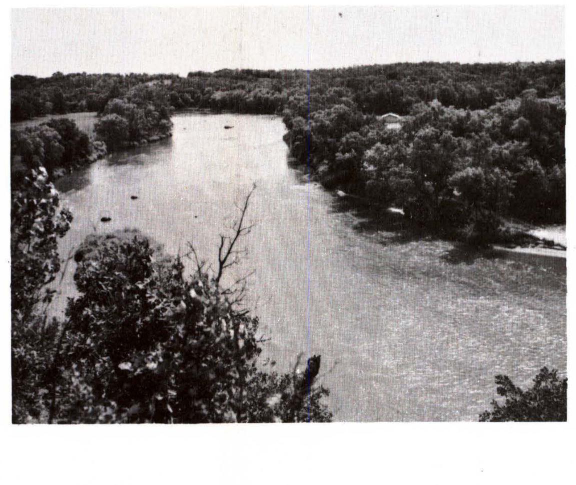
DESCRIPTION

The Red Lake River shows diverse scenery and character; open, placid, prolific swamps and a long, straight, dredged channel in the upper reaches; high till cliffs and rapids in the midreaches; and meandering, placid, repetitious lower reaches. In July 1966 the U.S. Geological Survey made a reconnaissance of 185 miles of river from the outlet of Lower Red Lake to the Red River of the North and found the river generally navigable by canoe with portages around two large dams and one washed-out dam. The gage at High Landing at the time of the reconnaissance trip read 6.62 feet.

The reach above the weir at mile 174 passes through open swamp. The view of swamp vegetation and wildlife is exceptional. Other than the swamp grasses and bulrushes, the largest plants growing in the swamp are the sparsely distributed scrub willows. Large aquatic plants abound, algae are prevalent, and yellow and white water lilies also are common, but no unattractive algae scum was seen on the trip. The bottom vegetation can be seen through 5 feet of the pale green water which has none of the amber color of carboxylic acids common in most rivers of northern Minnesota. The bottom material is gray to gray-green silt to fine sand in which are mixed many small shells and shell fragments. There are few camping possibilities within the swamp reach and only one access at mile 179. Between the weir and High Landing there are many farms. The river flows between stable banks about 2 feet high, with grass, willows, and a sparse growth of small scrub trees. Some poplar and elm are growing on high ground back from the river. The channel has been dredged and its width is very constant; about 75 feet. The bottom material is predominantly coarse, mainly coarse gravel and shells. In the reach below High Landing vegetation includes trees 1 to 2 feet in diameter, the banks are lower, and the river meanders extensively. Generally, the river has a wilderness look, but farms are numerous. The water color is green, though quite clear; only 10 JTU (Jackson turbidity units). The width below High Landing exceeds 100 feet and the depth to the sand and gravel bottom is generally more than 6 feet. In the upper reaches the river level is very stable because of the moderating effect of swamp storage. Many of the landowners upstream from the city of Thief River Falls have landscaped the banks of the river and the city has developed public access and boat launching facilities in city parks. The portage at the dam is short, but high, steep and difficult. Turbidity at this point doubled to 22 JTU, color remained a gray-green, and floating debris and small suspended solids were present below the dam. There are occasional rapids between Thief River Falls and St. Hilaire, but otherwise the river is similar to that above Thief River Falls. Downstream from St. Hilaire to mile 80 are a series of excellent rapids separated by short pools. Clearance for the canoe at the stage 6.62 (High Landing) is about 2 feet. Most rapids are navigable and probably would be, even with a 50 percent smaller volume of streamflow. Large boulders in the river add to the beauty of the mid-reaches. Below St. Hilaire wild celery and pondweed are common in the river and large slump areas, where massive bank erosion took place during the spring floods of 1965 and 1966, can be seen.

A 3-foot drop across an abandoned dam at Red Lake Falls can be run by canoe; however, submerged parts of the dam can badly damage a canoe or upset it. Below the dam is one of the most attractive reaches of river and one of the most surprising. The channel has cut into gray glacial till exposing picturesque steep slopes with cottonwoods growing on the lower slopes. Numerous rapids and pools are found in this canyon-like reach to mile 79 where the river flows out into the silt and clay deposits of glacial Lake Agassiz. The clay deposits are very hard when dry, but pliable and sticky when wet, and bedding planes can be exposed by separating the layered clay when dry. Bank vegetation is thicker and severe bank slump extends back from the river as far as 200 feet in this reach. The channel is uniformly deep, bottom sediment is silt and clay, and the river flows smoothly.

From 20 miles above to 25 miles below Crookston the river is locally shallow and moderately turbid (up to 98 JTU). Above the dam at Crookston the banks are littered with trash and debris. The dam is portaged over steep banks covered with loosely-piled, well-rounded boulders. Below the dam the banks are locally high in clay, and the land is commonly grazed on the outside of meanders and forested on the inside. Evidence indicates that the river follows paths completely different from the present thalweg during floods and, in some places, has cut significant new channels which, after several floods, may radically change the course of the river. The lower reaches of the river are characterized by large piles of trees along the outside of meander bends. These trees were torn from the eroded banks and large slump areas upstream and carried downstream by the spring floods. At East Grand Forks there is a small dam about a mile from the mouth of the river with a short, easy portage. Road access is available here or at the park on the left bank at the edge of the suburban housing development.



LOOKING UPSTREAM ON THE RED LAKE RIVER JUST ABOVE JUNCTION WITH CLEARWATER RIVER

HISTORY

The first natives of record in the Red Lake River area were the Sioux Indians. The Sioux were first mentioned in the "Jesuit Relations" of 1640. French fur traders visited the area in the 17th century and made further mention of the Sioux and Chippewa Indians in their notes. In the mid-17th century, French missionaries visited the Chippewa and noted in their records battles between the Chippewa and the Sioux over the rich fields of wild rice. At the time the French came the Sioux were dominant. About 1740 the Chippewa, using French fire arms, drove the Sioux into the southern part of the state and established permanent settlements around Lower Red Lake. The earliest detailed descriptions of these settlements were by fur traders who visited the area in 1793. The first recorded white settlement was the trading post, established by Jean Baptiste Cadotte (the younger) in 1798, at the confluence of the Red Lake and Clearwater Rivers, which is the present site of the town of Red Lake Falls. David Thompson visited this post on his way up the river from the Red River of the north to Lower Red Lake. The trading post was abandoned prior to 1800 when Alexander Henry (the younger), chief officer of the Northwest Fur Company for the Red River valley, traveled up the Red Lake River to Lower Red Lake.

There is no further record of white man on Red Lake River until July 1823 when Major Stephen H. Long, under orders from President James Monroe, explored the Red River of the North valley. Long crossed the Red Lake River, probably just west of present-day Crookston. Giacomo Constantino Beltrami, accompanying Long, left the expedition and traveled the Red Lake River to Lower Red Lake and then to Lake Julia, which he incorrectly proclaimed to be the source of the Mississippi River.

As travel increased in the area the necessity for a marked trail became evident, and in 1844 Kittson and Rolette marked out the Pembina Trail which crossed the Red Lake River approximately at the present site of Huot. Trade and population increased. Minnesota was declared a territory in 1849 and was admitted as the 32d State in 1858.

The most noteworthy raid and massacre on the white settlements by the Sioux occured in 1862 when Little Crow massacred 800 white settlers and soldiers. Relations with the Chippewa were generally peaceful, but there was an increasing pressure by the white man to acquire more of the Chippewa's land. The point where the Pembina Trail crosses the Red Lake River is called the "Old Crossing"; and at this place on October 2, 1863 the Red Lake and Pembina bands of Chippewas ceded, by treaty, about 5 million acres of land to the U.S. Government. The ceded area included northwestern Minnesota as far east as the Thief River and Red Lake River, and as far south as the present site of the town of Ada. This treaty, known as the "Old Crossing Treaty", was signed for the United States by Treaty Commissioner Alexander Ramsey and by the Indian Agent, Ashley Morrill. It opened northwestern Minnesota to white settlers for the first time. Four years later on the 19th of March the Chippewa ceded to the U.S. Government an additional area south of the Red Lake River between Thief River Falls and Huot. At this site, a park and a statue of a Chippewa Indian holding a peace pipe commemorates the signing.

One of the first towns to be settled was Crookston where it was anticipated that the railroad would cross the Red Lake River; however, the railroad crossed at Fisher's Landing which is now the town of Fisher. Crookston was still a major town and was named the seat of Polk County. The railroad was completed from Crookston to St. Vincent in 1879. One of the first settlers in Crookston was T. B. Walker, a lumberman, who moved from St. Anthony Falls to the "Northwest Slope" (the Red Lake River area), with his son Gilbert, and opened a mill. By 1889 Crookston was called the "Sawdust City", and Walker's Lumber Company had a monthly payroll of $18,000. Wheat was even more important and the Red Lake River area, with Crookston as its center, became the greatest wheat producing region of the world. Unfortunately, the wheat growing as well as the lumbering exploited the land, and early lumbering particularly was wasteful, leaving the land scarred and subject to large fires. The land was used for the maximum value that could be derived from it in the shortest possible time. Conservation of the land and its resources was not practiced by the early settlers.

There was agitation for more timberland for lumbering operations and Representative Knute Nelson, later a Senator and Governor of Minnesota, presented a bill to Congress which provided that all Chippewa except those at the Red Lake Indian Reservation should move to the White Earth Indian Reservation. The vacated land was divided according to the Dawes Severality Act of 1887, which provided for the granting of individual land holdings to civilized Indians who would renounce their tribal holdings. The remainder of the land was sold by the U.S. Government and the money from the sale put in trust for the Chippewa Indians. The Dawes Act provided that the land should be divided among the Indians at the rate of 160 acres to a head of a family and smaller amounts to others. In 1891 the Dawes Act was amended so that the head of a family received only 80 acres. On July 1 and 15, 1896, the sale of 115,000 acres of land of the Red Lake Indian Reservation began at Crookston according to the terms of the Nelson Act. Cries of fraud immediately arose; and claims were made of fraudulent reporting of the value of the land to the Government to the benefit of the lumbermen. Finally, in 1902 the Morris Bill, an amendment to the Nelson Act, passed Congress. This bill provided that the U.S. Government cut and log the timber and sell it, rather than the land, by sealed bid, and for the first time there were no accusations of fraud in the sale of timber. The present size of the Red Lake Indian Reservation was established in 1904 and although additional timber sales have been authorized the boundaries have remained the same since that time.

Where the Red Lake River flows through the Red Lake Indian Reservation the country is probably little changed since white men first saw it. From the edge of the reservation to Thief River Falls the country now is dominantly agricultural, and little timber remains. Downstream from Thief River Falls, although farming is now predominant, the appearance of the countryside from the river is one of an isolated wilderness, for the valley of the Red Lake River is deep and the farms do not intrude upon the edge of the valley. In this stretch of the river the canoeist can easily imagine that he is following a trail unchanged since it was first seen by Cadotte in 1798.

[1]Data from Minnesota State Historical Society

OLD CROSSING TREATY MEMORIAL

The Red River of the North valley then included in the state of Minnesota and the territory of Dakota was ceded to the United States in a treaty signed near this spot on Oct. 2, 1863. Negotiated by commissioners Alexander Ramsey, Ashley C. Morrill and the chiefs, head men and warriors of the Red Lake and Pembina bands of Chippewa Indians. Erected by the United States, 1932.

BIOTA

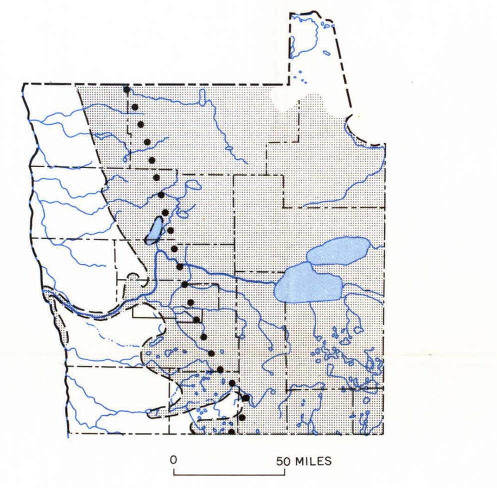
The Red Lake River flows through the northern coniferous forest, deciduous forest, and the grassland biotic provinces. The change between each of these vegetative regions is not abrupt and results in a transition zone or ecotone. Where the river flows through the grassland biome, the deciduous forest projects along the river to the Red River of the North.

Oaks, maple, boxelder, elm, basswood, alder, willow, cottonwood, and aspen grow along the river. There are also many kinds of wild fruits such as chokecherry, wild grape, raspberry, and high-bush cranberry. Wild flowers present are those found in a maple-basswood type area such as bloodroot, jack-in-the-pulpit, lily-of-the-valley, and violets. Many aquatic plants may be found, especially in the prolific swamp area above the weir at mile 179. Beavertail, duckweed, pondweed, (several types) sagittarius, wildcelery and wildrice are but a few of the more obvious ones.

Fishing is popular below the dams in Crookston and Red Lake Falls and at the junction of the Red Lake River and Thief River in Thief River Falls. Walleye, northern pike, catfish, and bullheads are usual catches. Sturgeon are believed to exist in the river also.

Mammals that might be encountered along the river range from moose and bear, in the area which flows through Beltrami County, to the more common small mammals such as deer mice and meadow voles. Deer are common throughout the entire length of the river. Beaver, mink, muskrat, red and gray squirrel, skunk, weasel, racoon, snowshoe hare, cottontail rabbits, bobcat, and fox also live in the area.

Some of the game birds that may be observed along the river are wood ducks, mallards, bluewinged teal, and ruffed grouse. The great blue heron may also be seen along the river. The largest number of species of song birds and shore-birds occur during the spring and fall migrations.



MAP SHOWING AREAS OF FOREST AND PRAIRIE IN THE 1800'S (AFTER UPHAM, 1884)

EXPLANATION

Areas covered by forest

Western limit (approx.) of pines, black spruce, and balsam fir

Present forested areas shown on main map for comparison

REFERENCE

Upham, Warren, 1884, catalog of the Flora of Minnesota including its Pheanogamous and Vascular Cryptogamous Plants: Geological and Natural History Survey of Minnesota, Twelfth Annual Report, Part VI, Minneapolis, Johnson, Smith and Harrison

HYDROLOGY 1

The character of a stream is influenced by the physical features of the stream channel and drainage basin. Some contributing factors are channel size, shape, and gradient, and the volume, velocity, and variation of flow, and depth of water. The stream and basin characteristics determine the uses for which a stream is best suited.

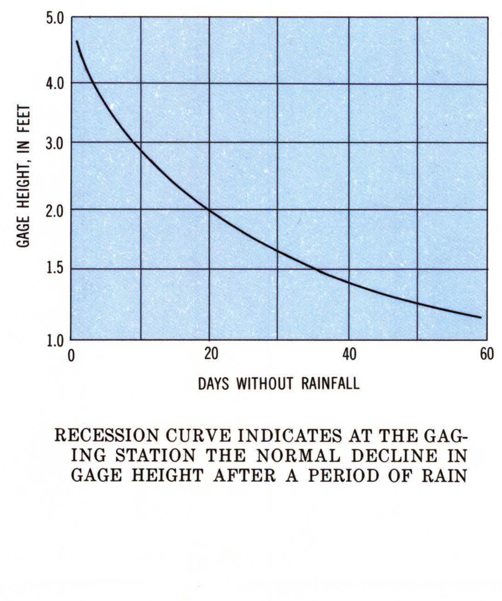
The flow characteristics of the Red Lake River determine the quality of canoeing available. Ideally, flow should provide safe canoeing with a minimum of portaging. Fast water reaches should be navigable; flat water reaches should retain perceptible velocity. The unique experience of river travel is provided in large part by white-water canoeing.

Through the upper part of the river the channel is broad and flat with large areas of swamp on either side. The flow is smooth and flat and has little variability, stabilized by the swamps and the Upper and Lower Red Lakes. Downstream flow variability increases and becomes most significant to navigability through the reach from Thief River Falls to Huot, a section of steep gradients and narrow deep channels. This is the white-water reach of the river and flow must be above a critical level to permit running the rapids. Below Huot, channel gradient is more uniform and navigability is not a significant problem.

The DURATION HYDROGRAPHS show the percentage of time that a given flow is equaled or exceeded based on the indicated 19-year period of record. The supposition is that future flows will correspond roughly to the indicated percentages. Thus, during periods of normal precipitation, one would expect flows to be approximately average. During periods of subnormal precipitation the lower indicated flows would be expected. It is, of course, impossible to predict the weather for extended periods and thereby indicate the short term anticipated flow of the river.

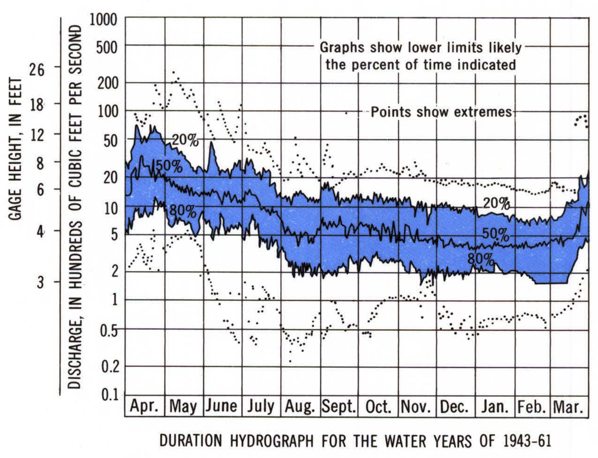
The three solid lines on the hydrographs indicate discharge, and corresponding gage height, which is exceeded the indicated percent of time. The dotted lines at the top and bottom show the largest and smallest flows that have been recorded during the indicated period of record. On the right hand side of the High Landing graph are indicated the probable number of portages that would be required to navigate the entire reach of the river from Lower Red Lake to Grand Forks. To illustrate the use of the graphs, assume that the river is navigable for most of its length with a gage height at High Landing of 5 feet. This corresponds to a discharge of approximately 600 cfs (cubic feet per second). At this discharge, there would be approximately 10 portages required between Red Lake River and Grand Forks. Half of these portages are over dams which must be portaged at any stage and the remainder are rapids or shoals. At several of these points one could wade through with the canoe. If a trip is planned in June or the first part of July there is a 50 percent chance that the stage would be at or above 5 feet and the flow would exceed 600 cfs. Most of these portages would be in the reach from Thief River Falls to Huot, where the gradient is steep and the river is a series of pools and rapids. In rapids areas, some reaches may be dangerous at high stages. As the minimum flow that will permit canoeing the shoal areas is exceeded approximately 60 percent of the time during June, July, and August, the Red Lake River would normally be excellent for canoe travel. It would be wise for the canoeist to check gage height at High Landing before starting on a trip. The stream velocity will average about 1 to 2 miles an hour to Thief River Falls and below Thief River Falls will average about 3 miles per hour to Crookston. The trip can be planned to take 4 days from High Landing to Huot. During this period, the river will fall from 5 feet to about 4 feet if no rainfall occurs during the trip. This would indicate that a few more portages would be required than the 10 indicated for a 5 foot stage.

During periods of no precipitation, the discharge of the Red Lake River is sustained partly by movement of ground water from the sides of the valley into the stream channel. This discharge of ground water to the stream takes place most rapidly when water levels in the ground are high and decreases as ground-water levels decline. Rainfall in the area increases the discharge in the river, but subsequent days without rainfall result in a decrease in streamflow. The RECESSION CURVE indicates the rate at which the streamflow will decrease. As an example, if the gage height is 4 feet at High Landing and there is no rain for 10 days, the gage height reading will drop to about 3 feet. After 20 days, the gage height would be approximately 2 feet.



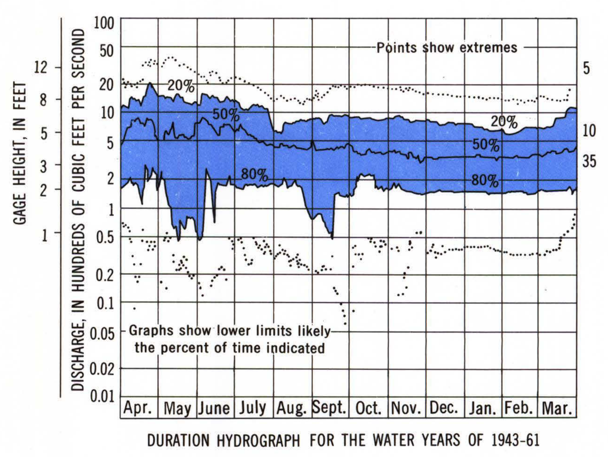
RECESSION CURVE INDICATES AT THE GAGING STATION THE NORMAL DECLINE IN GAGE HEIGHT AFTER A PERIOD OF RAIN

HYDROLOGY II



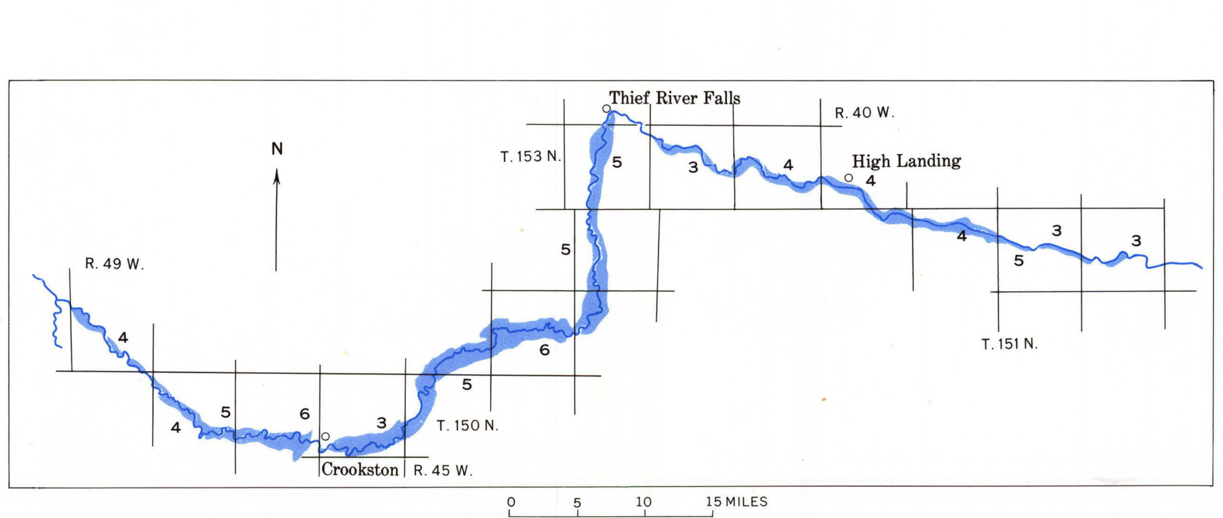
DURATION HYDROGRAPH FOR THE WATER YEARS OF 1943-61

RED LAKE RIVER AT CROOKSTON

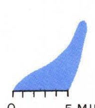


DURATION HYDROGRAPH FOR THE WATER YEARS OF 1943-61

RED LAKE RIVER AT HIGH LANDING NEAR GOODRIDGE



EXPLANATION



Velocity of flow, in miles per hour, at a gage height of 5 feet at the gaging station

4

Numbers indicate for normal flow the minimum gage height at High Landing at which the reach of river is generally navigable by canoe

FLOW REGULATED BY DAM ON LOWER RED LAKE

WATER QUALITY I

We are often asked what is "good" or "bad" water, or to otherwise qualify a quantitative physical chemistry description of a water sample or series of samples. This is difficult if not impossible to do, except in extreme cases of temperature, acid mine drainage, or other pollution. For every water type and range of fluctuation there exists both flora and fauna, including man, that can dwell within or otherwise utilize the water and its dissolved and included constituents. Some ecologic niches are sufficiently narrow and well defined that flora and fauna may be used as good indicators of water quality. Other plants and creatures, such as man, can utilize a very wide range of water types. Therefore, before we can qualify a water as "good", "bad", "desirable", "adequate", or other we must ask for what and for whom. Is it for supporting life, such as sport fish or attractive plants, for not supporting life such as "nuisance" algal blooms or pondweed, for drinking, swimming, industrial utilization or what? By consulting the appropriate ecologist, hydrologist, or engineer it may be possible to determine if the water in question meets with the selected criteria.

It must be kept in mind that the water's quality is not the only controlling factor in an ecologic system, though it strongly affects that system. The other members of the system may alter the water's quality. The description of the interrelationship of the physical chemistry of water and conditions that might be considered desirable is far too lengthy, complex, and little known to present here, but some specific examples pertinent to waters of Minnesota are given in the following paragraphs.

Calcium, magnesium, and bicarbonate in solution are related to the free CO_2 in the water and its pH and therefore affect and are affected by aquatic plant life. Some species of plants are typical of hard carbonate (high Ca, Mg) waters such as sago pondweed and clasping leaf pondweed and will also tolerate high sulfate concentration. Many other typical hard water species such as wildrice are not found in large stands where water exceeds 10 ppm (parts per million) (0.2 epm (equivalents per million)) sulfate. Calcium and magnesium also effect the amount of copper sulphate ($CuSO_4$) required for dosage in control of "nuisance" algal blooms. Moyle (1945a) has shown that in Minnesota lakes several species, especially bushy pondweed, widgeon grass, and bulrush, are generally limited to waters having a sulfate content greater than 50 ppm (1 epm) and grow best in areas having greater than 200 ppm (4 epm) sulfate present.

The nutrients, nitrogen and phosphorus, represent a major part of the fertility of a stream, contributing heavily to both phytoplankton and larger aquatics' growth which in turn will affect faunal conditions. The size and structure of a fish population may well reflect the chemistry of water and the factors that control its chemistry. It has also been found that mollusca populations are proportional to the total dissolved solids in the waters (Shoup, 1943), and that chlorides will control certain diatom populations. Temperature, dissolved oxygen, and turbidity are very closely related to each other and impose limits on fish population as well as other fauna and flora.

The following chart further illustrates the type of information that can be applied in interpreting the quality data. By comparing the concentration range on the dissolved oxygen plots to the range acceptable to a selected fish species one can predict the suitability of the water for that specie.

THRESHOLDS OF DISSOLVED OXYGEN FOR FISH

Observed concentration of dissolved oxygen, in parts per million, at which fish survived (S), or were killed (K) in the time indicated.

Species	Summer 24 hours		Winter 48 hours	
	S.	K.	S.	K.
Pike	6.0	3.1	3.1	2.3
Black bass	5.5	3.1	4.7	2.3
Black crappie	5.5	4.2	1.5	1.4
Common sunfish	4.2	3.1	1.4	0.8
Yellow perch	4.2	3.1	4.7	1.5
Sunfish	3.3	3.1	3.5	0.8
Black bullhead	3.3	2.9	1.1	0.3
Median values	4.2	3.1	3.1	1.4

(adapted from McKee and Wolfe, 1963)

It must be kept in mind when applying the above charts that dissolved oxygen content is not the only limiting factor. The fish also have limits of temperature, turbidity, and pH in which they can survive. The sampling frequency and time, even to the time of day, greatly restrict the information on highly variable parameters such as dissolved oxygen. Some extremes may have been missed but the known range and variation shown may be applied as a first step in a process of elimination when determining the suitability of the water for certain species. Other known limiting factors for both plants and creatures can be applied in a like manner to the information presented in the water quality sections below.

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WATER QUALITY II

The graphs and tables are summaries of most of the physical chemistry data presently available.

The semilog- "equivalents per million- (milliequivalents per liter)" plots of the concentration of major ions in the water enclose, by shaded area, the values from all analyses at a given station. This shows the general type of water and the known ranges of major ion concentration. The heavy enclosed line represents the average of the samples. Most data are from regular U.S. Geological Survey sampling stations. The units, equivalents per million, (equal to milliequivalents* per liter, within limits of these data) as the name implies, bears a direct relationship to the number, rather than the weight, of ions in solution with a factor included to allow for combining capabilities or equivalent reactive amounts. This system permits easier chemical comparison and balancing of the quantities of ions in solution. The tic marks on each vertical division represent the parts per million by weight scale as indicated. All the tics falling between the 1 and 10 epm values are the 100 ppm tics and so on. This method enables concentrations to be read in either units.

From these graphs it can be seen that the Lower Red Lake, the Thief River, and the Red Lake River itself at Crookston are of similar water type, i.e. calcium and bicarbonate predominating with magnesium and sulfate almost equally high. All constituents lie below 10 epm (with exception of the one extreme sample shown as a dotted line on the Thief River plot). This, in part, reflects the geology of the area, being mostly dolomitic till containing pebbles of dolomite, $CaMg(CO_3)_2$, and limestone, $CaCO_3$, and the finely disseminated carbonates, as well as gypsum, $CaSO_4 \cdot 2H_2O$. The range in concentration of each ion or radical increases generally downstream, especially in the SO_4 and Cl ions.

The semilog plot of concentration versus date of sample shows the change in samples from one sampling time to another and also the relationship of the concentration of the different ions in each sample. There is a fairly constant relationship between calcium and magnesium, and a similar relationship to sodium though a general increase is indicated in the latter. The bicarbonate does not correlate well with the others and sulfate is very uncorrelated. The chloride content was 0.00 in early samples as it was also in two 1949 samples not plotted. The indicated increase infers increased pollution.

The correlation graph of the easily measured conductivity is useful in estimating the hardness or total dissolved solids of the river water. Because hardness is primarily calcium plus magnesium, and the relationship to each other and other ions can be seen on the previously discussed two types of semilog plots, a rough estimate of some of the other water quality constituents can also be made using a simple, portable, conductivity meter.

The minor elements presented in the summary table are from published and prepublished data from the same samples as represented in the previous charts. The trace element data are from two samples on which spectrographic analyses were run.

The dissolved oxygen - temperature - turbidity graphs are based upon published data of the Minnesota Department of Health.

Phosphorus values are also summarized from Minnesota Department of Health published data.

Abbreviations and Definitions

Ca	calcium cation
Mg	magnesium cation
Na	sodium cation
K	potassium cation
HCO_3	bicarbonate anionic radical
SO_4	sulfate anionic radical
Cl	chloride anion
NO_3	nitrate anionic radical
specific conductance	ability to pass electric current, expressed in micromhos per centimeter with reference to standard cell
JTU	Jackson turbidity units, a standard measure of light transmittance
epm	equivalents per million*
ppm	parts per million by weight

*One milliequivalent is the atomic or formula weight in milligrams (mg.) divided by the electron charge or valence per unit formula; or the weight in mg. of the substance reacting with one millimole of hydrogen ion (H+) or one half millimole of oxygen (O).

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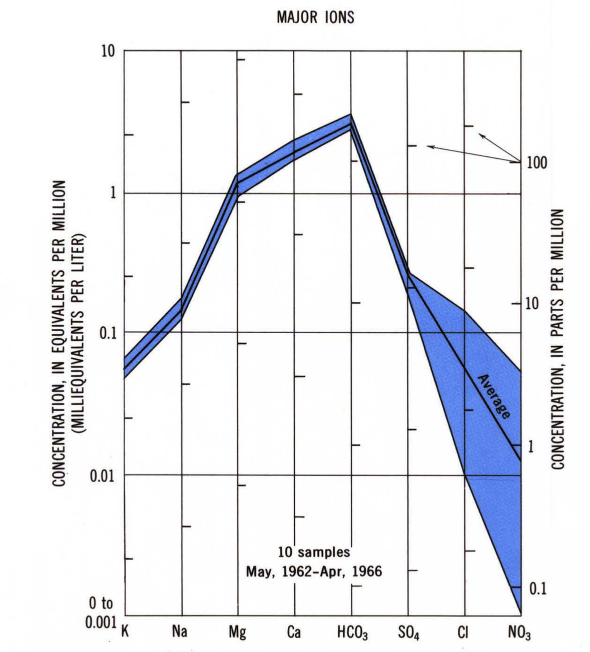
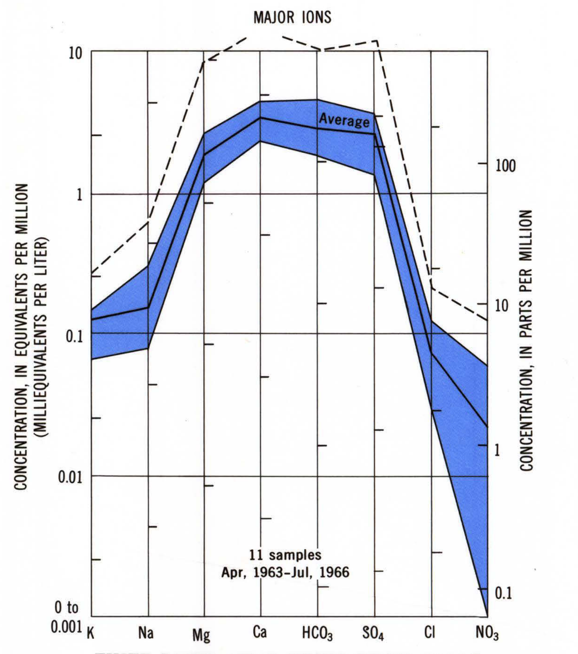
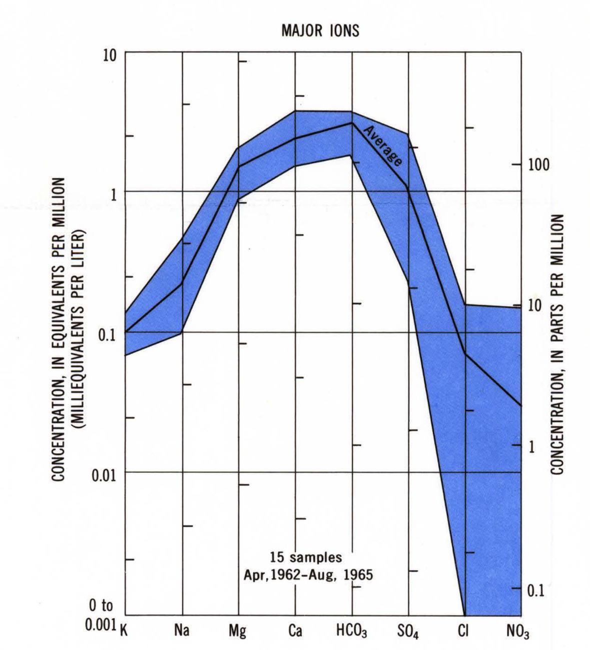
WATER QUALITY III

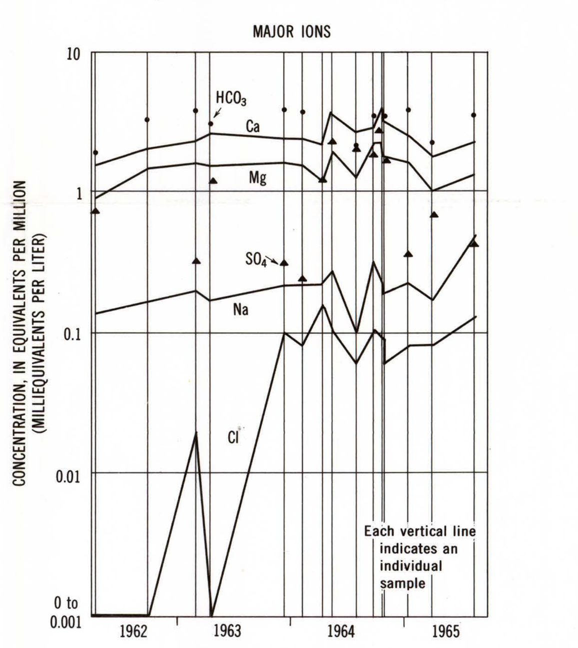


LOWER RED LAKE NEAR RED LAKE



THIEF RIVER NEAR THIEF RIVER FALLS

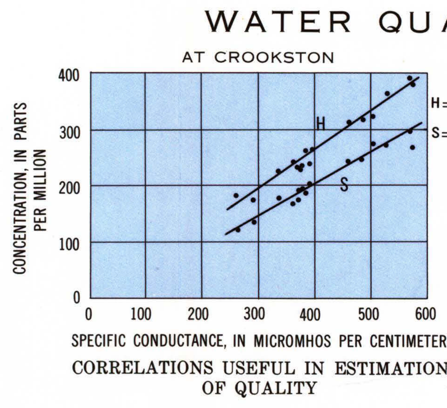




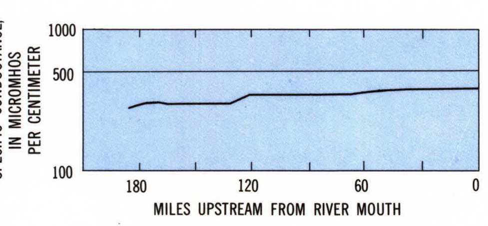
RED LAKE RIVER AT CROOKSTON

WATER QUALITY IV

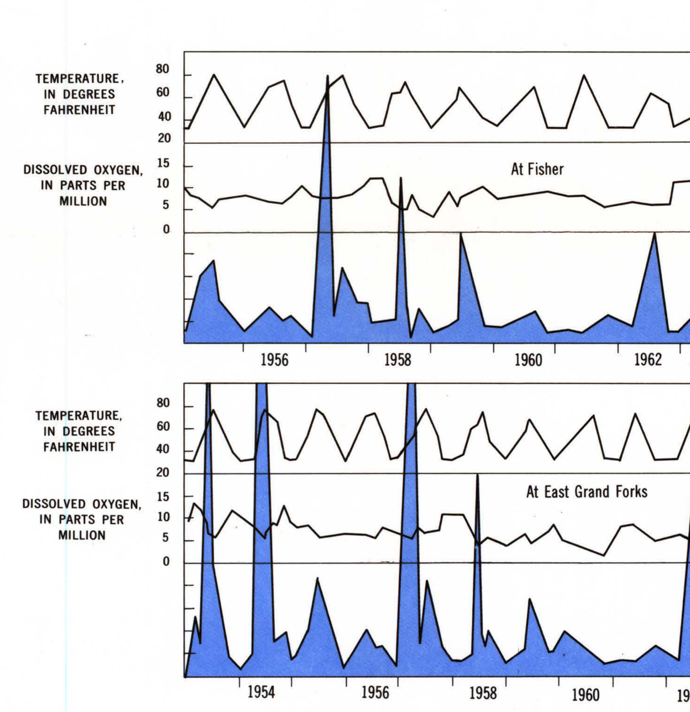
AT CROOKSTON



CORRELATIONS USEFUL IN ESTIMATION OF QUALITY



DOWNSTREAM VARIATION IN SPECIFIC CONDUCTANCE JULY 19-23, 1966



TEMPERATURE, DISSOLVED OXYGEN, AND TURBIDITY ARE OF HIGH SIGNIFICANCE TO ECOLOGY

AT CROOKSTON

	High	Average	Low	Samples
Total hardness	298	209	123	17 1949-65
Total dissolved solids	388	270	173	17 1949-65
SiO_2	16	9.9	3.2	15 1962-65
Fe	0.14	0.07	0.02	15 1962-65
Mn	0.10	0.03	0.00	14 1962-65
B	0.08	0.04	0.03	15 1962-65
Al	1.6	0.3	0.1	10 1963-65
PO_4	0.27	0.12	0.00	11 1963-65
Ar	0.01		0.00	2 1964
Br	<0.38		0.10	2 1964
CN	0.02		0.00	2 1964
I	1.0		0.04	2 1964
Se	0.01		0.01	2 1964

MINOR ELEMENTS, IN PARTS PER MILLION

AT CROOKSTON

	1	2		1	2
Al	370	55	Mo	1	2
Ba	46	67	Ni	3	<5
Be	<0.8	<2	Rb	4	4
B	100	62	Ag	<0.2	<0.03
Cr	<4	<2	Sr	69	110
Co	<4	<5	Sn	<4	<5
Cu	3	1	Ti	14	<5
Fe	33	46	V	2	<5
Pb	<4	<5	Zn	<120	<100
Li	8	5	Zr	<4	<5
Mn	9	26			
Bi,Cd,Ga,Ge	Not detected				

(1) Oct. 31, 1964 (2) May 20, 1964

TRACE ELEMENTS, IN PARTS PER BILLION

High	Low	Average	Samples
0.51	0.04	0.17	13
At East Grand Forks			
0.32	0.04	0.14	13
At Gentilly 1958-59 1962-63			

NUTRIENT PHOSPHORUS, IN PARTS PER MILLION

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1969—W68171

RECONNAISSANCE OF THE RED LAKE RIVER, MINNESOTA

By
L. H. Ropes, R. F. Brown, and D. E. Wheat

1969