SIMULATED EFFECTS OF THE PROPOSED GARRISON DIVERSION UNIT ON STREAMFLOW AND DISSOLVED SOLIDS IN THE SHEYENNE RIVER AND THE RED RIVER OF THE NORTH, NORTH DAKOTA AND MINNESOTA

By R. Scott Guenthner

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CONTENTS

CONTENTS, Continued

Page

ILLUSTRATIONS

ILLUSTRATIONS, Continued

TABLES

TABLES, Continued

CONVERSION FACTORS, VERTICAL DATUM, AND WATER-QUALITY UNITS

Multiply	By	To obtain
acre-foot	1,233	cubic meter
cubic foot per second	0.02832	cubic meter per second
foot per mile	0.1894	meter per kilometer
foot	0.3048	meter
inch	25.4	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), use the following formula: °C = (°F - 32)/1.8.

Sea level: In this report sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Milligrams per liter is a unit expressing the concentration of a chemical constituent in solution as weight (milligrams) of solute per unit volume (liter) of water.

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ABSTRACT

Future development of the Garrison Diversion Unit in North Dakota could deliver 100 cubic feet per second of water for the cities of Fargo, Grand Forks, and surrounding communities. Missouri River water from the Garrison Diversion Unit Sheyenne River water supply would be delivered to the upper reaches of the Sheyenne River, which would convey the water to the Red River of the North. Potential effects of releasing Missouri River water to the Sheyenne River on the quantity and quality of streamflow in the Sheyenne River and in the Red River of the North are evaluated for two proposed operating plans--year-round operation (12 months each year) and nonwinter operation (April through October each year). The Project Canals, Reservoirs, and River Systems (PROCRRS) and Canals, Rivers, and Reservoirs Salinity Accounting Procedures (CRRSAP) monthly accounting models are used to predict streamflow and dissolved-solids changes that could result from the proposed release of treated Missouri River water into the Sheyenne River and the Red River of the North. For year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the period 1931-84, the maximum quantity of water that must be delivered to the upper reaches of the Sheyenne River so that 100 cubic feet per second of Missouri River water can be delivered to Fargo, N.Dak., and Grand Forks, N.Dak., was estimated to be about 151 cubic feet per second for August 1976. For nonwinter operation the maximum quantity of water was estimated to be about 210 cubic feet per second.

Model simulations were used to assess the effects that operation of the Garrison Diversion Unit Sheyenne River water supply could have on streamflow and water quality of the Sheyenne River and the Red River of the North. Effects were assessed by comparing simulated streamflows that include Missouri River water to baseline conditions, which represent hydrologic conditions before addition of Missouri River water.

Simulated mean monthly dissolved-solids concentrations for Sheyenne River nodes for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply generally were less than those for baseline conditions. Simulated mean monthly dissolved-solids concentrations for Red River of the North nodes for year-round and nonwinter operation generally were greater than those for baseline conditions.

Streamflow for 1933-42 was about 25 percent of the mean annual streamflow for 1931-84. Simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation for node 125, Sheyenne River near Cooperstown, N.Dak., for the low-flow conditions of 1933-42 were less than those for baseline conditions. Annual variability of simulated dissolved-solids concentrations for year-round operation was less than annual variability for nonwinter operation and for baseline conditions. Simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation for node 250, Sheyenne River near Kindred, N.Dak., for the low-flow conditions of 1933-42 ranged from 500 to 600 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for baseline conditions ranged from 300 milligrams per liter to greater than 1,000 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for year-round operation. For node 700, Red River of the North at Grand Forks, N.Dak., the magnitude of simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation for the low-flow conditions of 1933-42 were about the same as those for baseline conditions.

Streamflow for 1973-82 was about 30 percent greater than the mean annual streamflow for 1931-84. For the high-flow conditions of 1973-82, simulated monthly mean dissolved-solids concentrations for node 125 for year-round operation ranged from about 325 to 650 milligrams per liter, and simulated monthly mean dissolved-solids concentrations for baseline conditions and for nonwinter operation generally ranged from 325 to 800 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for node 250 for year-round and nonwinter operation were about the same as those for baseline conditions. Simulated monthly mean dissolved-solids concentrations for node 700 for year-round and nonwinter operation also were about the same as those for baseline conditions.

INTRODUCTION

The Garrison Diversion Unit in North Dakota was authorized by Congressional Act of August 5, 1965, Public Law 89-108. The Garrison Diversion Unit was to provide (1) water for irrigation of 250,000 acres; (2) municipal, rural, and industrial water; (3) fish and wildlife habitat; (4) recreation; and (5) flood control. The Garrison Diversion Unit Reformulation Act of 1986, Public Law 99-294, specified several modifications and amendments to the 1965 Act. An amendment to Section 5 authorized and directed the Secretary of the Interior to construct, operate, and maintain a Sheyenne River water supply and release feature capable of delivering 100 cubic feet per second of water for the cities of Fargo and Grand Forks and the surrounding communities. Water from the Garrison Diversion Unit would be delivered to the upper reaches of the Sheyenne River, which would convey the water to the Red River of the North (pl. 1, in pocket).

Potential effects of releasing treated Missouri River water to the Sheyenne River on the quantity and quality of streamflow in the Sheyenne River and the Red River of the North needed to be evaluated. Consequently, the U.S. Geological Survey, in cooperation with the U.S. Bureau of Reclamation, conducted a study to address these needs. The U.S. Bureau of Reclamation's Project Canals, Reservoirs, and River Systems (PROCRRS) streamflow model (Hoovestol and Associates, 1988a) and Canals, Rivers, and Reservoirs Salinity Accounting Procedures (CRRSAP) water-quality model (Hoovestol and Associates, 1988b) can be used to predict streamflow and water-quality changes that could result from the proposed release of treated Missouri River water into the Sheyenne River and the Red River of the North.

Purpose and Scope

This report provides the results of the study to determine the effects that operation of the Garrison Diversion Unit Sheyenne River water supply may have on streamflow and dissolved solids in the Sheyenne River and the Red River of the North. The specific objectives are to: (1) estimate the quantity of water that must be delivered to the upper reaches of the Sheyenne River from the Garrison Diversion Unit so that 100 cubic feet per second of Missouri River water can be delivered to Fargo, N.Dak., and Grand Forks, N.Dak., and surrounding communities; (2) use existing data to calibrate the PROCRRS and CRRSAP models; (3) use the calibrated models to simulate streamflow and dissolved solids for baseline conditions and for two proposed operating plans (year-round and nonwinter operation) of the Garrison Diversion Unit; and (4) compare simulated streamflow and dissolved-solids values for the two proposed operating plans to simulated values for baseline conditions to determine the effects of operation of the Garrison Diversion Unit Sheyenne River water supply on streamflow and dissolved solids in the Sheyenne River and the Red River of the North. As used in this report, baseline conditions in the Red River of the North basin, including the Sheyenne River basin, represent the hydrologic conditions that exist in the basin before addition of Missouri River water to the river system.

The models are to be used to simulate 54 years of monthly mean streamflow and dissolved solids. Streamflows that occurred in the Red River of the North basin during 1931-84 are assumed to be representative of future flows.

Description of Study Area

The Red River of the North basin is part of the Hudson Bay drainage system (pl. 1). Parts of Montana, South Dakota, North Dakota, and Minnesota in the United States, and parts of Saskatchewan and Manitoba in Canada are drained by the Red River of the North. The North Dakota-Minnesota boundary is formed by the Red River of the North. Drainage area of the Red River of the North at the Emerson, Man., streamflow-gaging station, which is 0.8 mile downstream from the international boundary, is 40,200 square miles (U.S. Geological Survey, 1988, p. 143). The Red River of the North is formed where the Ottertail and the Bois de Sioux Rivers join at Wahpeton, N.Dak., and Breckenridge, Minn. The river flows northward 394 miles to the United States-Canadian boundary. From the international boundary, the Red River of the North flows north about 155 miles and discharges into Lake Winnipeg. The

Red River of the North basin upstream from the international boundary (not including the Souris River basin) is the only part of the basin included in the study area.

The Red River of the North flows over lacustrine deposits of glacial Lake Agassiz through its entire length in North Dakota. The slope of the river is extremely flat. The river falls only about 200 feet in its 394-mile course from Wahpeton to the international boundary (Miller and Frink, 1984).

Water quality in the river is affected by the lacustrine deposits, by inflow from major tributaries from both North Dakota and Minnesota, and by ground-water discharge. Mean dissolved-solids concentrations ranged from 327 milligrams per liter in 472 water samples collected from May 16, 1949, through September 16, 1986, at the Red River of the North at Fargo, N.Dak., gaging station to 430 milligrams per liter in 72 water samples collected from July 9, 1974, through September 23, 1986, near the international boundary at the Red River of the North at Emerson, Man., gaging station.

The Sheyenne River is one of the major tributaries to the Red River of the North. The Sheyenne River has a drainage area of about 6,910 square miles (not including the closed Devils Lake basin). From its headwaters near Harvey, N.Dak., the Sheyenne River, which is about 500 miles long, flows eastward about 150 miles, southward about 200 miles, and then northeastward to its confluence with the Red River of the North, north of Fargo, N.Dak. (Souris-Red-Rainy River Basins Commission, 1972, p. D-50).

The Sheyenne River basin lies in three distinct physiographic areas. The drift prairie area extends from the headwaters to the vicinity of Valley City, N.Dak.; a hilly delta area extends from Valley City, N.Dak., to the vicinity of Kindred, N.Dak.; and the glacial Lake Agassiz area extends from the vicinity of Kindred, N.Dak., to the confluence of the Sheyenne River and the Red River of the North. Most of the Sheyenne River valley from the headwaters to Kindred, N.Dak., is incised into glacial till. The valley from Sheyenne, N.Dak., to Kindred, N.Dak., ranges from 100 to 200 feet in depth and 0.2 to 2 miles in width. The Sheyenne River from Kindred, N.Dak., to the confluence of the Sheyenne River and the Red River of the North flows over lacustrine deposits of glacial Lake Agassiz. Average gradient of the river is 1.5 feet per mile in the drift prairie and hilly delta areas and about 1 foot per mile in the glacial Lake Agassiz area.

No flow has been recorded at times in the upper reaches of the Sheyenne River. Flow in the lower reaches of the river is regulated partly by releases from Baldhill Dam, which began regulating streamflow in 1949. Lake Ashtabula, formed by Baldhill Dam, has a capacity of 69,100 acre-feet between the invert of the outlet conduit and the normal pool elevation. Lake Ashtabula is operated for flood control (capacity at maximum pool elevation of 1,273.2 feet is 116,500 acre-feet), municipal water supply, recreation, and low-flow augmentation.

Dissolved-solids concentrations are greater in water samples collected upstream of Lake Ashtabula than in water samples collected downstream of Lake Ashtabula. Mean dissolved-solids concentrations ranged from 867 milligrams per liter in 100 water samples collected from October 4, 1971, through August 18, 1986, at the Sheyenne River above Harvey, N.Dak., gaging station, upstream of Lake Ashtabula, to 432 milligrams per liter in 90 water samples collected from June 5, 1959, through September 15, 1986, at the Sheyenne River below Baldhill Dam, N.Dak., gaging station.

PROPOSED GARRISON DIVERSION UNIT WATER SUPPLY

The proposed Garrison Diversion Unit Sheyenne River water supply needs to be capable of delivering a sufficient quantity of Missouri River water to the upper reaches of the Sheyenne River to provide 100 cubic feet per second of water for the cities of Fargo and Grand Forks and surrounding communities for 12 months each year. The quantity of Garrison Diversion Unit water proposed for delivery to the Sheyenne River was estimated for two delivery alternatives: (1) deliver Missouri River water to the Sheyenne River for 12 months each year (year-round operation), and (2) deliver Missouri River water to the Sheyenne River for 7 months each year (nonwinter operation). For both alternatives, water would be released from Lake Ashtabula to provide 100 cubic feet per second for 12 months each year.

Because water loss will likely occur between the delivery point and the withdrawal points, the Garrison Diversion Unit needs to be capable of delivering 100 cubic feet per second of water plus the maximum water losses that can be expected to occur. Water losses could include, but are not limited to, stream infiltration, bank storage, and evaporation. Determination of water losses by stream infiltration and bank storage is beyond the scope of this study; therefore, this report considers only water loss caused by evaporation.

Evaporation loss, as estimated in this report, is the difference between evaporation from the water surface before addition of Missouri River water to the Sheyenne River and the Red River of the North and evaporation after addition of Missouri River water. The estimated evaporation loss includes only that evaporation loss that occurs after Missouri River water is delivered to the Sheyenne River. No evaporation loss is included for the Garrison Diversion Unit delivery facilities necessary for delivery of Missouri River water to the Sheyenne River.

Estimated evaporation from the water surface of the rivers is the product of net evaporation and the increase in water-surface area. The maximum net evaporation from the rivers for each month of the year was computed from evaporation and precipitation data for 1931-84 (Guenthner and others, 1990).

Increase in water-surface area was estimated as the product of channel length and the increase in channel width. A channel length of 512 miles was estimated for the Sheyenne River and 134 miles was estimated for the

Red River of the North. Discharge measurement records for gaging stations on the Sheyenne River and the Red River of the North were examined to estimate the maximum channel-width increase that could occur from addition of 100 cubic feet per second of water to the rivers. A maximum channel-width increase of 75 feet was estimated for the Sheyenne River and 15 feet was estimated for the Red River of the North.

The estimated maximum monthly water delivery requirements based on estimated maximum evaporation losses for the period 1931-84 are listed in table 1. The estimated maximum evaporation loss was 51.0 cubic feet per second in August 1976, for an estimated maximum delivery of 151 cubic feet per second. If the Garrison Diversion Unit delivery canal to the Sheyenne River is operated for only 7 months during the year (nonwinter operation), estimated maximum delivery of Missouri River water to the Sheyenne River is about 210 cubic feet per second. The estimated maximum delivery for 7 months during the year was calculated as the sum of the 12-month delivery requirements (table 1) spread equally over 7 months (1,471 cubic feet per second/7 months).

Table 1.--Estimated monthly water delivery requirements for the Garrison Diversion Unit Sheyenne River water supply based on estimated maximum monthly evaporation losses for the period 1931-84

Month	Year of occurrence	Estimated maximum evaporation loss: Inches	Estimated maximum evaporation loss: Cubic feet per second	Estimated water delivery requirements (cubic feet per second)
January	1963	0.21	1.4	101.4
February	1934	.28	2.1	102.1
March	1958	.66	4.5	104.5
April	1980	1.78	12.6	112.6
May	1980	6.66	45.6	145.6
June	1974	5.49	38.8	138.8
July	1936	7.21	49.4	149.4
August	1976	7.42	51.0	151.0
September	1948	5.68	40.2	140.2
October	1945	2.62	17.9	117.9
November	1939	.87	6.2	106.2
December	1939	.23	1.6	101.6

DESCRIPTION OF THE MODELS

A brief description of the PROCRRS and CRRSAP models is presented in this report. A complete discussion of the models is given in the Programmers Manuals (Hoovestol and Associates, 1988a, 1988b) and Draft Users Guide (McDanel and others, 1989). The PROCRRS and CRRSAP models have been used to evaluate effects of the Garrison Diversion Unit on water quantity and quality in the James River in North Dakota and South Dakota (U.S. Bureau of Reclamation, 1986, 1989a). The model studies on the James River were used as a source of documentation and application of the models.

Project Canals, Reservoirs, and River Systems Streamflow Model

Capability and Application

The PROCRRS model is a digital computer-based model used to simulate flows through project canals, reservoirs, and natural river systems. For this study, the model was used to simulate flows through one reservoir, Lake Ashtabula, and the Sheyenne River and the Red River of the North system. The PROCRRS model is a monthly accounting procedure that accounts for streamflow through a river system. A river system is made up of river segments called reaches. The river system is represented as a series of nodes. At each node, streamflow is adjusted for accruals and withdrawals. Each node corresponds to the location of a gaging station, the mouth of a tributary, or other locations where adjustments are needed.

The operations program for the PROCRRS model is a water accounting program. The accounting program allows for the accrual of project flows, natural inflow, irrigation or municipal return flows, and precipitation on the river water surface and allows for withdrawals that can include irrigation and municipal demands and evaporation from the river water surface. The model uses a monthly time step to complete flow simulations. The working equation for the model is $A + B = C$, where A is the inflow to the reach, B is the accrual or withdrawal along the river reach or at a specific location along the reach, and C is the resultant outflow. Outflow C from one reach becomes the inflow A of the next downstream reach.

The model reaches, tributary inflows, and gaging stations used to define the water quantity and quality at the downstream model nodes and tributary inflow nodes are listed in table 2. The river system and corresponding node structure used in the Sheyenne River and Red River of the North model is shown in figure 1.

Data Requirements and Availability

Primary input data needed by the PROCRRS model include end-of-month elevations and end-of-month contents for Lake Ashtabula, net evaporation from Lake Ashtabula, monthly streamflow for the Sheyenne River and the Red River of the North, evaporation from the water surface of the Sheyenne River and the Red River of the North, and permitted water-right withdrawals.

Table 2.--Model reaches, tributary inflows, and gaging stations used to define water quantity and quality at the downstream model node for the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Reservoirs Salinity Accounting Procedures models of the Sheyenne River and the Red River of the North

[Methods for determining water quantity and quality at model nodes are described by Guenthner and others (1990) and Guenthner (1991)]

Model reaches on the Sheyenne River	Gaging station used to define water quantity and quality at the downstream model node
Harvey to Warwick	Sheyenne River near Warwick, N.Dak.
Warwick to Cooperstown	Sheyenne River near Cooperstown, N.Dak.
Cooperstown to Baldhill Dam	Lake Ashtabula at Baldhill Dam, N.Dak., and Sheyenne River below Baldhill Dam, N.Dak.
Baldhill Dam to Valley City	Sheyenne River at Valley City, N.Dak.
Valley City to Lisbon	Sheyenne River at Lisbon, N.Dak.
Lisbon to Kindred	Sheyenne River near Kindred, N.Dak.
Kindred to West Fargo	Sheyenne River at West Fargo,N.Dak.

Tributary inflow to the Sheyenne River	Gaging station used to define water quantity and quality at the tributary inflow node
Sheyenne River headwaters	Sheyenne River above Harvey, N.Dak.
Baldhill Creek	Baldhill Creek near Dazey, N.Dak.
Maple River	Maple River near Enderlin, N.Dak.
Rush River	Rush River at Amenia, N.Dak.

Model reaches on the Red River of the North	Gaging station used to define water quantity and quality at the downstream model node
Fargo to Halstad	Red River of the North at Halstad, Minn.
Halstad to Grand Forks	Red River of the North at Grand Forks, N.Dak.
Grand Forks to Drayton	Red River of the North at Drayton, N.Dak.
Drayton to Emerson	Red River of the North at Emerson, Man.

Tributary inflow to the Red River of the North	Gaging station used to define water quantity and quality at the tributary inflow node
Red River of the North headwaters	Red River of the North at Fargo, N.Dak., or Red River of the North below Fargo, N.Dak.
Buffalo River	Buffalo River near Dilworth, Minn.
Elm River	Elm River near Kelso, N.Dak.
Wild Rice River	Wild Rice River at Hendrum, Minn.
Goose River	Goose River at Hillsboro, N.Dak.
Marsh River	Marsh River near Shelly, Minn.
Sand Hill River	Sand Hill River at Climax, Minn.
Red Lake River	Red Lake River at Crookston, Minn.
Turtle River	Turtle River at Manvel, N.Dak.
Forest River	Forest River at Minto, N.Dak.
Snake River	Snake River at Warren, Minn., and Middle River at Argyle, Minn.
Park River	Park River at Grafton, N.Dak.
Pembina River	Pembina River at Neche, N.Dak., and Tongue River at Akra, N.Dak.

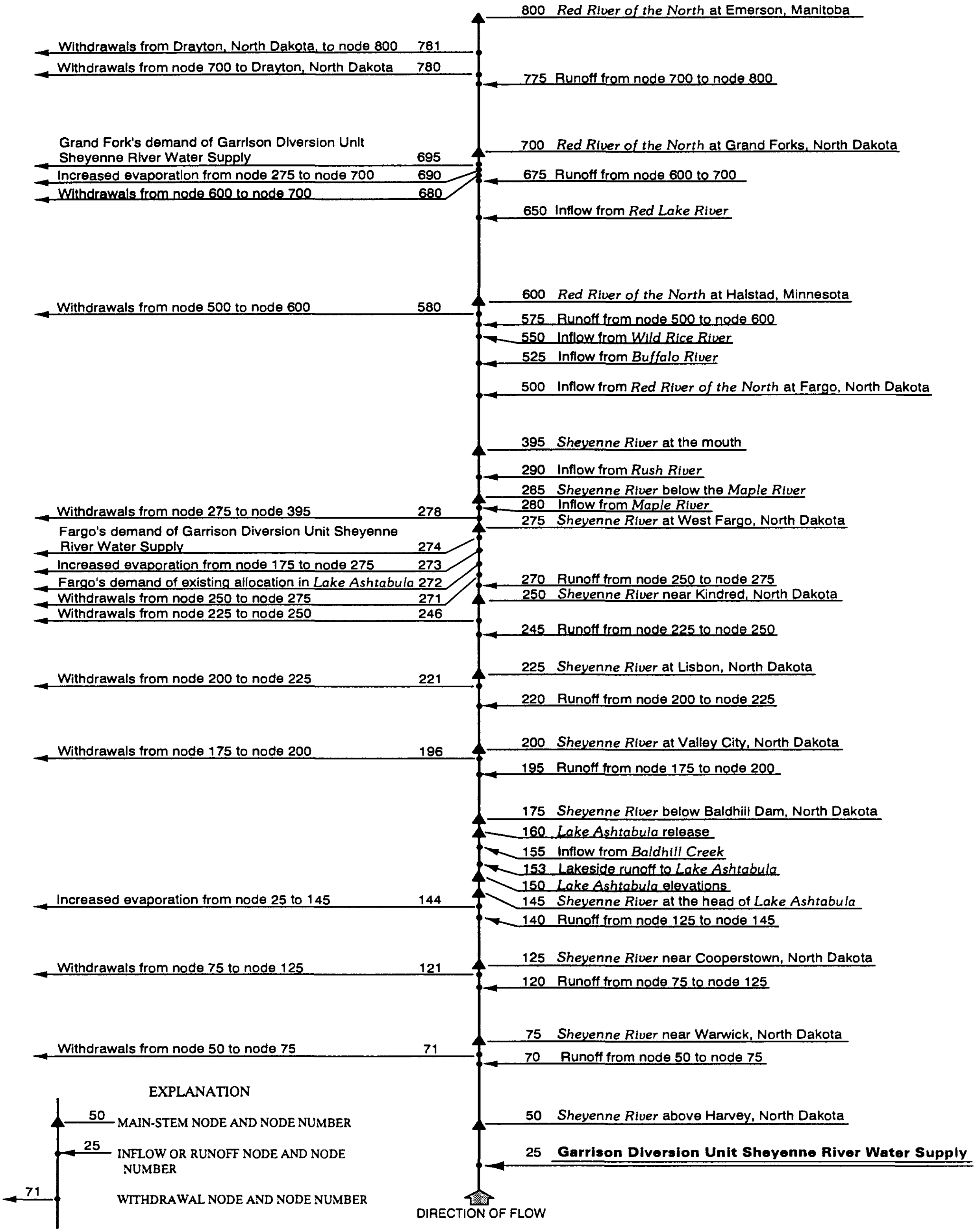

Figure 1.--River system and corresponding node structure used in models of the Sheyenne River and the Red River of the North.

A reservoir node in the PROCRRS model requires a number of input files. Lake Ashtabula began storing water in August 1949 when Baldhill Dam was completed on the Sheyenne River. End-of-month water-surface elevations and end-of-month contents of Lake Ashtabula for August 1949 through September 1984 (U.S. Geological Survey, 1959, 1964, 1971, 1971-86, 1976) were used as input data. Lake Ashtabula area-capacity data were input to the model after constructing a file from area-capacity curves received from the U.S. Army Corps of Engineers (E.G. Eaton, written commun., 1986). Net evaporation, the difference between evaporation and precipitation, from Lake Ashtabula was calculated from estimated evaporation from Lake Ashtabula and precipitation on Lake Ashtabula for 1931-84 (Guenthner and others, 1990).

Gaged and estimated monthly mean streamflow and estimated unregulated monthly mean streamflow data were compiled for a number of sites on the Sheyenne River and the Red River of the North (Guenthner and others, 1990). The PROCRRS model of the Sheyenne River and the Red River of the North was designed so model nodes corresponded to these sites. Streamflow data for these sites were used to calculate the gain or loss of streamflow in each river reach and the gain or loss data were used as model input. Gaged and estimated monthly mean streamflow and estimated unregulated monthly mean streamflow data for selected tributaries to the Sheyenne River and the Red River of the North also were used as model input. Streamflow data were input to the model through external files containing data for each month for 1931-84.

Water-right withdrawal permits have been granted to water users for almost all river reaches in the study area. The quantity of water granted by permits through 1984 was grouped by river reach and was used as input data for each river reach (table 3). Information on water-right withdrawal permits through 1984 was obtained from the North Dakota State Water Commission (Craig Odenbach, written commun., 1986) and the Minnesota Department of Natural Resources (Gil Young, written commun., 1987).

Evaporation and precipitation has an effect on the quantity of streamflow in the Sheyenne River and the Red River of the North. The loss or gain of streamflow caused by evaporation and precipitation has been accounted for in the monthly streamflow data base for reaches of the Sheyenne River and the Red River of the North.

The increased loss or gain of streamflow caused by evaporation and precipitation after Missouri River water is added to the rivers was estimated. Estimated evaporation from the water surface of the rivers after Missouri River water is added is the product of net evaporation and the increase in water-surface area. Evaporation after addition of Missouri River water was estimated for the Sheyenne River upstream from Lake Ashtabula; the Sheyenne River between Baldhill Dam and West Fargo, N.Dak.; and the Sheyenne River from West Fargo, N.Dak., to the Red River of the North at Grand Forks, N.Dak. Net evaporation was estimated from monthly evaporation and precipitation data for 1931-84 (Guenthner and others, 1990).

Increase in water-surface area was estimated as the product of channel length and the increase in channel width. The channel length of the Sheyenne

Table 3.--Permitted surface-water withdrawals in 1984 for river reaches or tributaries in the Red River of the North basin

[All values are in cubic feet per second]

River reach or tributary	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sheyenne River												
Headwaters to near Warwick	3.5	3.5	3.5	15.93	17.26	17.26	17.26	17.26	4.83	3.5	3.5	3.5
Near Warwick to near Cooperstown	0	0	0	0	5.41	5.41	5.41	5.41	5.41	0	0	0
Near Cooperstown to Baldhill Dam	0	0	3.01	3.01	9.75	9.75	6.74	6.74	6.74	0	0	0
Valley City to Lisbon	1.0	1.0	.30	.30	15.99	15.99	15.99	15.99	15.99	0	1.0	1.0
Lisbon to near Kindred	3.34	3.34	5.0	5.0	46.33	46.33	41.33	41.33	41.33	3.34	3.34	3.34
Near Kindred to West Fargo	4.56	4.56	4.56	4.56	5.56	5.56	5.56	5.56	5.56	4.56	4.56	4.56
West Fargo to the mouth	0	0	0	0	2.55	2.55	2.55	2.55	2.55	0	0	0
Buffalo River	10.68	10.68	10.68	10.68	14.08	14.08	14.08	14.08	14.08	10.68	10.68	10.68
Elm River	.78	.78	.78	.78	3.59	3.59	3.59	3.59	3.59	.78	.78	.78
Wild Rice River	0	0	0	0	1.00	1.00	1.00	1.00	1.00	0	0	0
Red River of the North												
Sheyenne River at the mouth to Halstad	0	0	0	0	8.88	8.88	8.88	8.88	8.88	0	0	0
Goose River	4.00	4.00	4.00	4.00	14.91	14.91	14.91	14.91	14.91	4.00	4.00	4.00
Sand Hill River	0	0	0	0	.48	.48	.48	.48	.48	0	0	0
Red Lake River	28.50	28.50	28.50	28.50	151.00	151.00	151.00	151.00	151.00	28.50	28.50	28.50
Red River of the North												
Halstad to Grand Forks	75.00	75.00	75.00	75.00	84.41	84.41	84.41	84.41	84.41	75.00	75.00	75.00
Turtle River	.05	.05	.05	.05	.55	.55	.55	.55	.55	.05	.05	.05
Forest River	1.00	1.00	1.00	1.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	1.00
Snake River	.07	.07	.07	.07	.20	.20	.20	.20	.20	.07	.07	.07
Park River	7.69	7.69	7.69	7.69	9.92	9.92	9.92	9.92	9.92	7.69	7.69	7.69
Red River of the North												
Grand Forks to Drayton	18.00	18.00	18.00	18.00	27.88	27.88	27.88	27.88	27.88	18.00	18.00	18.00
Tongue River	.25	.25	.25	.25	2.30	2.30	2.30	2.30	2.30	.25	.25	.25
Red River of the North												
Drayton to Emerson	0	0	0	14.70	6.86	6.86	6.86	6.86	21.56	14.70	14.70	14.70

River upstream from Lake Ashtabula is 241 miles; the channel length of the Sheyenne River downstream from Baldhill Dam to West Fargo, N.Dak., is 246 miles. The channel length from the Sheyenne River at West Fargo, N.Dak., to the Red River of the North at Grand Forks, N.Dak., is 159 miles. Depending on the volume of streamflow in the Sheyenne River and the Red River of the North, the increase in channel width will vary. Estimates of increase in channel width were based on examination of instantaneous discharge measurements. Mean monthly streamflow for 1931-84 for the Sheyenne River near Cooperstown, N.Dak., gaging-station was used to estimate the increase in channel width for each month for the Sheyenne River upstream of Lake Ashtabula. Mean monthly streamflow for 1931-84 for the Sheyenne River near Kindred, N.Dak., gaging station was used to estimate the increase in channel width for each month for the Sheyenne River between Baldhill Dam and the Sheyenne River at West Fargo, N.Dak. The maximum width increase for the Sheyenne River was estimated to be 75 feet when Missouri River water augments the mean monthly streamflow of between zero and 10 cubic feet per second. The width increase from the Sheyenne River at West Fargo N.Dak., to the Red River of the North at Grand Forks, N.Dak., was estimated to be 15 feet throughout. Estimated channel width increases are listed in table 4.

Additional input data developed during this study will be discussed later in this report where the data are first used for the model simulation.

Assumption and Limitations

The PROCRRS model uses a monthly time step to calculate inflow and outflow for each node. The model assumes that all flows into the first node of the river system being studied will be passed out the last node of the river system the same month. This assumption does not consider traveltime in the process. As such, the model of the river system is of a spatial dimension such that traveltimes though the river system do not exceed 1 month. For purposes of this study, it was assumed that traveltimes did not exceed 1 month; although, during periods of low flow, traveltime from the headwaters of the Sheyenne River to the Red River of the North at Emerson, Man., may actually exceed 1 month.

The PROCRRS model is a simple water-accounting model and does not route streamflow through a reservoir or river system. Simulations were performed without routing considered. Traveltimes and routing considerations, such as bank and channel storage, already are included in monthly mean gaged and monthly mean unregulated streamflow model input. Garrison Diversion Unit Sheyenne River water supply flows essentially will be steady state, so bank and channel storage gains and losses resulting from the addition of Missouri River water to the Sheyenne River and Red River of the North should be negligible.

No method is available in the model for prioritizing demands by date of first use or by class of use. For example, municipal and irrigation diversions are treated equally and the flow is allocated to the demand most upstream in the river system. In addition, shortages that occur cannot be allocated to several demands. Demands will be satisfied by available water until a shortage is encountered; all subsequent downstream demands will be

Table 4.--Mean monthly streamflow for 1931-84 and estimated increase in channel width caused by flow augmentation used to estimate evaporation for the Sheyenne River and the Red River of the North

[--, constant channel width increase was assumed; therefore, streamflow data are not needed to estimate channel width increase]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sheyenne River upstream from Lake Ashtabula												
Mean monthly streamflow, cubic feet per second	6.0	6.6	127	76	168	85.3	40.0	12.8	12.8	18.1	17.2	10.1
Channel width increase, feet	75	75	24	23	24	28	34	42	42	42	42	75
Sheyenne River between Baldhill Dam, N.Dak., and West Fargo, N.Dak.												
Mean monthly streamflow, cubic feet per second	65.5	70.1	167	629	298	143	97.1	30.6	23.1	51.1	59.7	49.7
Channel width increase, feet	28	28	24	23	23	24	28	34	42	28	28	34
Sheyenne River at West Fargo, N.Dak., to the Red River of the North at Grand Forks, N.Dak.												
Mean monthly streamflow, cubic feet per second	--	--	--	--	--	--	--	--	--	--	--	--
Channel width increase, feet	15	15	15	15	15	15	15	15	15	15	15	15

allocated a shortage until inflow can again satisfy demands farther downstream.

Canals, Rivers, and Reservoirs Salinity Accounting Procedures Water-Quality Model

Capability and Application

The CRRSAP model is a monthly water-quality accounting procedure that accounts for a conservative substance load through a river system. A conservative substance is one that does not decay in time in a river system.

For this study, the model was used to simulate dissolved-solids load through the Sheyenne River and the Red River of the North system. The dissolved-solids load for each node is estimated as the product of the monthly mean streamflow and the monthly mean dissolved-solids concentration. The change in dissolved solids due to the increase in streambed width was not accounted for. Dissolved-solids load is added or withdrawn for nodes proceeding downstream. Thus, only three items need to be accounted for in the procedure for each node: (1) the dissolved-solids load from the upstream reach, (2) the dissolved-solids load added or withdrawn for the reach, and (3) the dissolved-solids load carried to the next downstream reach. Streamflow components that may be added or withdrawn for a node are: (1) Runoff; (2) irrigation return flows; (3) net evaporation or precipitation; and (4) withdrawals for irrigation, municipal, or industrial use.

The CRRSAP model accepts input from the PROCRRS streamflow model and, therefore, has a node structure identical to the PROCRRS model (fig. 1 and table 2).

Data Requirements and Availability

Primary input data used by the CRRSAP model are streamflow and dissolved-solids concentrations for the headwaters and tributaries of the Sheyenne River and the Red River of the North. Streamflow data are available from the PROCRRS model. Monthly mean dissolved-solids concentrations for the headwaters and tributaries are not available directly from field samples for 1931-84. Generally, dissolved-solids concentrations were not measured frequently enough during any month to adequately define the monthly mean dissolved-solids concentration. Therefore, relations between dissolved-solids concentration and streamflow for selected gaging stations in the Red River of the North basin (Guenthner, 1991) were used to estimate monthly mean dissolved-solids concentrations for the headwaters and gaged tributaries of the Sheyenne River and the Red River of the North.

Relations between dissolved-solids concentration and streamflow for ungaged runoff to the Sheyenne River and the Red River of the North have not been developed. Monthly mean dissolved-solids concentrations for ungaged runoff into a river reach were estimated using the relation between dissolved-solids concentration and streamflow for the downstream gaging station. The coefficients in the relation between dissolved-solids concentration and streamflow were adjusted and applied to the runoff into the reach immediately upstream of the gaging station. Runoff into a reach includes all ungaged inflow between an upstream and downstream gaging station. Adjustment of coefficients is explained fully in the "Calibration of the Canals, Rivers, and Reservoirs Salinity Accounting Procedures Model" section of this report.

Ground-water accrual has been identified as a source for two reaches of the Sheyenne River (Guenthner, 1991). Low-flow seepage measurements conducted in October 1986 indicated ground-water accrual occurs in the vicinity of Warwick, N.Dak. Paulson and Akin (1964) and Randich (1971) also indicated ground-water accrual occurs in the vicinity of Warwick. Paulson (1964) identified ground-water accrual between the Sheyenne River at Lisbon, N.Dak., gaging station and the Sheyenne River near Kindred, N.Dak., gaging station. Estimated dissolved-solids concentrations in ground-water accrual for the two reaches are given in Guenthner (1991).

Assumptions and Limitations

Relations between dissolved-solids concentration and streamflow use instantaneous measurements of dissolved-solids concentration and streamflow. However, an assumption was made (Guenthner, 1991) that a reasonable estimate of monthly mean dissolved-solids concentration would be obtained if monthly mean streamflow was used in the relations between dissolved-solids concentration and streamflow. Monthly mean dissolved-solids concentration estimated from the relations between dissolved solids and streamflow may be much larger or smaller than the actual monthly mean concentration for that month. As an example; during spring runoff, field samples generally are obtained when streamflow is at or near the peak. Obtaining field samples at times of peak streamflow generally results in small values of dissolved-solids concentration. If the duration of the streamflow peak is only for a short period of time during the month, dissolved-solids concentration obtained during the peak cannot be used to accurately define monthly mean dissolved-solids concentration for the month. Estimated monthly mean dissolved-solids concentrations in this report are used as actual monthly mean dissolved-solids concentrations and are compared to model simulated data for calibration and error analysis.

The relations developed between dissolved-solids concentration and streamflow are logarithmic; thus, as streamflow approaches zero, dissolved-solids concentration becomes very large. At low flows, reasonable estimates of dissolved-solids concentration were obtained with the CRRSAP model by setting a maximum limit on dissolved-solids concentration. The dissolved-solids concentration for streamflow of 1.0 cubic foot per second was used as the dissolved-solids concentration for all streamflows of 1.0 cubic foot per second or less. The maximum limit on dissolved-solids concentration for streamflow of 1.0 cubic foot per second or less will be different for each node because the relation between dissolved solids and streamflow is different for each node.

CALIBRATION OF MODELS

Project Canals, Reservoirs, and River Systems Streamflow Model

The primary goal of calibrating the PROCRRS model is to minimize the difference between simulated and gaged streamflow data. Nodes upstream of node 175, the Sheyenne River below Baldhill Dam, N.Dak., were calibrated by depleting the unregulated flows by historic depletions. If the difference between simulated and gaged streamflow data were minimized for node 175, then nodes downstream of node 175 would be calibrated. Therefore, the PROCRRS model was calibrated by minimizing the differences between simulated and gaged streamflow data for node 175. Measured inflows, end-of-months contents, and outflows are available for Lake Ashtabula for 1950-84. Therefore, the PROCRRS model was calibrated for 1950-84. A description of nodes used in the calibrated PROCRRS model is given in table 5.

The PROCRRS model uses a water-balance procedure to account for gains and losses to Lake Ashtabula. The initial step in calibration of the PROCRRS model was to account for all inflow to Lake Ashtabula. Total Lake Ashtabula inflow (1950-84) was considered equal to the unregulated streamflow of the Sheyenne River below Baldhill Dam, N.Dak., gaging station, node 175. All input in the water balance has been accounted for by Guenthner and others (1990) except for the streamflow gain at node 140, which represents the streamflow gain between node 125, Sheyenne River near Cooperstown, N.Dak., and node 145, Sheyenne River at the head of Lake Ashtabula, and the inflow at node 153, Lake Ashtabula lakeside runoff.

Streamflow for node 145 was estimated by the drainage-area ratio method, as presented by Hirsch (1979). The drainage-area ratio method assumes the ratio of the streamflow at two sites is equal to the ratio of their drainage areas. Streamflow for node 125 was used to estimate the steamflow for node 145 by adjusting by the drainage-area ratio. The drainage area for node 125 is 1,270 square miles and the drainage area for node 145 is 1,334 square miles. The streamflow gain between node 125 and node 145 was assumed to be 5 percent of the streamflow at node 125.

Lakeside runoff to Lake Ashtabula (node 153) for 1950-84 was computed as the difference between total Lake Ashtabula inflow (node 175) and inflow from the Sheyenne River at the head of Lake Ashtabula (node 145), inflow from Baldhill Creek at the mouth (node 155), evaporation and precipitation (node 144), and change in reservoir storage (node 150). Lakeside runoff includes actual runoff plus unaccounted for gains to and losses from Lake Ashtabula. Unaccounted for gains to and losses from Lake Ashtabula include errors associated with estimating streamflow into the reservoir, releases from the reservoir, evaporation, precipitation, and changes in reservoir storage.

Lake Ashtabula is operated by the U.S. Army Corps of Engineers according to an established water-control plan (E.G. Eaton, written commun., 1986). Generalized target elevations, which are the maximum elevations the reservoir pool is allowed to reach at the end of each month, are established by the U.S. Army Corps of Engineers. These generalized target elevations were used in the model as end-of-month elevations of Lake Ashtabula. The model simulated

Table 5.--Description of nodes used in the calibrated Project Canals, Reservoirs, and River Systems model

Node number	Description
50	Station 05054500, Sheyenne River above Harvey, N.Dak.
70	Runoff from above Harvey to near Warwick
75	Station 05056000, Sheyenne River near Warwick, N.Dak.
120	Runoff from near Warwick to near Cooperstown
125	Station 05057000, Sheyenne River near Cooperstown, N.Dak.
140	Runoff from near Cooperstown to head of Lake Ashtabula
145	Sheyenne River at the head of Lake Ashtabula
150	Lake Ashtabula storage
150	Station 05057500, Lake Ashtabula elevations
150	Lake Ashtabula net evaporation
153	Lake Ashtabula lakeside runoff
155	Baldhill Creek at the mouth
160	Lake Ashtabula releases
175	Station 05058000, Sheyenne River below Baldhill Dam, N.Dak.
195	Runoff from below Baldhill Dam to Valley City
200	Station 05058500, Sheyenne River at Valley City, N.Dak.
220	Runoff from Valley City to Lisbon
225	Station 05058700, Sheyenne River at Lisbon, N.Dak.
245	Runoff from Lisbon to near Kindred
250	Station 05059000, Sheyenne River near Kindred, N.Dak.
270	Runoff from near Kindred to West Fargo
275	Station 05059500, Sheyenne River at West Fargo, N.Dak.
280	Maple River at the mouth
285	Sheyenne River below the Maple River
290	Rush River at the mouth
395	Sheyenne River at the mouth
500	Station 05054000, Red River of the North at Fargo, N.Dak.
525	Buffalo River at the mouth
550	Wild Rice River at the mouth
575	Runoff from Fargo to Halstad
600	Station 05064500, Red River of the North at Halstad, Minn.
650	Red Lake River at the mouth
675	Runoff from Halstad to Grand Forks
700	Station 05082500, Red River of the North at Grand Forks, N.Dak.
775	Runoff from Grand Forks to Emerson
800	Station 05102500, Red River of the North at Emerson, Man.

releases from Lake Ashtabula so that the simulated end-of-month elevations of Lake Ashtabula do not exceed the target elevations.

The U.S. Army Corps of Engineers water-control plan for Lake Ashtabula specifies a minimum instream flow below Baldhill Dam of 15 cubic feet per second, except when end-of-month elevations of Lake Ashtabula are less than 1,257.0 feet. Therefore, the PROCRRS model was set to release a minimum instream flow of 15 cubic feet per second for all months except March. The minimum instream flow requirement for March was set at 40 cubic feet per second to account for higher streamflows that usually occur in March because of snowmelt runoff.

Simulated mean monthly, measured mean monthly, and end-of-month target elevations of Lake Ashtabula for 1950-84 are listed in table 6. Simulated and measured mean monthly elevations are in close agreement for April when Lake Ashtabula is being filled by snowmelt runoff. Simulated mean monthly elevations are higher than measured mean monthly elevations for all months except April. The greatest difference, which occurred in March, was 1.27 feet. Simulated mean monthly elevations were higher than measured mean monthly elevations because actual operation of Lake Ashtabula allows for adjustment of end-of-month target elevations depending on forecasted runoff into the reservoir, but the model allows the reservoir pool to reach end-of-month target elevations before water is released downstream.

Table 6.--Simulated mean monthly, measured mean monthly, and end-of-month target elevations of Lake Ashtabula, in feet above sea level, 1950-84

Month	Simulated mean monthly elevation	Measured mean monthly elevation	End-of-month target elevation
January	1,263.17	1,261.92	1,263.20
February	1,262.49	1,261.41	1,262.50
March	1,263.69	1,262.42	1,266.00
April	1,265.47	1,265.48	1,266.00
May	1,265.57	1,265.30	1,266.00
June	1,265.68	1,265.01	1,266.00
July	1,265.63	1,264.66	1,266.00
August	1,265.43	1,264.33	1,266.00
September	1,265.07	1,264.06	1,265.50
October	1,264.71	1,263.83	1,265.00
November	1,264.32	1,263.49	1,264.50
December	1,263.89	1,263.10	1,264.00

Simulated mean monthly streamflow for node 175, Sheyenne River below Baldhill Dam, N.Dak., was greater than gaged mean monthly streamflow for April and for September through February for 1950-84 hydrologic conditions (fig. 2). The largest difference was for April when simulated mean monthly streamflow was 55.4 cubic feet per second greater than gaged mean monthly streamflow. Simulated mean monthly steamflow was less than gaged mean monthly steamflow for March and for May through August. Simulated annual streamflow generally was in good agreement with gaged annual streamflow for 1950-84 hydrologic conditions (fig. 3). Simulated mean annual streamflow for 1950-84 was 2,074 acre-feet, or about 2 percent, greater than gaged mean annual streamflow. Simulated streamflow was 33,602 acre-feet greater than gaged streamflow in 1952 when the gaged streamflow was only 11,375 acre-feet. Prior to April 1952, the reservoir pool was maintained below normal pool elevations. The difference between simulated and gaged streamflow in 1952 reflects the quantity of water that went into reservoir storage to bring the pool to normal operating elevations.

Canals, Rivers, and Reservoirs Salinity Accounting Procedures Model

The primary goal of calibrating the CRRSAP model is to minimize the difference between simulated and measured dissolved-solids concentration data. The CRRSAP model was calibrated at selected nodes by graphically comparing the relation between simulated dissolved-solids concentration and streamflow to the relation between measured dissolved-solids concentration and streamflow. The coefficients for the simulated relation were adjusted until the difference between the two relations appeared to be minimized. The mean-square-error objective function was used to quantify the errors.

The model was calibrated for the range of streamflow that occurred during the period of water-quality record for each node. If only the low-flow or the high-flow part of the hydrologic regime were to be evaluated, recalibration of the model for that hydrologic regime could further reduce the error at some nodes. The model was calibrated for key nodes for the period when measured data were available for the node. The period of record differs among nodes.

The equations used to describe the relations between dissolved-solids concentration and streamflow (Guenthner, 1991) are shown in table 7. Each of these equations is significant at the 95 percent confidence level, unless otherwise noted.

Calibration for Selected Nodes

Node 50, Sheyenne River above Harvey, N.Dak.--Dissolved-solids concentrations for node 50 were calculated using monthly mean streamflow of the Sheyenne River above Harvey, N.Dak., in the relation between dissolved-solids concentration and streamflow developed by Guenthner (1991).

Node 75, Sheyenne River near Warwick, N.Dak.--A single relation between dissolved-solids concentration and streamflow for node 75 could not be developed (Guenthner, 1991). Therefore, a relation between dissolved-solids concentration and streamflow was developed for each month and the 12 individual monthly relations were used to estimate the dissolved-solids

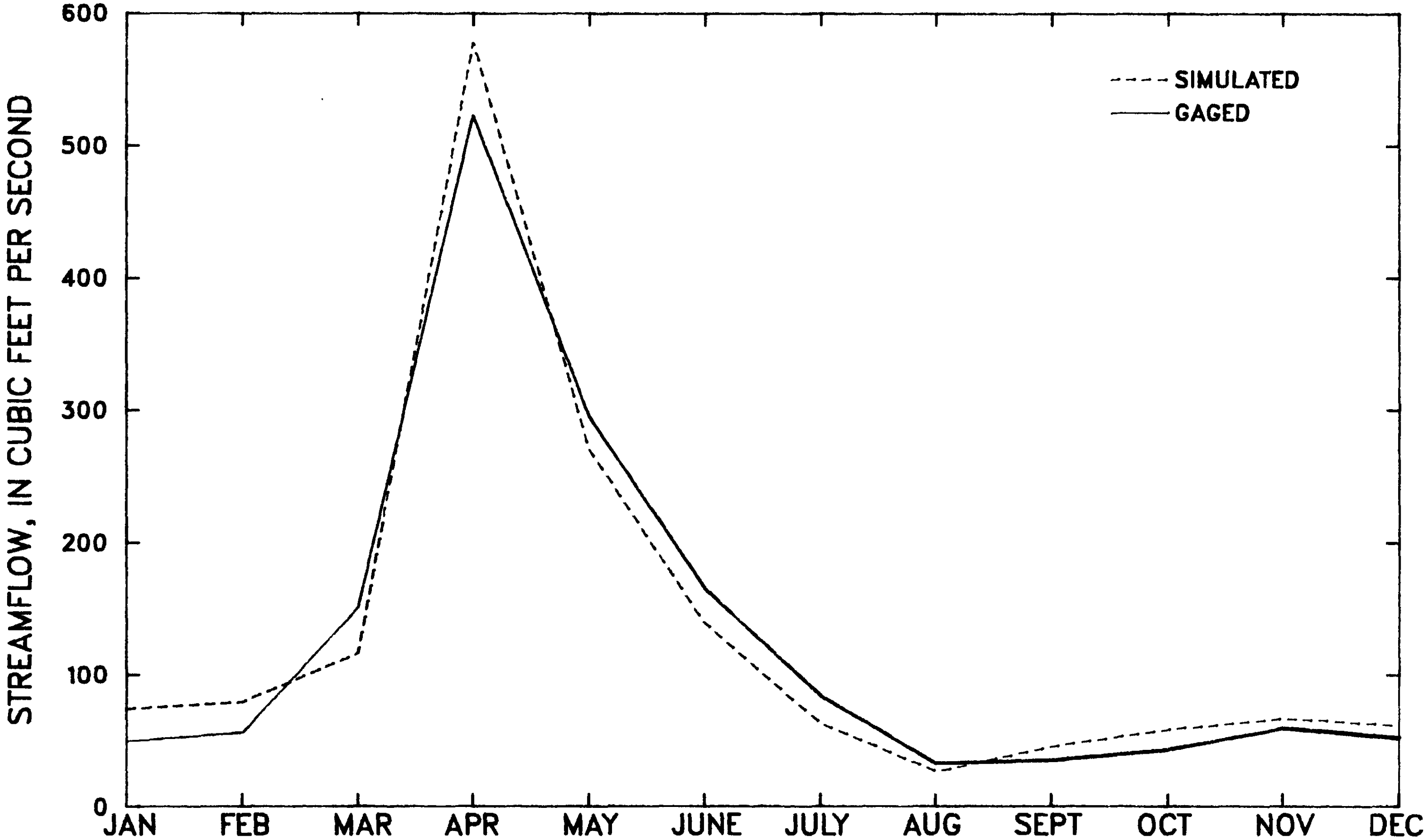

Figure 2.--Simulated mean monthly and gaged mean monthly streamflow for node 175, Sheyenne River below Baldhill Dam, North Dakota, 1950-84.

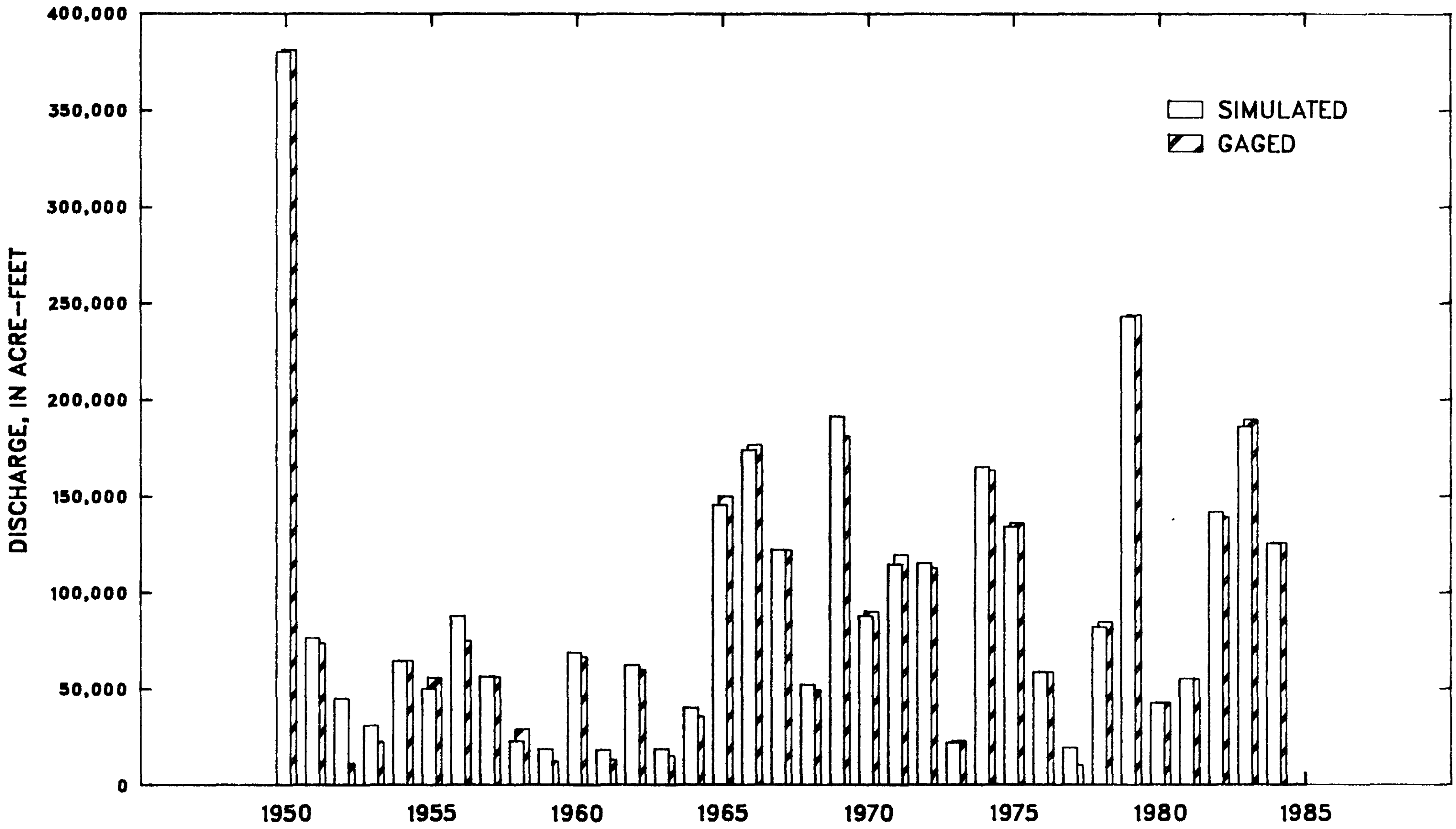

Figure 3.--Simulated annual and gaged annual streamflow for node 175, Sheyenne River below Baldhill Dam, North Dakota, 1950-84.

Table 7.--Relations between dissolved-solids concentration and streamflow for nodes in the Canals, Rivers, and Reservoirs Salinity Accounting Procedures model

[Modified from Guenthner, 1991; *DS*, dissolved-solids concentration, in milligrams per liter; *Q*, streamflow, in cubic feet per second]

Node number	Gaging station used to define water quality at the node	Equation
50	Station 05054500, Sheyenne River above Harvey, N.Dak.	$DS = 987 - 77.2 \ln Q$
125	Station 05057000, Sheyenne River near Cooperstown, N.Dak.	$DS = 730 - 43.8 \ln Q$
155	Station 05057200, Baldhill Creek near Dazey, N.Dak.	$DS = 597\ Q^{-0.175}$
225	Station 05058700, Sheyenne River at Lisbon, N.Dak.	$DS = 1{,}010\ Q^{-0.151}$
250	Station 05059000, Sheyenne River near Kindred, N.Dak.	$DS = 841 - 69.2 \ln Q$
275	Station 05059500, Sheyenne River at West Fargo, N.Dak.	$DS = 753 - 62.6 \ln Q$
280	Station 05059700, Maple River near Enderlin, N.Dak.	$DS = 1{,}510\ Q^{-0.247}$
290	Station 05060500, Rush River at Amenia, N.Dak.	$DS = 997\ Q^{-0.206}$
500	Station 05054000, Red River of the North below Fargo, N.Dak.	$DS = 605\ Q^{-0.093}$
525	Station 05062000, Buffalo River near Dilworth, Minn.	$DS = 915\ Q^{-0.165}$
550	Station 05064000, Wild Rice River at Hendrum, Minn.	$DS = 737\ Q^{-0.163}$
600	Station 05064500, Red River of the North at Halstad, Minn.	$DS = 904\ Q^{-0.116}$
650	Station 05079000, Red Lake River at Crookston, Minn.	$DS = 402\ Q^{-0.070}$
700	Station 05082500, Red River of the North at Grand Forks, N.Dak.	$DS = 506\ Q^{-0.052}$
800	Station 05102500, Red River of the North at Emerson, Man.	$DS = 1{,}460\ Q^{-0.168}$

concentrations for model input. Monthly mean runoff between nodes 50 and 75 was used in the relations to estimate dissolved-solids concentrations of the runoff (node 70). The monthly relations between dissolved-solids concentration and streamflow for node 75 are listed in table 8. The dissolved-solids concentrations for node 50 were added to those for node 70 to estimate the dissolved-solids concentrations for node 75.

Ground-water accrual has been identified as a significant contribution to streamflow in the reach between nodes 50 and 75 (Guenthner, 1991). The differences between simulated monthly mean dissolved-solids concentrations and measured dissolved-solids concentrations were about the same when ground-water accrual was included in the simulations and when ground-water accrual was not included in the simulations. Because the model was not sensitive to the ground-water dissolved-solids concentrations, ground-water accrual was not included in the final calibration for dissolved solids.

Generally, the magnitude of simulated monthly mean dissolved-solids concentrations for node 75 was in about the same range as measured dissolved-solids concentrations (fig. 4). For streamflows of less than 10 cubic feet per second, simulated monthly mean dissolved-solids concentrations tended to be greater than measured dissolved-solids concentrations.

Table 8.--Relations between dissolved-solids concentration and streamflow for node 75, by month, Sheyenne River near Warwick, North Dakota

[Modified from Guenthner, 1991; *DS*, dissolved-solids concentration, in milligrams per liter; *Q*, streamflow, in cubic feet per second]

Month	Equation
January	[1] $DS = 345 + 127 \ln Q$
February	[2] $DS = 608 - 61.4 \ln Q$
March	[2] $DS = 591 - 49.0 \ln Q$
April	[1] $DS = 739\ Q^{-0.170}$
May	[2,3] $DS = 724 - 50.8 \ln Q$
June	[2,3] $DS = 449 + 73.3 \ln Q$
July	[1] $DS = 435 + 32.1 \ln Q$
August	[1] $DS = 404 + 65.0 \ln Q$
September	[1] $DS = 346 + 65.8 \ln Q$
October	[2] $DS = 295 + 82.9 \ln Q$
November	[2] $DS = 183 + 153 \ln Q$
December	[1] $DS = 246 + 183 \ln Q$

[1] *Q* is daily mean streamflow.
[2] *Q* is instantaneous streamflow
[3] Relation is not significant at the 95 percent level.

Node 125, Sheyenne River near Cooperstown, N.Dak.--Calibration for node 125 was accomplished by a trial and error process. The period of calibration was 1960-84, when measured dissolved-solids concentrations were available. The relation between dissolved-solids concentration and streamflow (table 7) was developed using the streamflow for the Sheyenne River near Cooperstown, N.Dak., gaging station. Because dissolved-solids concentration of runoff between nodes 75 and 125 (node 120) was needed, the relation developed by Guenthner (1991) for the Sheyenne River near Cooperstown, N.Dak., could not be used directly. The trial and error calibration process was as follows: (1) The relation for the Sheyenne River near Cooperstown, N.Dak., was used with runoff between nodes 75 and 125 (node 120) and a simulation was completed for node 125; (2) a new relation between simulated monthly mean dissolved-solids concentration and simulated mean monthly streamflow was developed for node 125; (3) the new relation developed for node 125 in step 2 was compared to the relation developed from measured values for the Sheyenne River near Cooperstown, N.Dak.; (4) coefficients of the relation for node 120 in step 1 were increased or decreased depending on the comparison obtained in step 3; and (5) steps 2, 3, and 4 were repeated until no improvement could be detected in the comparison between the relations discussed in step 3. The relations between simulated monthly mean dissolved-solids concentration and streamflow

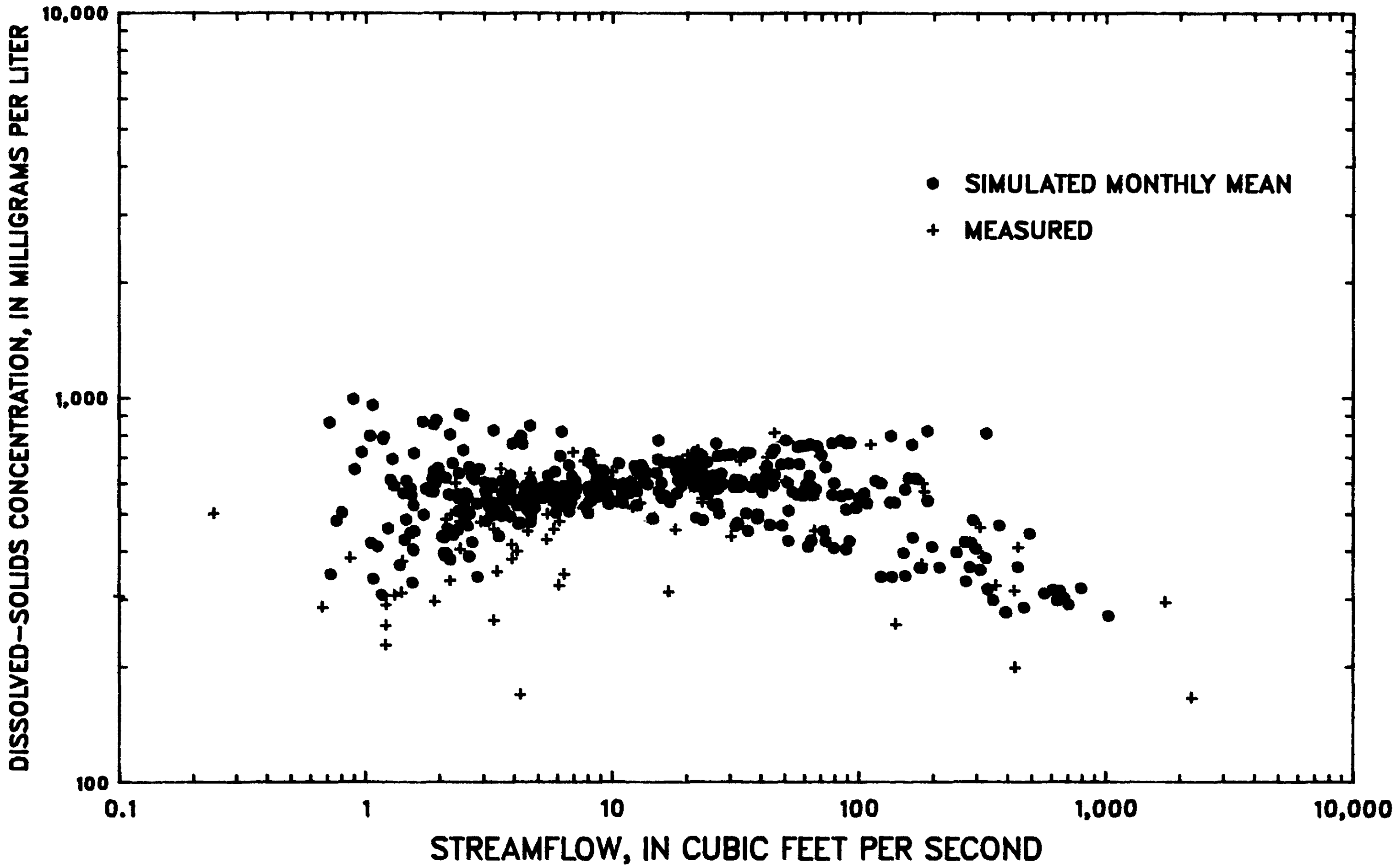

Figure 4.--Simulated monthly mean and measured dissolved-solids concentrations for node 75, Sheyenne River near Warwick, North Dakota, 1951-84.

and measured dissolved-solids concentration and streamflow for node 125 are shown in figure 5. The relation between simulated dissolved-solids concentration and runoff for node 120 is listed in table 9. Simulated monthly mean dissolved-solids concentrations and measured dissolved-solids concentrations will be about the same for a wide range of streamflow.

Node 145, Sheyenne River at the head of Lake Ashtabula; node 153, Lake Ashtabula lakeside runoff; and node 155, Baldhill Creek at the mouth.--No relation between dissolved-solids concentration and streamflow has been developed for the runoff between nodes 125 and 145 (node 140) or for node 153. The relation developed for Baldhill Creek near Dazey, N.Dak., was used for the runoff between nodes 125 and 145 (node 140), for node 153, and for node 155. No calibration was completed for these nodes.

Node 175, Sheyenne River below Baldhill Dam, N.Dak.--The model mixes inflow to Lake Ashtabula with the storage in the reservoir on a monthly basis. Releases from the reservoir are made at the concentration computed after all inflows have been mixed. Net evaporation leaves the reservoir as pure water (dissolved-solids concentration equal to zero milligrams per liter), leaving a larger concentration of dissolved solids in the lake. Reservoir storage at the beginning of January 1951 was 8,956 acre-feet. Initial dissolved-solids concentration was set at 480 milligrams per liter. Because initial storage is small in relation to total reservoir capacity and annual inflow, error in the beginning dissolved-solids concentration has little effect on long-term dissolved-solids concentration of storage in Lake Ashtabula. Mean simulated dissolved-solids concentration of storage in Lake Ashtabula for 1951-84 was 471 milligrams per liter.

Changes in dissolved-solids concentration could not be explained by changes in streamflow for node 175 (Guenthner, 1991). Dissolved-solids concentrations in streamflow immediately downstream from a large reservoir should remain relatively constant regardless of the magnitude of releases from the reservoir if storage is relatively well mixed. No attempt was made to calibrate node 175.

Simulated mean monthly dissolved-solids concentration and measured mean monthly dissolved-solids concentration for node 175 (fig. 6) are presented only to show the reader how simulated mean monthly values compare with measured values for 1960-84. Simulated mean monthly dissolved-solids concentrations shown in figure 6 can be used as an interpretation of dissolved-solids load released from Lake Ashtabula when used with mean monthly streamflow. Measured dissolved-solids concentrations shown in figure 6 are means of instantaneous values and should not be used as an interpretation of the dissolved-solids load released from Lake Ashtabula.

Node 200, Sheyenne River at Valley City, N.Dak.--Changes in dissolved-solids concentration could not be explained by changes in streamflow for node 200 (Guenthner, 1991), probably because of the influence of Lake Ashtabula. The relation between dissolved-solids concentration and streamflow that applies to the runoff between nodes 200 and 225 (node 220; table 9) also was used for the runoff between nodes 175 and 200 (node 195; table 9). No attempt was made to calibrate node 200.

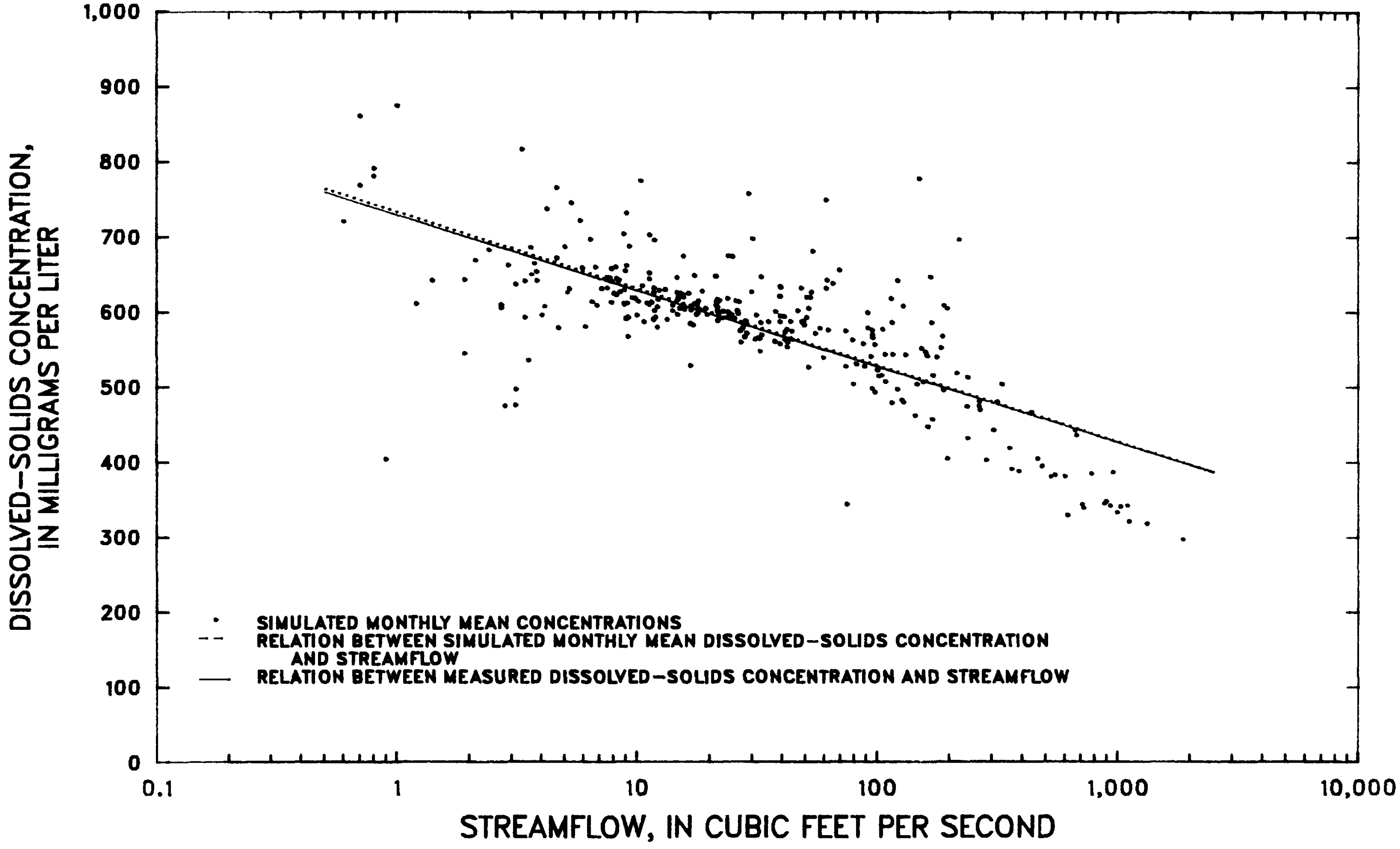

Figure 5.--Relation of streamflow to simulated monthly mean and measured dissolved-solids concentrations for node 125, Sheyenne River near Cooperstown, North Dakota, 1960-84.

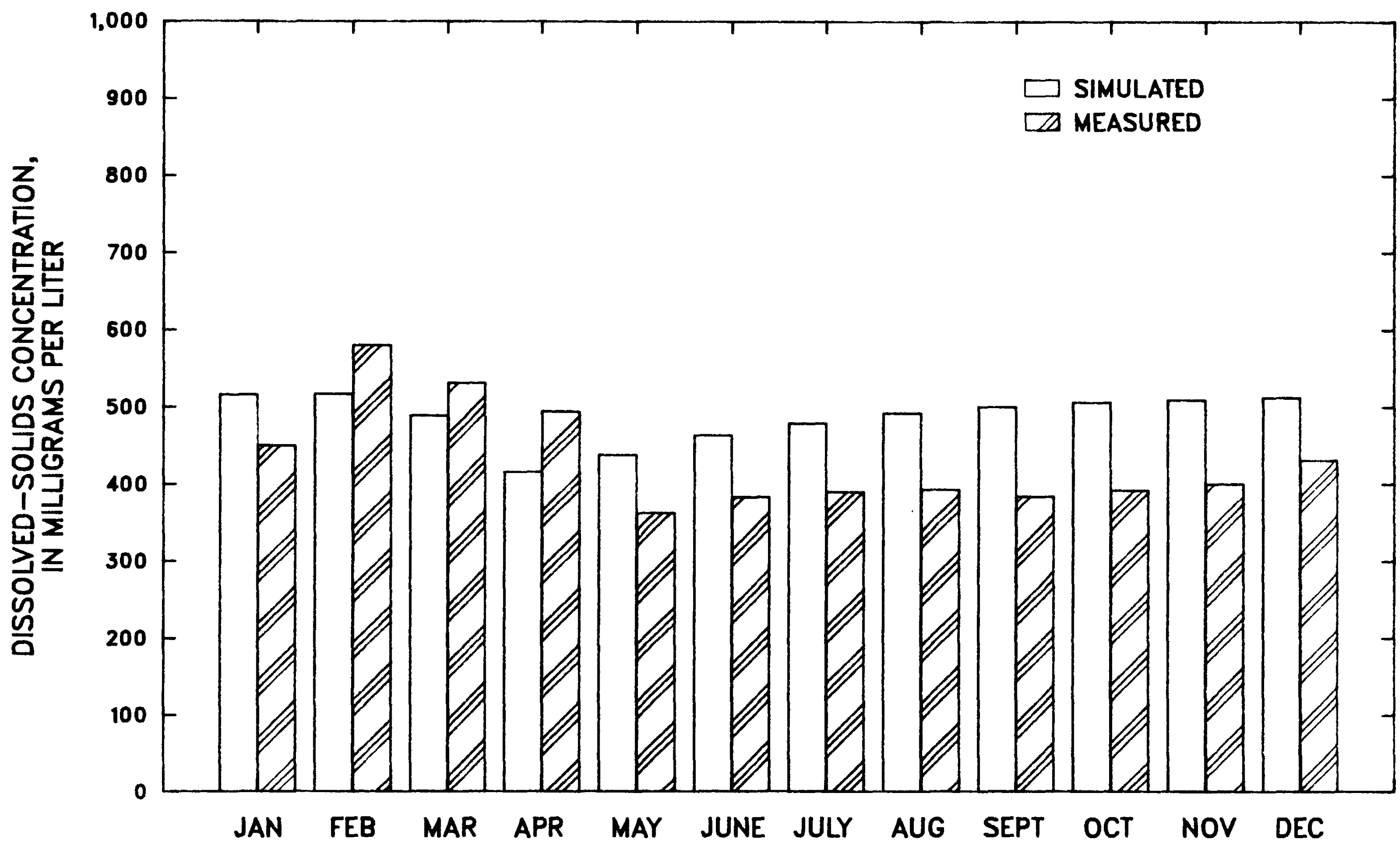

Figure 6.--Simulated and measured mean monthly dissolved-solids concentrations for node 175, Sheyenne River below Baldhill Dam, North Dakota, 1960-84.

Table 9.--Relations between simulated dissolved-solids concentration and runoff for selected nodes in the Canals, Rivers, and Reservoirs Salinity Accounting Procedures model

[*DS*, dissolved-solids concentration, in milligrams per liter; *Q*, streamflow, in cubic feet per second]

Node number	Description	Equation
120	Runoff into the Sheyenne River from Warwick to Cooperstown	$DS = 800 - 70.0 \ln Q$
195	Runoff into the Sheyenne River from Baldhill Dam to Valley City	$DS = 2{,}253\ Q^{-0.44}$
220	Runoff into the Sheyenne River from Valley City to Lisbon	$DS = 2{,}253\ Q^{-0.44}$
245	Runoff into the Sheyenne River from Lisbon to Kindred	$DS = 800 - 68.4 \ln Q$
270	Runoff into the Sheyenne River from Kindred to West Fargo	$DS = 575 - 71.0 \ln Q$
575	Runoff into the Red River of the North from Fargo to Halstad	$DS = 992\ Q^{-0.0900}$
675	Runoff into the Red River of the North from Halstad to Grand Forks	$DS = 1{,}096\ Q^{-0.0550}$
775	Runoff into the Red River of the North from Grand Forks to Emerson	$DS = 7{,}000\ Q^{-0.5500}$

Node 225, Sheyenne River at Lisbon, N.Dak.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 225. Coefficients of the relation for node 220, table 9, were adjusted to calibrate node 225. The period of calibration for node 225 was 1957-84. The relations between simulated monthly mean dissolved-solids concentration and streamflow and measured dissolved-solids concentration and streamflow for node 225 are shown in figure 7. Simulated monthly mean dissolved-solids concentrations were about the same as measured dissolved-solids concentrations for node 225 for the range of streamflow that has been measured for node 225 (fig. 7).

Node 250, Sheyenne River near Kindred, N.Dak.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 250. Coefficients of the relation for node 245, table 9, were adjusted to calibrate node 250. The period of calibration for node 250 was 1972-84. Ground-water accrual contributes to streamflow

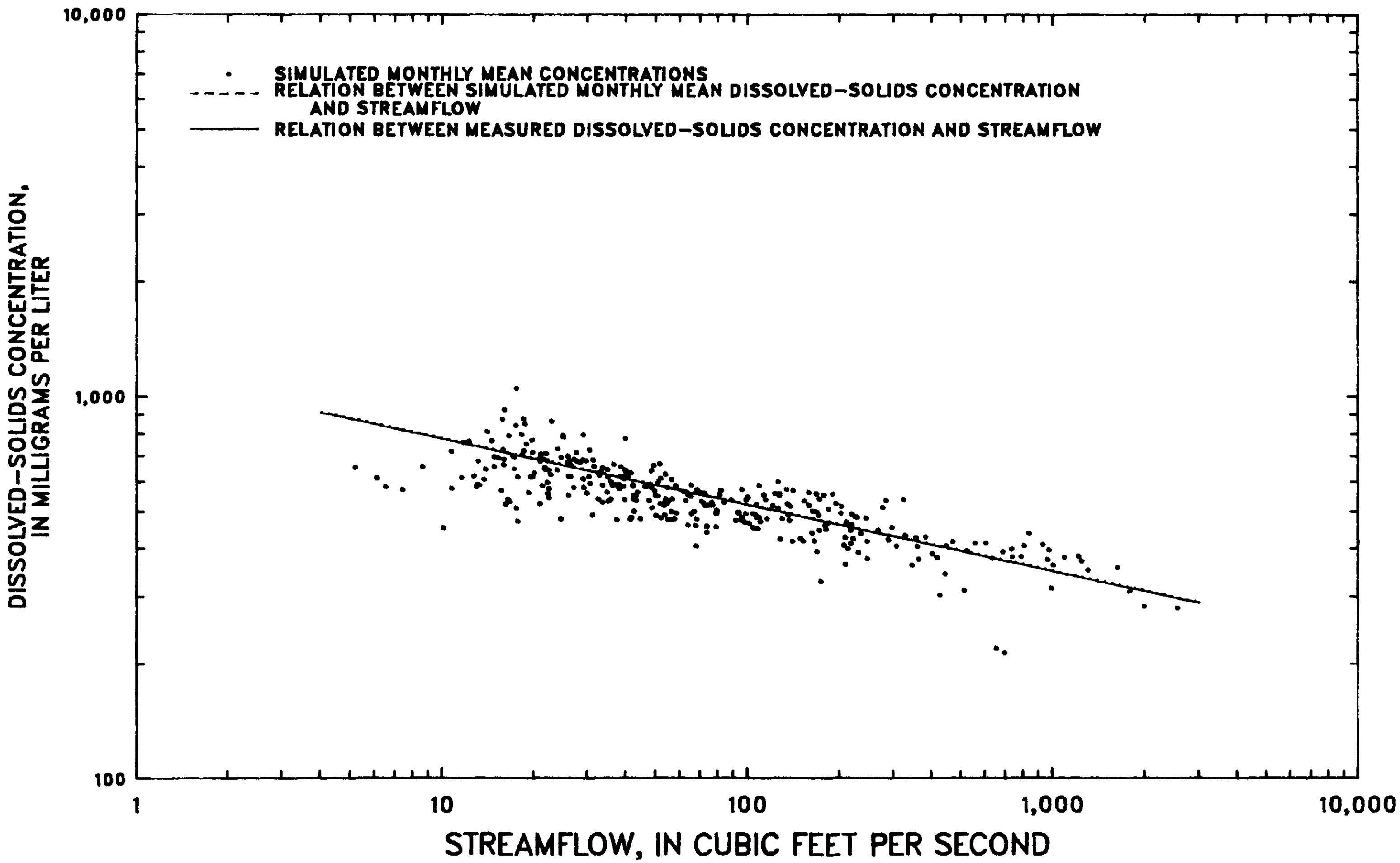

Figure 7.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 225, Sheyenne River at Lisbon, North Dakota, 1957-84.

between nodes 225 and 250, node 245. For modeling purposes, ground-water accrual is considered a source of inflow and dissolved solids when total runoff into the reach is less than 15 cubic feet per second. Ground-water accrual contributes at a rate equal to the total runoff into the reach but not at a rate of greater than 15 cubic feet per second. Dissolved-solids concentration of ground-water accrual was set at 440 milligrams per liter (Guenthner, 1991). At low flows, simulated monthly mean dissolved-solids concentrations would be about the same as measured dissolved-solids concentrations for node 250 (fig. 8). As streamflow increases, simulated monthly mean dissolved-solids concentrations gradually would become greater than measured dissolved-solids concentrations. At 3,000 cubic feet per second, simulated monthly mean dissolved-solids concentrations were about 16 milligrams per liter greater than measured dissolved-solids concentrations of 287 milligrams per liter (fig. 8).

Node 275, Sheyenne River at West Fargo, N.Dak.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 275. Coefficients of the relation for node 270, table 9, were adjusted to calibrate node 275. The period of calibration for node 275 was 1970-84. For the range of streamflow that has been measured for node 275, simulated monthly mean dissolved-solids concentrations generally will be from 55 to 60 milligrams per liter greater than measured dissolved-solids concentrations (fig. 9). However, the relation between measured dissolved-solids concentration and streamflow was based on only 21 measured values of dissolved-solids concentration and streamflow. When dissolved-solids concentrations were estimated from the larger specific-conductance data base and compared to simulated monthly mean dissolved-solids concentrations, a more favorable comparison was observed (fig. 9). Simulated monthly mean dissolved-solids concentrations ranged from about 60 milligrams per liter less to 30 milligrams per liter greater than dissolved-solids concentrations estimated from specific conductance. At the mean streamflow of 178 cubic feet per second, simulated monthly mean dissolved-solids concentration was only 14 milligrams per liter less than dissolved-solids concentration estimated from specific conductance.

Node 280, Maple River at the mouth, and node 290, Rush River at the mouth.--The relations between measured dissolved-solids concentration and streamflow for the Maple River near Enderlin, N.Dak., and for the Rush River at Amenia, N.Dak., were used to define the dissolved-solids concentrations for nodes 280 and 290, respectively. No calibration was necessary for these nodes because the model treats streamflow of the Maple River and the Rush River as inflow.

Node 500, Red River of the North at Fargo, N.Dak.--Although the Sheyenne River is a tributary of the Red River of the North, the model was set up to treat the Red River of the North as a tributary to the Sheyenne River. Treatment of the Red River of the North as a tributary allows the model to handle the Sheyenne River and the Red River of the North as one river system. Because the model treats streamflow of the Red River of the North upstream from Fargo as inflow, no calibration was necessary for node 500. The relation between measured dissolved-solids concentration and streamflow for the Red River of the North below Fargo, N.Dak., gaging station was used to define the dissolved-solids concentration for node 500.

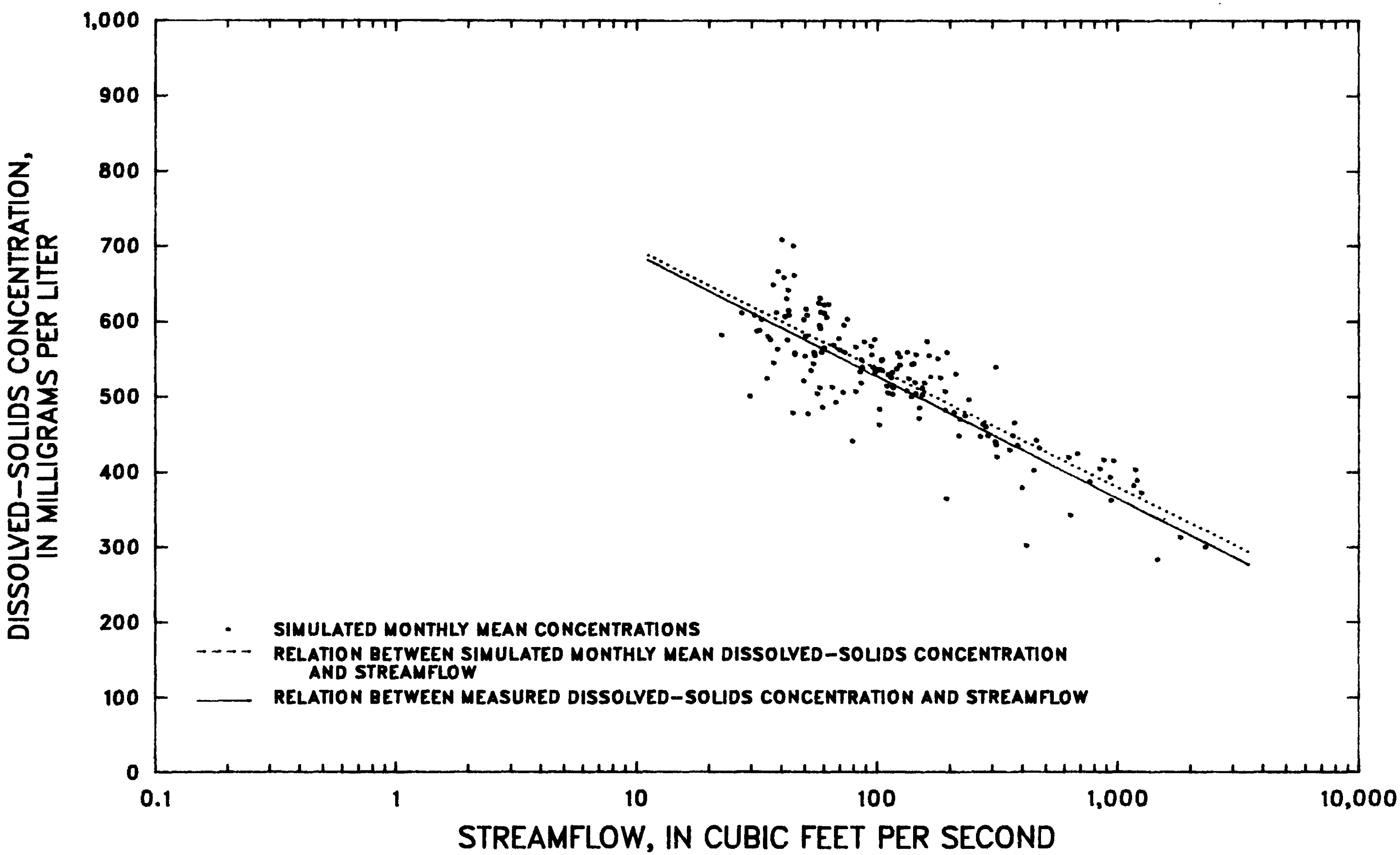

Figure 8.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 250, Sheyenne River near Kindred, North Dakota, 1972-84.

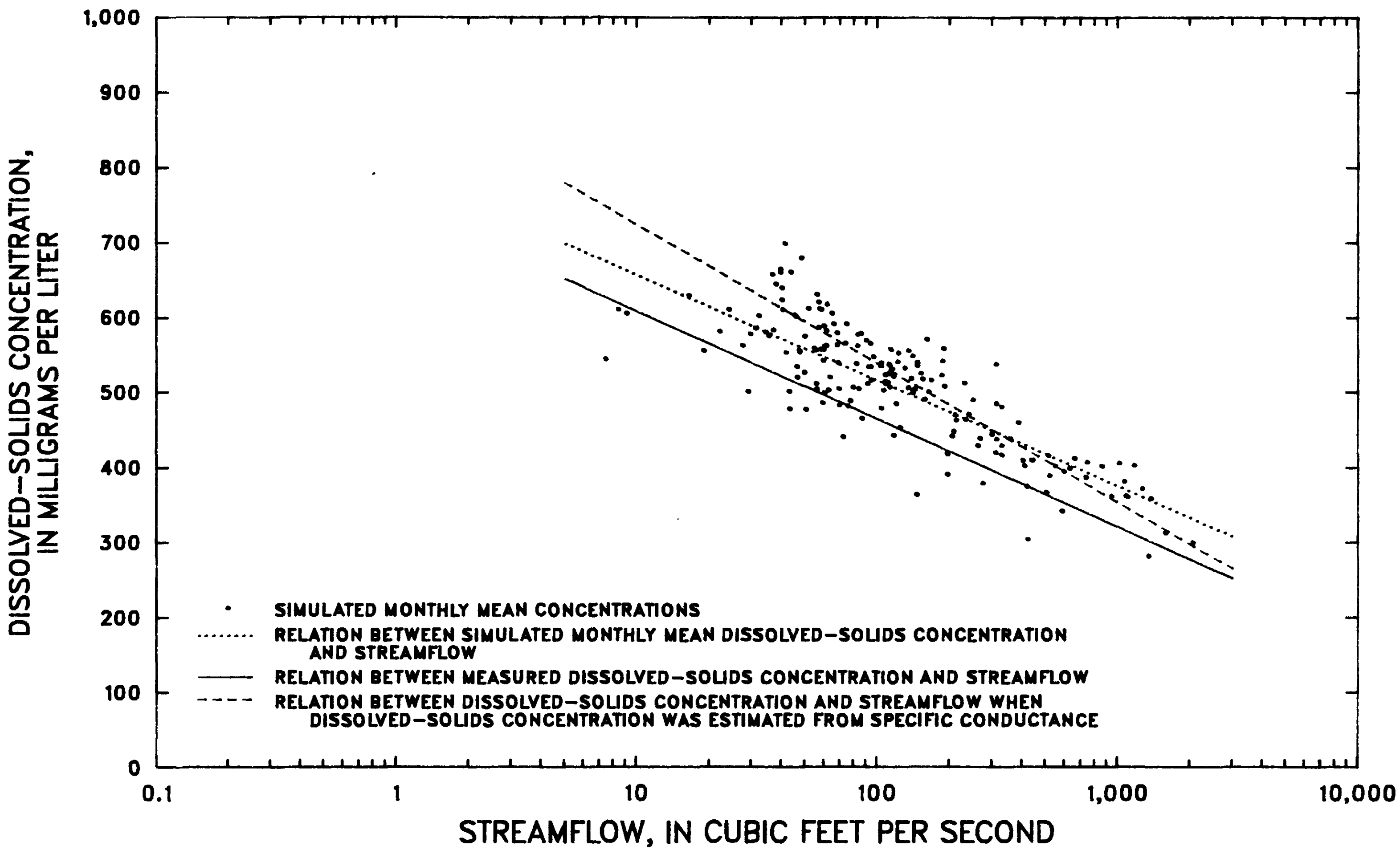

Figure 9.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 275, Sheyenne River at West Fargo, North Dakota, 1970-84.

Node 525, Buffalo River at the mouth, and node 550, Wild Rice River at the mouth.--The relations between measured dissolved-solids concentration and streamflow for the Buffalo River near Dilworth, N.Dak., and the Wild Rice River at Hendrum, Minn., were used to define the dissolved-solids concentrations for nodes 525 and 550, respectively. No calibration was necessary for these nodes because the model treats streamflow of the Buffalo River and the Wild Rice River as inflow.

Node 600, Red River of the North at Halstad, Minn.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 600. Coefficients of the relation for node 575, table 9, were adjusted to calibrate node 600. The period of calibration was 1970-84. For streamflow of less than 100 cubic feet per second, simulated monthly mean dissolved-solids concentrations would be slightly greater than measured dissolved-solids concentrations (fig. 10). For streamflow greater than 100 cubic feet per second, simulated monthly mean dissolved-solids concentrations would be about the same as measured dissolved-solids concentrations.

Node 650, Red Lake River at the mouth.--The relation between measured dissolved-solids concentration and streamflow for the Red Lake River at Crookston, Minn., was used to define the dissolved-solids concentrations for node 650. No calibration was necessary for node 650 because the model treats streamflow of the Red Lake River as inflow.

Node 700, Red River of the North at Grand Forks, N.Dak.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 700. Coefficients of the relations for node 675, table 9, were adjusted to calibrate node 700. The period of calibration was 1951-84. Simulated monthly mean dissolved-solids concentrations would range from 3 milligrams per liter less than measured dissolved-solids concentrations for streamflow of 100 cubic feet per second to 8 milligrams per liter less for streamflow of 36,000 cubic feet per second (fig. 11).

Node 800, Red River of the North at Emerson, Man.--The trial and error process used to calibrate node 125, Sheyenne River near Cooperstown, N.Dak., also was used to calibrate node 800. Coefficients of the relations for node 775, table 9, were adjusted to calibrate node 800. The period of calibration was 1977-84.

Calibration of node 800 initially was attempted by adding seven nodes to the model between nodes 700 and 800. The seven nodes added to the model represented inflow of the Turtle River, the Forest River, the Snake River, the Park River, and the Pembina River; ungaged runoff between node 700 and the Red River of the North at Drayton, N.Dak.; and ungaged runoff between the Red River of the North at Drayton, N.Dak., and node 800. Addition of the seven nodes between nodes 700 and 800 did not allow acceptable calibration of node 800. Therefore, the model was simplified and the seven nodes were combined as one node (node 775) to represent the total gain in streamflow and dissolved-solids load between nodes 700 and 800. A part of the streamflow and

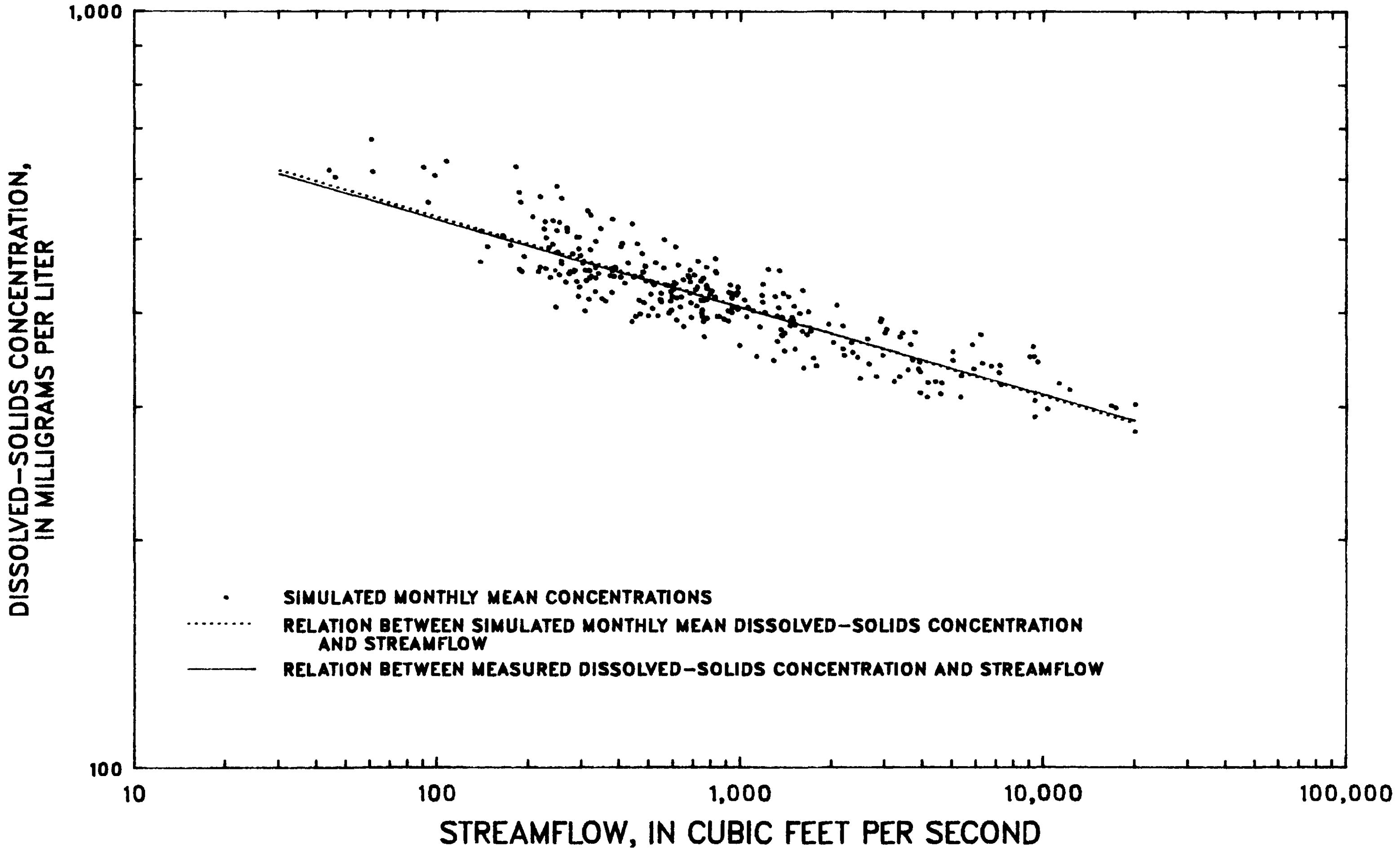

Figure 10.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 600, Red River of the North at Halstad, Minnesota, 1970-84.

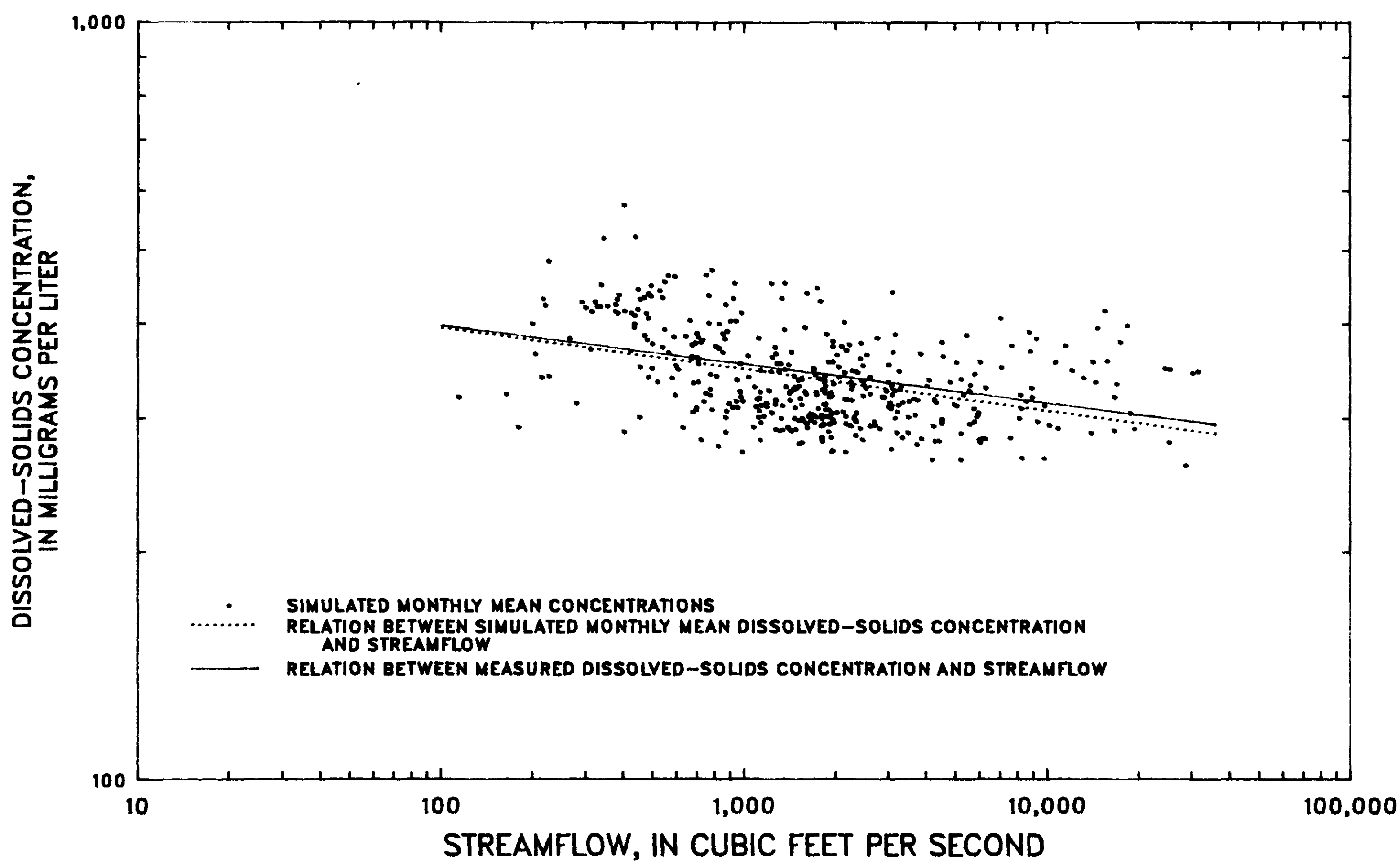

Figure 11.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 700, Red River of the North at Grand Forks, North Dakota, 1951-84.

dissolved-solids load for node 775 is from unaccounted-for sources. One possible source of streamflow and dissolved-solids load is ground-water accrual.

Ground-water accrual has been identified as a source contributing to streamflow between node 700 and node 800. Simulation of the regional flow system of the Cambrian-Ordovician aquifer by Downey (1984) indicated that ground-water accrual to the Red River of the North in northeastern North Dakota and eastern Manitoba ranged from about 10 to 40 cubic feet per second. Downey (1986) reported that dissolved-solids concentration of ground-water accrual may range from about 10,000 milligrams per liter to 50,000 milligrams per liter. The accepted calibration for node 800 was for ground-water accrual of 75 cubic feet per second and for ground-water dissolved-solids concentration of 5,000 milligrams per liter. For modeling purposes, ground water was assumed to contribute to streamflow when total runoff between nodes 700 and 800 is less than 1,000 cubic feet per second. For streamflow of 200 cubic feet per second, simulated monthly mean dissolved-solids concentrations would be about 44 milligrams per liter less than measured dissolved-solids concentrations (fig. 12). For streamflow of 2,500 cubic feet per second, simulated monthly mean dissolved-solids concentrations and measured dissolved-solids concentrations would be about equal. For streamflow of 36,000 cubic feet per second, simulated monthly mean dissolved-solids concentrations would be about 20 milligrams per liter greater than measured monthly mean dissolved-solids concentrations.

Recalibration of node 800 should be considered as additional information on the interaction of the surface-water and ground-water systems becomes available. Although recalibration of node 800 may be desirable, model results at node 700 may indicate the magnitude of dissolved-solids concentration change that may occur at node 800 as a result of operation of the Garrison Diversion Unit Sheyenne River water supply.

Error Analysis

The mean-square-error objective function also was used during calibration of the dissolved-solids model. The mean-square-error objective function was used during calibration of a similar model of selected tributaries of the Yampa River, northwestern Colorado (Parker and Norris, 1983) and of the Yampa River (Parker and Litke, 1987). The error function uses the differences between logarithms of concentrations estimated from the relations (Guenthner, 1991) and logarithms of concentrations simulated by the CRRSAP model. The mean square error is:

$$\mathrm{MSE} = x^2 + s^2, \tag{1}$$

where

x is bias, or mean of differences between logarithms of concentrations estimated from the relation and logarithms of concentrations simulated by the CRRSAP model; and

s^2 is variance of differences between logarithms of concentrations estimated from the relation and logarithms of concentrations simulated by the CRRSAP model.

The bias, variance, mean square error, and mean error in percent for dissolved-solids concentration for selected nodes for the period of

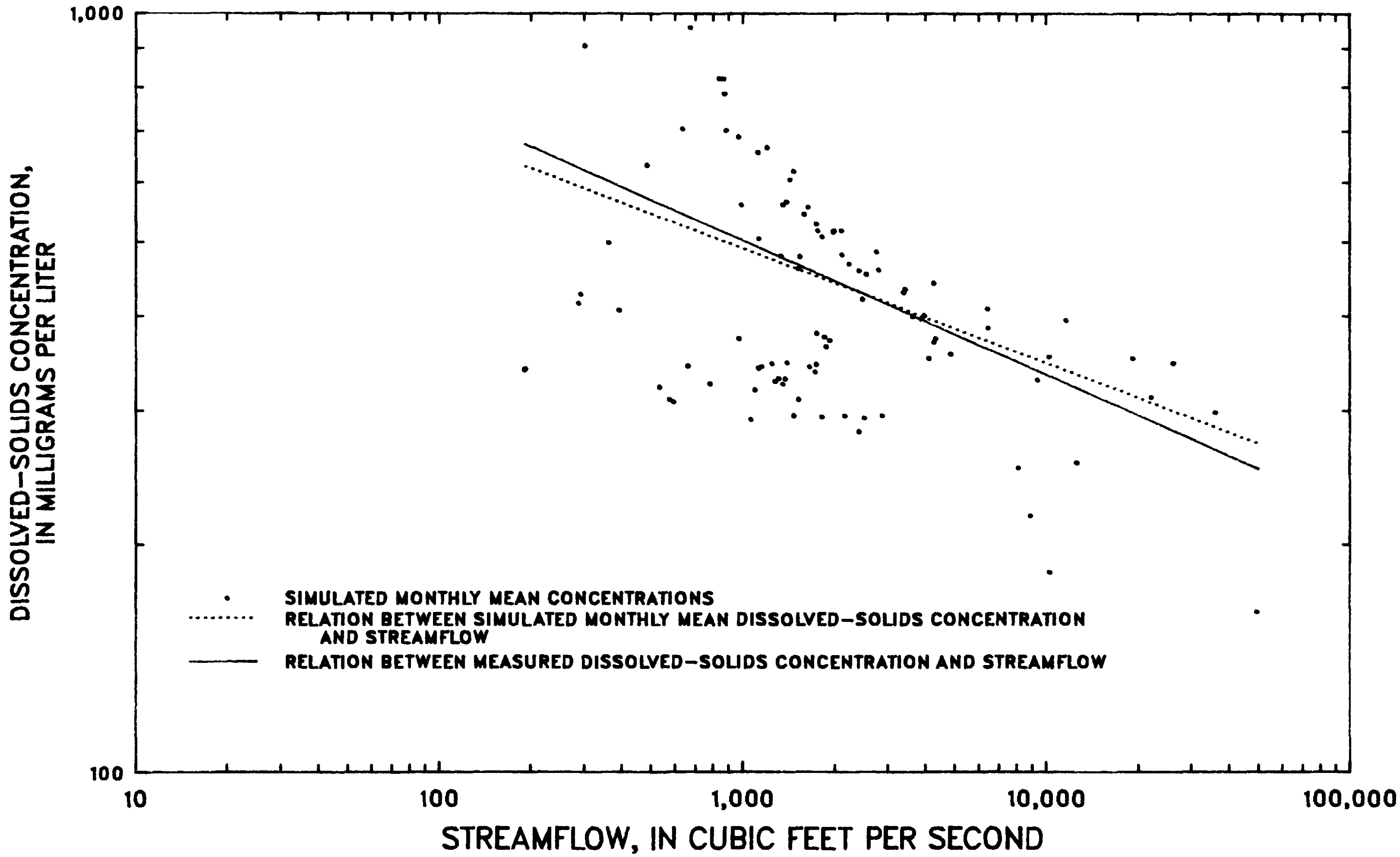

Figure 12.--Relation of streamflow to simulated and measured dissolved-solids concentrations for node 800, Red River of the North at Emerson, Manitoba, 1977-84.

calibration are listed in table 10. The mean error in percent can be derived from Matalas (1967) as:

$$\text{mean error} = \left(e^{x+\frac{s^2}{2}} - 1\right)100 \qquad (2)$$

where

e is base of natural logarithms, and

x and s^2 are as previously defined.

Mean error is difference between logarithms of concentrations estimated from the relations and logarithms of concentrations simulated by the CRRSAP model divided by simulated concentrations.

The mean error was less than 5 percent for all nodes except nodes 75, where the mean error was -13.8 percent, and 275, where the mean error was -10.4 percent (table 10). The error analysis assumes that estimated dissolved-solids concentrations are without error. However, this assumption is not satisfied because estimated dissolved-solids concentrations are estimates of measured values and include some error from the relation. Therefore, the mean error in percent for each node in the CRRSAP model may be larger than indicated in table 10.

SIMULATION OF GARRISON DIVERSION UNIT SHEYENNE RIVER WATER SUPPLY OPERATION

Streamflow modeling may be used to assess the effects the operation of the Garrison Diversion Unit Sheyenne River water supply could have on streamflow and water quality of the Sheyenne River and the Red River of the North. The PROCRRS and CRRSAP models were used to simulate three conditions: (1) baseline conditions, (2) year-round operation of the Garrison Diversion Unit Sheyenne River water supply, and (3) nonwinter operation (April through October) of the Garrison Diversion Unit Sheyenne River water supply. Effects were assessed by comparing simulated streamflows that include Missouri River water to simulated streamflows that do not include Missouri River water. In addition, the model was used to evaluate the potential of Lake Ashtabula as a storage facility for Missouri River water. Evaluation of storage in Lake Ashtabula is important because of concern regarding winter operation of the Garrison Diversion Unit canal system that delivers Missouri River water to the Sheyenne River. The delivery canal will carry water for the Sheyenne River water supply along with water for other uses. The ability of Lake Ashtabula to store Missouri River water determines, in part, what percentage of delivery-canal capacity should be reserved for the Garrison Diversion Unit Sheyenne River water supply.

Baseline Conditions

Baseline conditions represented in the models consist of: (1) Gaged and estimated streamflow (1931-84) of the Sheyenne River and the Red River of the North adjusted to reflect the absence of water-resource developments (unregulated streamflow), (2) 1984 permitted surface-water withdrawals for irrigation and municipal use, and (3) estimated 1990 demands for municipal releases from Lake Ashtabula for Fargo, N.Dak., and Moorhead, Minn. Unregulated streamflow, as used in this report, is the streamflow that would

Table 10.--Error analysis of simulated mean monthly dissolved-solids concentration for selected nodes in the Canals, Rivers, and Reservoirs Salinity Accounting Procedures model

Node number	Bias (x)	Variance (s^2)	Mean square error (MSE)	Mean error (percent)
75	-0.1742	0.0512	0.0812	-13.8
125	.0044	.0135	.0135	1.1
225	-.0018	.0170	.0170	.7
250	-.0181	.0073	.0076	-1.4
275	-.1142	.0083	.0212	-10.4
600	-.0080	.0055	.0055	.5
700	.0167	.0161	.0164	2.5
800	-.0051	.0925	.0925	4.2

occur if the hydrologic effects of Lake Ashtabula and surface-water withdrawals were eliminated. The hydrologic effects of small ponds and reservoirs constructed during the data-development period were not considered in the computation of unregulated streamflows.

Gaged streamflow of the Sheyenne River and the Red River of the North adjusted to reflect the absence of water-resource developments (unregulated streamflow) was estimated by Guenthner and others (1990). Unregulated streamflow of gaged tributaries to the Sheyenne River and the Red River of the North and unregulated ungaged runoff into selected river reaches were used as model input for baseline conditions in place of gaged streamflow used for model calibration.

Unregulated streamflow of the Sheyenne River downstream from Baldhill Dam has the regulated effect of Lake Ashtabula and permitted surface-water withdrawals removed from the gaged streamflow record. Unregulated streamflow of the Red River of the North has the effects of Lake Ashtabula and permitted surface-water withdrawals removed from the gaged streamflow record, but not the effects of other reservoirs in the basin.

Streamflow of the Red River of the North is regulated partly by Orwell Reservoir on the Ottertail River and Lake Traverse on the Bois de Sioux River, along with other controlled lakes and ponds and several powerplants. Therefore, the unregulated streamflow of the Red River of the North still has effects of some reservoirs. Storage capacities and operation of some reservoirs have changed during 1931-84 so streamflows that occurred during 1931-84 may not occur in the future. Because the model does not simulate operation of reservoirs upstream of node 500 on the Red River of the North, streamflows simulated by the model may not represent streamflow that would occur for present operating criteria of Orwell Reservoir, Lake Traverse, and other controlled lakes and ponds.

Nodes that represent permitted surface-water withdrawals for 1984 are listed in table 11. Model simulation of baseline conditions for 1931-84 (648 months) indicated that all monthly permitted surface-water withdrawals could not be satisfied by unregulated streamflow. The number of months that surface-water shortages occurred for selected river reaches and tributaries is listed in table 12. Permitted surface-water withdrawals for 1984 were reduced by the quantity of the shortage, referred to as adjusted 1984 surface-water withdrawals, and the adjusted 1984 surface-water withdrawals were used in the models for simulation of baseline conditions.

The cities of Fargo, N.Dak., and Moorhead, Minn., have an existing allotment of water from Lake Ashtabula. A node that represents delivery of the existing municipal allotment of water from Lake Ashtabula to Fargo, N.Dak., and Moorhead, Minn., is included in the model (node 272). The U.S. Army Corps of Engineers conducted a low-flow reservoir-systems analysis of the Red River of the North basin in 1979 (Bill Spychalla, written commun., 1987). As part of that analysis, municipal water demands for Fargo, N.Dak., and Moorhead, Minn., were estimated for the future, including 1990. The 1990 estimated demands for municipal water from Lake Ashtabula for Fargo, N.Dak., and Moorhead, Minn., were used as the 1984 demands and were used for simulation of baseline conditions. The U.S. Army Corps of Engineers reservoir-systems analysis of 1990 demands for hydrologic conditions for January 1931 through September 1976 indicated that water from Lake Ashtabula

Table 11.--Nodes used to represent diversion for 1984 permitted surface-water withdrawals

Node number	Description
71	Permitted withdrawals from headwaters to near Warwick
121	Permitted withdrawals from near Warwick to near Cooperstown
196	Permitted withdrawals from below Baldhill Dam to Valley City
221	Permitted withdrawals from Valley City to Lisbon
246	Permitted withdrawals from Lisbon to near Kindred
271	Permitted withdrawals from near Kindred to West Fargo
272	Withdrawal of Fargo, N.Dak. and Moorhead, Minn., municipal allocation from Lake Ashtabula
276	Permitted withdrawals from West Fargo to the Sheyenne River mouth
580	Permitted withdrawals from Fargo to Halstad
680	Permitted withdrawals from Halstad to Grand Forks
780	Permitted withdrawals from Grand Forks to Drayton
781	Permitted withdrawals from Drayton to Emerson

Table 12.--Number of months surface-water shortages occurred at the 1984 level of withdrawal for selected river reaches and tributaries during simulation of 1931-84 baseline conditions

River reach or tributary	Number of months shortages occurred
Sheyenne River	
Headwaters to near Warwick	216
Near Warwick to near Cooperstown	61
Near Cooperstown to below Baldhill Dam	0
Below Baldhill Dam to Valley City	49
Valley City to Lisbon	66
Lisbon to near Kindred	41
Near Kindred to West Fargo	71
West Fargo to the mouth	125
Buffalo River	69
Elm River	483
Wild Rice River	4
Red River of the North	
Sheyenne River at the mouth to Halstad	13
Goose River	350
Sand Hill River	
Red Lake River	50
Red River of the North	
Halstad to Grand Forks	52
Turtle River	41
Forest River	115
Snake River	
Park River	391
Red River of the North	
Grand Forks to Drayton	44
Tongue River	42
Red River of the North	
Drayton to Emerson	32

was diverted during 23 months (table 13) for the Fargo, N.Dak., and Moorhead, Minn., water supply (Bill Spychalla, written commun., 1987). Water demands from Lake Ashtabula for October 1977 through December 1984 were estimated to be 25 cubic feet per second for months when the streamflow of the Red River of the North below the city of Fargo, N.Dak., water-supply facility was less than 10 cubic feet per second (one of the criteria in the U.S. Army Corps of Engineers analysis). The months water was diverted and the quantity of water diverted from Lake Ashtabula for the Fargo, N.Dak., and Moorhead, Minn., water supply are listed in table 13.

For baseline conditions, initial dissolved-solids concentration of storage in Lake Ashtabula was set at 505 milligrams per liter, which was the long-term mean concentration of water releases from Lake Ashtabula as measured for the Sheyenne River below Baldhill Dam, N.Dak., gaging station (Guenthner, 1991). Beginning reservoir content of Lake Ashtabula was set at 59,900 acre-feet.

Sensitivity of the model was tested by simulating baseline conditions for two different initial dissolved-solids concentrations of storage in Lake Ashtabula. Initial dissolved-solids concentration of storage in Lake Ashtabula was first set at 505 milligrams per liter and then at 450 milligrams per liter. The value of 505 is based on existing data and the value of 450 was arbitrarily picked. Comparison of dissolved-solids concentrations of storage for the two baseline simulations for 1931-84 indicated dissolved-solids concentrations converged in December 1942. Dissolved-solids concentrations of Lake Ashtabula storage were the same for the two baseline simulations after December 1942. Streamflows for 1933-41 were relatively low compared to streamflows for other periods during 1931-84. Dissolved-solids concentrations for the two baseline simulations would have converged earlier than December 1942 if streamflow would have been more representative of normal streamflow for the period 1931-84. Selection of 505 or 450 milligrams per liter for initial dissolved-solids concentration of storage in Lake Ashtabula did not significantly influence long-term or monthly mean dissolved-solids concentrations in Lake Ashtabula or of nodes downstream from Lake Ashtabula.

Model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84, is summarized in the Supplemental Information section.

Year-Round Operation

One of the operating plans of the Garrison Diversion Unit Sheyenne River water supply is to deliver Missouri River water to the Sheyenne River for 12 months each year. Nodes used to represent year-round delivery of Missouri River water and to represent withdrawals of the water from the river system for municipal and industrial use are listed in table 14. For model purposes, 67 cubic feet per second was withdrawn from the river system by the city of Fargo, N.Dak., and 33 cubic feet per second was withdrawn by the city of Grand Forks, N.Dak.

Table 13.--Estimated quantity of water that would be required to be delivered to Fargo, North Dakota, and Moorhead, Minnesota, from muncipal storage in Lake Ashtabula to satisfy estimated 1990 demands for hydrologic conditions during 1931-84

[All values are in cubic feet per second]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1931	0	0	0	0	0	0	0	0	25.0	0	0	0
1932	0	0	0	0	0	0	25.0	25.0	25.0	25.0	0	0
1933	0	0	0	0	0	0	0	0	25.0	0	0	0
1934	0	0	0	25.0	0	0	0	25.0	25.0	25.0	25.0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	25.0	25.0	25.0	25.0	25.0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	25.0	25.0	14.8	0	0
1940	0	0	0	0	0	0	0	0	25.0	25.0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	25.0	25.0	25.0	25.0	25.0
1977	25.0	25.0	0	0	0	0	0	25.0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	25.0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0

Table 14.--Description of nodes used for simulation of year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply

Node number	Description
25	Garrison Diversion Unit Sheyenne River water supply
144	Increased evaporation from upper Sheyenne River
273	Increased evaporation from lower Sheyenne River
274	Withdrawal of Garrison Diversion Unit water for the city of Fargo, N.Dak., and vicinity
690	Increased evaporation from the Red River of the North
695	Withdrawal of Garrison Diversion Unit water for the city of Grand Forks, N.Dak., and vicinity

Monthly mean dissolved-solids concentrations for Missouri River water entering the Sheyenne River were obtained from the U.S. Bureau of Reclamation. The U.S. Bureau of Reclamation conducted model studies similar to this study on the James River in North Dakota and South Dakota (U.S. Bureau of Reclamation, 1989b, 1989c). The James River model studies, option S6 (U.S. Bureau of Reclamation, 1989c), included a water allocation for the Garrison Diversion Unit Sheyenne River water supply through the proposed Sykeston Canal. Monthly mean dissolved-solids concentrations of water in the proposed Sykeston Canal simulated by the James River model were used as the monthly mean dissolved-solids concentrations of Missouri River water discharging to the Sheyenne River for 1953-82. Because the James River model studies only simulated dissolved-solids concentrations for 1953-82, dissolved-solids concentration data for 1931-52 and for 1983-84 were estimated. Monthly mean dissolved-solids concentrations of the Garrision Diversion Unit Sheyenne River water supply for 1932-51 and for 1983-84 were estimated to be the mean monthly dissolved-solids concentrations from the James River model option S6. Model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84, is summarized in the Supplemental Information section.

Nonwinter Operation

Delivery of Missouri River water to the Sheyenne River during the nonwinter period April through October could avoid the problem of canal icing. Nodes used to represent delivery of Missouri River water to the Sheyenne River for April through October and to represent withdrawals of the water from the river system for municipal and industrial use for January through December are listed in table 14.

Dissolved-solids concentrations of Missouri River water for nonwinter operation were the same as those used in simulation of the year-round operation of the Garrison Diversion Unit Sheyenne River water supply. Model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84, is summarized in the Supplemental Information section.

Comparison of Simulated Baseline Conditions, Year-Round Operation and Nonwinter Operation

Simulated mean monthly elevations of Lake Ashtabula for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for 1931-84 are shown in figure 13. Simulated elevations of Lake Ashtabula for baseline conditions and for year-round operation are identical and are greatest in April. Missouri River water can be delivered to Lake Ashtabula on a year-round basis without changing the existing operating criteria of the reservoir. However, the model representation of the operating criteria of Lake Ashtabula was modified to allow for nonwinter operation. To provide the necessary storage for nonwinter operation, the simulated water level of Lake Ashtabula was lowered during February and March. The lower elevation of Lake Ashtabula during February and March also offers the advantage of additional flood storage during spring runoff when compared to existing operation of the lake. Using the modified operating criteria, simulated elevations for nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply are greatest in October. The simulated differences in elevations between year-round operation and nonwinter operation reflect the additional storage in Lake Ashtabula necessary to maintain releases for November through March. Simulated mean monthly elevations for year-round operation of the Garrison Diversion Unit Sheyenne River water supply ranged from 1,260.87 to 1,264.26 feet above sea level. Simulated mean monthly elevations for nonwinter operation ranged from 1,258.37 to 1,265.66 feet above sea level.

Simulated mean annual evaporation from the water surface of Lake Ashtabula for year-round operation of the Garrison Diversion Unit Sheyenne River water supply was 87 acre-feet less than the simulated mean annual evaporation for nonwinter operation for 1931-84. Mean annual evaporation of 87 acre-feet is only 0.12 cubic foot per second.

For simulation of year-round and nonwinter operation, simulated Missouri River water was delivered to Fargo, N.Dak., during all months for 1931-84, but Missouri River water was not delivered to Grand Forks, N.Dak., during all months for 1931-84. Simulated Missouri River water was available in the river system at node 395, Sheyenne River at the mouth, but the water was lost in the Red River of the North between nodes 395, Sheyenne River at the mouth, and 700, Red River of the North at Grand Forks, N.Dak. The Red River of the North between Fargo, N.Dak., and Grand Forks, N.Dak., (excluding inflow of the Sheyenne River, the Buffalo River, the Wild Rice River, and the Red Lake River) historically loses streamflow during months of low streamflow. Simulated Missouri River water is used to satisfy this historic loss of streamflow. The loss of streamflow may be accounted for by real losses (such

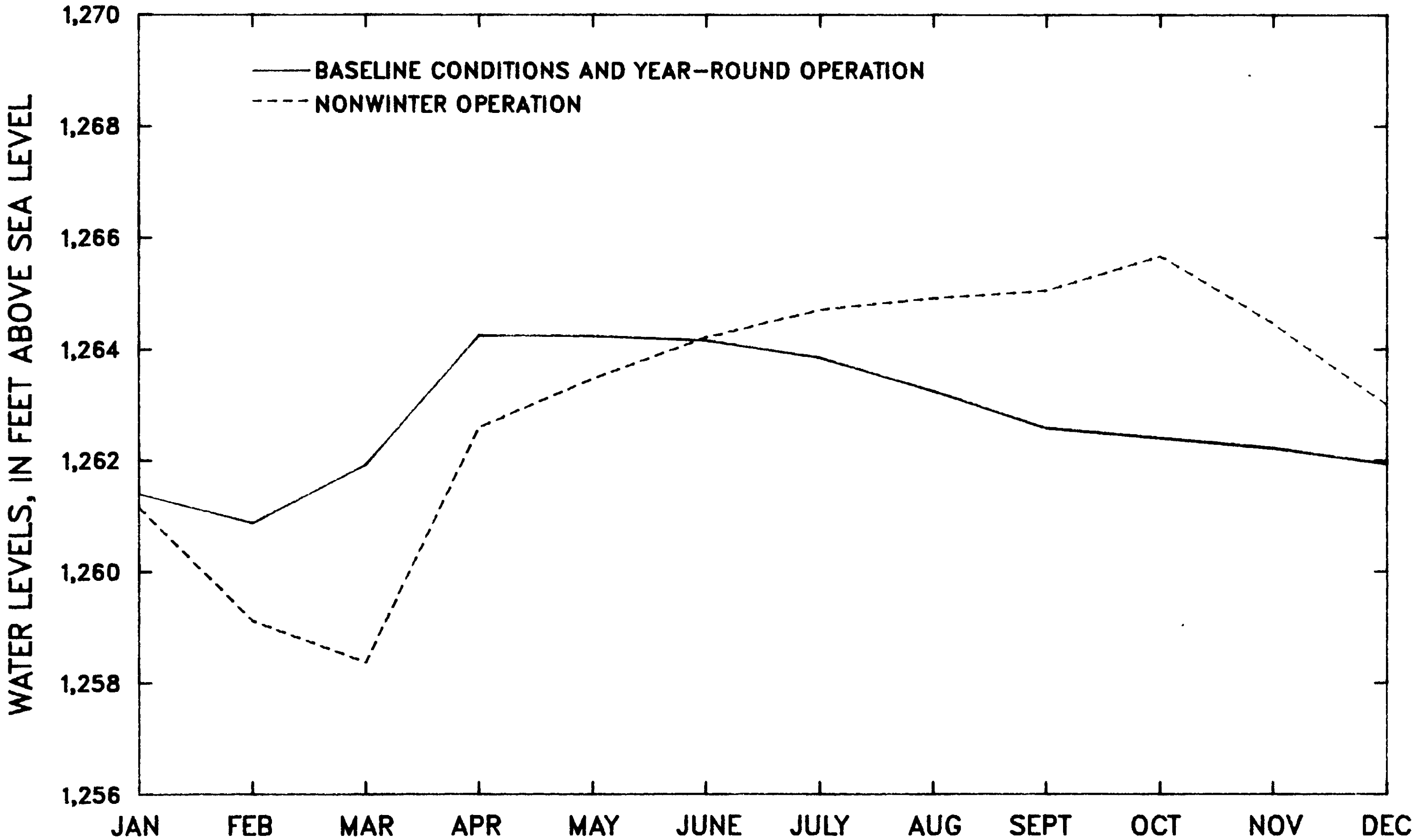

Figure 13.--Simulated mean monthly elevations of Lake Ashtabula for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply, 1931-84.

as evaporation, ground-water recharge, and temporary loss to ice storage) or to errors in estimating inflow from the Sheyenne River, the Buffalo River, the Wild Rice River, and the Red Lake River. It is possible that Missouri River water would not reach Grand Forks, N.Dak., during months of natural low streamflow during both year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply if only 33 cubic feet per second of Missouri River water is delivered to the mouth of the Sheyenne River.

Simulated mean monthly streamflows for selected nodes on the Sheyenne River for baseline conditions and year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for 1931-84 are listed in table 15. Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for selected nodes on the Sheyenne River and the Red River of the North for 1931-84 are listed in table 16 and shown in figures 14 through 23. Throughout most of this report, simulated mean values of streamflow and dissolved-solids concentration for baseline conditions and year-round and nonwinter operation of the Garrison Diversion Unit are compared. Because hydrologic data often are skewed, the reader also may want to compare median values. Simulated median values are given in the Supplemental Information section.

Median monthly dissolved-solids concentrations were compared for node 800 instead of mean mönthly dissolved-solids concentrations because, for streamflows of less than 1,000 cubic feet per second, the large dissolved-solids concentration of ground-water accrual between nodes 700 and 800 caused the simulated dissolved-solids concentrations to be skewed.

Periods of low streamflow are of special interest because dissolved-solids concentrations can increase above acceptable levels. One such period of low flow is 1933-42. The mean annual streamflow for 1933-42 was only about 25 percent of the mean annual streamflow for 1931-84. Simulated monthly mean dissolved-solids concentrations for baseline conditions, year-round operation, and nonwinter operation for node 125, Sheyenne River near Cooperstown, N.Dak., for 1933-42 are shown in figure 24. The simulated monthly mean dissolved-solids concentrations for node 125 are representative of the monthly mean dissolved-solids concentrations for nodes on the Sheyenne River upstream from Lake Ashtabula. Generally, simulated monthly mean dissolved-solids concentrations for year-round operation were less than those for baseline conditions. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for baseline conditions only during the months when Missouri River water was added to the Sheyenne River. Simulated monthly mean dissolved-solids concentrations for year-round operation ranged from 500 to 600 milligrams per liter, except for spring months during 1941 and 1942 when they were about 400 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation ranged from 500 to 800 milligrams per liter, except for spring months during 1941 and 1942 when they were about 400 milligrams per liter. Variability of concentrations for year-round operation was less than the variability for baseline conditions and nonwinter operation.

Table 15.--Simulated mean monthly streamflow for selected nodes for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply, 1931-84

[All values are in cubic feet per second]

Node number	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Baseline conditions												
25	Garrison Diversion Unit Sheyenne River water supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	Sheyenne River above Harvey, N.Dak.	.4	1.8	17.8	40.1	15.2	9.6	4.5	1.4	1.3	1.6	1.6	.8
75	Sheyenne River near Warwick, N.Dak.	1.4	5.6	82.9	250.7	76.3	35.9	17.2	3.7	5.7	7.7	6.9	2.9
125	Sheyenne River near Cooperstown, N.Dak.	5.9	6.9	125.4	469.2	165.2	84.3	39.4	12.8	12.7	17.9	17.2	10.3
175	Sheyenne River below Baldhill Dam, N.Dak.	53.6	59.2	101.7	434.4	202.6	106.7	51.2	46.3	54.4	29.6	37.4	40.5
225	Sheyenne River at Lisbon, N.Dak.	54.6	62.1	160.9	552.5	240.1	121.8	69.6	34.4	40.0	33.3	40.2	42.7
250	Sheyenne River near Kindred, N.Dak.	63.8	70.5	159.7	596.9	289.4	143.1	97.5	34.6	27.7	51.5	57.5	55.1
275	Sheyenne River at West Fargo, N.Dak.	59.3	66.6	140.3	604.7	292.4	149.9	101.5	31.4	18.8	46.1	54.2	51.7
600	Red River of the North at Halstad, Minn.	320.8	316.1	1,190.6	5,152.1	2,285.2	2,004.9	1,597.0	586.9	426.7	466.5	491.8	378.9
700	Red River of the North at Grand Forks, N.Dak.	748.7	527.6	1,950.5	9,856.0	4,881.9	3,813.0	2,804.7	1,187.0	1,023.1	1,243.9	1,073.1	853.9
800	Red River of the North at Emerson, Man.	727.7	685.6	1,687.0	13,183.0	9,188.4	5,092.2	3,559.2	1,460.4	1,198.0	1,364.5	1,223.8	869.5
	Year-round operation of the Garrison Diversion Unit Sheyenne River water supply												
25	Garrison Diversion Unit Sheyenne River water supply	98.8	99.1	99.8	100.9	105.9	105.1	110.1	112.1	110.7	104.0	100.9	99.0
50	Sheyenne River above Harvey, N.Dak.	99.2	100.9	117.6	141.0	121.1	114.7	114.6	113.5	112.0	105.7	102.5	99.9
75	Sheyenne River near Warwick, N.Dak.	100.2	104.6	182.7	351.6	182.2	141.0	127.3	115.8	116.3	111.7	107.8	102.0
125	Sheyenne River near Cooperstown, N.Dak.	104.7	105.9	225.2	570.1	271.1	189.4	149.5	124.8	123.3	122.0	118.1	109.3
175	Sheyenne River below Baldhill Dam, N.Dak.	153.2	158.8	201.6	534.9	306.0	209.5	156.6	152.3	160.3	131.5	137.9	140.1
225	Sheyenne River at Lisbon, N.Dak.	154.1	161.8	260.8	653.0	343.6	224.6	175.0	140.4	145.9	135.2	140.7	142.3
250	Sheyenne River near Kindred, N.Dak.	163.3	170.1	259.2	697.5	392.9	245.9	202.9	140.7	133.6	153.4	157.9	154.8
275	Sheyenne River at West Fargo, N.Dak.	92.2	99.4	172.9	637.9	326.4	183.7	135.9	65.6	52.9	79.6	87.3	84.6
600	Red River of the North at Halstad, Minn.	353.2	348.7	1,222.6	5,185.3	2,319.2	2,038.7	1,630.9	619.7	459.7	498.8	524.3	410.9
700	Red River of the North at Grand Forks, N.Dak.	748.6	527.6	1,950.0	9,856.0	4,881.9	3,812.9	2,804.6	1,186.2	1,023.0	1,243.9	1,073.1	853.9
800	Red River of the North at Emerson, Man.	727.6	685.5	1,686.6	13,182.9	9,188.4	5,092.1	3,559.1	1,459.6	1,197.9	1,364.5	1,223.8	869.5

Table 15.--Simulated mean monthly streamflow for selected nodes for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply, 1931-84--Continued

Node number	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply												
25	Garrison Diversion Unit Sheyenne River water supply	0.0	0.0	0.0	175.4	177.2	176.7	177.9	177.9	177.3	176.1	0.0	0.0
50	Sheyenne River above Harvey, N.Dak.	.4	1.8	17.8	215.5	192.4	186.3	182.4	179.3	178.6	177.7	1.6	.8
75	Sheyenne River near Warwick, N.Dak.	1.4	5.6	82.9	426.1	253.4	212.6	195.1	181.6	183.0	183.8	6.9	2.9
125	Sheyenne River near Cooperstown, N.Dak.	5.9	6.9	125.4	644.6	342.4	261.0	217.3	190.6	189.9	194.0	17.2	10.3
175	Sheyenne River below Baldhill Dam, N.Dak.	153.2	158.9	202.0	534.9	306.0	209.5	156.6	152.5	160.3	131.6	137.9	140.1
225	Sheyenne River at Lisbon, N.Dak.	154.1	161.8	261.2	653.0	343.6	224.7	175.0	140.6	145.9	135.3	140.7	142.3
250	Sheyenne River near Kindred, N.Dak.	163.3	170.2	259.6	697.5	392.9	245.9	202.9	140.9	133.6	153.5	157.9	154.8
275	Sheyenne River at West Fargo, N.Dak.	92.2	99.5	173.3	637.9	326.4	183.8	135.9	65.8	53.0	79.6	87.3	84.6
600	Red River of the North at Halstad, Minn.	353.2	348.7	1,223.0	5,185.3	2,319.2	2,038.7	1,630.9	619.9	459.7	498.8	524.3	410.9
700	Red River of the North at Grand Forks, N.Dak.	748.6	527.6	1,950.5	9,856.0	4,881.9	3,813.0	2,804.6	1,186.4	1,023.1	1,244.0	1,073.1	853.9
800	Red River of the North at Emerson, N.Dak.	727.6	685.6	1,687.0	13,182.9	9,188.4	5,092.1	3,559.1	1,459.8	1,198.0	1,364.5	1,223.8	869.5

Table 16.--Simulated mean monthly dissolved-solids concentrations for selected nodes for baseline conditions and percent change from baseline conditions for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply, 1931-84

Node number	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		Dissolved-solids concentration, in milligrams per liter, for baseline conditions											
50	Sheyenne River above Harvey, N.Dak.	1,080.0	1,051.3	845.9	760.1	827.4	867.3	929.4	1,002.5	1,002.4	979.2	982.2	1,043.4
75	Sheyenne River near Warwick, N.Dak.	551.3	570.0	529.6	394.1	566.4	698.7	615.7	609.3	589.4	556.9	565.3	534.8
125	Sheyenne River near Cooperstown, N.Dak.	688.6	686.2	546.7	423.8	543.1	613.7	600.3	645.9	646.4	645.8	635.9	652.9
175	Sheyenne River below Baldhill Dam, N.Dak.	522.4	521.7	509.1	461.1	480.2	493.8	499.1	518.7	530.4	536.6	521.7	516.0
225	Sheyenne River at Lisbon, N.Dak.	659.3	662.9	536.0	461.9	536.9	556.4	596.3	625.6	603.9	702.9	695.9	719.1
250	Sheyenne River near Kindred, N.Dak.	574.2	573.5	507.3	447.0	498.8	519.2	534.3	571.1	581.9	632.2	605.3	587.9
275	Sheyenne River at West Fargo, N.Dak.	559.8	564.1	504.1	437.4	482.3	501.3	510.3	548.9	561.6	611.1	593.0	568.7
600	Red River of the North at Halstad, Minn.	476.8	470.1	421.0	374.3	384.9	393.4	419.2	459.0	474.3	469.4	496.9	496.1
700	Red River of the North at Grand Forks, N.Dak.	382.1	389.7	368.9	362.1	354.0	358.9	390.8	394.6	397.9	390.7	387.3	391.2
800	Red River of the North at Emerson, Man.	894.9	885.3	598.8	311.4	380.1	562.4	836.8	1,202.2	1,219.0	1,010.8	1,084.0	1,072.6
		Percent change in dissolved-solids concentrations for year-round operation of the Garrison Diversion Unit Sheyenne River water supply											
50	Sheyenne River above Harvey, N.Dak.	-47.4	-45.9	-31.0	-23.5	-35.8	-40.4	-45.7	-50.0	-49.4	-47.2	-41.0	-45.0
75	Sheyenne River near Warwick. N.Dak.	3.0	-1.3	.7	12.3	-8.0	-19.5	-17.2	-16.6	-13.9	-7.1	2.2	6.5
125	Sheyenne River near Cooperstown, N.Dak.	-17.0	-17.4	-2.1	4.6	-5.3	-10.7	-14.0	-20.4	-20.6	-19.0	-8.8	-12.1
175	Sheyenne River below Baldhill Dam, N.Dak.	4.3	4.4	3.4	2.4	1.1	1.1	2.7	1.3	.9	0	3.9	5.4
225	Sheyenne River at Lisbon, N.Dak.	-15.4	-15.5	-4.1	-.5	-7.0	-7.6	-11.8	-12.0	-8.0	-20.3	-19.0	-21.9
250	Sheyenne River near Kindred, N.Dak.	-2.8	-2.6	1.3	1.7	-.7	-1.1	-1.6	-3.7	-4.4	-11.3	-7.0	-4.9
275	Sheyenne River at West Fargo, N.Dak.	-.7	-1.3	1.6	2.5	2.8	2.1	4.1	3.4	3.0	-7.5	-5.3	-2.1
600	Red River of the North at Halstad, Minn.	-.2	.9	-.3	.8	1.2	1.3	1.9	2.6	2.5	.7	-.5	-.9
700	Red River of the North at Grand Forks, N.Dak.	2.0	1.7	1.7	.5	1.1	.9	.6	2.0	1.4	1.2	1.2	1.7
800	Red River of the North at Emerson, Man.	1.2	1.0	1.1	.4	.6	.4	.7	6.9	6.3	1.0	.6	.8

Table 16.--Simulated mean monthly dissolved-solids concentrations for selected nodes for baseline conditions and percent change from baseline conditions for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply, 1931-84--Continued

Node number	Description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		Percent change in dissolved-solids concentrations for nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply											
50	Sheyenne River above Harvey, N.Dak.	-5.3	-5.4	-1.4	-24.7	-36.9	-41.3	-46.2	-50.1	-49.6	-47.4	-6.6	-5.4
75	Sheyenne River near Warwick, N.Dak.	-1.7	.3	-.2	16.6	-9.0	-22.2	-18.1	-17.2	-14.2	-7.5	-.1	-.2
125	Sheyenne River near Cooperstown, N.Dak.	-.1	0	-.1	7.2	-6.1	-12.8	-15.1	-21.3	-21.2	-19.6	-.1	-.1
175	Sheyenne River below Baldhill Dam, N.Dak.	.7	.5	-.9	-.8	-1.0	-.7	.8	-1.0	-1.7	-2.5	.7	1.9
225	Sheyenne River at Lisbon, N.Dak.	-18.2	-18.4	-7.1	-2.9	-8.7	-9.0	-13.3	-13.9	-10.2	-22.1	-21.3	-24.4
250	Sheyenne River near Kindred, N.Dak.	-5.8	-5.8	-1.6	-.2	-2.0	-2.4	-3.0	-5.5	-6.5	-13.1	-9.3	-7.7
275	Sheyenne River at West Fargo, N.Dak.	-3.8	-4.5	-1.3	.6	1.5	.8	2.6	1.5	.8	-9.4	-7.6	-4.9
600	Red River of the North at Halstad, Minn.	-1.5	-.3	-.8	.5	1.1	1.1	1.4	1.7	1.6	-.1	-1.3	-2.0
700	Red River of the North at Grand Forks, N.Dak.	2.2	1.1	.5	.4	1.0	.8	.4	1.6	1.3	.8	1.6	2.0
800	Red River of the North at Emerson, Man.	4.8	4.6	.9	.3	.5	.4	.7	6.9	6.6	.9	3.6	3.9

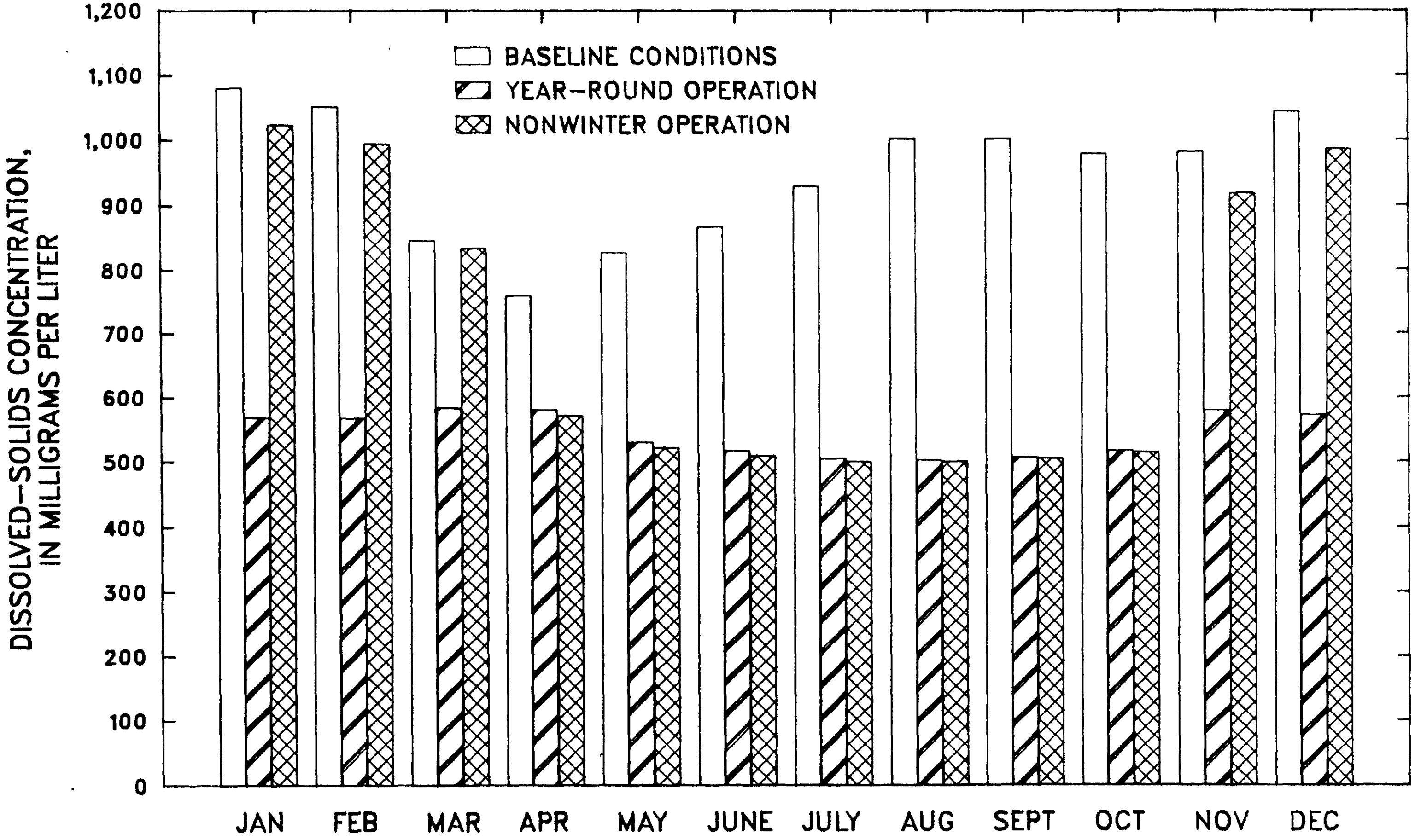

Figure 14.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 50, Sheyenne River above Harvey, North Dakota, 1931-84.

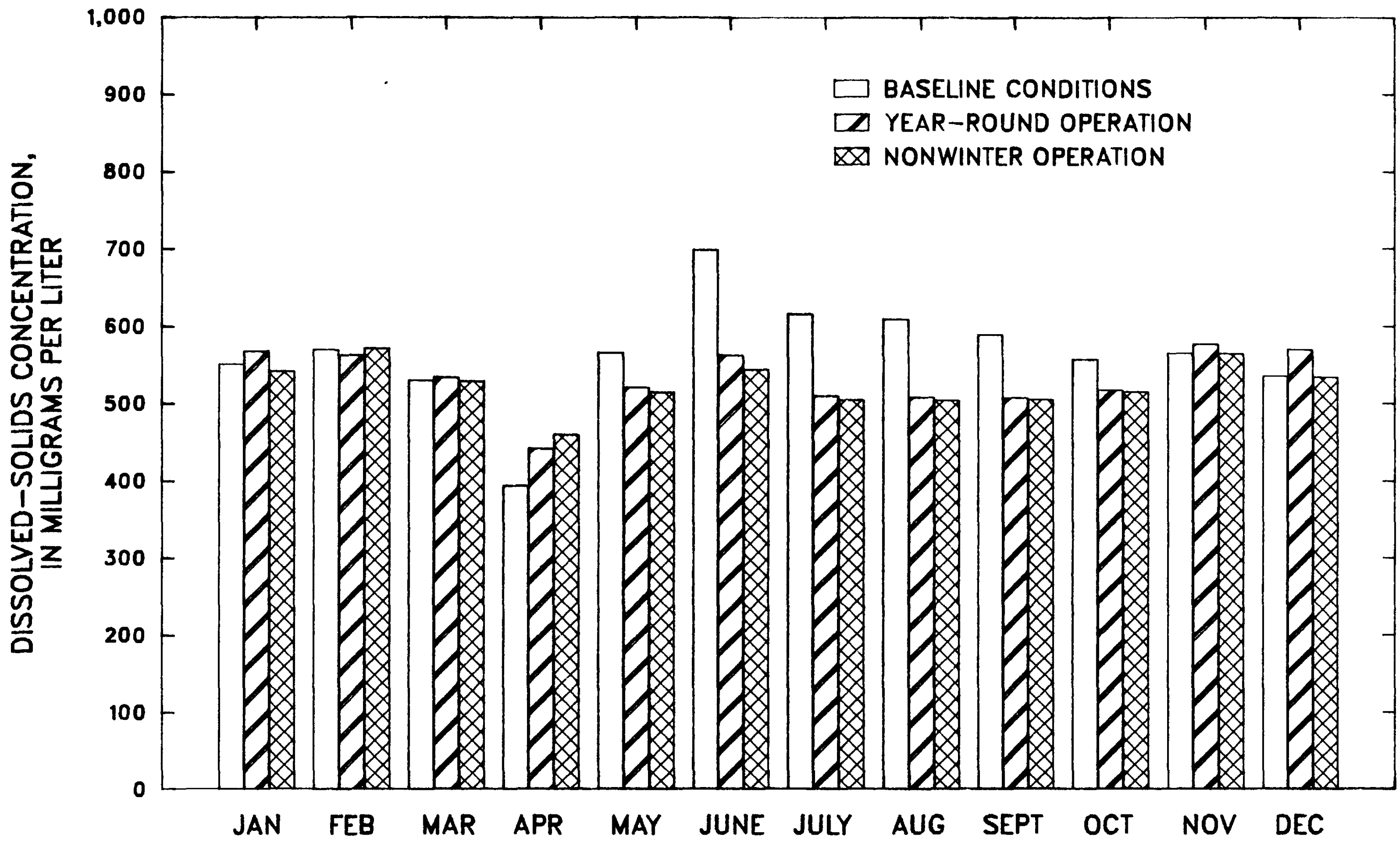

Figure 15.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 75, Sheyenne River near Warwick, North Dakota, 1931-84.

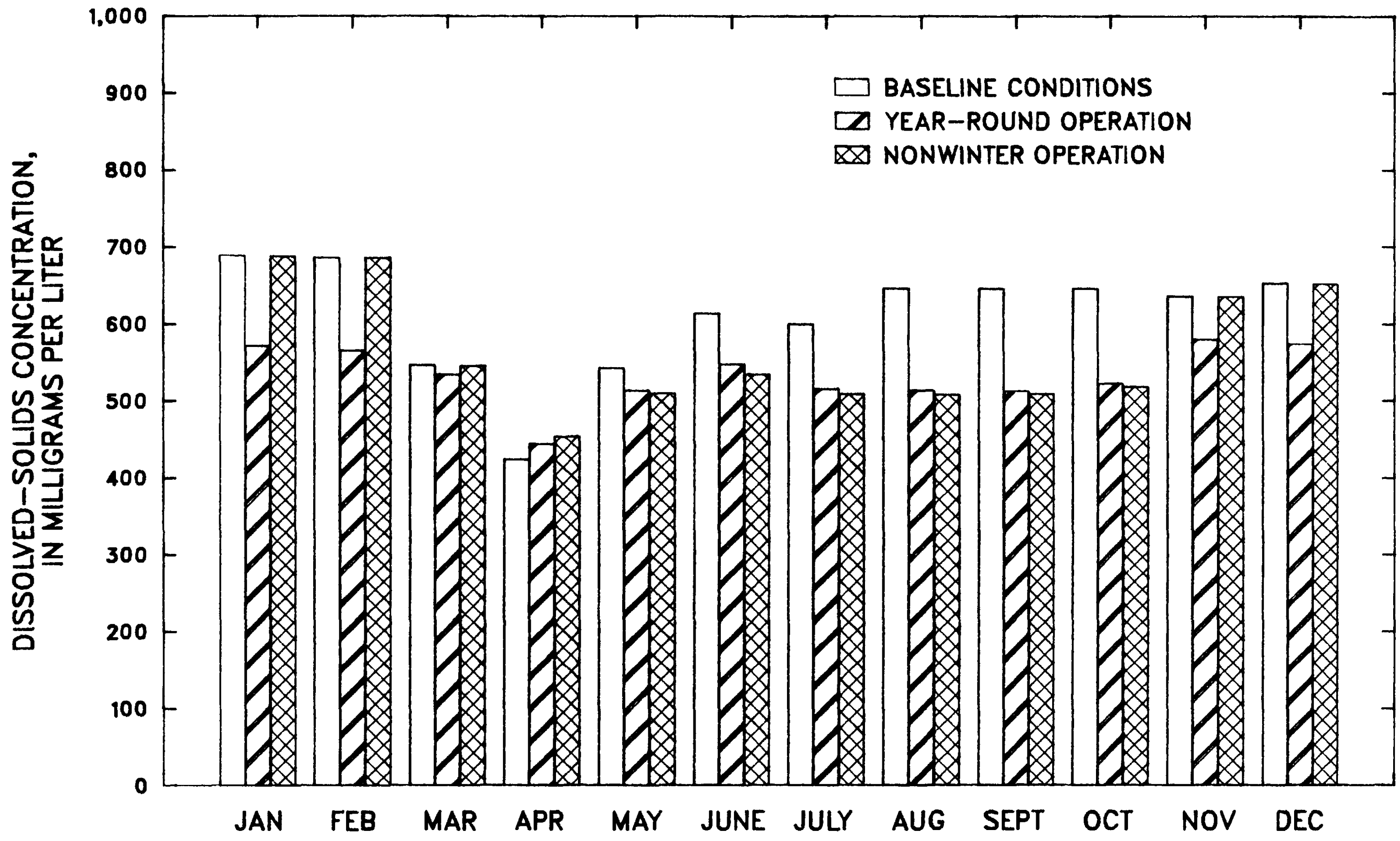

Figure 16.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 125, Sheyenne River near Cooperstown, North Dakota, 1931-84.

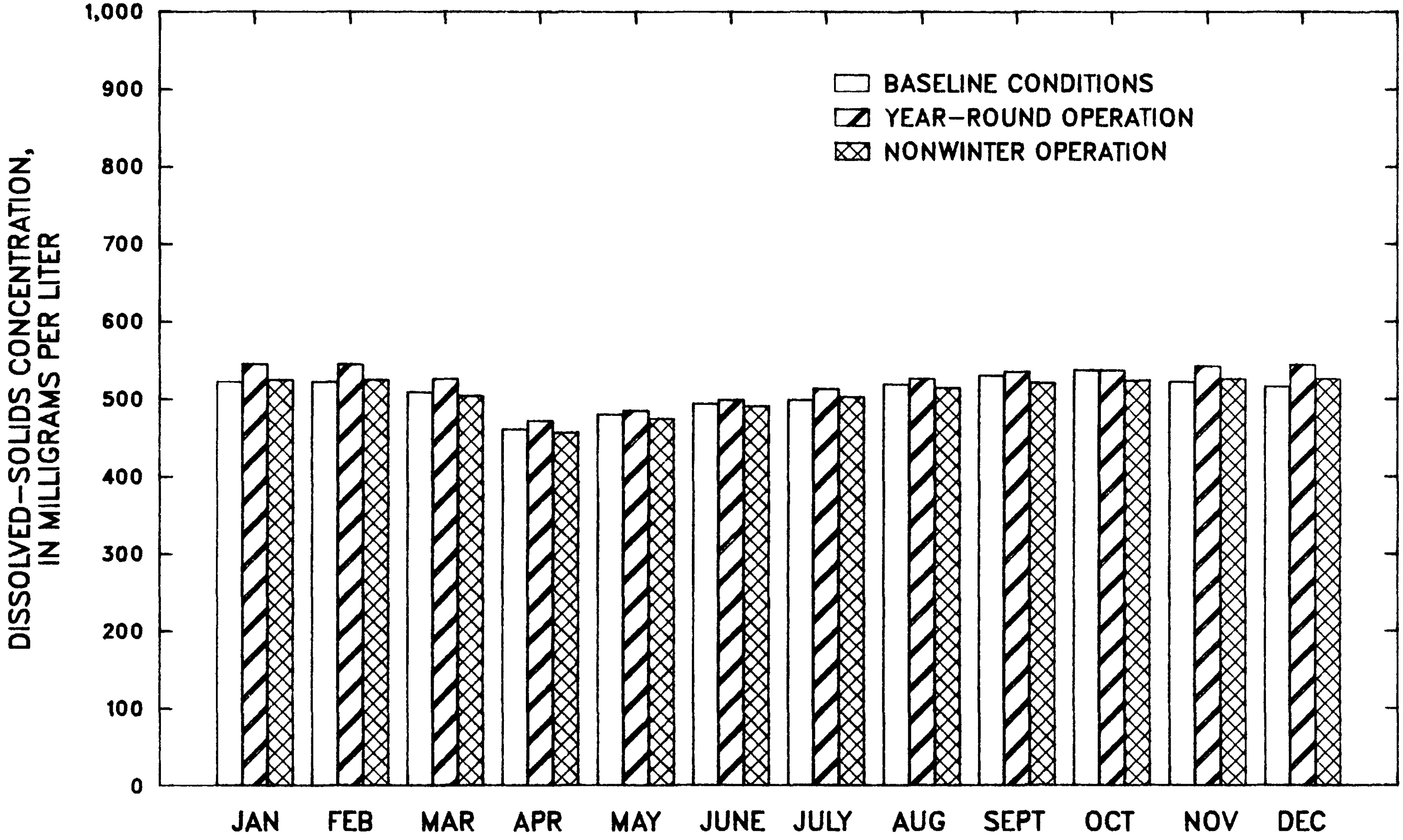

Figure 17.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 175, Sheyenne River below Baldhill Dam, North Dakota, 1931-84.

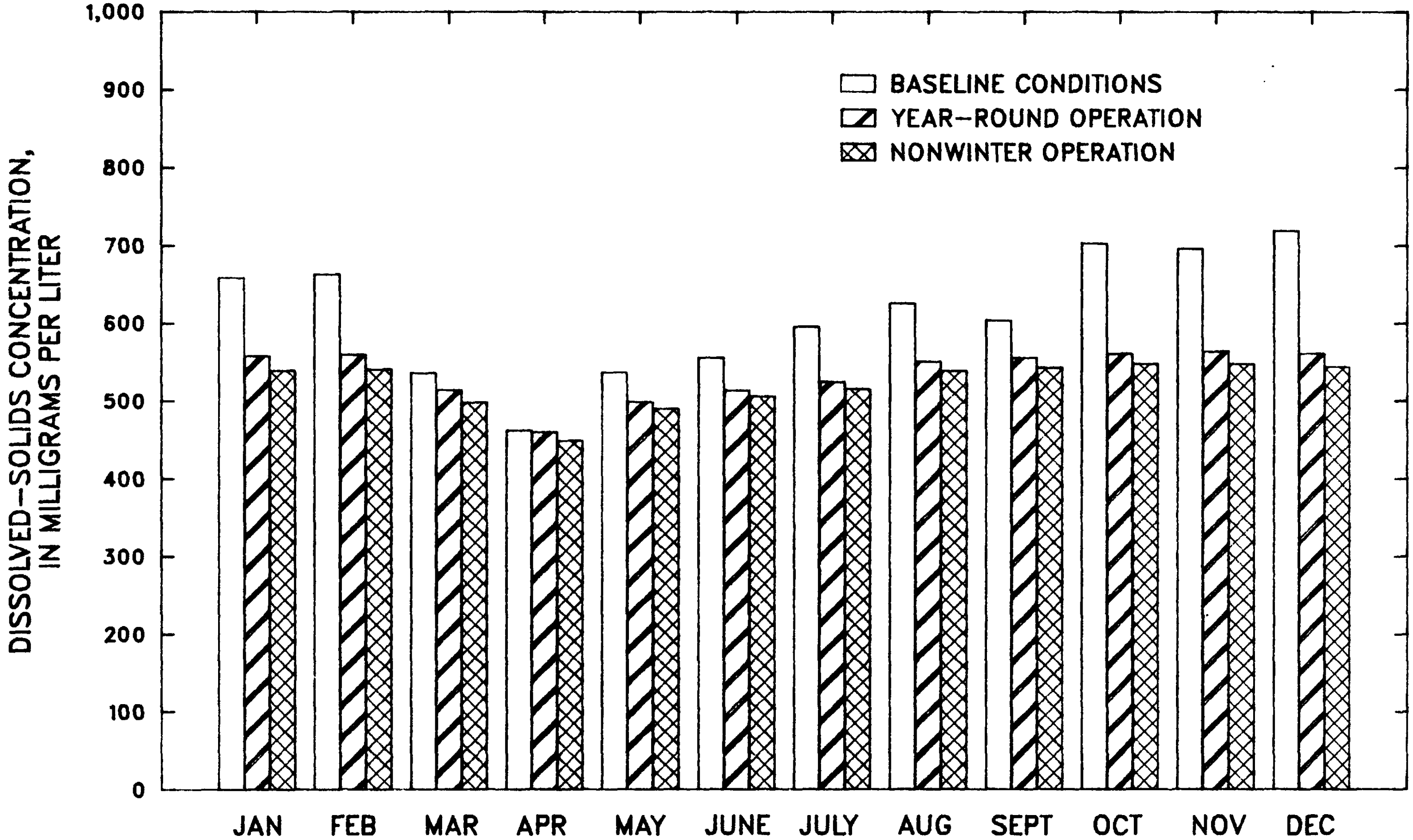

Figure 18.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 225, Sheyenne River at Lisbon, North Dakota, 1931-84.

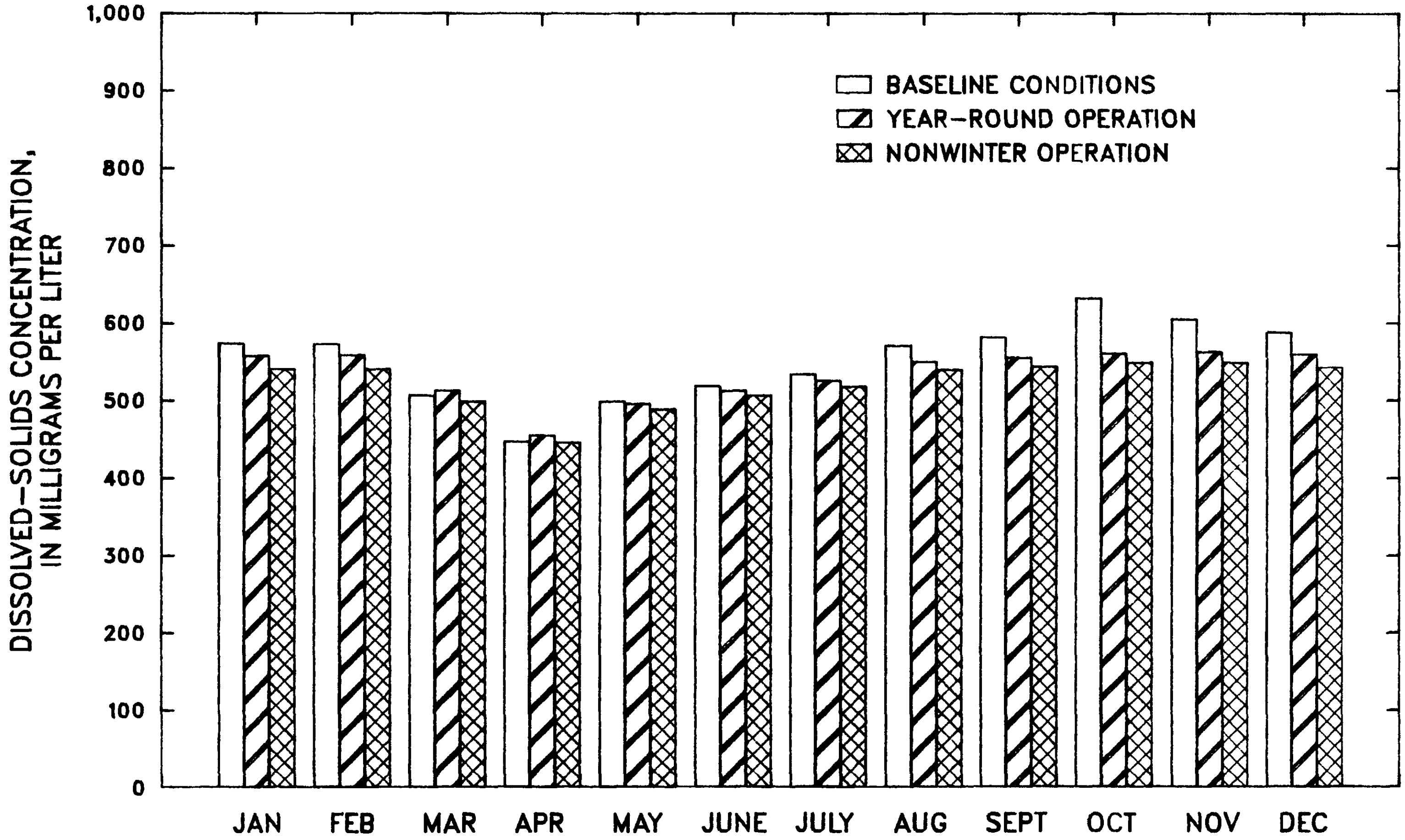

Figure 19.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 250, Sheyenne River near Kindred, North Dakota, 1931-84.

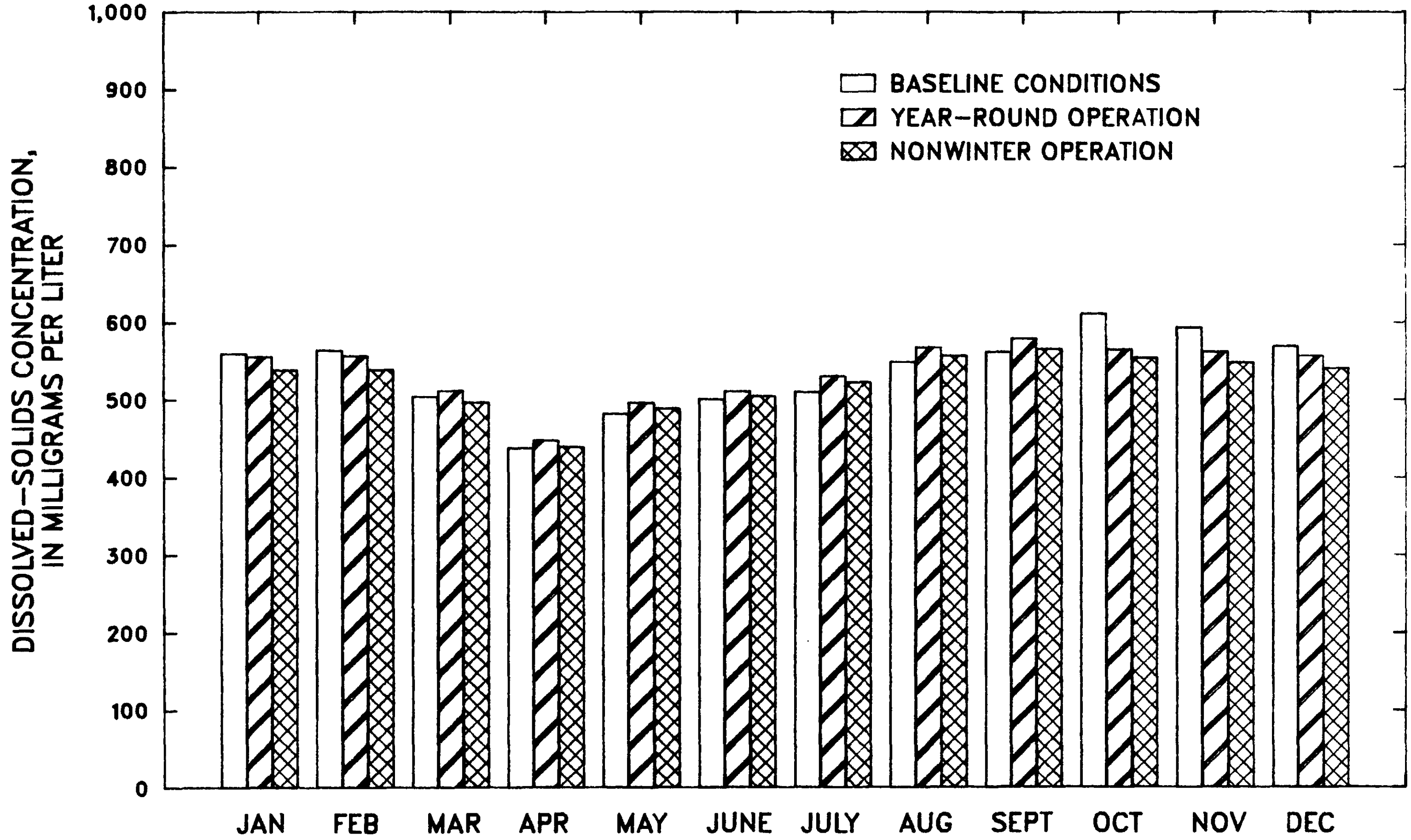

Figure 20.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 275, Sheyenne River at West Fargo, North Dakota, 1931-84.

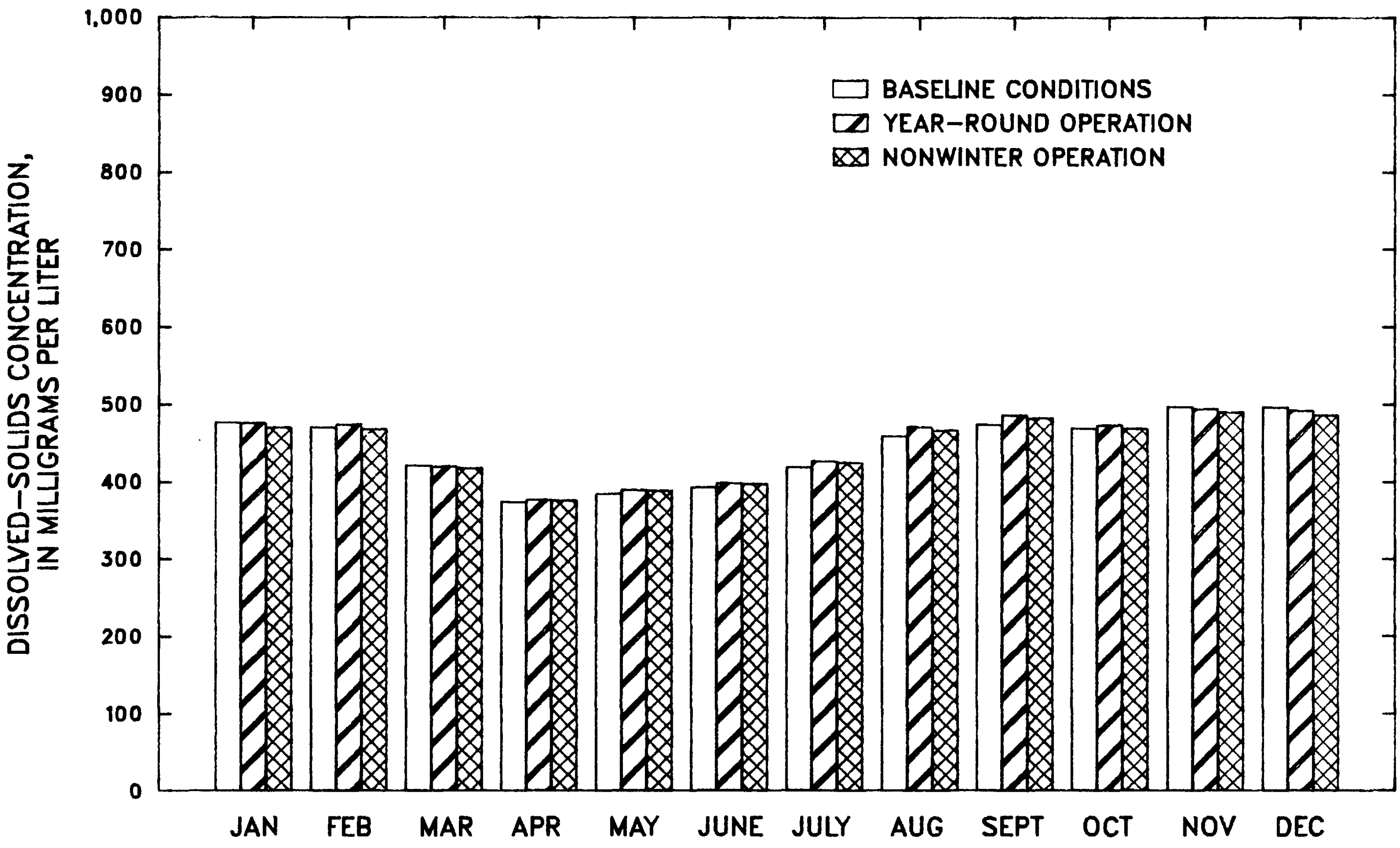

Figure 21.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 600, Red River of the North at Halstad, Minnesota, 1931-84.

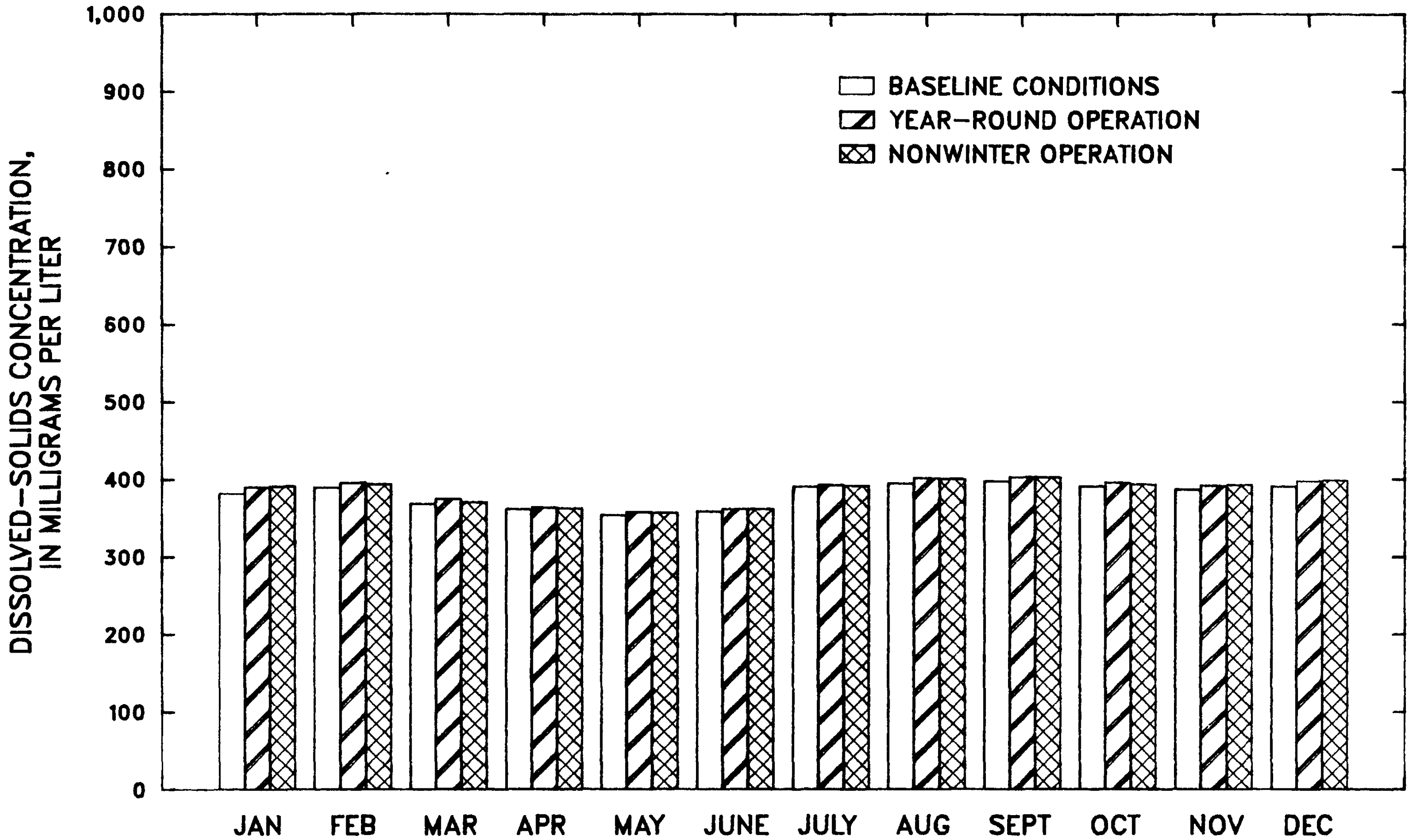

Figure 22.--Simulated mean monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 700, Red River of the North at Grand Forks, North Dakota, 1931-84.

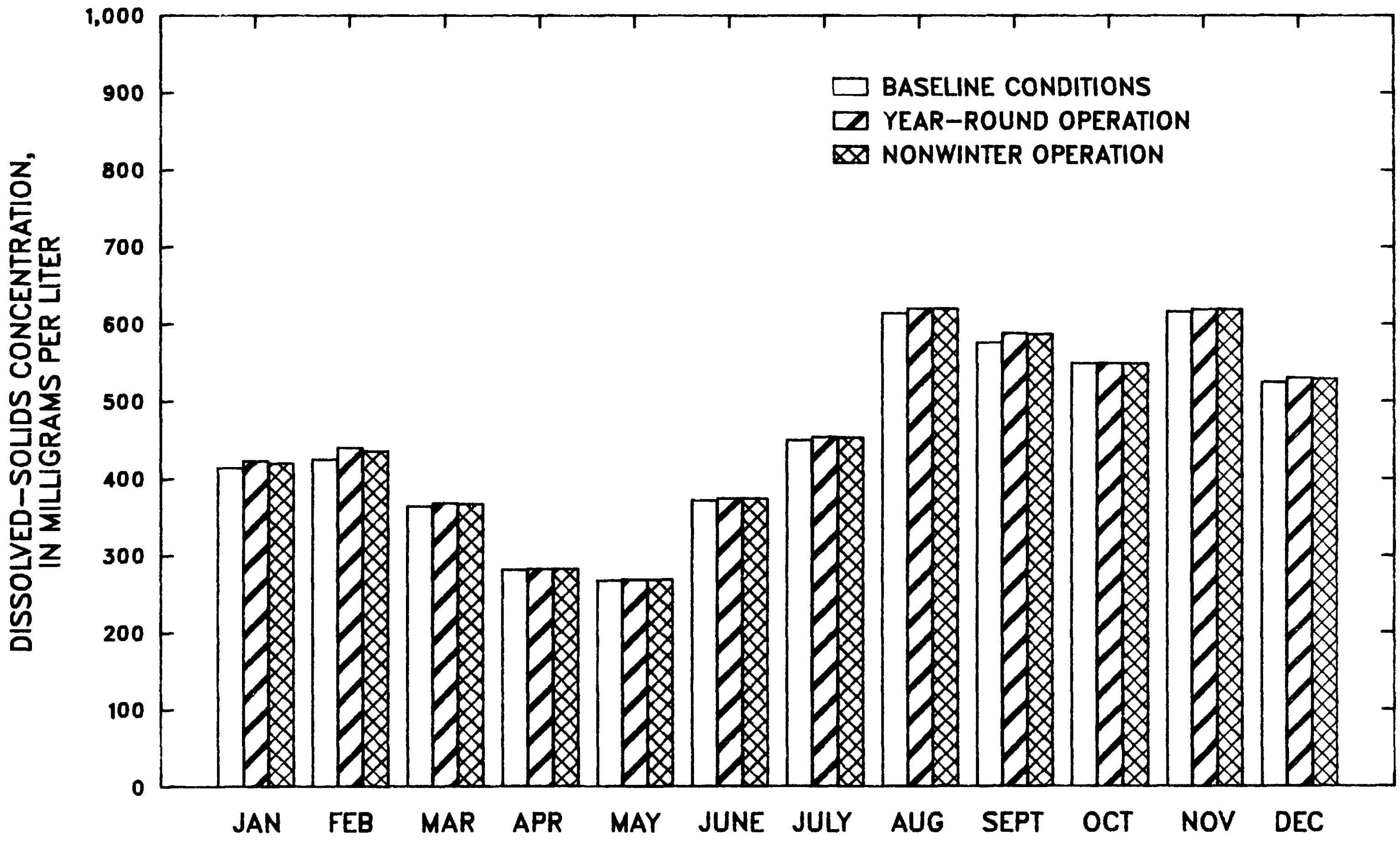

Figure 23.--Simulated median monthly dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 800, Red River of the North at Emerson, Manitoba, 1931-84.

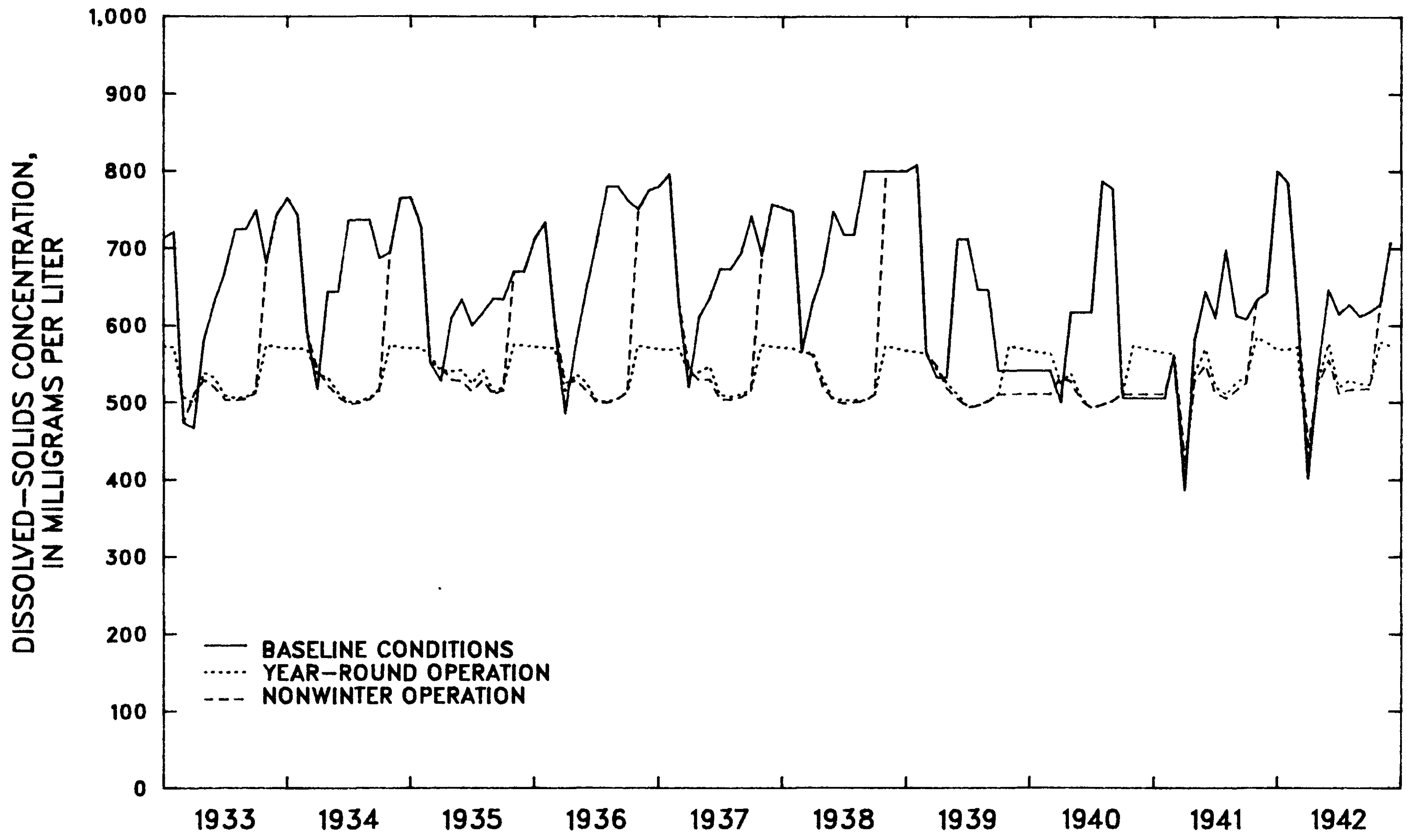

Figure 24.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 125, Sheyenne River near Cooperstown, North Dakota, 1933-42.

Simulated monthly mean dissolved-solids concentrations for node 250, Sheyenne River near Kindred, N.Dak., are representative of monthly mean dissolved-solids concentrations for nodes on the Sheyenne River downstream from Lake Ashtabula. Generally, simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation during 1933-42 ranged from 500 to 600 milligrams per liter, except for spring months during 1941 and 1942 when they were less than 400 milligrams per liter (fig. 25). Simulated monthly mean dissolved-solids concentrations for baseline conditions ranged from about 300 milligrams per liter to greater than 1,000 milligrams per liter (fig. 25). Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for year-round operation.

Simulated monthly mean dissolved-solids concentrations for node 700, Red River of the North at Grand Forks, N.Dak., are representative of monthly mean dissolved-solids concentrations for nodes on the Red River of the North. Generally, the magnitudes of monthly mean dissolved-solids concentrations for year-round and nonwinter operation were about the same as those for baseline conditions for 1933-42 (fig. 26). Annual variability of dissolved-solids concentrations for year-round and nonwinter operation was about the same as variability for baseline conditions. The months when dissolved-solids concentrations do not change, such as late 1934, represent periods when the water in the river did not flow. The concentrations reported for periods of no flow are the concentrations for the last month the water in the river did flow.

Periods of high streamflow also should be examined. One such period of high flow is 1973-82. Mean annual streamflow for 1973-82 was about 30 percent greater than the mean annual streamflow for 1931-84, when mean annual streamflow was about 81 cubic feet per second. Simulated monthly mean dissolved-solids concentrations for 1973-82 for node 125, Sheyenne River near Cooperstown, N.Dak., for year-round operation ranged from about 325 to 650 milligrams per liter (fig. 27). Simulated monthly mean dissolved-solids concentrations for baseline conditions and for nonwinter operation ranged from 325 to 800 milligrams per liter, except during 1982 when those for baseline conditions were greater than 1,000 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation had about the same annual variability as those for baseline conditions. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for baseline conditions for April through October each year and were about the same as those for year-round operation.

Simulated monthly mean dissolved-solids concentrations for node 250, Sheyenne River near Kindred, N.Dak., for year-round and nonwinter operation for 1973-82 generally were about the same as those for baseline conditions except monthly mean dissolved-solids peaks for year-round and nonwinter operation were reduced 25 to 100 milligrams per liter (fig. 28). Simulated monthly mean dissolved-solids concentrations for nonwinter operation generally were about 20 milligrams per liter less than those for year-round operation.

Simulated monthly mean dissolved-solids concentrations for node 700, Red River of the North at Grand Forks, N.Dak., for 1973-82 for year-round and nonwinter operation generally were about the same as those for baseline conditions (fig. 29). Seasonal and annual variability for year-round and nonwinter operation and for baseline conditions was about the same.

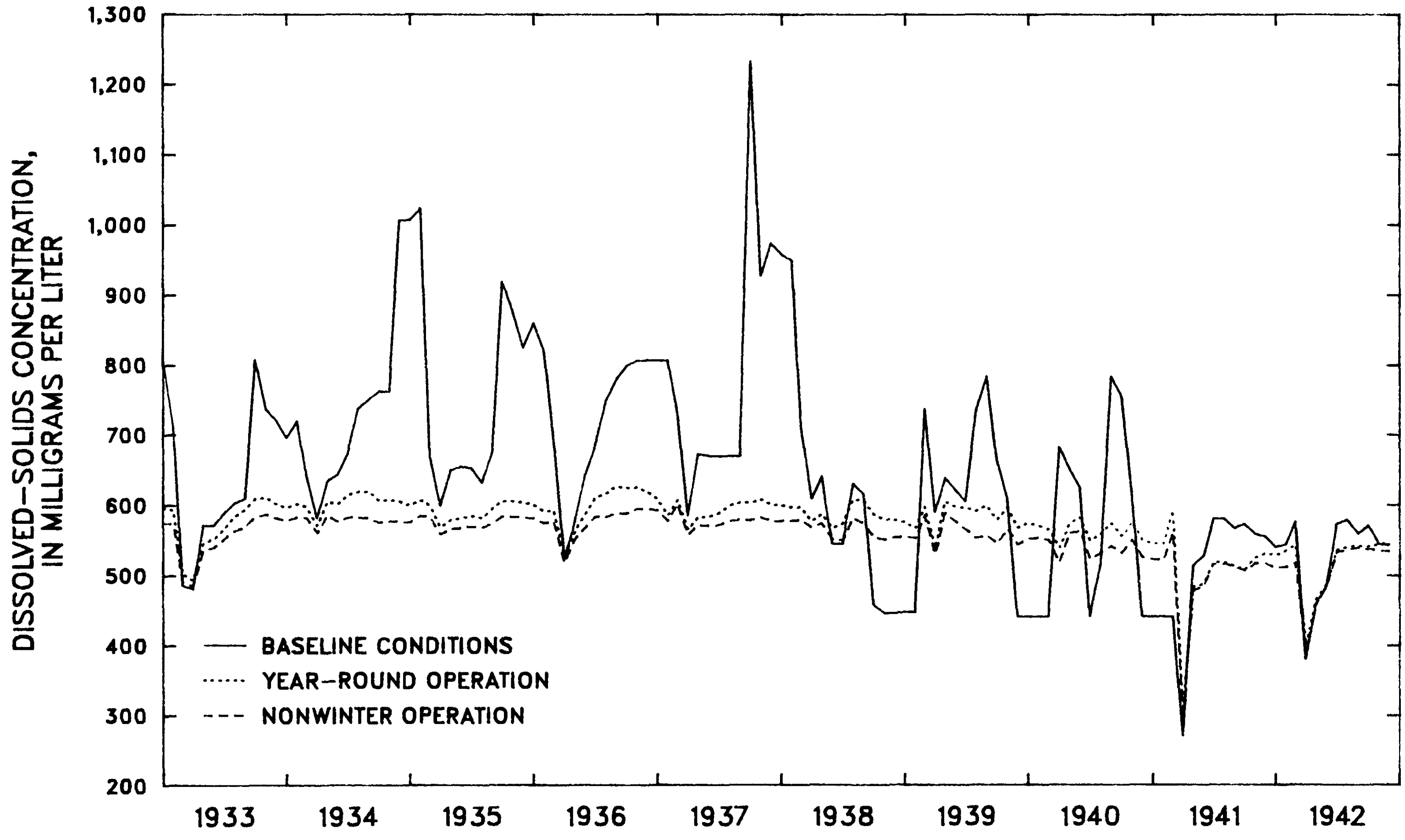

Figure 25.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 250, Sheyenne River near Kindred, North Dakota, 1933-42.

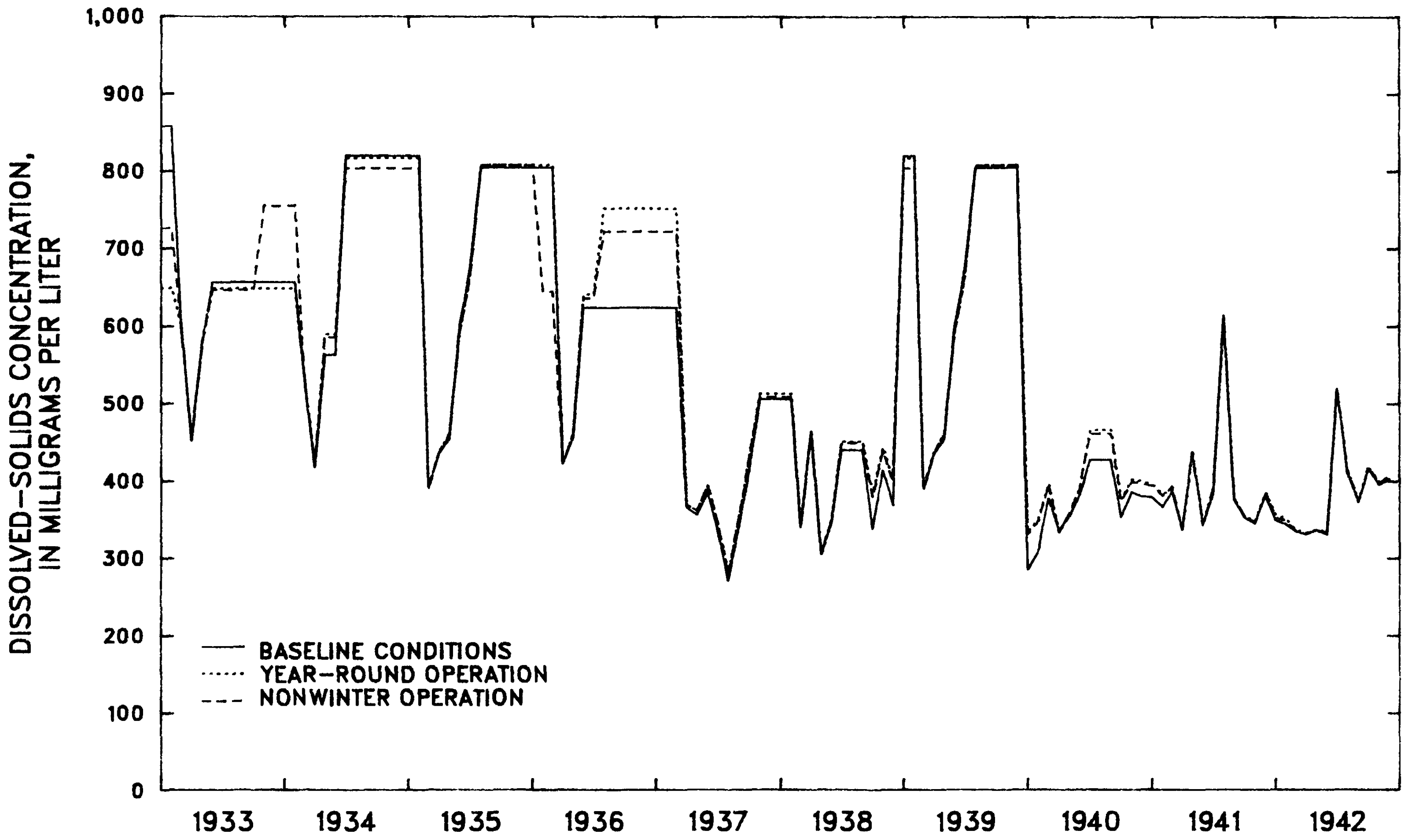

Figure 26.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 700, Red River of the North at Grand Forks, North Dakota, 1933-42.

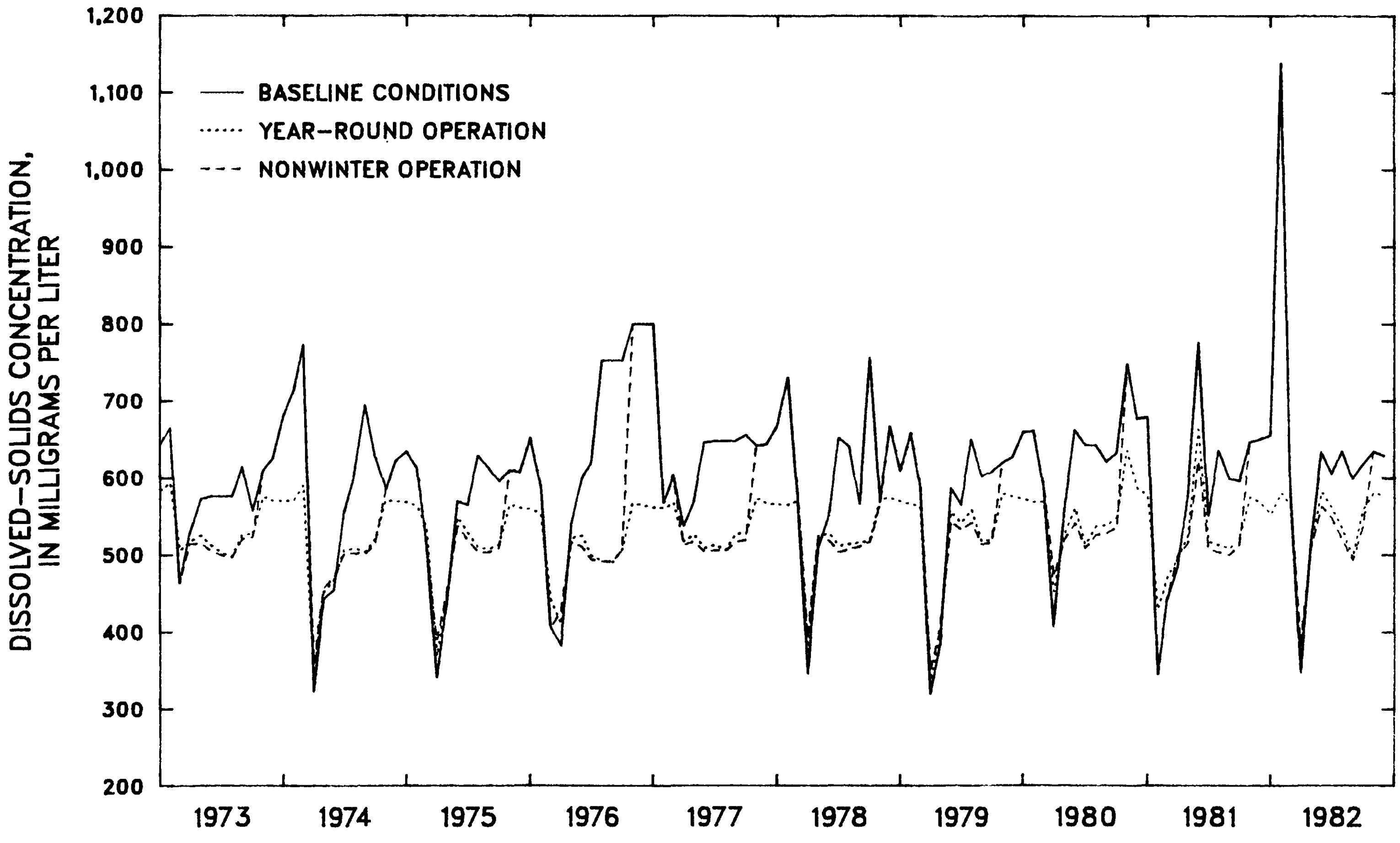

Figure 27.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 125, Sheyennne River near Cooperstown, North Dakota, 1973-82.

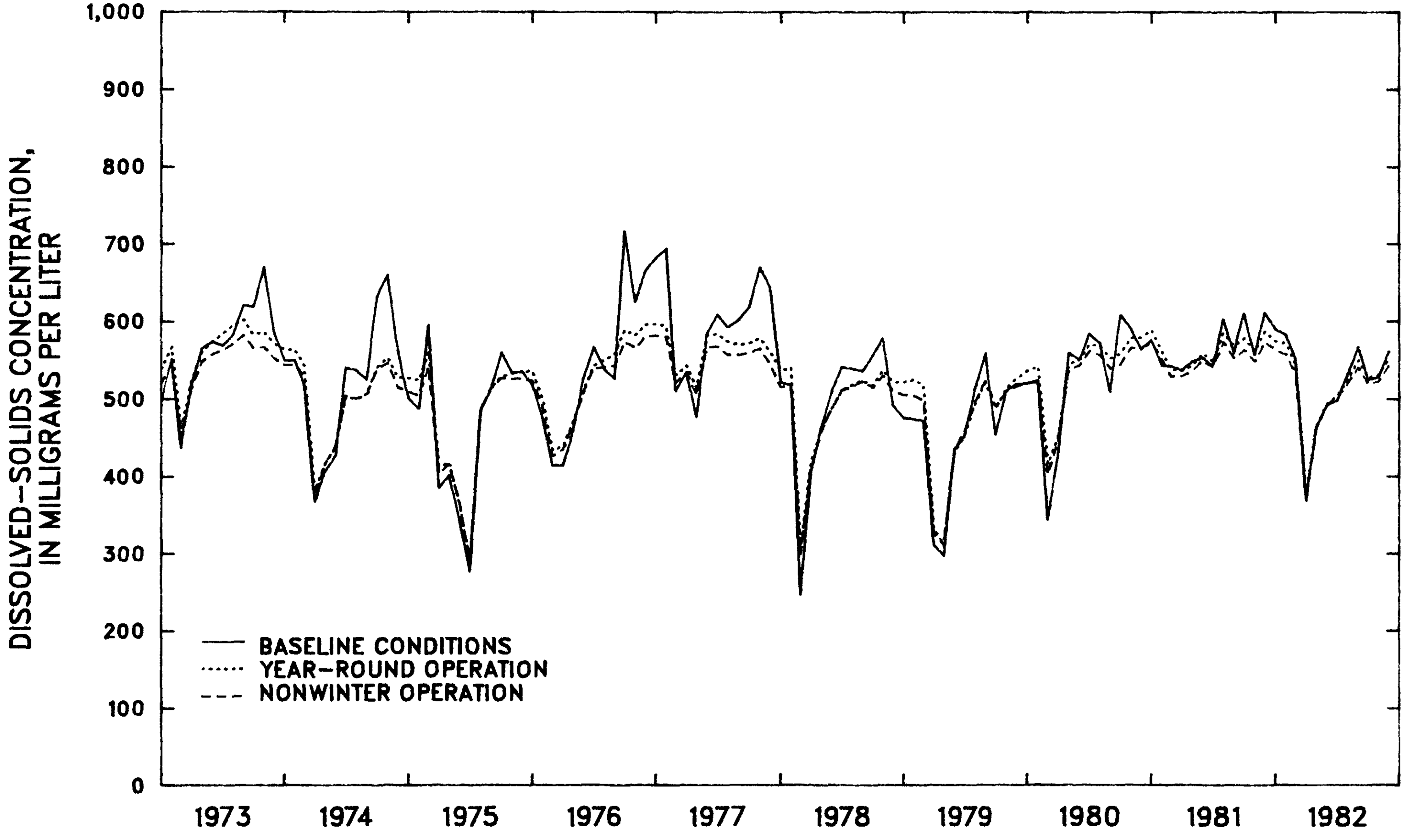

Figure 28.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 250, Sheyenne River water supply for node 250, Sheyenne River near Kindred, North Dakota, 1973-82.

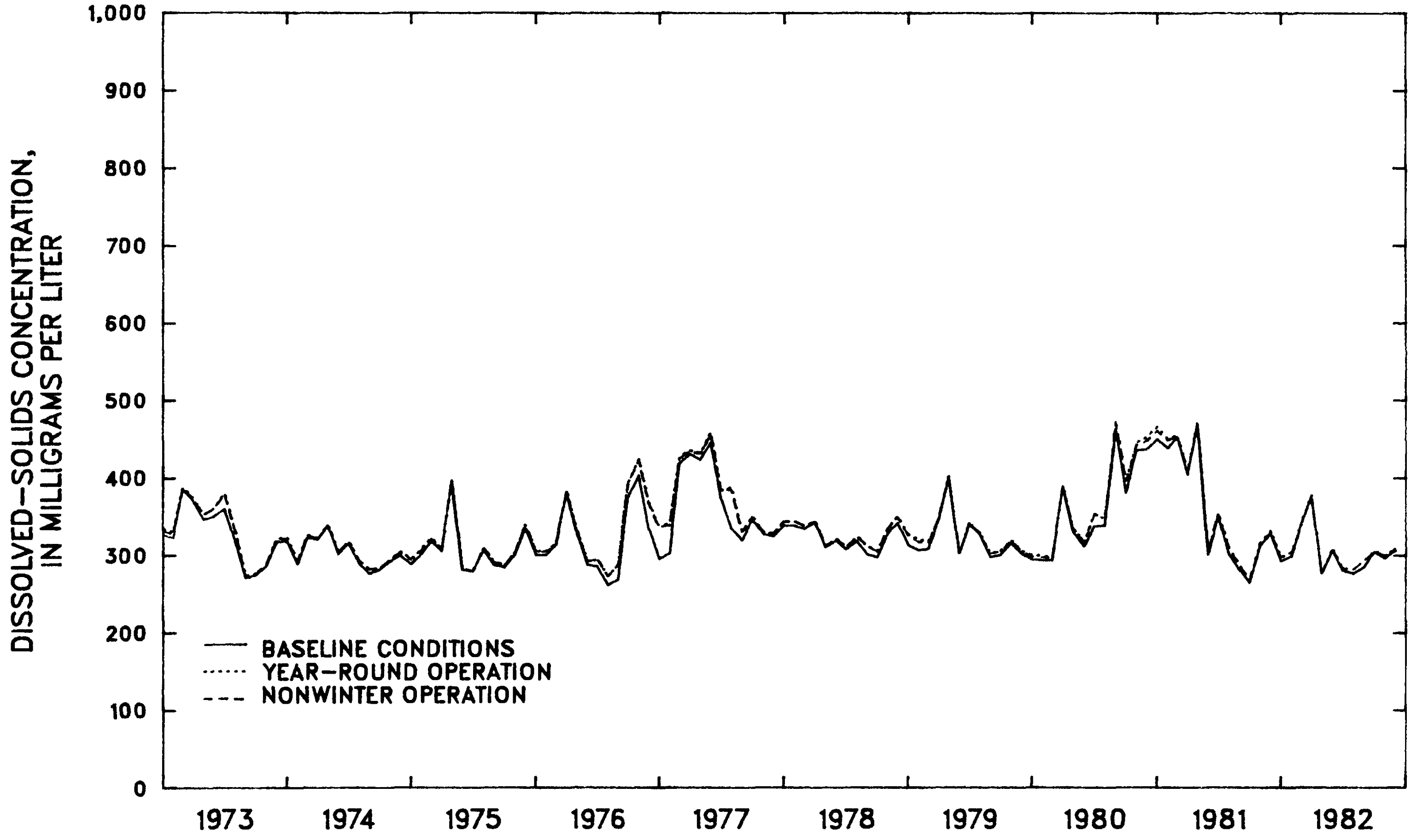

Figure 29.--Simulated monthly mean dissolved-solids concentrations for baseline conditions and for year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for node 700, Red River of the North at Grand Forks, North Dakota, 1973-82.

SUMMARY

The U.S. Bureau of Reclamation's Project Canals, Reservoirs, and River Systems (PROCRRS) streamflow model and Canals, Rivers, and Reservoirs Salinity Accounting Procedures (CRRSAP) water-quality model were used to predict streamflow and water-quality changes that could result from the proposed release of treated Missouri River water into the Sheyenne River and the Red River of the North river system. The quantity of Garrison Diversion Unit water proposed for delivery to the Sheyenne River was estimated for two proposed operating plans: (1) deliver Missouri River water for 12 months each year (year-round operation) and (2) deliver Missouri River water for 7 months each year (nonwinter operation). For both alternatives, water would be released from Lake Ashtabula to provide 100 cubic feet per second for 12 months each year.

Water loss may occur between the delivery point and the withdrawal points; therefore, the Garrison Diversion Unit must be capable of delivering 100 cubic feet per second of water plus the maximum water losses that can be expected to occur. For year-round operation, the maximum quantity of water that must be delivered to the upper reaches of the Sheyenne River to compensate for losses for hydrologic events that occurred during 1931-84 was estimated to be 151.0 cubic feet per second. Maximum delivery of Missouri River water for nonwinter operation was estimated to be about 210 cubic feet per second.

The PROCRRS model was calibrated by minimizing the differences between simulated and gaged streamflow data for node 175, the Sheyenne River below Baldhill Dam, N.Dak. The PROCRRS model was calibrated for 1950-84. Simulated mean annual streamflow for 1950-84 was 2,074 acre-feet, or about 2 percent, greater than gaged mean annual streamflow.

The CRRSAP model was calibrated by minimizing the difference between simulated and measured dissolved-solids concentration data. The CRRSAP model was calibrated for the range of streamflow that occurred during the period of water-quality record for each node.

Model simulations were used to assess the effects that operation of the Garrison Diversion Unit Sheyenne River water supply could have on streamflow and water quality of the Sheyenne River and the Red River of the North. Effects were assessed by comparing simulated streamflows that include Missouri River water to baseline conditions. Baseline conditions in the Red River of the North basin, including the Sheyenne River basin, represent the hydrologic conditions that exist in the basin before addition of Missouri River water to the river system.

Model simulations were made for baseline conditions and for year-round and nonwinter delivery of Missouri River water. Simulated mean monthly elevations of Lake Ashtabula for baseline conditions and for year-round operation of the Garrison Diversion Unit Sheyenne River water supply for 1931-84 are identical and are greatest in April. Simulated elevations for nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply are greatest in October. The differences in elevations between year-round operation and nonwinter operation reflect the additional storage in Lake Ashtabula necessary to maintain releases for November through March.

Mean annual streamflow for 1933-42, which was a low-flow period, was about 25 percent of the mean annual streamflow for 1931-84. For the Sheyenne River near Cooperstown, N.Dak., which is upstream from Lake Ashtabula, simulated monthly mean dissolved-solids concentrations for year-round operation were less than those for baseline conditions. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for baseline conditions only during the months when Missouri River water was added to the Sheyenne River. Variability of concentrations for year-round operation was less than the variability for baseline conditions and for nonwinter operation. For the Sheyenne River near Kindred, N.Dak., which is downstream from Lake Ashtabula, simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation ranged from 500 to 600 milligrams per liter, except for spring months during 1941 and 1942 when they were less than 400 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for baseline conditions ranged from about 300 milligrams per liter to greater than 1,000 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for year-round operation. For the Red River of the North at Grand Forks, N.Dak., the magnitudes of monthly mean dissolved-solids concentrations for year-round and nonwinter operation were about the same as those for baseline conditions for 1933-42. Annual variability of dissolved-solids concentrations for year-round and nonwinter operation was about the same as variability for baseline conditions.

Streamflow for 1973-82, which was a high-flow period, was about 30 percent greater than the mean annual streamflow for 1931-84, when mean annual streamflow was about 81 cubic feet per second. Simulated monthly mean dissolved-solids concentrations for 1973-82 for the Sheyenne River near Cooperstown, N.Dak., for year-round operation ranged from about 325 to 650 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for baseline conditions and for nonwinter operation ranged from 325 to 800 milligrams per liter, except during 1982 when those for baseline conditions were greater than 1,000 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation had about the same annual variability as those for baseline conditions. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were less than those for baseline conditions for April through October each year and were about the same as those for year-round operation.

For the Sheyenne River near Kindred, N.Dak., simulated monthly mean dissolved-solids concentrations for year-round and nonwinter operation were about the same as those for baseline conditions except monthly mean dissolved-solids peaks for year-round and nonwinter operation were reduced 25 to 100 milligrams per liter. Simulated monthly mean dissolved-solids concentrations for nonwinter operation were about 20 milligrams per liter less than those for year-round operation.

For the Red River of the North at Grand Forks, N.Dak., simulated monthly mean dissolved-solids concentrations for 1973-82 for year-round and nonwinter operation were about the same as those for baseline conditions. Seasonal and annual variability for year-round and nonwinter operation and for baseline conditions was about the same.

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SUPPLEMENTAL INFORMATION

The file names and a description of data in the files used in the U.S. Bureau of Reclamation's Project Canals, Reservoirs, and River Systems (PROCRRS) and Canals, Rivers, and Reservoirs Salinity Accounting Procedures (CRRSAP) models are listed in supplement 1. Examples of the model input control files for the model simulations discussed in this report are shown in supplements 2-9.

Both the PROCRRS and CRRSAP models are monthly models and simulate monthly values of streamflow and dissolved-solids concentration for the 1931-84 study period. The monthly model output data for the simulations discussed in this report are stored on the U.S. Bureau of Reclamation computer located in Denver, Colo. Summaries of model output for selected nodes for simulation of baseline conditions and for simulation of year-round and nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84, are given in supplements 10-12.

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Reservoirs Salinity Accounting Procedures models

[MR & I; municipal, recreation, and industrial; GDU, Garrison Diversion Unit]

File name	Description of data in the file
ASHAOP	Lake Ashtabula general end-of-month target elevations
ASHNEVP	Lake Ashtabula net evaporation rate (inches) 1949-1984
ASHOP02	Lake Ashtabula elevations (result of model run SRMOP02)
ASHOP03	Lake Ashtabula elevations (result of model run SRMOP03)
ASHOP06	Lake Ashtabula elevations for nonwinter operation
ASHTOP	Lake Ashtabula measured end-of-month elevations, 1949-84
EVAPDS	Dissolved-solids concentration of evaporation and precipitation from river surface
EVAPDS2	Dissolved-solids concentration of evaporation and precipitation from river surface
EVAPDS3	Dissolved-solids concentration of evaporation and precipitation from river surface
HARVDS	Dissolved-solids concentration of water for the Sheyenne River above Harvey
HASHTED	Net evaporation from Lake Ashtabula
HASHTLD	Sheyenne River - historic elevations of Lake Ashtabula
HBHCRSI	Historic inflow of Baldhill Creek
HBHVCDA	Adjusted 1984 demand - Sheyenne River from Baldhill Dam to Valley City
HBHVCDI	Sheyenne River permits from Baldhill Dam to Valley City - 1984 level of development
HBHVCSI	Sheyenne River - historic section gain from Baldhill Dam to Valley City
HBUFFDI	1984 Buffalo River permits
HBUFFSA	Demand shortage -- Buffalo River
HBUFFSI	Red River of the North - historic inflow of the Buffalo River
HCOASSI	Sheyenne River - historic section gain from Cooperstown to the head of Lake Ashtabula
HDREMDA	Demand less shortage - Drayton to Emerson (result of model run rrmop02)
HDREMDI	Red River of the North at Drayton to Emerson permits
HDREMSI	Red River of the North - historic gain from Drayton to Emerson (including tributaries)
HELMRDI	1984 Elm River permits
HELMRSA	Demand shortage -- Elm River

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
HELMRSI	Red River of the North - historic inflow of the Elm River
HFARGSI	Red River of the North - historic streamflow of the Red River of the North at Fargo
HFGHLDA	Demand less shortage - Fargo to Halstad (result of model run rrmop02)
HFGHLSI	Red River of the North - historic gain from Fargo to Halstad (less Sheyenne, Buffalo, Wild Rice)
HFRSTDI	1984 Forest River permits
HFRSTSA	Demand shortage -- Forest River
HFRSTSI	Red River of the North - historic inflow from the Forest River
HGFDRDA	Demand less shortage - Grand Forks to Drayton (result of model run rrmop02)
HGFDRDI	1984 Red River of the North at Grand Forks to Drayton
HGFDRSI	Red River of the North - historic gain from Grand Forks to Drayton (including tributaries)
HGFEMSI	Historic gain from Grand Forks to Emerson
HGOOSDI	1984 Goose River permits
HGOOSSA	Demand shortage -- Goose River
HGOOSSI	Red River of the North - historic inflow of the Goose River
HHARVSI	Sheyenne River - historic streamflow at Harvey (base inflow)
HHAWASI	Sheyenne River - historic section gain from Harvey to Warwick
HHEWADA	Adjusted 1984 demands - Sheyenne River headwatwers to Warwick
HHEWADI	Sheyenne River permits from headwaters to Warwick - 1984 level of development
HHLGFDA	Demand less shortage - Halstad to Grand Forks (result of model run rrmop02)
HHLGFDI	1984 Red River of the North at Halstad to Grand Forks permits
HHLGFSI	Red River of the North - section gain from Halstad to Grand Forks (not including Red Lake)
HKIWFDA	Adjusted 1984 demand - Sheyenne River from Kindred to West Fargo
HKIWFDI	Sheyenne River permits from Kindred to West Fargo - 1984 level of development
HKIWFSI	Sheyenne River - historic section gain from Kindred to West Fargo
HLIKIDA	Adjusted 1984 demand - Sheyenne River from Lisbon to Kindred

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
HLIKIDI	Sheyenne River permits from Lisbon to Kindred - 1984 level of development
HLIKISI	Sheyenne River - historic section gain from Lisbon to Kindred
HMAPLSI	Historic and unregulated streamflow of the Maple River at the mouth
HNATISI	Natural inflow to Lake Ashtabula - 1931- 1949 based on 177/1270 of Cooperstown,
HPARKDI	1984 Park River permits
HPARKSA	Demand shortage -- Park River
HPARKSI	Red River of the North - historic inflow of the Park River
HPEMBSA	Demand shortage -- Pembina River
HPEMBSI	Red River of the North - historic inflow of the Pembina River
HRLAKDI	1984 Red Lake River permits
HRLAKSA	Demand shortage -- Red Lake River
HRLAKSI	Red River of the North - historic inflow from the Red Lake River
HRUSHSI	Sheyenne River - historic inflow of the Rush River
HSANDDI	1984 Sand Hill River permits
HSANDSA	Demand shortage -- Sand Hill River
HSHHLDI	1984 Sheyenne mouth to Red River of the North at Halstad permits
HSNAKDI	1984 Snake River permits
HTONGDI	1984 Tongue River permits
HTURTDI	Turtle River 1984 permits
HTURTSA	Demand shortage -- Turtle River
HTURTSI	Red River of the North - historic inflow of the Turtle River
HVCLIDA	Adjusted 1984 demand - Sheyenne River from Valley City to Lisbon
HVCLIDI	Sheyenne River water right permits from Valley City to Lisbon - 1984 level of development
HVCLISI	Sheyenne River - historic section gain from Valley City to Lisbon
HWACODA	Adjusted 1984 demand - Sheyenne River from Warwick to Cooperstown

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
HWACODI	Sheyenne River permits from Warwick to Cooperstown - 1984 level of development
HWACOSI	Sheyenne River - historic section gain from Warwick to Cooperstown
HWFMODA	Adjusted 1984 demand - Sheyenne River from West Fargo to the mouth
HWFMODI	Sheyenne River permits from West Fargo to the mouth - 1984 level of development
HWFOCDI	Demands on Lake Ashtabula by Fargo/Moorhead - on call water
HWILDDI	1984 Wild Rice River permits
HWILDSA	Demand shortage -- Wild Rice River
HWILDSI	Red River of the North - historic inflow of the Wild Rice River
MSHEY0H	Sheyenne River at the mouth - results of model run srmop0h, modeled historic flows
MSHEY03	Simulated flows of the Sheyenne River at the mouth (results of model run srmop03)
MSHEY05	Sheyenne River at the mouth (results of model run srmop05)
MSHEY06	Simulated streamflow of Sheyenne River at the mouth (result of model run srmopb6)
PGFRKDI	Delivery of GDU water to Grand Forks via the Sheyenne River
PINSTDI	Sheyenne River instream flow requirement below Baldhill Dam
PREDUDD	Evaporation on Red River of the North
PSHUPDD	Evaporation from upper Sheyenne
PSHYLDD	Evaporation on lower Sheyenne
PSHYUDD	Evaporation on upper Sheyenne
PSRRTDI	Sheyenne River release - plus evaporation - variable based on mean monthly flows
PSSRPDI	Sheyenne River release - 7 month delivery plus evaporation
PWFGODI	GDU water delivered to West Fargo via the Sheyenne River
REDDS0H	Sheyenne River MR & I studies - historic Red River of the North streamflow
REDDS02	Sheyenne River MR & I studies - historic Red River of the North streamflow
REDDS05	Sheyenne River MR & I studies - historic Red River of the North streamflow
REDDS06	Sheyenne River MR & I studies - nonwinter Red River of the North streamflow

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
REDOPOH	Sheyenne River MR & I studies - historic Red River of the North streamflows
REDOP01	Sheyenne River MR & I studies - modeled historic Red River of the North streamflows
REDOP02	Sheyenne River MR & I studies - unregulated Red River of the North flows w/1984 demands
REDOP03	Sheyenne River MR & I studies - Fargo/Moorhead water called from Lake Ashtabula
REDOP04	Sheyenne River MR & I studies - Sheyenne River release - 12 month release
REDOP05	Sheyenne River MR & I studies - year-round operation of the GDU
REDOP06	Sheyenne River MR & I studies - nonwinter operation of the GDU
SHEYCMP	
SHEYDS3	Dissolved-solids concentration of Sheyenne River at the mouth (result of model run srmop03)
SHEYDS5	Dissolved-solids concentrations of Sheyenne River at the mouth for 12 month GDU
SHEYDS6	Dissolved-solids concentration of the Sheyenne River at the mouth
SHYCAL	Sheyenne River MR & I studies - historic Sheyenne streamflows (results of model run shyop0h)
SHYDSB6	Sheyenne River MR & I studies - 7 month Sheyenne River release
SHYDSOH	Sheyenne River at the mouth - dissolved-solids concentration (result of model run srmds0h)
SHYDS03	Sheyenne River MR & I studies - Fargo/Moorhead water called from Lake Ashtabula
SHYDS05	Sheyenne River MR & I studies - Sheyenne River release (12 months) + Fargo on-call
SHYOPB6	Sheyenne River MR & I studies - 7 month Sheyenne River release
SHYOPOH	Sheyenne River MR & I studies - historic Sheyenne streamflows (results of model run shyop0h)
SHYOP01	Sheyenne River MR & I studies - modeled historic Sheyenne streamflows (results of model run shyop01)
SHYOP02	Sheyenne River MR & I studies - unregulated Sheyenne streamflow with demands
SHYOP03	Sheyenne River MR & I studies - Fargo/Moorhead water called from Lake Ashtabula
SHYOP04	Sheyenne River MR & I studies - Sheyenne River release - 12 month release
SHYOP05	Sheyenne River MR & I studies - Sheyenne River release (12 months) + Fargo on-call
SHYOP06	Sheyenne River MR & I studies - Sheyenne River release (7 months) + Fargo on-call
SRELV02	Lake Ashtabula end-of-month elevations (results of model run srmop02)

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
SRELV03	Lake Ashtabula end-of-month elevations (results of model run srmop03)
SRRDS07	Dissolved-solids concentration of Sheyenne release from Sykeston canal (results of model run wqouts6)
SRRDS12	Dissolved-solids concentration of Sheyenne release from Sykeston canal (results of model run wqouts6)
UBHVCSI	Sheyenne River- unregulated section gain from Baldhill Dam to Valley City
UBUFFSA	Demand shortage -- Buffalo River
UBUFFSI	Red River of the North - unregulated inflow from the Buffalo River
UDREMS2	Unregulated section gain from Drayton to Emerson (including all tributaries)
UELMRSA	Demand shortage -- Elm River
UELMRSI	Red River of the North - unregulated inflow from the Elm River
UFGHLS2	Unregulated section gain from Fargo to Halstad (not including Sheyenne, Buffalo, Wild Rice)
UFRSTSA	Demand shortage -- Forest River
UFRSTSI	Red River of the North - unregulated inflow from the Forest River
UGFDRS2	Red River of the North - section gain from Grand Forks to Drayton
UGFEMSI	Unregulated gain from Grand Forks to Emerson
UGOOSSA	Demand shortage -- Goose River
UGOOSSI	Red River of the North - unregulated inflow from the Goose River
UHAWASI	Sheyenne River- unregulated section gain from Harvey to Warwick
UHLGFS2	Unregulated section gain from Halstad to Grand Forks (not including Red Lake River)
UKIWFSI	Sheyenne River- unregulated section gain from Kindred to West Fargo
ULIKISI	Sheyenne River- unregulated section gain from Lisbon to Kindred
UPARKSA	Demand shortage -- Park River
UPARKSI	Red River of the North - unregulated inflow of the Park River
UPEMBSA	Demand shortage -- Pembina River
UPEMBSI	Red River of the North - unregulated inflow from the Pembina River

Supplement 1.--Files used in the Project Canals, Reservoirs, and River Systems and Canals, Rivers, and Salinity Accounting Procedures models--Continued

File name	Description of data in the file
URLAKSA	Demand shortage -- Red Lake River
URLAKSI	Red River of the North - unregulated inflow from the Red Lake River
USHHLS2	Red River of the North - unregulated section gain from Sheyenne to Halstad
UVCLISI	Sheyenne River- unregulated section gain from Valley City to Lisbon
UWACOSI	Sheyenne River- unregulated section gain from Warwick to Cooperstown
UWILDSA	Demand shortage -- Wild Rice River
UWILDSI	Red River of the North - unregulated inflow from the Wild Rice River
WARWDS2	Dissolved-solids of Harvey to Warwick gain from monthly regression

Supplement 2.--Model input control file for simulation of historic conditions on the Sheyenne River

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 SHEYENNE RIVER MR&I STUDIES - HISTORIC SHEYENNE RIVER STREAMFLOWS             SHEYENNE RIVER MR&I STUDIES
        GARRISON DIVERSION UNIT                          P-SMBP              SHEYENNE RIVER DISSOLVED-SOLIDS CALIBRATION
  1 1951   12 1984                                                         1 SHYBIOH
BSINFLW   25 HHARVSI          .000000001         SHEYENNE RIVER ABOVE HARVEY  HARVDS
NTINFLW   70 HHAWASI                             HIST SECTION GAIN TO WARWICK WARWDS2
PRINT     75                                     SHEYENNE RIVER AT WARWICK
NTINFLW  120 HWACOSI                             HIST SEC GAIN TO COOPERSTOWN       A 800.    -70.0    0.0    0.0   0.0   0.0
PRINT    125                                     SHEYENNE RIVER AT COOPERSTOWN
NTINFLW  140 HCOASSI                             HIST SEC GAIN TO ASHTABULA         B 597.    -0.1750  0.0    0.0   0.0   0.0
PRINT    145                                     SHEYENNE RIVER AT HEAD OF AS.
RESBGNC  150 ASHTOP              1247.07         BEGIN LAKE ASHTABULA                 8956    480
NTINFLW  153 HNATISI                             LAKE ASHTABULA NATURAL INFLOW      B 597.    -0.1750  0.0    0.0   0.0   0.0
NTINFLW  155 HBHCRSI                             BALDHILL CREEK INFLOW              B 597.    -0.1750  0.0    0.0   0.0   0.0
RESEND   160                                     END LAKE ASHTABULA
PRINT    175                                     SHEYENNE R. BELOW BALDHILL D
NTINFLW  195 HBHVCSI                             HIST SEC GAIN TO VALLEY CITY       B 2253.   -0.4400  0.0    0.0   0.0   0.0
PRINT    200                                     SHEYENNE RIVER AT VALLEY CITY
NTINFLW  220 HVCLISI                             HIST SECTION GAIN TO LISBON        B 2253.   -0.4400  0.0    0.0   0.0   0.0
PRINT    225                                     SHEYENNE RIVER AT LISBON
NTINFLW  245 HLIKISI                             HIST SECTION GAIN TO KINDRED       A 800.    -68.4    0.0   15.0   440  15.0
PRINT    250                                     SHEYENNE RIVER AT KINDRED
NTINFLW  270 HKIWFSI                             HIST SEC GAIN TO WEST FARGO        A 575.    -71.0    0.0    0.0   0.0   0.0
PRINT    275                                     SHEYENNE RIVER AT WEST FARGO
NTINFLW  280 HMAPLSI                             MAPLE RIVER INFLOW                 B 1510    -0.2470  0.0    0.0   0.0   0.0
PRINT    285                                     SHEYENNE RIVER BELOW MAPLE RR
NTINFLW  290 HRUSHSI                             RUSH RIVER INFLOW                  B 997.    -0.2060  0.0    0.0   0.0   0.0
PRINT    395                                     SHEYENNE RIVER AT THE MOUTH
END      480 SHYBIOH                              PROCRRS RESULTS           SHYTTTT
```

Supplement 3.--Model input control file for simulation of baseline conditions on the Sheyenne River

```
 SHEYENNE RIVER MR&I STUDIES -  BASELINE CONDITIONS                    SHEYENNE RIVER MR&I STUDIES
         GARRISON DIVERSION UNIT                     P-SMBP      SHYOP03          DISSOLVED-SOLIDS CONCENTRATION - BASELINE
   1 1931   12 1984                                                           1 SHYBIO3
BSINFLW   50 HHARVSI         .000000001      SHEYENNE RIVER ABOVE HARVEY  HARVDS
NTINFLW   70 UHAWASI                         UNREGULATED GAIN TO WARWICK  WARWDS2
DIVERSN   71 HHEWADA                         ADJ.DEMAND -  HEADWTRS TO WAR
PRINT     75                                 SHEYENNE RIVER NEAR WARWICK
NTINFLW  120 UWACOSI                         UNREGULATED GAIN TO COOPERSTN       A 800.     -70.0    0.0    0.0   0.0   0.0
DIVERSN  121 HWACODA                         ADJ.DEMAND -  WARWICK TO COOP
PRINT    125                                 SHEYENNE RIVER NEAR COOPERSTN
NTINFLW  140 HCOASSI                         UNREGULATED GAIN TO ASHTABULA       B 597.     -0.1750  0.0    0.0   0.0   0.0
PRINT    145                                 SHEYENNE RIVER AT HEAD OF AS.
RESBGNC  150 ASHOP02            1264.00      BEGIN LAKE ASHTABULA                  59900    505
NTINFLW  153 HNATISI                         LAKE ASHTABULA NATURAL INFLOW       B 597.     -0.1750  0.0    0.0   0.0   0.0
NTINFLW  155 HBHCRSI                         BALDHILL CREEK INFLOW               B 597.     -0.1750  0.0    0.0   0.0   0.0
RESEND   160                                 END LAKE ASHTABULA
PRINT    175                                 SHEYENNE R. BELOW BALDHILL D
NTINFLW  195 UBHVCSI                         UNREGULATED GAIN TO VALLEY CY       B 2253.    -0.4400  0.0    0.0   0.0   0.0
DIVERSN  196 HBHVCDA                         ADJ.DEMANDS - BALDHILL TO VC
PRINT    200                                 SHEYENNE RIVER AT VALLEY CITY
NTINFLW  220 UVCLISI                         UNREGULATED  GAIN TO LISBON         B 2253.    -0.4400  0.0    0.0   0.0   0.0
DIVERSN  221 HVCLIDA                         ADJ.DEMANDS - VALC TO LISBON
PRINT    225                                 SHEYENNE RIVER AT LISBON
NTINFLW  245 ULIKISI                         UNREGULATED  GAIN TO KINDRED        A 800.0    -68.4    0.0    15.0  440   15.0
DIVERSN  246 HLIKIDA                         ADJ.DEMAND - LISBON TO KIND
PRINT    250                                 SHEYENNE RIVER AT KINDRED
NTINFLW  270 UKIWFSI                         UNREGULATED GAIN TO WEST FARO       A 575.     -71.0    0.0    0.0   0.0   0.0
DIVERSN  271 HKIWFDA                         ADJ.DEMAND - KIND TO W.FARGO
DIVERSN  274 HWFOCDI                         FARGO ON-CALL WATER, ASHTABUA
PRINT    275                                 SHEYENNE RIVER AT WEST FARGO
DIVERSN  276 HWFMODA                         ADJ.DEMAND - W.FARGO TO MOUTH
NTINFLW  280 HMAPLSI                         MAPLE RIVER INFLOW                  B 1510.    -0.2470  0.0    0.0   0.0   0.0
PRINT    285                                 SHEYENNE RIVER BELOW MAPLE RR
NTINFLW  290 HRUSHSI                         RUSH RIVER INFLOW                   B 997.     -0.2060  0.0    0.0   0.0   0.0
PRINT    395                                 SHEYENNE RIVER AT THE MOUTH
END      480 SHYBIO3                         PROCRRS RESULTS              SHY3333
```

Supplement 4.--Model input control file for simulation of year-round operation of the Garrison Diversion Unit

Sheyenne River water supply on the Sheyenne River

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 SHEYENNE RIVER MR&I STUDIES -  YEAR-ROUND OPERATION                                    SHEYENNE RIVER MR&I STUDIES
 OF THE GARRISON DIVERSION UNIT                          P-SMBP         SHYOP05       DISSOLVED-SOLIDS CONCENTRATION - YEAR-ROUND OP.
   1 1931   12 1984                                                             1 SHYBI05
BSINFLW   25 PSRRTDI          .000000001          12 MONTH SHEYENNE RELEASE    SRRDS12
NTINFLW   50 HHARVSI                              SHEYENNE RIVER ABOVE HARVEY  HARVDS
NTINFLW   70 UHAWASI                              UNREGULATED GAIN TO WARWICK  WARWDS2
DIVERSN   71 HHEWADA                              ADJ.DEMAND - HEADWTRS TO WARW
PRINT     75                                      SHEYENNE RIVER NEAR WARWICK
NTINFLW  120 UWACOSI                              UNREG GAIN TO COOPERSTOWN           A 800.     -70.0    0.0    0.0    0.0    0.0
DIVERSN  121 HWACODA                              ADJ.DEMAND -  WARWICK TO COOP
PRINT    125                                      SHEYENNE RIVER NEAR COOPERSTN
NTINFLW  140 HCOASSI                              UNREGULATED GAIN TO ASHTABULA       B 597.     -0.1750  0.0    0.0    0.0    0.0
OTHRIN   144 PSHYUDD                              EVAPORATION - UPPER SHEYENNE EVAPDS
PRINT    145                                      SHEYENNE RIVER AT HEAD OF AS.
RESBGNC  150 ASHOP03             1264.00          BEGIN LAKE ASHTABULA                  59900    505
NTINFLW  153 HNATISI                              LAKE ASHTABULA NATURAL INFLOW       B 597.     -0.1750  0.0    0.0    0.0    0.0
NTINFLW  155 HBHCRSI                              BALDHILL CREEK INFLOW               B 597.     -0.1750  0.0    0.0    0.0    0.0
RESEND   160                                      END LAKE ASHTABULA
PRINT    175                                      SHEYENNE R. BELOW BALDHILL D
NTINFLW  195 UBHVCSI                              UNREG. GAIN TO VALLEY CITY          B 2253.    -0.4400  0.0    0.0    0.0    0.0
DIVERSN  196 HBHVCDA                              ADJ.DEMANDS - BALDHILL TO VC
PRINT    200                                      SHEYENNE RIVER AT VALLEY CITY
NTINFLW  220 UVCLISI                              UNREGULATED  GAIN TO LISBON         B 2253.    -0.4400  0.0    0.0    0.0    0.0
DIVERSN  221 HVCLIDA                              ADJ.DEMANDS - VALC TO LISB
PRINT    225                                      SHEYENNE RIVER AT LISBON
NTINFLW  245 ULIKISI                              UNREGULATED  GAIN TO KINDRED        A 800.     -68.4    0.0    15.0   440.0  15.0
DIVERSN  246 HLIKIDA                              ADJ.DEMAND - LISBON TO KIND
PRINT    250                                      SHEYENNE RIVER AT KINDRED
NTINFLW  270 UKIWFSI                              UNREG. GAIN TO WEST FARGO           A 575.     -71.0    0.0    0.0    0.0    0.0
DIVERSN  271 HKIWFDA                              ADJ.DEMAND - KIND TO W.FARGO
DIVERSN  272 HWFOCDI                              FARGO ON-CALL FROM L.ASHTABUA
OTHRIN   273 PSHYLDD                              EVAPORATION - LOWER SHEYENNE EVAPDS2
DIVERSN  274 PWFGODI                              FARGO'S DEMAND OF SR RELEASE
PRINT    275                                      SHEYENNE RIVER AT WEST FARGO
DIVERSN  276 HWFMODA                              ADJ.DEMAND - W.FARGO TO MOUTH
NTINFLW  280 HMAPLSI                              MAPLE RIVER INFLOW                  B 1510.    -0.2470  0.0    0.0    0.0    0.0
PRINT    285                                      SHEYENNE RIVER BELOW MAPLE RR
NTINFLW  290 HRUSHSI                              RUSH RIVER INFLOW                   B 997.     -0.2060  0.0    0.0    0.0    0.0
PRINT    395                                      SHEYENNE RIVER AT THE MOUTH
OTHRIN   420 PREDUDD                              RED RIVER EVAPORATION        EVAPDS3
DIVERSN  425 PGFRKDI                              GRAND FORKS' DEMAND OF SRR
END      480 SHYBI05                              PROCRRS RESULTS              SHY5555
```

Supplement 5.--Model input control file for simulation of nonwinter operation of the Garrison Diversion Unit

Sheyenne River water supply on the Sheyenne River

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  SHEYENNE RIVER MR&I STUDIES -  NONWINTER OPERATION                                              SHEYENNE RIVER MR&I STUDIES
   OF THE GARRISON DIVERSION UNIT                        P-SMBP        SHYOPB6          DISSOLVED SOLIDS CONCENTRATION - NONWINTER OPER.
    1 1931   12 1984                                                             1 SHYBIB6
BSINFLW   25 PSSRPDI        .000000001        7 MONTH SHEYENNE RELEASE     SRRDS07
NTINFLW   50 HHARVSI                          SHEYENNE RIVER ABOVE HARVEY  HARVDS
NTINFLW   70 UHAWASI                          UNREGULATED GAIN TO WARWICK  WARWDS2
DIVERSN   71 HHEWADA                          ADJ.DEMAND - HEADWTRS TO WARW
PRINT     75                                  SHEYENNE RIVER NEAR WARWICK
NTINFLW  120 UWACOSI                          UNREG GAIN TO COOPERSTOWN          A 800.    -70.0    0.0    0.0   0.0   0.0
DIVERSN  121 HWACODA                          ADJ.DEMAND -  WARWICK TO COOP
PRINT    125                                  SHEYENNE RIVER NEAR COOPERSTN
NTINFLW  140 HCOASSI                          UNREGULATED GAIN TO ASHTABULA      B 597.    -0.1750  0.0    0.0   0.0   0.0
OTHRIN   144 PSHUPDD                          PRECIP TO & EVAP FROM SHEY R.EVAPDS
PRINT    145                                  SHEYENNE RIVER AT HEAD OF AS.
RESBGNC  150 ASHOP06          1264.00         BEGIN LAKE ASHTABULA                 59900   505
NTINFLW  153 HNATISI                          LAKE ASHTABULA NATURAL INFLOW      B 597.    -0.1750  0.0    0.0   0.0   0.0
NTINFLW  155 HBHCRSI                          BALDHILL CREEK INFLOW              B 597.    -0.1750  0.0    0.0   0.0   0.0
RESEND   160                                  END LAKE ASHTABULA
PRINT    175                                  SHEYENNE R. BELOW BALDHILL
NTINFLW  195 UBHVCSI                          UNREGULATED GAIN TO VALC           B 2253.   -0.4400  0.0    0.0   0.0   0.0
DIVERSN  196 HBHVCDA                          ADJ.DEMANDS - BALD D. TO VALC
PRINT    200                                  SHEYENNE RIVER AT VALC
NTINFLW  220 UVCLISI                          UNREGULATED  GAIN TO LISBON        B 2253.   -0.4400  0.0    0.0   0.0   0.0
DIVERSN  221 HVCLIDA                          ADJ.DEMANDS - VALC TO LISB
PRINT    225                                  SHEYENNE RIVER AT LISBON
NTINFLW  245 ULIKISI                          UNREGULATED  GAIN TO KINDRED       A 800.    -68.4    0.0   15.0  440   15.0
DIVERSN  246 HLIKIDA                          ADJ.DEMAND - LISB TO KIND
PRINT    250                                  SHEYENNE RIVER AT KINDRED
NTINFLW  270 UKIWFSI                          UNREGULATED GAIN TO WEST FARO      A 575.    -71.0    0.0    0.0   0.0   0.0
DIVERSN  271 HKIWFDA                          ADJ.DEMAND - KIND TO W. FARGO
DIVERSN  272 HWFOCDI                          FARGO ON-CALL FROM L.ASHTABUA
OTHRIN   273 PSHYLDD                          PRECIP TO & EVAP FROM SHEY R.EVAPDS2
DIVERSN  274 PWFGODI                          FARGO'S DEMAND OF SR RELEASE
PRINT    275                                  SHEYENNE RIVER AT WEST FARGO
DIVERSN  276 HWFMODA                          ADJ.DEMAND - W.FARGO TO MOUTH
NTINFLW  280 HMAPLSI                          MAPLE RIVER INFLOW                 B 1510.   -0.2470  0.0    0.0   0.0   0.0
PRINT    285                                  SHEYENNE RIVER BELOW MAPLE R
NTINFLW  290 HRUSHSI                          RUSH RIVER INFLOW                  B 997.    -0.2060  0.0    0.0   0.0   0.0
PRINT    395                                  SHEYENNE RIVER AT THE MOUTH
INSTRM   400 MSHEY03                          INSTREAM AT SHEYENNE MOUTH
OTHRIN   420 PREDUDD                          PRECIP TO & EVAP FROM RED R. EVAPDS3
DIVERSN  425 PGFRKDI                          GRAND FORKS DEMAND OF SRR
END      480 SHYBIB6                          PROCRRS RESULTS              SHY6666
```

Supplement 6.--Model input control file for simulation of historic conditions on the Red River of the North

```
  SHEYENNE RIVER MR&I STUDIES - HISTORIC RED RIVER OF THE NORTH STREAMFLOW          SHEYENNE RIVER MR&I STUDIES
          GARRISON DIVERSION UNIT                              P-SMBP     REDOPOH        RED RIVER CALIBRATION OF DISSOLVED SOLIDS
   1 1977   12 1984                                                               1 RRNBIOH
BSINFLW  395 MSHEYOH         .000000001        SHEYENNE RIVER INFLOW        SHYDSOH
NTINFLW  500 HFARGSI                           RED RIVER AT FARGO                  B 605     -.0930  0.0    0.0   0.0   0.0
PRINT    505                                   RED RIVER BELOW SHEYENNE R.
NTINFLW  525 HBUFFSA                           BUFFALO RIVER INFLOW                B 915     -.1650  0.0    0.0   0.0   0.0
PRINT    530                                   RED RIVER BELOW BUFFALO RIVER
NTINFLW  550 HWILDSA                           WILD RICE RIVER INFLOW              B 737     -.1630  0.0    0.0   0.0   0.0
PRINT    555                                   RED RIVER BELOW WILD RICE R.
NTINFLW  575 HFGHLSI                           HIST SEC GAIN FARGO-HALSTAD         B 992     -.0900  0.0    0.0   0.0   0.0
PRINT    600                                   RED RIVER AT HALSTAD
NTINFLW  650 HRLAKSI                           RED LAKE RIVER INFLOW               B 402     -.0700  0.0    0.0   0.0   0.0
PRINT    655                                   RED RIVER BELOW RED LAKE R.
NTINFLW  675 HHLGFSI                           HIST SEC GAIN HALSTAD-G.FORKS       B 1096    -.0550  0.0    0.0   0.0   0.0
PRINT    700                                   RED RIVER AT GRAND FORKS
NTINFLW  775 HGFEMSI                           HIST SEC GAIN G.FORKS-EMERSON       B 7000    -.5500  0.0    75    5000  1000
PRINT    800                                   RED RIVER AT EMERSON, MAN.
END     1000 RRNBIOH                           PROCRRS RESULTS              REDHHHH
```

Supplement 7.--Model input control file for simulation of baseline conditions on the Red River of the North

```
 SHEYENNE RIVER MR&I STUDIES - BASELINE CONDITIONS                                     SHEYENNE RIVER MR&I STUDIES
        GARRISON DIVERSION UNIT                           P-SMBP     REDDS02       RED RIVER OF THE NORTH - BASELINE CONDITIONS
  1 1931   12 1984                                                              1 RRNBI05
BSINFLW  395 MSHEY05          .000000001         SHEYENNE RIVER INFLOW        SHEYDS5
NTINFLW  500 HFARGSI                             RED RIVER AT FARGO                  B 605     -.0930  0.0    0.0   0.0   0.0
PRINT    505                                     RED RIVER BELOW SHEYENNE R.
NTINFLW  525 UBUFFSA                             BUFFALO RIVER INFLOW                B 915     -.1650  0.0    0.0   0.0   0.0
PRINT    530                                     RED RIVER BELOW BUFFALO RIVER
NTINFLW  550 UWILDSA                             WILD RICE RIVER INFLOW              B 737     -.1630  0.0    0.0   0.0   0.0
PRINT    555                                     RED RIVER BELOW WILD RICE R.
NTINFLW  575 UFGHLS2                             UNRG SEC GAIN FARGO-HALSTAD         B 992     -.0900  0.0    0.0   0.0   0.0
DIVERSN  580 HFGHLDA                             ADJ. 1984 DEMANDS TO HAL
PRINT    600                                     RED RIVER AT HALSTAD
NTINFLW  650 URLAKSI                             RED LAKE RIVER INFLOW               B 402     -.0700  0.0    0.0   0.0   0.0
PRINT    655                                     RED RIVER BELOW RED LAKE R.
NTINFLW  675 UHLGFS2                             UNRG SEC GAIN HALSTAD-G.FORKS       B 1096    -.0550  0.0    0.0   0.0   0.0
DIVERSN  680 HHLGFDA                             ADJ. 1984 DEMANDS TO G.F
DIVERSN  690 PREDUEI                             EVAP. ON RED DUE TO GDU
DIVERSN  695 PGFRKDI                             GRAND FORKS DEMAND OF GDU
PRINT    700                                     RED RIVER AT GRAND FORKS
NTINFLW  775 UGFEMSI                             UNRG SEC GAIN G.FORKS-EMERSON       B 7000    -.5500  0.0    75    5000  1000
DIVERSN  780 HGFDRDA                             ADJ. 1984 DEMANDS TO DRAYTON
DIVERSN  781 HDREMDA                             ADJ. 1984 DEMANDS TO EMERSON
PRINT    800                                     RED RIVER AT EMERSON, MAN.
END     1000 RRNBI05                             PROCRRS RESULTS              RED5555
```

Supplement 8.--Model input control file for simulation of year-round operation of the Garrison Diverion Unit Sheyenne River water supply on the Red River of the North

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 SHEYENNE RIVER MR&I STUDIES - YEAR-ROUND OPERATION                                  SHEYENNE RIVER MR&I STUDIES
  OF THE GARRISON DIVERSION UNIT                     P-SMBP     REDDS02            RED RIVER OF THE NORTH - YEAR-ROUND OPERATION
   1 1931   12 1984                                                              1 RRNBI05
BSINFLW  395 MSHEY05          .000000001       SHEYENNE RIVER INFLOW       SHEYDS5
NTINFLW  500 HFARGSI                           RED RIVER AT FARGO                 B 605     -.0930  0.0    0.0   0.0    0.0
PRINT    505                                   RED RIVER BELOW SHEYENNE R.
NTINFLW  525 UBUFFSA                           BUFFALO RIVER INFLOW               B 915     -.1650  0.0    0.0   0.0    0.0
PRINT    530                                   RED RIVER BELOW BUFFALO RIVER
NTINFLW  550 UWILDSA                           WILD RICE RIVER INFLOW             B 737     -.1630  0.0    0.0   0.0    0.0
PRINT    555                                   RED RIVER BELOW WILD RICE R.
NTINFLW  575 UFGHLS2                           UNRG SEC GAIN FARGO-HALSTAD        B 992     -.0900  0.0    0.0   0.0    0.0
DIVERSN  580 HFGHLDA                           ADJ. 1984 DEMANDS TO HAL
PRINT    600                                   RED RIVER AT HALSTAD
NTINFLW  650 URLAKSI                           RED LAKE RIVER INFLOW              B 402     -.0700  0.0    0.0   0.0    0.0
PRINT    655                                   RED RIVER BELOW RED LAKE R.
NTINFLW  675 UHLGFS2                           UNRG SEC GAIN HALSTAD-G.FORKS      B 1096    -.0550  0.0    0.0   0.0    0.0
DIVERSN  680 HHLGFDA                           ADJ. 1984 DEMANDS TO G.F
OTHRIN   690 PREDUDD                           EVAP. ON RED DUE TO GDU     EVAPDS3
DIVERSN  695 PGFRKDI                           GRAND FORKS DEMAND OF GDU
PRINT    700                                   RED RIVER AT GRAND FORKS
NTINFLW  775 UGFEMSI                           UNRG SEC GAIN G.FORKS-EMERSON      B 7000    -.5500  0.0    75    5000   1000
DIVERSN  780 HGFDRDA                           ADJ. 1984 DEMANDS TO DRAYTON
DIVERSN  781 HDREMDA                           ADJ. 1984 DEMANDS TO EMERSON
PRINT    800                                   RED RIVER AT EMERSON, MAN.
END     1000 RRNBI05                           PROCRRS RESULTS             RED5555
```

Supplement 9.--Model input for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply on the Red River of the North

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 SHEYENNE RIVER MR&I STUDIES - NONWINTER OPERATION                        SHEYENNE RIVER MR&I STUDIES
  OF THE GARRISON DIVERSION UNIT                    P-SMBP     REDDS06   RED RIVER OF THE NORTH - NONWINTER OPERATION
   1 1931   12 1984                                                    1 RRNBI06
BSINFLW  395 MSHEY06          .000000001     SHEYENNE RIVER INFLOW        SHEYDS6
NTINFLW  500 HFARGSI                         RED RIVER AT FARGO                  B 606     -.0930  0.0   0.0   0.0   0.0
PRINT    505                                 RED RIVER BELOW SHEYENNE R.
NTINFLW  525 UBUFFSA                         BUFFALO RIVER INFLOW                B 915     -.1650  0.0   0.0   0.0   0.0
PRINT    530                                 RED RIVER BELOW BUFFALO RIVER
NTINFLW  550 UWILDSA                         WILD RICE RIVER INFLOW              B 737     -.1630  0.0   0.0   0.0   0.0
PRINT    555                                 RED RIVER BELOW WILD RICE R.
NTINFLW  575 UFGHLS2                         UNRG SEC GAIN FARGO-HALSTAD         B 992     -.0900  0.0   0.0   0.0   0.0
DIVERSN  580 HFGHLDA                         ADJ. 1984 DEMANDS TO HAL
PRINT    600                                 RED RIVER AT HALSTAD
NTINFLW  650 URLAKSI                         RED LAKE RIVER INFLOW               B 402     -.0700  0.0   0.0   0.0   0.0
PRINT    655                                 RED RIVER BELOW RED LAKE R.
NTINFLW  675 UHLGFS2                         UNRG SEC GAIN HALSTAD-G.FORKS       B 1096    -.0550  0.0   0.0   0.0   0.0
DIVERSN  680 HHLGFDA                         ADJ. 1984 DEMANDS TO G.F
OTHRIN   690 PREDUDD                         EVAP. ON RED DUE TO GDU      EVAPDS3
DIVERSN  695 PGFRKDI                         GRAND FORKS DEMAND OF GDU
PRINT    700                                 RED RIVER AT GRAND FORKS
NTINFLW  775 UGFEMSI                         UNRG SEC GAIN G.FORKS-EMERSON       B 7000    -.5500  0.0   75    5000  1000
DIVERSN  780 HGFDRDA                         ADJ. 1984 DEMANDS TO DRAYTON
DIVERSN  781 HDREMDA                         ADJ. 1984 DEMANDS TO EMERSON
PRINT    800                                 RED RIVER AT EMERSON, MAN.
END     1000 RRNBI06                         PROCRRS RESULTS              RED6666
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Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84

Node 50, Sheyenne River above Harvey, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	0.4	1.8	17.8	40.1	15.2	9.6	4.5	1.4	1.3	1.6	1.6	0.8	8.0
Standard deviation	.8	4.8	26.2	53.5	26.3	13.6	7.0	1.7	1.5	1.9	1.7	1.0	7.7
Minimum	0	0	0	2.7	1.0	.2	0	0	0	0	0	0	.8
10 percentile	0	0	.6	3.7	2.2	1.1	.4	0	0	0	0	0	1.8
25 percentile	0	0	2.9	6.8	3.6	2.2	1.1	.2	.2	.6	.8	.2	2.6
Median	.2	.2	6.1	15.7	7.1	5.3	2.7	.9	.8	1.2	1.4	.7	5.2
75 percentile	.5	.8	20.7	66.0	14.8	11.8	4.6	1.6	1.8	2.1	1.9	1.1	10.8
90 percentile	1.0	5.9	50.2	101.0	30.0	20.0	9.3	4.7	3.6	3.8	2.8	1.6	15.7
Maximum	4.1	26.8	123.0	287.0	178.0	76.3	43.4	6.8	7.3	11.8	10.4	6.3	41.9
						Dissolved-solids concentration, in milligrams per liter							
Mean	1,080.0	1,051.3	845.9	760.1	827.4	867.3	929.4	1,002.5	1,002.4	979.2	982.2	1,043.4	947.6
Standard deviation	97.1	129.4	131.1	96.9	81.9	96.8	107.3	99.1	94.9	88.9	94.3	93.7	60.8
Minimum	878.0	734.0	616.0	551.0	587.0	653.0	696.0	839.0	834.0	797.0	807.0	846.0	805.1
10 percentile	952.4	850.0	685.3	631.0	725.1	756.3	814.8	867.8	888.3	884.2	908.8	951.5	886.9
25 percentile	1,005.0	984.0	753.0	664.0	779.0	797.0	870.0	949.0	934.0	930.0	935.0	984.0	906.5
Median	1,081.5	1,063.0	847.5	775.0	836.0	858.0	912.0	988.5	989.0	967.0	959.0	1,014.5	943.8
75 percentile	1,145.0	1,145.0	906.0	840.0	890.0	928.0	984.0	1,056.0	1,049.0	1,000.0	1,003.0	1,108.0	980.8
90 percentile	1,220.7	1,219.0	1,025.8	886.0	926.1	983.6	1,054.2	1,152.4	1,145.6	1,090.0	1,111.7	1,165.8	1,023.6
Maximum	1,289.0	1,289.0	1,182.0	912.0	986.0	1,124.0	1,289.0	1,258.0	1,258.0	1,289.0	1,289.0	1,289.0	1,096.2

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 75, Sheyenne River near Warwick, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	1.4	5.6	82.9	250.7	76.3	35.9	17.2	3.7	5.7	7.7	6.9	2.9	41.4
Standard deviation	3.5	21.9	150.0	297.8	142.2	54.6	34.4	9.1	11.4	13.3	8.9	4.6	38.7
Minimum	0	0	0	.3	0	0	0	0	0	0	0	0	1.3
10 percentile	0	0	1.5	16.6	3.2	0	0	0	0	0	0	0	3.9
25 percentile	0	0	9.5	35.4	7.8	0	0	0	0	0	.8	0	10.8
Median	0	0	21.0	148.0	27.9	18.3	2.3	0	.2	2.3	5.1	1.4	31.5
75 percentile	1.2	1.6	87.5	327.1	72.0	43.9	16.0	.5	5.3	7.7	8.7	3.7	61.4
90 percentile	4.1	7.7	239.1	660.6	183.9	85.1	48.7	11.8	20.4	27.8	17.4	6.5	92.7
Maximum	22.8	150.5	789.6	1,405.1	836.7	308.7	152.7	40.4	58.2	70.1	46.8	26.5	197.2
						Dissolved-solids concentration, in milligrams per liter							
Mean	551.3	570.0	529.6	394.1	566.4	698.7	615.7	609.3	589.4	556.9	565.3	534.8	565.1
Standard deviation	106.5	146.0	121.3	78.2	55.8	77.7	65.9	71.9	150.7	74.7	79.5	72.3	41.2
Minimum	329.0	343.8	315.0	270.5	433.4	464.5	464.5	427.0	427.0	358.0	342.0	342.0	473.1
10 percentile	443.1	467.2	403.8	293.9	477.6	599.1	560.2	516.0	478.8	466.2	490.9	461.3	513.7
25 percentile	497.1	512.0	432.6	327.1	534.0	679.4	582.6	581.9	535.8	519.0	522.8	494.0	541.0
Median	540.0	549.3	525.0	384.8	570.1	718.4	599.1	606.0	562.2	556.6	563.8	537.7	564.8
75 percentile	591.8	606.5	581.2	463.7	604.6	748.4	645.3	654.6	598.3	593.2	601.8	581.9	583.2
90 percentile	660.7	677.7	671.2	492.5	631.0	766.1	718.8	708.3	656.0	629.8	662.3	605.6	628.5
Maximum	1,022.0	1,419.8	907.2	562.7	675.7	819.2	762.8	762.8	1,468.7	762.2	775.0	710.0	673.9

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 125, Sheyenne River near Cooperstown, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
							Streamflow, in cubic feet per second						
Mean	5.9	6.9	125.4	469.2	165.2	84.3	39.4	12.8	12.7	17.9	17.2	10.3	80.6
Standard deviation	5.3	11.5	215.2	496.7	306.4	88.3	49.9	26.0	24.9	23.6	15.8	9.9	72.9
Minimum	0	0	0	11.4	0	0	0	0	0	0	0	0	4.3
10 percentile	.8	0	5.3	56.8	16.6	3.3	0	0	0	.4	1.7	1.6	10.3
25 percentile	2.1	1.5	18.7	93.1	26.3	17.6	3.4	0	0	2.2	6.0	3.5	27.1
Median	4.9	3.8	42.7	357.6	57.0	59.8	21.0	3.3	.3	9.9	12.9	8.2	58.9
75 percentile	7.7	7.1	139.9	662.1	154.6	132.8	62.9	11.3	16.5	24.5	20.7	13.5	117.4
90 percentile	12.1	13.2	352.3	1098.9	335.8	215.6	112.1	39.9	37.6	44.9	43.3	20.4	189.0
Maximum	25.4	71.2	1,090.6	2,277.1	1,930.3	413.1	190.6	131.0	144.9	110.9	61.9	57.9	389.7
							Dissolved-solids concentration, in milligrams per liter						
Mean	688.6	686.2	546.7	423.8	543.1	613.7	600.3	645.9	646.4	645.8	635.9	652.9	610.8
Standard deviation	64.5	107.8	100.6	80.1	62.5	72.4	58.8	60.0	69.5	77.8	62.0	60.0	41.4
Minimum	505.3	343.8	340.8	296.8	363.3	455.3	483.7	471.3	489.3	505.3	505.3	505.3	524.0
10 percentile	628.9	558.2	417.8	321.4	462.2	515.9	538.1	581.7	569.8	563.9	574.7	601.8	563.5
25 percentile	651.6	647.6	464.8	347.6	508.8	569.9	564.2	616.6	598.3	586.5	602.7	619.3	581.4
Median	673.1	681.8	555.4	397.7	558.2	632.0	593.5	643.5	631.4	619.6	622.7	640.7	611.2
75 percentile	739.7	747.1	591.8	484.8	580.8	645.9	640.2	676.7	694.3	705.5	655.4	683.0	633.9
90 percentile	782.2	791.1	673.1	528.4	610.8	693.1	687.8	725.7	754.3	762.8	748.6	745.7	659.2
Maximum	800.0	1,138.1	800.0	629.7	669.8	807.0	736.8	787.4	800.0	800.0	800.0	800.0	729.0

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 175, Sheyenne River below Baldhill Dam, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	53.6	59.2	101.7	434.4	202.6	106.7	51.2	46.3	54.4	29.6	37.4	40.5	101.5
Standard deviation	33.0	35.7	218.4	603.0	409.7	99.8	44.4	24.0	27.6	38.3	35.9	29.6	94.7
Minimum	0	0	0	0	6.7	2.6	0	0	0	0	0	0	6.4
10 percentile	4.1	2.3	28.3	14.9	20.7	18.2	15.4	18.7	24.1	8.7	6.6	.8	27.6
25 percentile	18.8	18.8	39.8	15.2	33.2	39.7	23.9	27.6	35.0	14.6	15.1	15.0	39.1
Median	70.8	71.0	40.4	164.1	60.3	68.1	33.1	42.5	55.8	15.0	21.4	39.9	64.4
75 percentile	76.5	80.7	57.1	661.8	195.8	160.7	69.7	59.7	65.0	24.9	62.1	65.8	149.3
90 percentile	82.6	95.3	180.0	1,069.7	375.4	231.9	109.2	80.9	92.0	76.9	82.2	78.0	229.9
Maximum	122.7	155.1	1,190.4	2,634.6	2,648.2	480.0	202.5	105.7	139.6	181.4	147.2	97.9	514.5
						Dissolved-solids concentration, in milligrams per liter							
Mean	522.4	521.7	509.1	461.1	480.2	493.8	499.1	518.7	530.4	536.6	521.7	516.0	516.9
Standard deviation	72.7	71.4	84.1	93.5	94.4	92.6	83.8	98.2	106.1	106.9	71.4	61.3	91.7
Minimum	419.6	422.6	362.9	312.1	322.2	356.4	375.7	390.2	398.0	408.1	413.4	416.3	394.7
10 percentile	446.1	447.0	428.6	368.9	390.1	408.7	413.1	425.7	431.9	441.1	444.7	445.9	423.0
25 percentile	469.9	471.8	450.0	391.7	406.2	431.9	438.1	452.3	459.2	466.1	469.1	468.9	455.1
Median	512.6	509.6	492.2	452.5	463.2	476.6	485.5	501.9	504.7	512.5	509.7	510.3	505.5
75 percentile	564.7	558.4	538.4	509.3	520.1	527.5	533.9	547.9	564.9	565.2	564.7	560.7	543.7
90 percentile	602.0	602.3	591.5	563.7	604.1	611.9	599.9	622.1	643.1	651.1	617.6	584.5	630.8
Maximum	807.5	801.2	811.1	765.5	765.8	793.4	817.4	863.4	905.6	918.2	727.8	708.5	828.1

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 225, Sheyenne River at Lisbon, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	54.6	62.1	160.9	552.5	240.1	121.8	69.6	34.4	40.0	33.3	40.2	42.7	121.0
Standard deviation	35.5	39.7	241.4	700.8	512.4	139.0	119.1	23.1	24.5	39.0	35.4	31.5	113.6
Minimum	0	0	0	16.1	6.7	2.6	0	0	0	.4	0	0	8.9
10 percentile	5.3	5.9	39.8	37.9	15.0	18.2	14.7	15.0	15.4	7.2	7.9	3.5	28.9
25 percentile	16.9	20.8	51.8	65.4	21.6	34.4	17.0	21.5	24.9	15.7	16.9	15.3	42.3
Median	69.0	71.8	86.6	247.4	57.4	63.7	28.6	30.1	37.9	19.9	23.6	41.5	78.2
75 percentile	79.1	85.5	163.6	793.0	236.1	146.1	70.0	43.2	46.9	28.8	73.1	74.6	175.0
90 percentile	87.2	111.7	320.9	1,403.6	468.8	302.5	142.2	59.5	71.4	80.1	91.3	82.2	266.7
Maximum	130.0	171.7	1,382.6	2,961.4	3,173.5	650.5	634.6	144.3	118.2	173.3	155.1	107.3	612.3
						Dissolved-solids concentration, in milligrams per liter							
Mean	659.3	662.9	536.0	461.9	536.9	556.4	596.3	625.6	603.9	702.9	695.9	719.1	613.1
Standard deviation	347.6	327.4	165.3	126.4	149.4	177.0	203.1	180.4	114.6	228.8	274.3	407.0	173.2
Minimum	446.8	457.1	245.7	270.3	277.5	304.7	191.9	441.5	422.5	442.5	457.2	446.0	432.6
10 percentile	474.5	473.2	356.7	305.4	383.3	416.0	414.5	489.2	505.7	495.2	495.9	480.6	472.3
25 percentile	501.4	512.5	416.3	377.2	425.5	464.3	502.9	531.3	533.9	583.5	546.3	525.5	500.3
Median.	542.5	550.3	520.2	414.1	551.0	532.3	597.1	598.8	590.9	679.1	619.5	572.0	566.2
75 percentile	628.9	675.3	618.1	557.3	629.4	605.7	641.3	652.0	633.7	727.7	759.3	723.1	627.7
90 percentile	924.5	922.5	747.4	635.1	689.6	658.9	688.8	721.2	762.8	904.4	911.3	949.4	895.7
Maximum	2,253.0	2,253.0	1,162.4	822.7	1,071.5	1,410.4	1,501.4	1,461.5	1,056.3	1,946.4	2,253.0	2,253.0	1,167.6

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 250, Sheyenne River near Kindred, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	63.8	70.5	159.7	596.9	289.4	143.1	97.5	34.6	27.7	51.5	57.5	55.1	137.3
Standard deviation	40.6	50.8	220.6	614.0	507.3	196.2	223.1	37.2	17.5	44.5	40.7	38.7	118.7
Minimum	0	0	0	55.7	5.8	2.6	0	0	0	1.6	7.7	0	7.7
10 percentile	8.9	8.7	39.9	87.9	17.1	15.3	15.1	14.9	15.7	10.0	13.4	9.2	29.0
25 percentile	24.9	24.4	55.1	125.2	21.5	21.5	20.9	19.0	19.7	26.7	26.7	20.8	49.2
Median	77.3	79.1	90.5	283.6	96.6	69.1	29.6	22.6	23.5	39.7	45.6	59.2	101.4
75 percentile	92.9	101.6	158.1	929.8	347.2	192.7	94.0	29.5	30.1	60.4	84.7	89.2	205.0
90 percentile	106.0	114.3	295.7	1,340.1	758.8	288.3	163.0	70.1	42.7	105.5	120.0	102.8	299.3
Maximum	141.0	251.7	1,195.5	2,700.7	2,669.2	1,089.2	1,361.8	201.4	109.9	222.5	188.8	145.0	593.5
						Dissolved-solids concentration, in milligrams per liter							
Mean	574.2	573.5	507.3	447.0	498.8	519.2	534.3	571.1	581.9	632.2	605.3	587.9	552.7
Standard deviation	119.0	117.1	109.9	95.6	89.4	74.3	78.2	61.0	68.9	125.7	99.6	124.5	74.8
Minimum	440.0	440.0	245.7	270.3	293.6	335.6	276.0	443.0	478.9	452.9	444.9	440.0	449.9
10 percentile	482.7	472.2	367.0	328.4	394.9	426.5	444.8	503.0	520.6	515.0	507.3	483.4	476.5
25 percentile	505.9	507.6	431.9	378.7	438.4	465.0	498.5	532.5	538.4	559.7	553.7	519.6	495.4
Median	537.7	544.5	510.9	425.8	504.3	523.4	542.7	562.7	564.6	609.4	582.0	554.6	538.1
75 percentile	591.0	580.1	595.0	523.6	561.9	571.0	583.1	597.8	606.4	662.9	640.8	619.4	578.6
90 percentile	734.0	720.6	643.6	581.6	634.4	620.3	604.2	631.6	670.0	766.3	738.3	728.4	642.5
Maximum	1,007.3	1,024.5	737.1	682.0	673.4	669.2	687.3	748.7	783.8	1,233.5	926.0	1,007.3	784.3

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 275, Sheyenne River at West Fargo, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	59.3	66.6	140.3	604.7	292.4	149.9	101.5	31.4	18.8	46.1	54.2	51.7	134.7
Standard deviation	41.0	50.7	190.0	576.7	463.8	191.4	215.6	40.2	17.2	48.5	44.7	40.2	113.4
Minimum	0	0	0	53.9	2.5	2.5	0	0	0	0	0	0	6.5
10 percentile	4.4	4.5	39.4	89.2	17.1	17.0	2.5	2.3	.1	0	6.6	4.1	17.4
25 percentile	15.4	15.6	49.8	127.8	20.5	17.7	17.6	17.3	16.6	17.4	21.6	16.8	47.5
Median	76.3	75.9	79.3	315.0	95.1	61.5	36.7	17.9	17.4	35.6	41.6	50.7	98.7
75 percentile	89.1	99.5	150.2	967.1	421.5	213.5	104.7	24.2	18.4	57.3	88.8	84.8	211.3
90 percentile	101.9	122.5	295.6	1,433.3	778.5	345.9	186.1	82.0	33.0	103.4	122.6	100.5	301.3
Maximum	142.1	237.1	1,010.6	2,433.8	2,264.6	930.6	1,248.2	195.8	106.0	225.9	184.2	162.4	539.7
						Dissolved-solids concentration, in milligrams per liter							
Mean	559.8	564.1	504.1	437.4	482.3	501.3	510.3	548.9	561.6	611.1	593.0	568.7	536.9
Standard deviation	94.6	104.0	106.5	92.3	86.7	79.6	87.3	54.8	46.3	111.6	95.0	96.4	65.2
Minimum	444.4	444.4	250.7	280.7	293.6	324.8	269.3	443.0	479.8	452.9	418.8	443.4	444.8
10 percentile	481.5	468.5	367.0	316.4	374.1	410.2	425.0	473.1	507.1	505.6	483.7	480.5	460.7
25 percentile	503.9	507.6	430.3	366.6	417.4	425.8	458.3	516.7	534.5	555.6	542.8	519.4	493.7
Median	535.8	544.6	502.1	413.5	486.4	510.1	517.1	550.0	550.1	595.0	577.2	544.6	526.9
75 percentile	588.0	575.0	586.2	510.3	542.9	557.9	568.9	588.5	592.7	648.7	634.1	610.8	567.7
90 percentile	686.4	708.0	640.0	574.4	621.0	605.2	590.1	613.5	620.1	689.0	687.1	688.4	636.9
Maximum	933.5	936.9	732.6	673.3	637.2	643.4	685.6	685.6	685.6	1,127.3	908.6	947.1	724.5

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 600, Red River of the North at Halstad, Minn.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	320.8	316.1	1,190.6	5,152.1	2,285.2	2,004.9	1,597.0	586.9	426.7	466.5	491.8	378.9	1,268.1
Standard deviation	235.2	212.9	1,744.0	4,888.5	2,146.0	1,997.4	2,924.7	691.3	455.1	427.2	369.5	280.0	921.5
Minimum	0	0	0	449.1	153.6	29.1	0	0	0	0	0	0	92.3
10 percentile	12.2	18.4	161.4	728.7	360.8	128.7	55.1	0	10.8	2.0	57.2	27.5	247.2
25 percentile	151.3	160.0	291.0	1399.3	861.7	537.0	271.4	167.7	146.7	127.4	228.4	190.7	658.2
Median	310.9	302.1	637.2	3,130.9	1,892.0	1,522.3	940.4	387.4	299.1	365.8	433.5	338.4	1,013.3
75 percentile	485.9	468.0	1,067.9	7,395.8	2,964.5	2,879.9	1,652.9	797.6	595.1	651.5	725.1	565.7	1,775.0
90 percentile	690.2	613.5	3,616.8	12,213.4	4,912.8	4,516.6	2,764.0	1,300.2	894.9	1,229.3	922.9	794.6	2,741.8
Maximum	911.3	832.5	9,487.4	20,301.0	11,110.5	10,159.2	19,920.8	3,758.0	2,452.0	1,625.1	1,745.6	1,069.3	3,918.6
						Dissolved-solids concentration, in milligrams per liter							
Mean	476.8	470.1	421.0	374.3	384.9	393.4	419.2	459.0	474.3	469.4	496.9	496.1	444.6
Standard deviation	96.5	75.3	74.1	52.2	62.9	71.0	89.0	83.6	97.7	91.3	93.3	100.8	66.1
Minimum	377.9	360.0	305.8	278.9	304.7	294.5	290.3	333.7	335.1	352.5	337.4	376.4	369.7
10 percentile	407.5	396.8	351.9	316.0	327.4	320.7	338.2	371.4	378.7	379.9	407.0	406.1	385.7
25 percentile	423.0	421.9	385.1	337.1	339.7	336.4	366.6	401.5	405.9	401.7	431.5	436.9	397.9
Median	446.0	451.5	404.2	366.5	358.1	374.4	403.9	434.7	445.7	445.7	476.8	470.7	421.0
75 percentile	486.0	492.3	429.4	404.1	424.6	436.4	453.0	488.8	528.9	520.0	535.3	514.8	467.4
90 percentile	590.9	575.6	523.7	459.0	474.9	496.0	526.3	545.9	624.6	607.2	645.2	619.2	541.6
Maximum	949.8	711.0	708.4	498.7	589.1	624.5	737.3	737.3	737.3	737.3	737.3	949.8	658.1

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 700, Red River of the North at Grand Forks, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	748.7	527.6	1,950.5	9,856.0	4,881.9	3,813.0	2,804.7	1,187.0	1,023.1	1,243.9	1,073.1	853.9	2,497.0
Standard deviation	582.8	463.8	2,332.3	8,521.7	5,797.8	3,636.4	3,879.8	1,168.7	924.5	1,081.8	937.9	684.7	1,803.1
Minimum	0	0	0	797.0	69.5	0	0	0	0	0	0	0	136.3
10 percentile	0	0	295.9	1,272.8	518.5	144.7	62.4	0	0	0	59.9	0	430.9
25 percentile	211.9	112.5	577.8	2,978.1	1,346.7	1,035.7	473.7	367.3	329.2	276.6	322.0	185.1	1,028.5
Median	664.0	420.3	1,322.8	6,762.9	2,978.2	3,009.3	1,896.6	819.4	924.1	1,133.3	990.3	759.7	2,081.0
75 percentile	1,207.5	776.4	1,865.0	16,606.3	7,095.9	4,936.5	3,276.2	1,729.5	1,507.7	1,831.3	1710.7	1,389.4	3,614.8
90 percentile	1,597.9	1,322.3	5,476.9	24,259.2	10,599.2	9,455.3	5,519.5	2,704.9	2,239.0	2,680.8	2207.1	1,776.4	5,008.9
Maximum	1,862.1	1,715.7	10,209.5	31,503.6	35,839.9	18,941.9	24,980.1	5,535.3	3,745.9	4,214.0	5093.5	2,881.7	7,604.3
						Dissolved-solids concentration, in milligrams per liter							
Mean	382.1	389.7	368.9	362.1	354.0	358.9	390.8	394.6	397.9	390.7	387.3	391.2	380.7
Standard deviation	135.9	137.3	96.6	43.9	66.3	101.9	134.6	146.2	147.1	147.9	132.5	129.9	105.3
Minimum	271.6	274.0	283.3	261.0	263.9	265.1	260.4	260.7	269.1	264.3	264.5	272.4	297.7
10 percentile	292.0	292.2	294.1	319.0	293.9	282.5	287.6	290.2	279.7	282.8	293.9	297.4	306.9
25 percentile	299.6	306.4	309.3	333.9	310.8	298.3	316.0	307.0	300.9	297.5	304.1	315.6	321.4
Median	337.6	342.4	335.6	354.5	331.4	326.6	348.6	336.8	335.1	338.5	346.6	361.3	342.5
75 percentile	391.4	408.1	386.2	388.0	392.1	373.0	388.8	409.3	463.5	411.6	410.5	407.3	390.9
90 percentile	591.1	610.6	458.8	427.2	454.5	457.8	627.7	627.7	627.7	627.7	517.9	517.9	540.4
Maximum	857.2	857.2	804.9	462.8	575.7	760.0	857.2	857.2	857.2	857.2	857.2	857.2	708.3

Supplement 10.--Summary of model output for selected nodes for simulation of baseline conditions for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 800, Red River of the North at Emerson, Man.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Annual
	Streamflow, in cubic feet per second												
Mean	727.7	685.6	1,687.0	13,183.0	9,188.4	5,092.2	3,559.2	1,460.4	1,198.0	1,364.5	1,223.8	869.5	3,353.3
Standard deviation	581.6	533.1	2,036.0	9,827.4	12,802.9	5,096.4	4,415.9	1,411.4	1,210.9	1,193.6	1,053.6	725.3	2,477.7
Minimum	0	0	0	1,083.3	315.8	3.8	0	0	0	0	0	0	210.3
10 percentile	0	0	182.7	2,386.2	977.9	291.8	102.3	1.8	0	0	47.1	0	643.4
25 percentile	180.2	191.3	516.6	4,654.6	2,052.4	1,300.2	725.0	425.2	322.6	295.3	391.5	197.2	1,232.9
Median	658.2	639.5	1,253.3	12,593.9	4,061.5	3,800.1	2,600.8	1,148.1	1,003.2	1,275.9	1,176.2	758.3	2,968.5
75 percentile	1,216.6	1,178.3	1,702.3	19,237.4	10,504.8	6,602.6	5,031.8	2,121.6	1,718.2	1,964.1	1,891.8	1,437.7	4,700.2
90 percentile	1,561.1	1,453.6	5,366.6	25,543.1	23,005.8	11,385.6	6,397.6	3,061.3	2,513.9	3,243.6	2,307.8	1,831.6	6,619.6
Maximum	1,965.2	1,802.1	9,171.5	45,522.8	72,099.3	24,984.2	27,683.8	6,813.2	5,775.9	4,309.3	5,007.9	2,611.0	12,084.8
	Dissolved-solids concentration, in milligrams per liter												
Mean	894.9	885.3	598.8	311.4	380.1	562.4	836.8	1,202.2	1,219.0	1,010.8	1,084.0	1,072.6	838.2
Standard deviation	1,269.1	1,270.3	878.2	115.1	250.4	713.7	1,065.9	1,411.5	1,464.7	1,248.4	1,216.3	1,354.0	847.0
Minimum	284.1	176.2	292.4	128.9	131.3	170.7	153.9	221.2	195.3	251.6	223.6	247.8	329.5
10 percentile	295.7	297.3	294.1	199.2	161.3	227.6	240.3	388.8	315.6	333.9	435.5	327.2	360.3
25 percentile	325.5	328.0	318.6	235.5	219.9	256.1	348.6	481.3	448.9	375.6	484.2	367.8	384.2
Median	413.5	425.1	364.4	281.6	268.4	372.2	450.5	614.5	576.2	548.9	616.5	524.5	462.9
75 percentile	658.3	591.7	447.1	351.9	486.0	573.5	804.0	900.0	1,056.9	904.6	1,150.1	1,081.5	776.6
90 percentile	2,504.9	2,504.9	753.1	508.4	671.4	905.1	1,853.8	3,612.5	4,842.2	2,983.7	2,504.9	3,357.2	2,152.4
Maximum	5,000.0	5,000.0	5,000.0	740.9	1,401.1	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	3,724.2

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84

Node 25, Garrison Diversion Unit Sheyenne River water supply

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
					Streamflow, in cubic feet per second								
Mean	98.8	99.1	99.8	100.9	105.9	105.1	110.1	112.1	110.7	104.0	100.9	99.0	103.9
Standard deviation	1.6	1.9	1.3	2.1	4.6	4.5	5.7	7.0	8.0	3.9	1.8	1.5	1.4
Minimum	91.7	91.4	94.6	96.0	95.7	93.4	94.2	88.5	90.3	90.3	94.4	95.4	100.0
10 percentile	96.9	96.2	98.1	97.5	99.5	99.8	103.9	103.8	97.7	98.8	98.5	96.8	102.3
25 percentile	97.9	98.6	99.1	99.3	103.6	101.9	107.3	108.4	107.2	102.5	100.4	98.0	103.2
Median	99.2	99.6	100.1	101.6	104.8	105.0	110.3	112.8	111.5	105.0	101.4	99.2	103.9
75 percentile	99.9	100.3	100.7	102.7	110.0	107.8	113.6	116.9	117.6	107.1	102.0	100.3	104.7
90 percentile	100.5	100.9	101.3	103.1	112.3	111.9	117.7	119.9	118.5	107.8	102.5	100.9	105.5
Maximum	100.9	101.4	101.5	103.9	115.2	114.1	120.8	125.5	122.1	108.4	102.9	101.3	107.3
					Dissolved-solids concentration, in milligrams per liter								
Mean	566.9	563.8	563.8	556.1	506.0	495.9	492.2	496.2	501.9	511.1	574.0	570.0	533.2
Standard deviation	5.3	4.9	4.9	32.3	6.0	4.6	4.4	5.7	6.1	5.9	7.3	6.8	5.5
Minimum	545.0	543.0	543.0	498.0	490.0	481.0	481.0	475.0	483.0	484.0	544.0	541.0	516.8
10 percentile	562.8	560.8	560.8	506.7	498.0	490.9	486.8	489.9	494.0	508.0	568.9	564.9	526.9
25 percentile	566.0	563.0	563.0	553.0	504.0	495.0	492.0	496.0	502.0	511.0	574.0	570.0	532.8
Median	567.0	564.0	564.0	556.0	506.0	496.0	492.0	496.0	502.0	511.0	574.0	570.0	533.2
75 percentile	567.0	564.0	564.0	584.0	506.0	498.0	495.0	497.0	502.0	513.0	576.0	571.0	534.8
90 percentile	573.0	570.0	570.0	601.0	516.0	501.0	498.0	503.0	511.0	518.0	582.2	578.1	542.0
Maximum	577.0	573.0	573.0	605.0	521.0	509.0	503.0	509.0	514.0	521.0	587.0	582.0	545.7

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 50, Sheyenne River above Harvey, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Streamflow, in cubic feet per second													
Mean	99.2	100.9	117.6	141.0	121.1	114.7	114.6	113.5	112.0	105.7	102.5	99.9	111.9
Standard deviation	1.8	5.4	26.0	53.8	25.2	13.3	8.4	6.4	7.5	3.2	2.2	2.0	7.7
Minimum	91.7	91.7	96.5	102.0	102.5	100.4	97.0	93.9	92.5	97.5	95.7	96.1	101.6
10 percentile	96.9	96.2	100.2	105.8	106.7	104.1	105.6	104.9	100.3	101.3	100.4	97.1	105.3
25 percentile	98.2	98.6	102.7	107.2	109.4	107.3	110.2	110.2	108.7	104.1	101.4	98.7	106.7
Median	99.7	100.0	106.6	117.8	114.1	111.4	114.5	114.1	112.8	106.4	102.7	99.9	110.0
75 percentile	100.3	100.9	121.2	165.8	121.2	115.8	118.4	117.0	118.2	108.2	103.6	101.0	115.3
90 percentile	101.0	106.1	149.7	203.6	139.3	131.6	121.4	122.2	119.3	108.8	104.3	102.5	119.6
Maximum	103.0	126.2	221.6	388.6	273.7	180.1	149.9	125.5	122.1	110.8	110.2	106.5	145.5
Dissolved-solids concentration, in milligrams per liter													
Mean	568.6	568.1	583.6	581.4	530.9	516.8	504.6	501.5	507.0	517.4	579.5	573.3	544.4
Standard deviation	5.9	7.5	13.2	34.3	17.2	16.3	11.6	7.6	7.8	6.5	6.9	6.0	6.2
Minimum	545.9	555.8	561.5	512.3	503.6	488.7	485.0	486.6	486.3	502.7	558.0	554.9	532.5
10 percentile	562.8	561.2	565.3	526.4	511.2	498.8	494.4	494.2	496.8	511.0	573.0	567.7	536.0
25 percentile	567.0	564.0	573.0	566.2	516.7	506.7	497.2	496.7	502.1	512.5	574.3	570.0	539.2
Median	568.5	566.5	580.6	584.1	529.2	512.7	501.1	500.2	506.0	516.1	578.6	573.5	544.5
75 percentile	572.0	570.0	595.9	615.9	544.1	524.9	507.5	506.6	513.8	520.4	583.9	575.9	548.6
90 percentile	575.9	579.4	604.5	619.6	558.8	541.3	522.2	510.0	517.5	525.7	589.8	580.6	552.0
Maximum	579.4	600.1	609.9	630.4	569.9	564.3	543.9	530.3	524.0	539.7	592.5	586.2	556.7

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 75, Sheyenne River near Warwick, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	100.2	104.6	182.7	351.6	182.2	141.0	127.3	115.8	116.3	111.7	107.8	102.0	145.3
Standard deviation	3.9	22.1	149.6	297.9	140.6	53.9	33.5	10.6	11.3	12.1	8.7	5.2	38.6
Minimum	91.7	91.4	98.8	102.2	100.6	98.8	96.9	98.0	93.8	97.4	95.2	95.4	101.3
10 percentile	97.0	96.5	101.0	115.1	110.8	104.8	108.6	104.4	104.7	102.3	101.0	97.5	108.9
25 percentile	98.6	98.6	109.8	136.5	115.0	109.5	111.2	110.0	111.5	104.5	102.3	99.2	115.5
Median	99.8	100.2	121.6	250.1	136.4	122.4	115.5	114.2	116.4	107.7	106.0	100.5	135.0
75 percentile	100.7	101.0	186.8	424.4	182.6	146.9	126.5	119.8	119.8	112.4	109.5	103.4	165.7
90 percentile	102.8	106.5	338.8	762.9	293.7	189.8	162.2	129.8	123.2	127.5	118.3	106.5	195.8
Maximum	121.6	249.8	887.2	1506.7	932.4	412.5	263.0	147.8	156.1	160.4	148.5	126.7	300.8
						Dissolved-solids concentration, in milligrams per liter							
Mean	567.6	562.7	533.7	442.3	520.6	563.0	510.1	507.9	507.3	517.2	577.4	569.8	531.6
Standard deviation	7.9	19.7	57.5	73.0	20.1	53.9	18.2	16.0	11.8	11.4	12.0	5.7	9.1
Minimum	547.1	428.1	347.1	300.6	440.7	496.2	484.5	487.8	487.4	501.7	559.7	552.2	507.9
10 percentile	561.2	559.5	443.4	338.1	511.5	502.6	494.2	496.0	496.2	507.6	569.2	563.5	519.6
25 percentile	564.4	562.6	507.4	387.2	518.0	522.1	499.1	498.0	500.9	511.0	570.8	566.3	525.5
Median	567.1	564.3	557.6	453.0	525.2	552.2	505.4	502.0	504.1	512.6	574.0	568.9	532.2
75 percentile	570.4	566.6	565.2	508.3	532.5	588.9	512.2	511.6	511.4	518.9	581.0	572.3	536.8
90 percentile	573.8	571.4	580.4	531.1	534.8	625.3	535.9	533.2	524.5	535.1	587.4	578.9	542.3
Maximum	607.7	589.1	607.9	556.9	540.8	732.6	568.2	561.9	556.2	563.9	636.6	582.1	554.8

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 125, Sheyenne River near Cooperstown, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Streamflow, in cubic feet per second													
Mean	104.7	105.9	225.2	570.1	271.1	189.4	149.5	124.8	123.3	122.0	118.1	109.3	184.4
Standard deviation	5.4	12.0	214.8	496.6	304.8	87.8	49.3	25.7	23.0	22.3	15.6	10.2	72.8
Minimum	96.7	92.3	98.8	113.2	101.6	101.9	100.3	87.7	95.3	100.2	101.0	96.4	109.5
10 percentile	99.7	97.7	105.3	155.4	122.8	113.0	109.7	109.2	108.2	105.4	103.5	100.5	114.0
25 percentile	101.2	99.8	118.7	193.7	133.8	121.5	117.9	113.0	112.5	107.8	105.0	102.8	131.4
Median	103.5	103.6	142.9	459.5	165.0	162.4	128.7	117.5	118.3	113.8	114.3	107.3	162.3
75 percentile	107.0	107.0	237.9	764.7	262.0	237.1	167.2	124.4	124.7	126.7	121.9	112.5	221.4
90 percentile	112.2	113.2	451.3	1,198.0	446.2	315.6	225.6	154.2	140.1	149.0	141.5	120.6	293.0
Maximum	124.2	170.5	1,188.2	2,378.7	2,026.0	527.2	300.8	238.4	242.8	201.2	161.7	158.1	493.2
Dissolved-solids concentration, in milligrams per liter													
Mean	571.9	566.5	535.3	443.5	514.4	548.4	516.0	513.9	512.8	523.4	580.2	574.2	533.4
Standard deviation	7.8	20.3	55.4	71.7	35.0	45.1	14.8	15.2	11.6	10.4	10.4	5.4	10.8
Minimum	552.2	428.1	360.6	312.6	369.9	468.1	492.2	486.8	490.4	507.2	566.3	559.7	510.5
10 percentile	565.3	561.6	448.0	343.0	478.0	504.2	499.4	497.3	497.1	512.5	573.1	568.1	517.5
25 percentile	568.4	565.2	506.5	374.9	511.6	520.0	507.8	505.3	505.4	515.5	574.6	571.0	528.0
Median	571.4	569.6	562.9	430.9	527.3	541.0	513.9	510.6	510.3	522.0	578.5	573.7	534.9
75 percentile	574.3	571.5	569.4	513.4	533.3	564.0	521.4	521.7	521.4	527.5	582.5	577.7	538.8
90 percentile	578.7	576.1	572.4	535.8	539.3	585.4	531.2	536.9	528.6	536.5	587.5	581.1	543.7
Maximum	610.3	594.0	597.9	564.2	540.3	732.6	563.7	559.0	538.8	559.1	636.4	586.5	560.6

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 175, Sheyenne River below Baldhill Dam, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
					Streamflow, in cubic feet per second								
Mean	153.2	158.8	201.6	534.9	306.0	209.5	156.6	152.3	160.3	131.5	137.9	140.1	203.6
Standard deviation	32.9	35.8	218.1	602.9	408.8	99.7	43.8	24.4	27.2	37.6	35.9	29.7	94.6
Minimum	98.8	97.1	99.2	98.8	114.3	106.0	104.3	105.7	106.3	103.2	100.2	99.0	109.3
10 percentile	103.9	101.3	128.5	113.8	125.6	122.3	121.9	125.0	129.1	111.5	107.1	101.1	130.6
25 percentile	119.1	119.3	139.9	116.7	138.0	141.5	127.3	137.4	141.7	116.0	115.4	114.4	140.9
Median	170.8	170.7	140.5	265.0	163.3	170.9	141.0	149.7	161.8	117.6	122.2	140.0	166.5
75 percentile	175.7	180.4	157.3	762.8	295.4	262.8	175.1	166.6	170.7	124.5	162.9	165.4	251.0
90 percentile	181.8	195.3	279.5	1,171.0	476.3	330.6	215.5	191.8	200.0	179.1	183.5	177.9	331.8
Maximum	222.3	255.5	1,288.9	2,735.6	2,745.7	587.8	306.0	209.5	234.2	276.7	247.1	198.0	616.4
					Dissolved-solids concentration, in milligrams per liter								
Mean	544.6	544.9	526.4	471.9	485.2	499.2	512.7	525.7	534.6	537.1	542.3	544.0	522.4
Standard deviation	26.3	22.8	38.4	64.0	60.2	53.2	48.3	43.9	42.0	36.8	33.0	29.3	37.4
Minimum	491.2	499.2	391.0	337.6	332.9	374.4	404.3	429.5	443.9	459.7	473.2	482.3	440.8
10 percentile	509.6	513.1	483.2	392.8	411.7	431.4	451.2	462.6	476.1	485.6	497.1	505.6	470.8
25 percentile	527.4	529.5	509.5	419.2	444.3	457.5	479.6	494.4	504.0	513.4	521.9	526.3	491.9
Median	540.2	542.8	535.4	480.5	495.0	498.4	512.0	529.1	534.0	534.7	536.3	536.8	520.6
75 percentile	565.6	561.5	557.9	529.0	541.2	546.3	550.9	560.2	568.7	566.2	569.2	567.7	549.6
90 percentile	578.0	575.9	570.2	546.5	550.3	562.3	570.4	583.4	589.8	582.9	582.2	579.8	570.5
Maximum	590.4	586.2	573.7	563.0	586.9	582.8	597.6	603.6	610.1	605.3	603.0	596.8	585.5

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 225, Sheyenne River at Lisbon, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Streamflow, in cubic feet per second													
Mean	154.1	161.8	260.8	653.0	343.6	224.6	175.0	140.4	145.9	135.2	140.7	142.3	223.1
Standard deviation	35.4	39.9	241.2	700.7	511.6	138.7	118.3	23.1	23.6	38.4	35.4	31.5	113.5
Minimum	98.8	97.1	99.4	116.2	114.0	106.0	104.3	105.7	106.3	104.1	100.3	99.0	111.8
10 percentile	105.0	105.0	140.0	139.6	117.4	118.9	116.7	119.5	119.8	108.8	108.9	103.8	131.2
25 percentile	116.8	120.9	151.1	164.3	127.8	136.5	122.7	126.5	131.3	118.1	116.2	114.9	144.8
Median	169.2	171.2	187.2	347.5	160.3	165.4	135.7	135.8	142.5	122.1	123.4	141.3	180.5
75 percentile	178.8	183.6	263.8	894.0	335.7	249.6	177.5	149.1	153.8	130.3	173.9	174.1	277.3
90 percentile	187.1	211.4	421.6	1,505.3	573.8	406.6	245.0	166.5	181.9	182.6	192.2	181.6	368.3
Maximum	229.6	272.1	1,481.0	3,062.4	3,271.0	752.9	741.8	248.1	212.8	272.7	255.3	207.3	714.2
Dissolved-solids concentration, in milligrams per liter													
Mean	557.8	560.1	514.2	459.9	499.2	513.9	525.5	550.6	555.6	560.5	563.8	561.5	535.2
Standard deviation	29.3	26.4	74.7	85.0	78.7	65.1	75.7	43.6	39.7	39.1	34.0	31.0	43.1
Minimum	509.1	508.2	306.6	303.5	293.4	322.6	232.7	457.4	449.4	478.3	493.6	499.6	446.9
10 percentile	520.3	527.7	415.0	329.3	402.9	433.6	434.6	490.6	510.5	502.4	515.3	513.9	480.2
25 percentile	532.3	541.9	458.7	393.8	446.1	462.6	500.6	514.6	529.4	533.5	540.7	540.2	501.8
Median	552.3	557.7	535.6	449.7	519.0	518.8	543.1	558.6	549.8	561.5	562.9	558.6	533.7
75 percentile	583.9	579.1	575.0	538.5	563.8	569.2	575.1	580.3	591.1	596.8	594.9	585.6	571.1
90 percentile	599.6	596.4	597.5	569.2	584.2	581.5	593.2	604.3	606.7	610.0	610.4	604.2	594.8
Maximum	610.0	611.1	617.1	602.9	620.7	613.1	617.7	625.3	628.8	626.9	628.3	619.8	607.7

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 250, Sheyenne River near Kindred, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	163.3	170.1	259.2	697.5	392.9	245.9	202.9	140.7	133.6	153.4	157.9	154.8	239.3
Standard deviation	40.5	50.9	220.6	613.9	506.5	195.9	222.6	37.3	16.6	44.1	40.7	38.8	118.6
Minimum	99.1	97.0	77.9	154.5	107.9	106.0	104.3	105.6	106.3	104.7	108.7	99.9	109.3
10 percentile	107.8	108.4	139.7	189.3	120.5	118.3	119.0	117.5	118.1	113.5	114.7	108.4	132.8
25 percentile	124.9	124.3	155.4	227.2	126.1	126.4	125.4	124.2	124.4	128.7	127.2	120.6	149.4
Median	176.6	178.6	190.8	384.6	200.2	174.7	136.7	129.1	131.0	143.0	146.3	159.1	203.7
75 percentile	192.0	201.3	258.5	1,029.9	453.4	295.9	203.4	136.8	137.2	163.7	185.4	189.5	306.8
90 percentile	205.1	214.2	395.6	1,438.1	857.9	391.8	269.1	178.5	149.3	208.5	220.3	203.0	401.8
Maximum	240.1	351.3	1,293.9	2,802.2	2,766.7	1,191.6	1,469.0	308.8	204.5	325.4	289.0	245.0	695.4
						Dissolved-solids concentration, in milligrams per liter							
Mean	557.9	558.8	513.4	454.6	495.5	513.2	525.5	549.8	556.3	560.7	562.8	559.1	534.0
Standard deviation	26.2	25.1	71.0	78.2	71.3	58.6	63.0	39.3	35.1	35.2	30.8	28.2	38.6
Minimum	516.1	497.8	306.6	303.5	303.3	343.9	290.1	463.9	473.6	487.8	503.7	501.4	455.5
10 percentile	525.7	526.1	415.0	345.3	415.7	443.1	452.7	494.1	514.2	509.5	515.1	520.9	484.7
25 percentile	536.5	539.5	458.2	398.8	444.6	469.4	501.6	523.7	527.5	540.4	543.7	540.5	502.8
Median	551.2	560.4	538.4	447.9	509.6	513.6	535.8	552.6	553.5	559.6	562.2	553.6	533.7
75 percentile	576.8	576.4	569.9	536.3	549.5	560.0	566.6	580.7	588.1	590.6	585.9	581.5	563.4
90 percentile	597.8	596.0	592.7	544.1	579.5	582.2	585.6	599.1	602.1	606.1	604.4	600.7	585.0
Maximum	607.8	606.7	607.1	576.4	605.5	600.5	614.8	618.7	626.8	624.5	625.3	617.6	603.4

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 275, Sheyenne River at West Fargo, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	92.2	99.4	172.9	637.9	326.4	183.7	135.9	65.6	52.9	79.6	87.3	84.6	168.2
Standard deviation	41.0	50.8	190.3	576.7	463.6	191.3	215.4	40.3	16.8	48.4	44.7	40.3	113.4
Minimum	32.5	32.2	11.0	87.5	36.4	35.4	33.9	34.1	34.0	32.6	32.8	32.8	39.9
10 percentile	37.3	37.4	72.3	122.5	51.0	50.7	38.3	35.8	35.3	33.7	39.7	37.0	51.3
25 percentile	48.4	48.5	81.8	161.2	54.3	52.0	52.1	50.9	49.6	50.4	54.6	49.6	78.9
Median	109.1	108.0	112.3	348.3	128.3	96.2	71.2	52.3	51.3	69.4	74.5	83.7	132.3
75 percentile	122.1	132.4	182.9	999.8	455.4	247.8	138.7	59.8	52.9	90.9	122.1	117.8	244.7
90 percentile	134.8	155.4	328.5	1,466.6	811.2	378.0	221.0	116.8	66.7	136.8	155.8	133.2	334.9
Maximum	175.0	270.0	1,043.1	2,467.1	2,296.9	964.3	1,283.1	230.5	138.0	259.7	217.2	195.4	573.2
						Dissolved-solids concentration, in milligrams per liter							
Mean	556.1	556.7	511.9	447.9	495.7	511.3	530.7	567.7	578.8	565.1	561.6	556.8	536.7
Standard deviation	26.3	24.8	70.3	78.1	79.5	69.2	74.7	47.0	45.6	38.2	34.8	28.8	41.6
Minimum	515.0	497.3	309.5	306.1	303.1	344.5	291.3	472.8	475.8	493.9	468.9	500.6	456.7
10 percentile	524.4	525.9	414.5	332.9	403.2	421.6	444.9	499.7	524.9	506.7	515.6	520.2	474.9
25 percentile	534.2	538.3	456.0	383.3	432.8	456.4	503.3	535.0	549.8	539.3	544.0	536.2	503.4
Median	550.6	559.9	536.2	435.8	506.6	516.5	541.0	568.9	573.2	564.6	560.0	551.6	537.0
75 percentile	574.4	572.4	571.4	528.1	557.3	569.5	583.1	603.2	614.9	594.9	585.6	579.1	567.7
90 percentile	596.6	591.1	593.3	538.8	585.8	597.2	600.6	627.5	639.6	615.8	607.1	598.3	598.6
Maximum	603.1	608.4	609.1	577.7	635.1	610.0	658.0	654.1	677.3	641.0	629.9	618.1	614.2

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 600, Red River of the North at Halstad, Minn.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	353.2	348.7	1,222.6	5,185.3	2,319.2	2,038.7	1,630.9	619.7	459.7	498.8	524.3	410.9	1,301.0
Standard deviation	236.0	213.3	1,744.6	4,888.4	2,145.6	1,997.3	2,924.9	692.4	456.0	428.5	370.3	281.2	922.2
Minimum	18.8	24.0	8.9	482.5	189.2	62.4	15.6	0	15.3	8.4	17.3	15.0	120.7
10 percentile	44.7	51.1	194.4	762.2	394.5	163.5	89.3	34.4	45.6	34.4	89.9	60.2	276.9
25 percentile	184.4	192.6	323.9	1,432.8	895.3	572.1	305.7	203.1	179.7	160.4	261.5	223.6	691.8
Median	343.8	334.3	670.3	3,164.5	1,925.3	1,556.4	975.3	422.0	333.3	399.5	466.3	371.3	1,046.8
75 percentile	518.6	501.0	1,100.7	7,428.0	2,998.6	2,915.2	1,686.4	830.8	630.1	684.8	758.3	598.7	1,808.6
90 percentile	723.1	646.4	3,649.4	2,246.4	4,945.4	4,549.2	2,797.5	1334.2	928.8	1,261.1	955.9	827.4	2,775.3
Maximum	944.1	865.4	9,520.0	20,334.5	11,142.7	10,193.3	19,955.7	3792.5	2,486.2	1,657.9	1,778.9	1,102.3	3,952.0
						Dissolved-solids concentration, in milligrams per liter							
Mean	475.9	474.5	419.8	377.3	389.7	398.6	427.2	470.9	486.3	472.7	494.4	491.5	448.2
Standard deviation	55.7	56.2	58.1	52.5	64.1	72.8	88.1	82.9	91.9	78.4	78.8	67.1	58.3
Minimum	387.7	370.0	308.4	280.8	305.8	295.6	292.1	336.4	341.2	357.4	342.1	388.8	375.7
10 percentile	418.3	406.0	356.6	317.1	332.7	323.3	343.6	377.0	387.5	385.3	414.4	410.7	391.2
25 percentile	432.2	431.9	390.2	339.9	344.2	340.3	371.5	408.1	421.3	406.5	434.2	443.5	403.4
Median	463.5	466.1	410.1	368.4	362.7	378.6	410.6	447.4	466.1	451.3	483.2	477.3	427.8
75 percentile	507.4	507.3	436.8	408.7	434.4	444.3	459.2	509.0	540.7	540.5	537.6	525.9	471.4
90 percentile	572.5	567.5	517.3	460.5	480.7	505.8	558.9	607.4	622.6	603.2	623.4	608.1	536.8
Maximum	593.0	593.7	571.6	499.5	597.7	619.1	695.4	675.0	693.0	633.0	650.2	633.8	598.8

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 700, Red River of the North at Grand Forks, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	748.6	527.6	1,950.0	9,856.0	4,881.9	3,812.9	2,804.6	1,186.2	1,023.0	1,243.9	1,073.1	853.9	2,496.8
Standard deviation	582.9	463.8	2,332.6	8,521.7	5,797.8	3,636.4	3,879.9	1,169.4	924.5	1,081.8	937.9	684.7	1,803.2
Minimum	0	0	0	797.0	69.5	0	0	0	0	0	0	0	136.3
10 percentile	0	0	286.8	1,272.8	518.5	144.7	62.3	0	0	0	60.0	0	430.9
25 percentile	211.9	112.5	577.8	2,978.2	1,346.7	1,035.7	473.8	367.2	329.2	276.3	322.0	185.2	1,028.5
Median	663.9	420.4	1,322.9	6,762.9	2,978.2	3,009.3	1,896.6	819.0	924.2	1,133.2	990.3	759.7	2,080.8
75 percentile	1,207.4	776.5	1,865.1	16,606.3	7,095.9	4,936.6	3,276.2	1,729.4	1,507.7	1,831.3	1,710.6	1,389.4	3,614.9
90 percentile	1,597.9	1,322.2	5,476.9	24,259.2	10,599.2	9,455.4	5,519.5	2,704.9	2,239.0	2,680.8	2,207.1	1,776.4	5,008.9
Maximum	1,862.1	1,715.7	10,209.5	31,503.7	35,839.8	18,942.0	24,980.1	5,535.3	3,746.0	4,214.0	5,093.6	2,881.7	7,604.3
						Dissolved-solids concentration, in milligrams per liter							
Mean	389.7	396.4	375.3	363.9	357.8	362.2	393.0	402.3	403.4	395.5	391.9	397.9	385.8
Standard deviation	127.2	128.7	103.1	44.1	68.4	100.8	124.9	141.5	141.5	142.4	125.9	122.5	101.4
Minimum	276.8	279.4	284.8	262.4	264.6	266.0	263.0	271.4	272.7	268.2	266.6	276.8	301.8
10 percentile	299.5	298.0	297.3	320.0	295.9	285.4	294.4	293.5	289.0	285.4	298.3	301.5	310.2
25 percentile	314.5	314.8	316.9	333.0	313.8	299.2	319.6	313.9	304.0	301.8	308.4	320.7	325.3
Median	344.9	350.3	339.9	356.1	335.8	328.9	353.0	347.1	342.5	346.4	356.5	369.5	347.8
75 percentile	415.2	423.3	391.5	390.4	397.7	373.6	394.4	413.2	473.3	417.8	425.3	415.8	395.4
90 percentile	584.2	602.4	461.4	430.4	460.6	471.9	642.1	655.5	655.5	655.5	526.6	526.6	536.8
Maximum	816.6	816.6	807.6	465.0	590.4	726.5	816.6	816.6	816.6	816.6	816.6	816.6	695.5

Supplement 11.--Summary of model output for selected nodes for simulation of year-round operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 800, Red River of the North at Emerson, Man.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
							Streamflow, in cubic feet per second						
Mean	727.6	685.5	1,686.6	13,182.9	9,188.4	5,092.1	3,559.1	1,459.6	1,197.9	1,364.5	1,223.8	869.5	2,353.1
Standard deviation	581.7	533.1	2,036.3	9,827.4	12,802.9	5,096.4	4,415.9	1,412.1	1,210.9	1,193.6	1,053.6	725.3	2,477.8
Minimum	0	0	0	1,083.3	315.7	3.8	0	0	0	0	0	0	210.3
10 percentile	0	0	162.9	2,386.2	977.8	291.8	102.1	1.8	0	0	47.0	0	643.4
25 percentile	180.2	190.2	516.4	4,654.6	2,052.4	1,300.1	724.8	425.2	322.4	295.0	391.5	197.2	1,232.9
Median	658.1	639.5	1,253.3	12,593.8	4,061.4	3,800.1	2,600.7	1,148.0	1,003.1	1,275.7	1,176.2	758.3	2,968.5
75 percentile	1,216.6	1,178.2	1,702.3	19,237.4	10,504.7	6,602.5	5,031.7	2,121.5	1,718.0	1,964.1	1,891.8	1,437.7	4,700.2
90 percentile	1,561.1	1,453.6	5,366.6	25,543.1	23,005.7	11,385.5	6,397.6	3,061.3	2,513.8	3,243.6	2,307.8	1,831.6	6,619.5
Maximum	1,965.2	1,802.2	9,171.5	45,522.8	72,099.2	24,984.1	27,683.7	6,813.0	5,775.7	4,309.2	5,008.0	2,611.0	12,084.8
							Dissolved-solids concentration, in milligrams per liter						
Mean	905.5	894.1	605.1	312.6	382.3	564.7	843.0	1,285.2	1,296.2	1,020.9	1,090.8	1081.1	856.8
Standard deviation	271.2	1273.0	889.9	115.4	251.9	713.5	1,077.2	1,509.7	1,548.6	1,263.9	1,220.5	1355.6	859.2
Minimum	300.1	177.0	293.3	129.4	131.7	171.5	156.3	224.1	198.1	252.8	225.2	250.3	332.6
10 percentile	313.5	302.9	297.3	200.2	161.7	228.9	242.4	390.7	326.6	355.8	438.6	332.5	363.5
25 percentile	334.4	341.4	322.6	236.2	221.1	257.7	350.4	484.9	454.0	394.8	488.9	377.5	387.6
Median	422.8	439.8	367.8	283.2	269.3	374.3	453.8	620.4	587.7	549.0	619.1	530.1	466.6
75 percentile	669.8	591.7	452.2	353.0	489.3	578.2	813.5	911.8	1,057.5	910.4	1,155.0	1093.7	785.1
90 percentile	2,506.4	2,506.4	756.3	507.0	677.2	912.4	1,861.4	4,988.8	4,865.1	2,971.8	2,506.4	3355.7	2153.5
Maximum	5,000.0	5,000.0	5,000.0	742.5	1,406.6	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5000.0	3724.9

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84

Node 25, Garrison Diversion Unit Sheyenne River water supply

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	0.0	0.0	0.0	175.4	177.2	176.7	177.9	177.9	177.3	176.1	0.0	0.0	103.2
Standard deviation	0	0	0	1.6	2.5	2.2	2.5	2.6	2.7	1.7	0	0	1.1
Minimum	0	0	0	170.7	172.7	172.4	170.9	170.4	170.0	172.0	0	0	100.5
10 percentile	0	0	0	173.2	173.9	173.8	175.0	174.3	174.0	174.0	0	0	101.8
25 percentile	0	0	0	174.8	175.3	175.0	177.0	176.7	175.7	175.2	0	0	102.7
Median	0	0	0	175.4	176.9	176.6	177.9	177.9	177.7	176.1	0	0	103.2
75 percentile	0	0	0	176.5	179.2	178.4	179.2	179.8	179.0	177.0	0	0	103.8
90 percentile	0	0	0	177.3	180.7	179.5	180.6	181.3	180.8	178.5	0	0	104.5
Maximum	0	0	0	179.4	182.9	182.0	184.0	184.3	182.4	180.3	0	0	106.0
						Dissolved-solids concentration, in milligrams per liter							
Mean	511.1	511.1	511.1	556.1	506.0	495.9	492.2	496.2	501.9	511.1	511.1	511.1	509.6
Standard deviation	5.9	5.9	5.9	32.3	6.0	4.6	4.4	5.7	6.1	5.9	5.9	5.9	5.3
Minimum	484.0	484.0	484.0	498.0	490.0	481.0	481.0	475.0	483.0	484.0	484.0	484.0	494.7
10 percentile	508.0	508.0	508.0	506.7	498.0	490.9	486.8	489.9	494.0	508.0	508.0	508.0	503.4
25 percentile	510.8	510.8	510.8	553.0	504.0	495.0	492.0	496.0	502.0	511.0	511.0	511.0	507.8
Median	511.0	511.0	511.0	556.0	506.0	496.0	492.0	496.0	502.0	511.0	511.0	511.0	509.5
75 percentile	513.3	513.3	513.3	584.0	506.0	498.0	495.0	497.0	502.0	513.0	513.0	513.0	511.3
90 percentile	518.0	518.0	518.0	601.0	516.0	501.0	498.0	503.0	511.0	518.0	518.0	518.0	517.5
Maximum	521.0	521.0	521.0	605.0	521.0	509.0	503.0	509.0	514.0	521.0	521.0	521.0	521.4

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 50, Sheyenne River above Harvey, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	0.4	1.8	17.8	215.5	192.4	186.3	182.4	179.3	178.6	177.7	1.6	0.8	111.2
Standard deviation	.8	4.8	26.2	53.7	25.9	13.3	7.0	2.4	2.4	1.8	1.7	1.0	7.7
Minimum	0	0	0	175.6	174.8	174.8	171.9	173.6	172.2	174.3	0	0	102.3
10 percentile	0	0	.6	179.4	179.0	177.5	178.1	176.4	175.6	175.5	0	0	104.9
25 percentile	0	0	2.9	182.3	180.9	179.8	179.2	178.1	177.2	176.8	.8	.2	105.9
Median	.2	.2	6.1	193.2	184.8	182.3	181.4	179.2	178.9	177.7	1.4	.7	109.1
75 percentile	.5	.8	20.7	241.0	191.6	186.1	183.0	181.1	180.5	178.6	1.9	1.1	114.5
90 percentile	1.0	5.9	50.2	276.8	209.7	197.8	187.0	182.2	181.5	179.6	2.8	1.6	119.0
Maximum	4.1	26.8	123.0	462.3	351.2	252.3	219.8	184.4	182.6	183.9	10.4	6.3	144.8
						Dissolved-solids concentration, in milligrams per liter							
Mean	1,022.7	994.0	834.0	572.4	521.9	509.0	500.1	499.5	505.0	514.8	917.5	986.2	698.1
Standard deviation	188.9	199.1	131.9	33.5	12.9	11.4	8.1	6.2	6.6	5.5	164.0	175.4	49.0
Minimum	511.0	511.0	511.0	508.2	500.3	485.5	484.3	484.2	485.2	499.1	510.0	511.0	511.8
10 percentile	841.3	711.7	670.0	515.0	506.8	497.7	492.1	492.1	495.5	510.3	511.0	812.5	624.3
25 percentile	990.0	932.0	752.0	552.9	512.9	502.5	494.9	496.3	502.0	511.1	917.0	960.0	689.2
Median	1,057.0	1,031.5	847.0	573.7	519.8	506.8	498.8	498.7	504.4	513.8	948.5	1,005.5	710.1
75 percentile	1,134.0	1,129.0	902.0	604.7	530.4	513.9	502.8	502.6	509.5	518.6	989.0	1,068.0	727.5
90 percentile	1,177.6	1,177.6	1,016.7	612.0	544.6	527.1	513.1	507.2	513.5	521.6	1,024.3	1,165.0	745.1
Maximum	1,289.0	1,289.0	1,182.0	619.0	549.4	545.6	524.3	521.2	518.9	531.8	1,289.0	1,289.0	767.8

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 75, Sheyenne River near Warwick, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	1.4	5.6	82.9	426.1	253.4	212.6	195.1	181.6	183.0	183.8	6.9	2.9	144.6
Standard deviation	3.5	21.9	150.0	297.8	141.6	54.2	33.8	8.8	10.5	12.5	8.9	4.6	38.6
Minimum	0	0	0	173.2	173.3	173.6	170.9	172.8	170.8	172.7	0	0	102.0
10 percentile	0	0	1.5	192.2	181.8	176.2	177.7	176.3	176.6	176.2	0	0	108.0
25 percentile	0	0	9.5	210.8	184.1	179.5	179.1	177.2	178.2	177.3	.8	0	114.4
Median	0	0	21.0	323.8	206.6	195.8	181.1	179.0	180.0	179.0	5.1	1.4	134.4
75 percentile	1.2	1.6	87.5	499.3	250.4	219.1	191.3	181.3	183.2	182.7	8.7	3.7	165.0
90 percentile	4.1	7.7	239.1	836.0	362.8	261.1	227.4	191.3	191.0	200.2	17.4	6.5	195.6
Maximum	22.8	150.5	789.6	1,580.4	1,009.9	484.7	330.3	214.1	230.1	242.2	46.8	26.5	300.2
						Dissolved-solids concentration, in milligrams per liter							
Mean	541.5	571.9	528.7	459.6	515.1	543.8	504.8	504.1	505.4	515.0	564.7	533.8	524.0
Standard deviation	77.3	141.6	118.9	67.5	16.8	43.3	14.3	11.5	9.1	7.7	71.5	63.3	23.2
Minimum	329.0	343.8	315.0	318.5	445.7	494.7	484.0	488.2	486.0	500.3	342.0	342.0	490.2
10 percentile	468.5	493.0	403.8	361.6	505.9	499.9	492.2	494.6	496.0	508.8	500.6	469.4	499.5
25 percentile	500.4	512.0	451.7	417.0	513.8	512.7	496.9	497.3	501.1	510.9	511.1	501.0	509.6
Median	521.8	542.9	519.4	473.8	518.7	534.5	501.2	500.0	503.2	512.0	554.8	529.4	523.5
75 percentile	585.6	605.3	579.8	511.7	524.4	558.8	505.7	507.5	510.2	516.9	597.2	578.6	533.7
90 percentile	637.1	677.7	671.2	540.1	528.0	592.1	525.8	521.2	515.0	528.2	661.7	600.2	540.9
Maximum	760.7	1,419.8	907.2	556.6	532.8	699.0	554.0	545.0	542.0	538.2	775.0	710.0	629.0

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 125, Sheyenne River near Cooperstown, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	5.9	6.9	125.4	644.6	342.4	261.0	217.3	190.6	189.9	194.0	17.2	10.3	183.8
Standard deviation	5.3	11.5	215.2	496.6	305.8	87.9	49.4	25.4	23.8	22.6	15.8	9.9	72.8
Minimum	0	0	0	188.7	177.9	176.8	174.3	165.5	170.8	176.6	0	0	108.8
10 percentile	.8	0	5.3	231.3	194.5	179.6	179.2	177.2	177.3	178.4	1.7	1.6	112.9
25 percentile	2.1	1.5	18.7	265.6	204.8	194.4	182.7	179.1	178.5	179.5	6.0	3.5	130.5
Median	4.9	3.8	42.7	532.5	235.2	233.5	198.4	182.3	181.1	186.2	12.9	8.2	161.6
75 percentile	7.7	7.1	139.9	838.3	331.9	308.8	240.4	188.5	192.3	199.7	20.7	13.5	220.9
90 percentile	12.1	13.2	352.3	1,273.9	515.0	390.2	290.8	218.4	213.2	220.8	43.3	20.4	292.3
Maximum	25.4	71.2	1,090.6	2,452.4	2,103.5	592.9	368.2	304.7	316.8	283.0	61.9	57.9	492.6
						Dissolved-solids concentration, in milligrams per liter							
Mean	688.1	685.7	546.2	454.4	509.7	535.5	509.2	508.3	509.0	519.1	635.4	652.4	562.8
Standard deviation	65.6	108.4	100.7	67.7	30.3	37.8	12.0	11.0	9.0	7.3	62.8	60.9	23.7
Minimum	511.0	343.8	340.8	321.2	374.9	471.5	492.1	488.9	491.3	507.1	511.0	511.0	509.9
10 percentile	628.9	557.7	417.8	357.6	484.8	502.6	497.8	496.3	498.3	511.1	574.7	601.8	532.1
25 percentile	651.6	647.6	464.8	392.9	511.4	511.9	501.4	501.8	503.5	513.4	602.7	619.3	546.8
Median	673.1	681.8	555.4	451.7	520.6	527.5	507.2	505.5	507.4	517.9	622.7	640.7	557.7
75 percentile	739.7	747.1	591.8	512.0	525.8	548.8	512.2	514.5	515.1	522.7	655.4	683.0	582.9
90 percentile	782.2	791.1	673.1	542.3	528.7	565.5	521.3	525.1	522.1	529.9	748.6	745.7	596.5
Maximum	800.0	1,138.1	800.0	561.0	529.7	699.0	552.0	541.6	528.2	537.7	800.0	800.0	606.8

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 175, Sheyenne River below Baldhill Dam, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	153.2	158.9	202.0	534.9	306.0	209.5	156.6	152.5	160.3	131.6	137.9	140.1	203.6
Standard deviation	32.9	35.8	218.0	602.9	408.8	99.6	43.8	24.3	27.2	37.6	35.9	29.7	94.6
Minimum	98.9	97.0	99.3	98.7	114.3	106.0	103.9	105.7	106.1	103.4	100.2	98.8	109.3
10 percentile	104.0	101.2	132.7	113.8	125.6	122.4	121.9	125.0	129.1	111.6	107.0	101.1	130.6
25 percentile	119.1	119.3	139.9	116.7	138.0	142.0	127.3	137.4	141.7	116.0	115.4	114.4	140.9
Median	170.8	170.7	140.5	265.0	163.3	170.9	141.0	149.7	161.9	117.6	122.2	140.0	166.5
75 percentile	175.7	180.4	157.4	762.9	295.4	262.7	175.1	166.6	170.7	124.9	162.9	165.4	251.0
90 percentile	181.9	195.2	279.5	1,170.9	476.3	330.6	215.5	191.8	200.2	179.1	183.5	177.9	331.8
Maximum	222.3	255.5	1,288.9	2,735.6	2,745.7	587.8	306.0	209.5	234.2	276.7	247.1	198.0	616.4
						Dissolved-solids concentration, in milligrams per liter							
Mean	525.5	524.7	504.5	457.2	475.0	490.6	502.9	513.8	521.0	523.8	525.7	525.8	507.5
Standard deviation	25.1	24.2	39.4	61.2	53.7	44.5	37.9	32.6	30.1	25.7	25.5	25.3	31.4
Minimum	473.7	475.8	370.9	328.0	333.5	381.7	413.6	438.3	452.7	467.4	470.7	471.9	437.6
10 percentile	491.3	490.6	459.7	378.8	409.4	432.7	453.6	464.7	476.9	485.4	488.8	490.6	466.5
25 percentile	507.8	508.1	482.9	409.9	433.8	456.2	477.3	490.0	499.0	507.8	509.5	510.0	482.3
Median	521.8	522.4	510.1	465.8	483.4	490.6	504.0	517.9	520.9	523.0	522.5	521.7	505.7
75 percentile	545.4	542.9	535.1	508.8	522.8	531.2	532.6	540.1	545.0	544.4	545.7	545.8	532.5
90 percentile	555.2	556.6	552.4	531.5	532.6	541.7	546.0	554.7	560.0	555.5	557.3	554.7	548.9
Maximum	575.4	574.3	564.3	547.0	566.1	569.7	570.2	574.5	571.6	571.5	573.9	575.0	556.6

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 225, Sheyenne River at Lisbon, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
					Streamflow, in cubic feet per second								
Mean	154.1	161.8	261.2	653.0	343.6	224.7	175.0	140.6	145.9	135.3	140.7	142.3	223.2
Standard deviation	35.4	39.8	240.9	700.7	511.6	138.7	118.3	23.0	23.6	38.4	35.4	31.5	113.4
Minimum	98.9	97.1	99.3	116.2	114.0	106.0	103.9	105.6	106.1	104.1	100.5	98.8	111.8
10 percentile	105.1	105.1	141.2	139.6	117.4	119.0	116.7	119.5	119.8	109.0	108.7	103.7	131.3
25 percentile	116.8	120.9	151.1	164.3	127.8	136.5	122.7	128.4	131.6	118.1	116.2	114.9	144.8
Median	169.2	171.2	187.2	347.5	160.3	165.4	135.8	136.2	142.6	122.2	123.4	141.3	180.5
75 percentile	178.9	183.6	263.9	894.0	335.7	249.7	177.5	149.1	153.9	130.5	173.9	174.1	277.3
90 percentile	187.1	211.5	421.6	1,505.3	573.8	406.6	245.0	166.6	181.9	182.5	192.3	181.6	368.3
Maximum	229.6	272.1	1,481.0	3,062.4	3,271.0	752.9	741.8	248.2	212.8	272.7	255.4	207.4	714.2
					Dissolved-solids concentration, in milligrams per liter								
Mean	539.0	540.7	497.7	448.8	490.4	506.1	516.5	539.1	542.5	547.6	547.9	543.8	521.7
Standard deviation	28.5	27.6	73.1	82.7	72.9	57.9	68.9	33.7	28.8	29.4	27.3	27.5	37.5
Minimum	492.0	492.9	297.2	295.7	294.4	327.1	232.8	465.5	458.2	485.9	487.9	489.5	443.7
10 percentile	500.6	504.2	401.1	325.6	401.1	433.2	439.9	491.6	510.4	505.7	508.5	502.9	473.3
25 percentile	515.5	520.4	443.4	386.5	442.6	466.3	501.3	511.7	524.3	529.8	530.0	524.3	491.0
Median	531.2	536.9	521.6	440.0	510.2	508.8	535.2	546.7	541.5	552.0	545.1	540.6	520.7
75 percentile	566.7	560.1	554.2	527.3	551.9	556.4	560.7	565.8	565.0	573.7	569.9	564.5	553.6
90 percentile	578.7	580.0	581.4	556.5	568.9	566.3	573.9	577.9	580.2	584.2	586.6	581.4	569.5
Maximum	594.3	599.3	611.5	590.8	598.3	584.2	586.8	608.7	595.9	599.7	597.5	595.9	581.8

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 250, Sheyenne River near Kindred, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	163.3	170.2	259.6	697.5	392.9	245.9	202.9	140.9	133.6	153.5	157.9	154.8	239.4
Standard deviation	40.5	50.9	220.3	613.9	506.5	195.9	222.6	37.2	16.6	44.1	40.7	38.8	118.5
Minimum	99.0	97.0	100.0	154.4	107.9	106.0	103.9	105.6	106.1	105.0	108.3	100.0	109.3
10 percentile	107.8	108.4	139.7	189.3	120.4	118.4	119.0	118.2	118.1	113.5	114.7	108.4	132.8
25 percentile	124.9	124.3	155.4	227.2	126.1	126.4	125.4	124.2	124.4	128.9	127.4	120.6	149.4
Median	176.5	178.7	190.8	384.6	200.2	174.7	136.7	129.1	131.0	143.0	146.3	159.1	203.7
75 percentile	192.0	201.4	258.5	1,029.8	453.4	295.9	203.5	136.8	137.2	163.7	185.4	189.4	306.8
90 percentile	205.1	214.2	395.6	1,438.2	857.9	391.8	269.1	178.5	149.3	208.5	220.2	202.9	401.9
Maximum	240.1	351.3	1,293.8	2,802.2	2,766.7	1,191.6	1,469.0	308.8	204.5	325.5	289.1	245.1	695.4
						Dissolved-solids concentration, in milligrams per liter							
Mean	540.6	540.8	498.7	445.9	489.1	506.8	518.0	539.7	544.4	549.1	548.7	543.0	522.1
Standard deviation	25.3	26.1	69.8	77.3	66.9	52.8	57.0	30.7	25.0	26.6	24.5	25.0	33.8
Minimum	497.7	487.5	297.2	295.7	303.9	346.6	290.2	461.2	479.6	490.2	498.9	491.3	452.3
10 percentile	509.0	505.6	401.4	336.6	415.1	442.2	456.8	496.6	513.4	512.9	512.9	511.2	477.8
25 percentile	521.2	521.4	443.3	387.3	443.4	473.3	502.1	519.6	528.3	533.7	533.0	525.7	494.8
Median	535.9	542.7	521.6	439.0	502.2	509.3	528.5	541.8	541.8	548.3	549.0	541.4	522.2
75 percentile	559.4	557.2	549.4	517.8	541.9	550.3	551.8	564.5	562.8	572.6	567.2	562.4	547.5
90 percentile	577.8	579.9	577.4	534.3	565.9	568.0	568.0	576.8	578.5	583.9	580.5	580.6	565.6
Maximum	592.3	591.2	601.8	568.2	588.3	576.1	583.7	598.4	589.1	599.9	594.9	593.9	578.3

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 275, Sheyenne River at West Fargo, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	92.2	99.5	173.3	637.9	326.4	183.8	135.9	65.8	53.0	79.6	87.3	84.6	168.3
Standard deviation	41.0	50.7	190.0	576.7	463.6	191.2	215.4	40.2	16.8	48.4	44.7	40.3	113.4
Minimum	32.7	32.2	32.7	87.5	36.1	35.9	34.0	34.4	34.2	32.6	33.3	33.0	39.9
10 percentile	37.3	37.4	72.3	122.6	51.0	50.7	38.3	35.9	35.4	34.0	39.7	37.0	51.3
25 percentile	48.5	48.5	81.8	161.2	54.3	52.0	52.1	50.9	49.6	50.4	54.7	49.6	80.7
Median	109.1	108.8	112.3	348.3	128.3	96.2	71.3	52.5	51.4	69.4	74.5	83.7	132.3
75 percentile	122.1	132.5	182.9	999.8	455.4	247.8	138.6	59.8	52.9	90.9	122.0	117.7	244.7
90 percentile	134.9	155.4	328.5	1,466.6	811.1	378.0	221.0	116.8	66.7	136.8	155.8	133.2	334.9
Maximum	175.0	270.0	1,043.1	2,467.1	2,296.9	964.3	1,283.0	230.5	138.0	259.7	217.3	195.4	573.2
						Dissolved-solids concentration, in milligrams per liter							
Mean	539.0	538.9	497.4	439.7	489.3	505.0	523.2	557.3	566.3	553.6	547.7	540.9	524.9
Standard deviation	25.4	25.6	69.2	77.2	75.0	63.4	68.2	37.9	34.8	29.6	28.6	25.5	36.6
Minimum	497.0	487.0	300.2	299.0	303.6	347.2	291.3	470.0	480.6	496.3	463.7	490.6	453.5
10 percentile	507.8	505.3	401.7	331.2	402.3	424.6	448.0	501.1	524.6	509.2	511.5	510.7	470.3
25 percentile	519.1	519.4	441.5	376.4	431.7	454.1	500.7	533.5	545.8	533.9	534.7	522.6	496.4
Median	534.8	541.5	519.6	430.0	499.6	510.9	537.7	559.0	564.3	553.9	548.4	536.6	527.2
75 percentile	556.8	557.0	549.5	517.7	546.9	559.6	569.5	590.3	592.8	569.7	569.3	560.5	551.7
90 percentile	577.0	574.8	578.4	533.7	572.3	580.8	585.0	604.9	613.6	594.1	583.9	580.0	573.9
Maximum	587.8	589.3	603.8	569.6	617.3	590.7	628.8	626.0	636.5	608.2	599.3	594.5	590.0

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 600, Red River of the North at Halstad, Minn.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	353.2	348.7	1,223.0	5,185.3	2,319.2	2,038.7	1,630.9	619.9	459.7	498.8	524.3	410.9	1,301.1
Standard deviation	236.0	213.3	1,744.3	4,888.4	2,145.6	1,997.3	2,924.9	692.3	455.9	428.4	370.3	281.2	922.2
Minimum	18.8	24.0	9.0	482.5	189.2	62.4	15.5	0	15.6	8.7	17.2	14.9	120.7
10 percentile	44.9	51.1	194.5	762.2	394.5	163.5	89.4	34.3	45.6	34.5	90.5	60.4	276.9
25 percentile	184.3	192.6	323.9	1,432.8	895.4	572.1	305.8	203.1	179.7	160.8	261.4	223.6	691.8
Median	343.8	335.1	670.3	3,164.5	1,925.3	1,556.4	975.2	422.4	333.6	399.5	466.3	371.3	1,046.8
75 percentile	518.7	501.0	1,100.7	7,428.0	2,998.5	2,915.2	1,686.5	830.9	630.0	684.8	758.3	598.7	1,808.6
90 percentile	723.1	646.4	3,649.4	12,246.5	4,945.4	4,549.2	2,797.5	1,334.2	928.7	1,261.1	956.0	827.4	2,775.3
Maximum	944.1	865.4	9,519.9	20,334.5	11,142.7	10,193.3	19,955.7	3,792.6	2,486.1	1,657.9	1,778.8	1,102.3	3,952.0
						Dissolved-solids concentration, in milligrams per liter							
Mean	469.6	468.5	417.7	376.2	389.1	397.7	425.2	466.7	481.7	469.0	490.2	485.9	444.8
Standard deviation	51.8	53.6	57.4	52.2	63.5	71.3	84.8	76.2	85.6	74.4	74.4	62.3	55.0
Minimum	384.9	368.7	306.8	280.1	305.5	295.4	292.1	336.3	340.5	356.5	341.4	387.1	375.0
10 percentile	415.5	403.0	355.6	315.8	332.2	323.3	343.7	376.5	387.3	385.0	413.6	409.5	390.2
25 percentile	428.5	428.5	388.9	338.5	343.7	339.9	371.2	407.5	419.2	405.3	432.4	441.4	402.0
Median	459.1	459.0	408.4	367.2	362.1	378.4	409.8	447.1	464.2	451.7	481.5	474.6	425.3
75 percentile	498.4	500.2	433.1	408.0	433.7	443.6	459.8	508.3	539.7	537.3	535.2	520.3	469.4
90 percentile	557.9	557.2	514.4	459.9	480.2	503.3	550.2	588.2	609.7	589.2	609.5	585.9	528.2
Maximum	580.6	575.8	567.8	498.2	592.7	613.6	679.9	639.0	658.2	622.2	630.0	625.5	581.8

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 700, Red River of the North at Grand Forks, N.Dak.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	748.6	527.6	1,950.5	9,856.0	4,881.9	3,813.0	2,804.6	1,186.4	1,023.1	1,244.0	1,073.1	853.9	2,496.9
Standard deviation	582.8	463.9	2,332.3	8,521.7	5,797.8	3,636.4	3,879.9	1,169.2	924.5	1,081.8	937.9	684.7	1,803.1
Minimum	0	0	0	797.0	69.5	0	0	0	0	0	0	0	136.3
10 percentile	0	0	295.9	1,272.8	518.5	144.7	62.4	0	0	0	60.0	0	430.9
25 percentile	211.9	112.5	577.7	2,978.1	1,346.7	1,035.8	473.8	367.3	329.3	276.7	322.0	185.2	1,028.5
Median	664.0	420.4	1,322.9	6,762.9	2,978.1	3,009.3	1,896.6	819.4	924.1	1,133.2	990.3	759.6	2,081.0
75 percentile	1,207.4	776.5	1,865.0	16,606.3	7,095.8	4,936.5	3,276.2	1,729.4	1,507.7	1,831.3	1,710.7	1,389.4	3,614.9
90 percentile	1,597.9	1,322.2	5,476.9	24,259.2	10,599.2	9,455.4	5,519.5	2,704.9	2,239.1	2,680.8	2,207.1	1,776.4	5,008.9
Maximum	1,862.1	1,715.7	10,209.4	31,503.6	35,839.8	18,942.0	24,980.1	5,535.4	3,745.9	4,214.0	5,093.5	2,881.7	7,604.3
						Dissolved-solids concentration, in milligrams per liter							
Mean	390.5	394.0	370.8	363.4	357.4	361.7	392.2	400.9	403.1	393.9	393.4	399.0	385.0
Standard deviation	133.2	126.8	89.7	44.0	68.0	100.0	123.5	139.1	140.2	140.2	131.7	128.5	101.6
Minimum	275.8	278.6	284.3	261.9	264.5	266.1	262.8	271.2	272.5	267.9	266.3	276.3	301.5
10 percentile	298.3	296.6	296.5	319.5	295.8	285.3	294.2	293.6	288.3	285.6	297.7	300.9	309.7
25 percentile	312.9	313.4	316.4	332.5	313.6	299.0	319.5	313.6	303.9	301.7	307.7	319.9	324.8
Median	343.5	348.1	338.7	355.6	335.5	328.8	353.0	348.2	342.0	346.2	355.9	367.9	347.0
75 percentile	412.9	421.6	392.9	389.9	397.5	373.6	393.9	413.0	472.4	417.6	423.8	413.7	395.1
90 percentile	586.6	598.3	460.5	429.8	460.2	470.1	636.7	653.4	653.4	653.4	530.6	530.6	536.4
Maximum	807.6	804.1	721.8	463.9	585.8	725.5	804.1	807.6	807.6	807.6	807.6	807.6	704.8

Supplement 12.--Summary of model output for selected nodes for simulation of nonwinter operation of the Garrison Diversion Unit Sheyenne River water supply for the Sheyenne River and the Red River of the North, 1931-84--Continued

Node 800, Red River of the North at Emerson, Man.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Streamflow, in cubic feet per second							
Mean	727.6	685.6	1,687.0	13,182.9	9,188.4	5,092.1	3,559.1	1,459.8	1,198.0	1,364.5	1,223.8	869.5	3,353.2
Standard deviation	581.7	533.1	2,036.0	9,827.4	12,802.9	5,096.4	4,415.9	1,411.9	1,210.9	1,193.6	1,053.6	725.3	2,477.8
Minimum	0	0	0	1,083.3	315.7	3.8	0	0	0	0	0	0	210.3
10 percentile	0	0	182.7	2,386.2	977.8	291.8	102.2	1.8	0	0	47.1	0	643.4
25 percentile	180.2	191.3	516.6	4,654.6	2,052.4	1,300.2	724.8	425.2	322.5	295.4	391.5	197.2	1,232.9
Median	658.2	639.5	1,253.3	12,593.9	4,061.4	3,800.0	2,600.7	1,148.0	1,003.2	1,275.9	1,176.2	758.3	2,968.5
75 percentile	1,216.6	1,178.2	1,702.3	19,237.4	10,504.7	6,602.5	5,031.8	2,121.5	1,718.1	1,964.1	1,891.8	1,437.7	4,700.2
90 percentile	1,561.1	1,453.6	5,366.6	25,543.1	23,005.8	11,385.5	6,397.6	3,061.3	2,513.8	3,243.6	2,307.8	1,831.7	6,619.5
Maximum	1,965.2	1,802.2	9,171.5	45,522.8	72,099.2	24,984.1	27,683.7	6,813.1	5,775.8	4,309.3	5,007.9	2,610.9	12,084.8
						Dissolved-solids concentration, in milligrams per liter							
Mean	937.5	926.1	604.4	312.2	382.1	564.4	842.6	1,284.7	1,299.3	1,020.4	1,123.6	1,113.9	867.6
Standard deviation	1,355.0	1,357.0	890.9	115.3	251.7	713.4	1,076.9	1,510.0	1,557.0	1,264.5	1,302.3	1,430.8	891.5
Minimum	299.0	176.7	293.1	129.2	131.5	171.4	156.2	223.9	198.0	252.7	224.8	249.7	332.2
10 percentile	312.0	301.9	296.5	199.6	161.7	228.7	242.6	390.8	325.9	355.9	438.3	331.8	363.1
25 percentile	333.3	339.4	321.5	236.0	221.0	257.6	350.2	484.8	452.9	393.8	488.7	376.9	386.8
Median	420.3	435.7	366.8	283.0	269.1	374.2	453.3	620.2	587.4	548.7	618.6	529.1	465.9
75 percentile	668.4	591.7	451.1	352.8	488.8	577.9	813.2	911.0	1,056.1	908.6	1,153.8	1,091.4	783.6
90 percentile	2,682.8	2,682.8	755.8	506.4	676.9	911.5	1,859.1	4,997.4	4,997.4	2,969.7	2,682.8	4,773.2	2,185.0
Maximum	5,000.0	5,000.0	5,000.0	741.8	1,405.7	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	5,000.0	4,018.0