 cubic feet per second

	Boron	Calcium	Iron	Magnesium	Manganese	Potassium	Sodium	Bicarbonate	Chloride	Fluoride	Nitrate	Phosphate	Silica	Sulfate	Color	Hardness	Total dissolved solids	pH
Maximum	0.39	234	0.16	118	0.42	12	178	484	110	0.5	15	1.4	36	692	50	973	1440	8.5
Medium	0.18	131	0.03	65	0.17	7.6	42	279	20	0.3	3.0	0.09	17	412	5	589	888	7.6
Minimum	0.03	42	0.01	11	0.00	5.8	5.1	104	0.9	0.1	0.1	0.01	8.3	64	3	151	242	6.9
U.S. Public Health Service recommended drinking water limits	—	—	0.3	—	0.05	—	—	—	250	0.7-1.2	45	—	—	250	15	—	500-1000	—



LINEAR RELATIONSHIPS BETWEEN SPECIFIC CONDUCTANCE AND DISSOLVED SOLIDS, HARDNESS, AND SULFATES CHARACTERIZE DISCHARGE IN THE REDWOOD RIVER.—*The streamflow is of the same chemical type as ground water in the glacial drift; calcium, magnesium, and sulfate are the predominant ions. Variations in water type occur occasionally, probably caused by discharge of ground water from sedimentary-rock aquifers.*

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WATER RESOURCES OF THE REDWOOD RIVER WATERSHED, SOUTHWESTERN MINNESOTA

By
W. A. Van Voast, L. A. Jerabek, and R. P. Novitzki

1970