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GEOLOGICAL SURVEY

DOCUMENTATION OF A DISSOLVED-SOLIDS MODEL OF THE TONGUE RIVER, SOUTHEASTERN MONTANA

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METRIC CONVERSION TABLE

To convert inch-pound units in this report to the International System (SI) of metric units, multiply by the following factors:

Multiply inch-pound unit	by	To obtain SI unit
acre	4047	square meter
acre-foot	1233	cubic meter
acre-foot per acre	0.3048	cubic meter per square meter
acre-foot per river mile per day	766.3	cubic meter per kilometer per day
cubic foot per second	28.32	liter per second
foot	0.3048	meter
inch	25.40	millimeter
mile	1.609	kilometer
ton (short)	0.9072	megagram
ton per acre	0.0002241	megagram per square meter
ton per acre-foot	0.0007357	megagram per cubic meter

DOCUMENTATION OF A DISSOLVED-SOLIDS MODEL OF THE TONGUE RIVER, SOUTHEASTERN MONTANA

By

Paul F. Woods

ABSTRACT

A model has been developed for assessing potential increases in dissolved solids of streams as a result of leaching of overburden materials used to backfill pits in surface coal-mining operations. The model allows spatial and temporal simulation of streamflow and dissolved-solids loads and concentrations under user-defined scenarios of surface coal mining and agricultural development. The model specifically addresses the Tongue River from the Tongue River Dam to Miles City, Montana, and its three major tributaries, Hanging Woman, Otter, and Pumpkin Creeks.

The model routes an input quantity of streamflow and dissolved solids from the upstream end to the downstream end of a stream reach while algebraically accounting for gains and losses of streamflow and dissolved solids within the stream reach. Input data needed to operate the model include the following: simulation number, designation of hydrologic conditions for each simulated month, either user-defined or regression-defined concentrations of dissolved solids input by the Tongue River Reservoir, number of irrigated acres, number of mined acres, dissolved-solids concentration of mine leachates, and quantity of other water losses.

The computer program is written in FORTRAN language. A listing of the computer program, definitions of all variables in the model, and an example output will permit use of the model by interested persons.

INTRODUCTION

Surface mining of coal in the western United States has rapidly increased in recent years, with much of the increase occurring in Montana and Wyoming. Water-quality impacts from such mining are a major concern in semiarid southeastern Montana where many of the coal beds are major aquifers. The quality of water obtained from these aquifers may be degraded because of methods used to mine the coal. Surface mining involves removal and stockpiling of overburden materials (spoils) in strips adjacent to the pit containing the coal. Following extraction of the coal, the pit is backfilled with the spoils. Dissolved solids may be leached as ground water moves through the spoils. Some ground water discharges to streams in the area, adding its load of spoils-derived dissolved solids to streamflow. If such dissolved-solids loads are large enough, streams will show an increase in dissolved-solids concentration.

Increased dissolved-solids concentrations resulting from surface mining of coal may conflict with the water-quality needs of the agricultural industry downstream from the mined area. Agriculture is Montana's principal industry and accounts for much of the consumptive water use in the southeastern part of the State (Koch and others, 1977). The Tongue River area supports an agricultural industry and also is the proposed site of numerous surface coal mines.

Resolution of conflicts is a major responsibility of agencies charged with managing water resources. Such agencies may rely on computer simulation models for evaluating potential impacts of planned developments. Recognizing the potential conflict between agriculture and mining in the Tongue River area, the U.S. Bureau of Land Management contracted with the U.S. Geological Survey for development of a model to evaluate effects of surface coal mining on dissolved solids. The resultant model is capable of temporal and spatial simulation of dissolved-solids concentration in the Tongue River under various land-use scenarios of surface coal mining and agriculture.

The purpose of this report is to document the model. The report discusses the theoretical development of the model, describes sources of data used in the model, provides input instructions, and lists the FORTRAN computer program. The final product of the overall project is intended to be a report explaining in detail the model's development and results of numerous simulations designed to assess the impacts of mining on dissolved solids in the Tongue River.

MODEL DESCRIPTION

The model simulates the hydrologic and dissolved-solids budgets of the Tongue River from the dam of the Tongue River Reservoir to the U.S. Geological Survey's streamflow-measurement station near Miles City (fig. 1). The Tongue River is subdivided into five reaches to permit spatial simulation. River mileages are based on a report of the Montana Department of Natural Resources and Conservation (1976). Model time step is monthly and each simulation is for a calendar year. The FORTRAN computer program (table 1) is composed of nine subroutines linked as shown in figure 2 and described in table 2. Model variables are defined in table 3.

Theoretical development

Streamflow and dissolved solids at the downstream end of a reach are simulated by routing an input quantity of streamflow and dissolved solids from the upstream end of the reach. Gains and losses of streamflow and dissolved solids within the reach are accounted for algebraically during routing. Although the model assumes a routing interval of 1 month, the actual routing interval from the Tongue River Dam to Miles City is highly dependent on streamflow magnitude. Using empirical equations presented by Boning (1974), the routing interval for the mean annual streamflow was estimated to be 10 days. Conceptually, the monthly streamflow from the Tongue River Reservoir is instantaneously routed to Miles City; gains and losses to this routed streamflow occur simultaneously. Routing of streamflow and dissolved solids is accomplished by two primary equations.

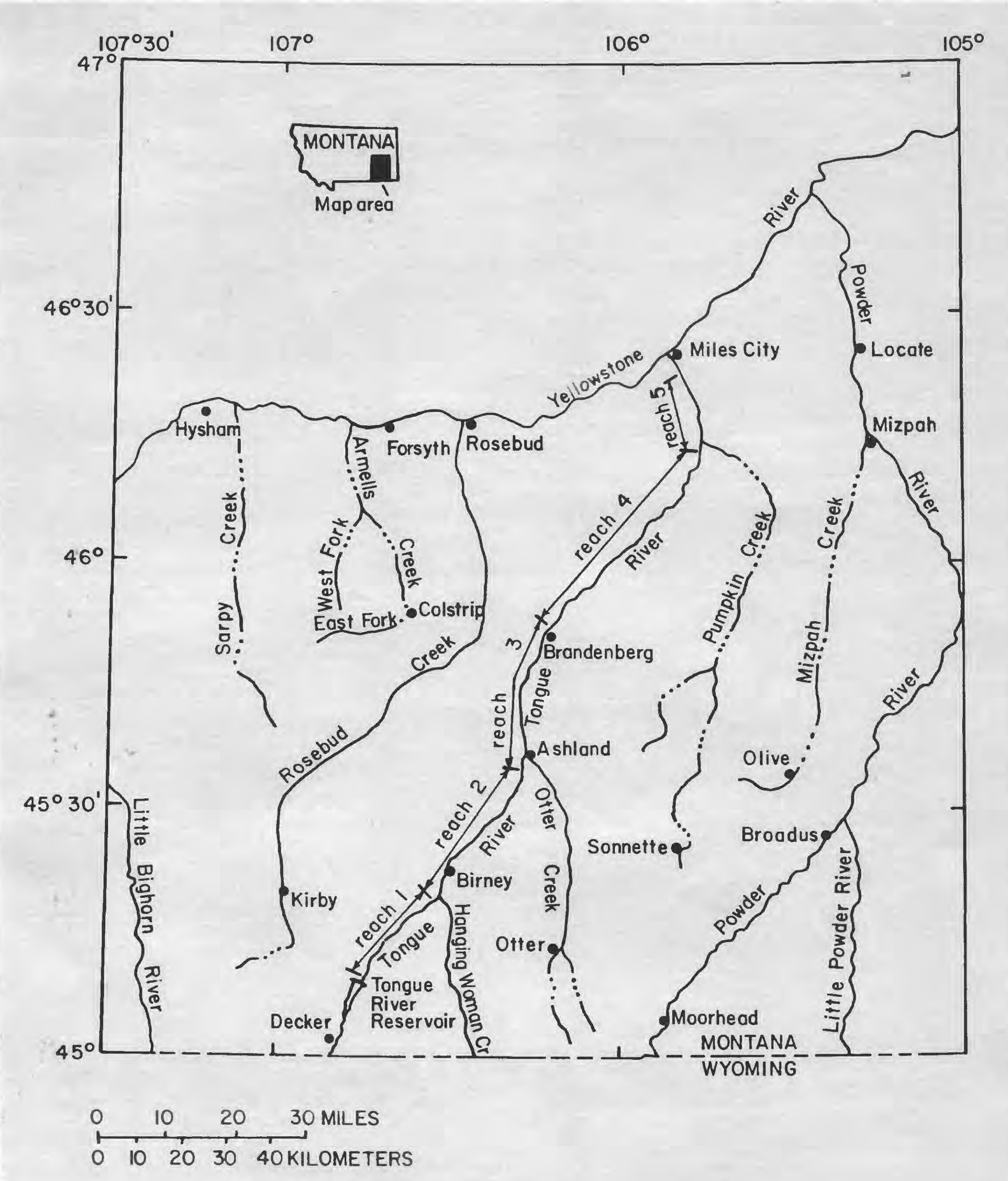

Figure 1.--Location of Tongue River and reaches simulated by the model.

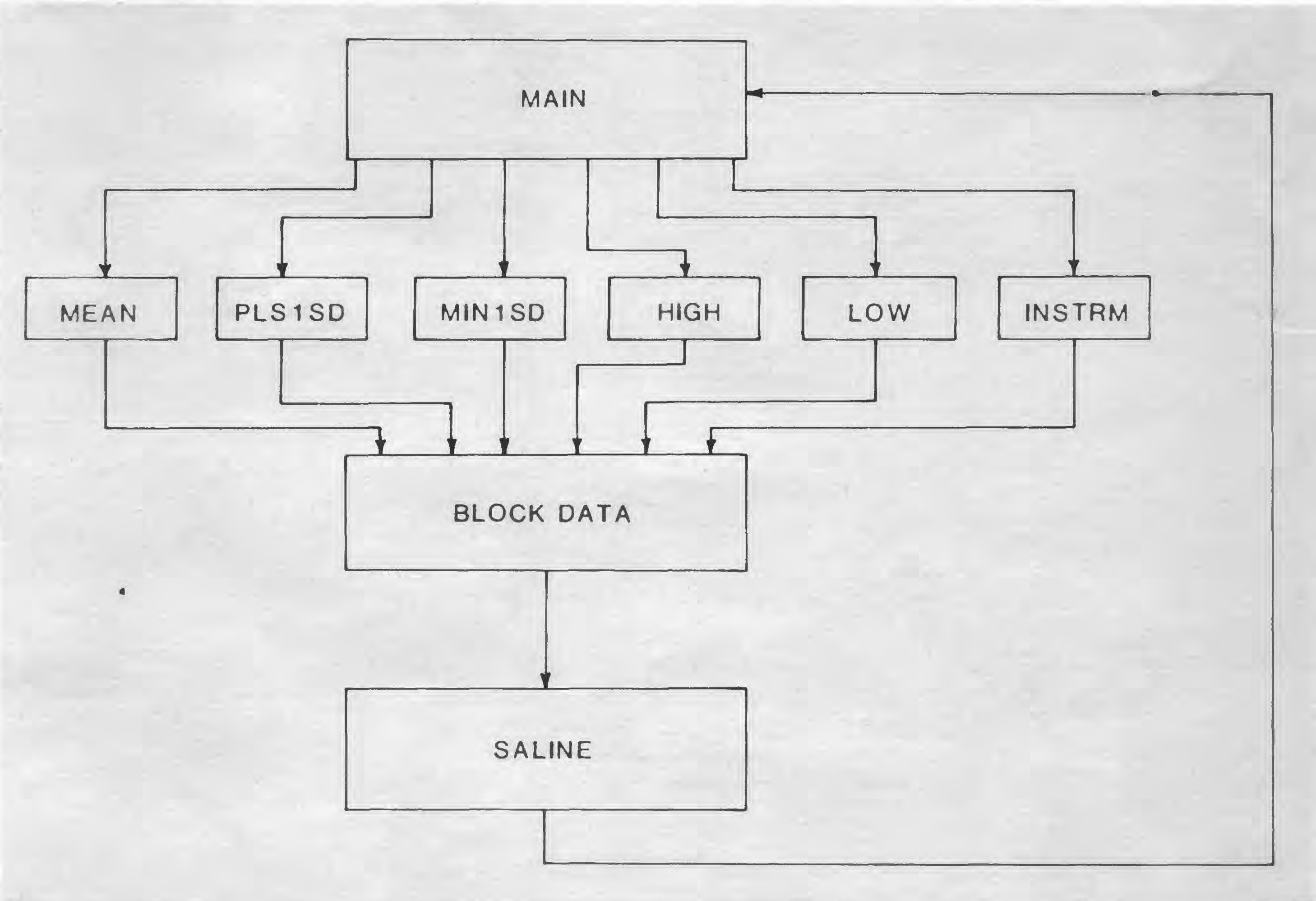

Figure 2.--Flow chart of model showing linkage of nine subroutines.

Table 2.--*Description of subroutines*

Subroutine name	Subroutine description
MAIN	Reads input data, writes simulation conditions, calls appropriate subroutines for passage of data to subroutine SALINE, writes headings for output of monthly results, performs statistical analyses of monthly results, and writes headings and results for simulation summary
BLOCK DATA	Contains data for six streamflow conditions used in the model
MEAN	Passes data associated with mean streamflow to subroutine SALINE
PLS1SD	Passes data associated with plus one standard deviation streamflow to subroutine SALINE
MIN1SD	Passes data associated with minus one standard deviation streamflow to subroutine SALINE
HIGH	Passes data associated with historic high streamflow to subroutine SALINE
LOW	Passes data associated with historic low streamflow to subroutine SALINE
INSTRM	Passes data associated with instream streamflow requirements to subroutine SALINE
SALINE	Calculates hydrologic and dissolved solids mass balances for five reaches of the Tongue River plus Hanging Woman, Otter, and Pumpkin Creeks and writes results of monthly computations

The streamflow balance of a reach is computed by the first primary equation:

$$Q_{OUT} = Q_{IN} + Q_P - Q_E + Q_{GW} + Q_{GA} + Q_{UGA} - Q_{IR} + Q_{IB} + Q_{IRF} - Q_{ID} - Q_{OL} \quad (1)$$

where all units are in acre-feet per month,
Q_{OUT} is streamflow at downstream end of reach,
Q_{IN} is streamflow at upstream end of reach,
Q_P is precipitation received on stream surface,
Q_E is evaporation loss from stream surface,
Q_{GW} is ground-water inflow,
Q_{GA} is streamflow from gaged tributaries,
Q_{UGA} is streamflow from ungaged tributaries,
Q_{IR} is volume of streamflow stored as ice,
Q_{IB} is volume of streamflow input by ice breakup,
Q_{IRF} is volume of irrigation return flow,
Q_{ID} is volume of irrigation water removed, and
Q_{OL} is volume of other water losses.

The dissolved-solids balance of a reach is computed by the second primary equation:

$$S_{OUT} = [(S_{IN} \times Q_{IN}) + (S_{GW} \times Q_{GW}) + (S_{GA} \times Q_{GA}) + (S_{UGA} \times Q_{UGA})$$
$$+ (S_{IRF} \times Q_{IRF}) - (S_{ID} \times Q_{ID}) - (S_{OL} \times Q_{OL})] \times f \quad (2)$$

where all concentrations are in milligrams per liter,
S_{OUT} is dissolved-solids load (in tons per month) at downstream end of reach,
S_{IN} is dissolved-solids concentration at upstream end of reach,
S_{GW} is dissolved-solids concentration of ground water,
S_{GA} is dissolved-solids concentration of gaged tributaries,
S_{UGA} is dissolved-solids concentration of ungaged tributaries,
S_{IRF} is dissolved-solids concentration of irrigation return flow,
S_{ID} is dissolved-solids concentration of irrigation water removed,
S_{OL} is dissolved-solids concentration of other water losses,
f is a factor (0.00136) to convert streamflow in acre-feet per month and dissolved-solids concentration in milligrams per liter into dissolved-solids load in tons per month, and
the remaining variables are as defined for equation 1.

Streamflow and dissolved-solids load at the downstream end of the reach are used to compute dissolved-solids concentration in milligrams per liter as follows:

$$DS_{OUT} = \frac{S_{OUT}}{Q_{OUT} \times f} \quad (3)$$

where DS_{OUT} is dissolved-solids concentration in milligrams per liter,
S_{OUT} is dissolved-solids load in tons per month,
Q_{OUT} is streamflow in acre-feet per month, and
f is a factor (0.00136) to convert streamflow in acre-feet per month and dissolved-solids load in tons per month to dissolved-solids concentration in milligrams per liter.

Numerous peripheral equations are used to compute values for input to the two primary equations. Development of these peripheral equations is described in the following two sections.

Hydrologic components

Comparison of the impacts of dissolved solids caused by various scenarios of surface coal mining is the major intended use of this model. To facilitate comparability, simulated hydrologic conditions were restricted to a discrete number (six) instead of using stochastic methods to generate hydrologic conditions. The six hydrologic conditions are based on streamflow data because dissolved solids and streamflow are highly correlated. Hydrologic conditions, on a monthly basis, include the mean, plus one and minus one standard deviation from the mean, historic high and low flows, and instream flows. Instream flows are the minimum flows necessary for maintenance of the existing physical and biological stream environment. In the case of streamflow and runoff coefficient for Hanging Woman, Otter, and Pumpkin Creeks, the mean is replaced by the 50th percentile, the plus one standard deviation from the mean is replaced with the 75th percentile, and the minus one standard deviation from the mean is replaced by the 25th percentile.

Releases from the Tongue River Dam provide the initial input for each month of a simulation. Except for instream flows, the six hydrologic conditions were developed from a statistical analysis of streamflow records spanning 1948 to 1980 for a U.S. Geological Survey streamflow-measurement station downstream from and near the Tongue River Dam. Instream-flow conditions were obtained from the Missouri River Basin Commission (1978). Changes in bank storage during a simulated month are assumed to equal zero or to be a negligible amount; therefore, no component for bank storage is included in the model.

The period of record at the Tongue River Dam greatly exceeds that available for Hanging Woman, Otter, and Pumpkin Creeks, each of which had 8 years of record or less. For small samples of hydrologic data, Yevjevich (1972) cautions that the 50th percentile, rather than the mean, is a better estimator of central tendency, especially when the data contain extreme values. Because the three tributaries have such extreme values, the 50th percentile is used to estimate their most likely streamflow, and standard deviations are replaced by the 25th and 75th percentiles.

Streamflow from ungaged tributaries is estimated by using runoff coefficients based on unit area. These coefficients were calculated with streamflow data from Hanging Woman, Otter, and Pumpkin Creeks.

Precipitation records are available for a number of stations within or near the study area; however, most are of short duration or are incomplete. The longest and most complete record is for Miles City FAA Airport (near Miles City, Mont., fig. 1). Based on 41 years of record, the mean annual precipitation at that station is 13.93 inches. The monthly precipitation data for the model were statistically derived from the 1949-78 records for the Miles City station so they would correspond to the 1948-80 streamflow data used in the model.

Evaporation data applicable to the study area are available for Sheridan Field Station (20 miles south of Decker, Mont., fig. 1), which has a period of record of 1951-79. The data were recorded with a U.S. Weather Bureau Class A pan and were, therefore, converted to corrected evaporation by application of a 0.7 coefficient as suggested by Hewlett and Nutter (1969). The mean annual corrected evaporation at the Sheridan station is 37.9 inches.

In the model, monthly amounts of precipitation and corrected evaporation are applied only to the stream surface areas of the Tongue River. This approach is used because inflows to the Tongue River from gaged and ungaged tributaries are not computed by hydrologic mass balance but are derived from analysis of historic streamflow records, which include the effects of precipitation and evaporation.

Irrigation withdrawals and return flows are important components of the model, because agriculture accounts for much of the consumptive use of water in the study area. Unfortunately, data are not available for actual volumes of irrigation withdrawals and return flows in the study area. These volumes were estimated by applying agricultural engineering practices to estimates of irrigated acreages (Woessner and others, 1981). Acreage irrigated within the study area was provided by Glen Smith (Montana Department of Natural Resources and Conservation, Helena, Mont., oral commun., 1980).

Irrigation withdrawal rates for the Tongue River are patterned after those measured from 1945 through 1967 at the Huntley Project, an irrigation diversion on the Yellowstone River near Billings, Mont. (77 miles southwest of Hysham, fig. 1). These historic data were also used in a water planning model developed for Montana by Boyd and Williams (1974). The Huntley Project data represent the only long-term information available and were judged likely to be applicable for the Tongue River. Withdrawal rates are increased by 10 percent when the precipitation component of the model is set for historic low or minus one standard deviation. This decision was based on a 10-percent increase in plant water requirements during months of little precipitation (Glen Smith, written commun., 1980). When the precipitation component is set to historic high or plus one standard deviation, the withdrawal rates are reduced by 10 percent. The model provides water for the entire irrigation season along the main stem Tongue River. Hanging Woman, Otter, and Pumpkin Creeks receive partial irrigation service, which involves a July 15 date for cutoff of irrigation water.

Tributary irrigation in the model is handled differently than Tongue River irrigation. Tributary streamflow is derived from statistical analysis of historic streamflow data and, as such, integrates all hydrologic components, including irrigation withdrawals, within the tributary drainage basin. Therefore, irrigation withdrawal rates for the three major tributaries are applied only to acreages in excess of those presently (1980) irrigated in that particular drainage basin.

Return flow occurs when irrigation water is applied in excess of the evapotranspiration requirements (consumptive use) of plants. Some of the applied water may percolate beneath shallow aquifers and be lost from the return-flow system. The remaining water returns to the stream via surface or shallow-subsurface flow. No quantitative data on actual return-flow rates were found for the study area; however, agricultural engineering estimates for the Tongue River (Woessner and others, 1981) indicate that 35 percent of applied irrigation water goes for consumptive use and 15 percent is lost to deep percolation. Of the remaining amount, 65 percent returns to the stream in the month of application, and 35 percent returns in equal increments over the next 8 months. In addition to these flows, return flows emanating from the year preceding the simulated year must also be estimated. Such antecedent return flow rates are based on application of mean irrigation withdrawal rates in the antecedent year. Antecedent return flows to the tributaries are insignificant because of partial irrigation service. Therefore, only the Tongue River receives antecedent return flows in the model.

Ground-water inflow was estimated from base-flow studies conducted November 2-5, 1977, on the Tongue River as reported by Lee, Slagle, and Stimson (1981). Analysis of their data indicated an overall ground-water inflow rate of 0.82 acre-foot per river mile per day, which equals 4,453 acre-feet of inflow in November for the 181-mile length of modeled river. Correcting for irrigation return flow that comprised part of the measured ground-water inflow, the volume of irrigation return flow in November for the modeled river distance was calculated to be 2,248 acre-feet. This value is based on an irrigated acreage of 14,500 acres and an irrigation return flow rate of 0.155 acre-foot per acre. Accordingly, the overall ground-water inflow rate measured by Lee, Slagle, and Stimson (1981) was reduced by 50 percent, to 0.41 acre-foot per river mile per day. In the model, each reach has a ground-water inflow rate, which is 50 percent of the rate measured by Lee, Slagle, and Stimson (1981) for that particular reach.

Part of the Tongue River streamflow is stored as ice during winter. Process-oriented models of ice storage and breakup are complex and beyond the scope of this model; therefore, ice storage for the model was estimated from ice-thickness data obtained by the Geological Survey during streamflow measurements on the Tongue River at the Tongue River Dam, near Ashland, near Brandenburg bridge, and at Miles City. Analysis of 9 years of that data indicated that ice generally occurred from December through February. During a simulation, streamflow is converted to ice based on surface area and average ice thickness of the reach being computed. In March, the quantity of streamflow removed as ice in the preceding 3 months is converted back to streamflow. Ice storage in reach 1 is reduced by 50 percent because records show that ice formation is inhibited by releases from the Tongue River Dam. Owing to lack of correlation between ice thickness and streamflow conditions, the same ice formation and breakup values are used in all simulations.

Provision is made for the model user to designate additional water losses. These losses could be due to the water requirements of specific industries, such as coal gasification plants, coal-fired electrical generating plants, or others.

Dissolved-solids components

Most dissolved-solids loads are computed by multiplying the volume of a hydrologic component by its associated dissolved-solids concentration. These concentrations are derived by various means.

Regression equations are used to estimate dissolved-solids concentration from streamflow input by the Tongue River Reservoir and Hanging Woman, Otter, and Pumpkin Creeks. The regression equations were derived from concurrent measurements of streamflow and dissolved-solids concentrations. Provision is made for the model user to input alternate concentrations at the Tongue River Dam in place of regression-derived values. The regression-derived dissolved-solids concentrations for Hanging Woman, Otter, and Pumpkin Creeks are used to compute dissolved-solids loads from ungaged tributaries.

Dissolved-solids concentrations for ground-water inflow to the five Tongue River reaches are based on values calculated from a 1978 base flow study of the Tongue River (W. R. Hotchkiss, U.S. Geological Survey, written commun., 1981). Dissolved-solids loads from leaching of backfilled spoils are transported via ground water. In the model, the load generated by leaching of spoils is calculated using methods developed by McWhorter and others (1979). The model equation is as follows:

$$L = A \times D \times R \times F \tag{4}$$

where L is dissolved-solids load in tons per month,
A is area of surface coal mine in acres,
D is dissolved-solids concentration of spoil leachate in milligrams per liter,
R is runoff coefficient for the mined drainage basin in inches per month, and
F is a factor (0.0001133) to convert equation units into tons per month.

The dissolved solids leached from mine spoils are modeled as the quantity entering streams after such leachates reach steady-state input rates. Based on aquifer characteristics in the study area, the production of leachates may occur for hundreds of years (Woessner and others, 1979). Therefore, it is assumed that all coal mines in the study area will discharge at a steady-state rate for a long time period, and they will all be discharging to streams at some common, but undetermined, time in the future. The model simulates this common future time.

Dissolved-solids loads removed by other water losses and irrigation-water withdrawal are computed as the product of the respective hydrologic component and the dissolved-solids concentration in the reach of withdrawal. For other water losses from Hanging Woman, Otter, and Pumpkin Creeks, such water is withdrawn from the Tongue River. The hydrologic components of precipitation, evaporation, ice storage, and ice breakup are not associated with a dissolved-solids component.

The dissolved-solids load from irrigation return flow is based on an assumption of salt balance. That is, the dissolved-solids load removed by irrigation-water withdrawal is returned in full with return flow. Return flows occur in the month of withdrawal and for the 8 months thereafter. Monthly loads were, therefore, a summation of that month's return flow load and loads returning from prior months. Additionally, some dissolved-solids load is input by antecedent return flow from irrigation in the year prior to simulation. These loads occur in January through June and are added to return-flow loads generated in the simulated year. Only the Tongue River receives such loads, because antecedent return flows to the three tributaries are insignificant.

MODEL INPUT

Most of the data used to compute streamflow and dissolved-solids loads are contained in the computer program, mostly in subroutine BLOCK DATA. The model could be adapted to other hydrologic conditions for the Tongue River by replacing the internal data statements with data statements representing the new conditions. No provision is made for simulation of the extra day in a leap year, but leap-year computations could be made by resetting variable ND in subroutine SALINE.

The model user selects the hydrologic condition for each month of simulation by inputting values for the monthly flow designator (model variable MFD). These values determine the hydrologic condition of streamflow releases from the Tongue River Dam. The model releases are internally programmed to select appropriate hydrologic conditions for the other hydrologic components of the model (table 4).

Table 4.--*Condition of hydrologic components during a simulation as selected by monthly flow designator*

[Hydrologic conditions: A = mean, B = plus one standard deviation, C = minus one standard deviation, D = historic high, E = historic low, F = instream flow

Monthly flow designator: 1 = mean, 2= plus one standard deviation, 3 = minus one standard deviation, 4 = historic high, 5 = historic low, 6 = instream flow]

Hydrologic component	Hydrologic condition based on status of monthly flow designator					
	1	2	3	4	5	6
Initial streamflow from Tongue River Dam	A	B	C	D	E	F
Precipitation rate	A	B	C	D	E	F
Evaporation rate	A	C	B	E	D	A
Initial streamflow of Hanging Woman Creek	A[a]	B[b]	C[c]	D	E	A[a]
Initial streamflow of Otter Creek	A[a]	B[b]	C[c]	D	E	A[a]
Initial streamflow of Pumpkin Creek	A[a]	B[b]	C[c]	D	E	A[a]
Runoff coefficient for Hanging Woman Creek	A[a]	B[b]	C[c]	B[b]	C[c]	A[a]
Runoff coefficient for Otter Creek	A[a]	B[b]	C[c]	B[b]	C[c]	A[a]
Runoff coefficient for Pumpkin Creek	A[a]	B[b]	C[c]	B[b]	C[c]	A[a]
Irrigation water diversion rate for Tongue River reaches	A	[d]	[e]	[d]	[e]	A
Irrigation water return-flow rate for Tongue River reaches	A	[d]	[e]	[d]	[e]	A
Irrigation water diversion rate for Hanging Woman, Otter, and Pumpkin Creeks	A	[d]	[e]	[d]	[e]	A

Table 4.--*Condition of hydrologic components during a simulation as selected by monthly flow designator*--Continued

Hydrologic component	Hydrologic condition based on status of monthly flow designator					
	1	2	3	4	5	6
Irrigation water return-flow rate for Hanging Woman, Otter, and Pumpkin Creeks	A	d	e	d	e	A

[a]50th percentile in place of mean.

[b]75th percentile in place of plus one standard deviation

[c]25th percentile in place of minus one standard deviation

[d]Minus 10 percent of mean value

[e]Plus 10 percent of mean value

Input data for a simulation is read into the computer program via subroutine MAIN with the following six data cards:

Card	Columns	Format	Variable	Description
1	1-5	A5	SN	Simulation number
	11-34	12I2	MFD	Monthly flow designator; enter 1 for mean, 2 for plus one standard deviation, 3 for minus one standard deviation, 4 for historic high, 5 for historic low, 6 for instream flow
2	1	I1	INTDS	Designator for dissolved-solids input by Tongue River Dam; enter 0 for regression-defined, 1 for user-defined
	6-65	12F5.0	TRDTDS	User-defined monthly concentration (in milligrams per liter) of dissolved solids input by Tongue River Dam
3	1-30	5F6.0	AIT	Acreage irrigated on each of five reaches of Tongue River
	31-36	F6.0	AIHW	Acreage irrigated on Hanging Woman Creek (enter acres in excess of 1,225 acres presently irrigated)
	37-42	F6.0	AIO	Acreage irrigated on Otter Creek (enter acres in excess of 785 acres presently irrigated)
	43-48	F6.0	AIP	Acreage irrigated on Pumpkin Creek (enter acres in excess of 2,875 acres presently irrigated)
4	1-30	5F6.0	AMT	Acreage of surface coal mines on each of five reaches of Tongue River
	31-36	F6.0	AMHW	Acreage of surface coal mines on Hanging Woman Creek
	37-42	F6.0	AMO	Acreage of surface coal mines on Otter Creek
	43-48	F6.0	AMP	Acreage of surface coal mines on Pumpkin Creek

Card	Columns	Format	Variable	Description
5	1-30	5F6.0	DST	Dissolved-solids concentration (in milligrams per liter) of leachate from surface coal mines on each of five reaches of Tongue River
	31-36	F6.0	DSHW	Dissolved-solids concentration (in milligrams per liter) of leachate from surface coal mines on Hanging Woman Creek
	37-42	F6.0	DSO	Dissolved-solids concentration (in milligrams per liter) of leachate from surface coal mines on Otter Creek
	43-48	F6.0	DSP	Dissolved-solids concentration (in milligrams per liter) of leachate from surface coal mines on Pumpkin Creek
6	1-30	5F6.0	QOLT	Other water losses (in acre-feet per year) from each of five reaches of Tongue River
	31-36	F6.0	QOLHW	Other water losses (in acre-feet per year) from Hanging Woman Creek
	37-42	F6.0	QOLO	Other water losses (in acre-feet per year) from Otter Creek
	43-48	F6.0	QOLP	Other water losses (in acre-feet per year) from Pumpkin Creek

MODEL OUTPUT

Model output consists of a description of simulation conditions input by the model user, monthly results of the simulation, and a summary of simulation results. Under simulation results, the output for each month consists of the streamflow, the dissolved-solids load and concentration for each reach, and the initial streamflow from the Tongue River Reservoir. In addition, the contribution of dissolved-solids load due to return flow or mining along each reach is tabulated as a percentage of the current dissolved-solids load. During routing the model computes the components of the total load of dissolved solids and prints the percentage of the cumulative dissolved-solids load due to return flow or mining. In the simulation summary, tabulations for each month consist of the dissolved-solids load and the dissolved-solids concentration discharged from the Tongue River Reservoir and at Miles City. A statistical summary of monthly dissolved-solids concentrations and percentage loads due to return flow or mining is then listed for each reach.

An example of model output is given in table 5. Input data for this example are not representative of conditions for the Tongue River.

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SUPPLEMENTAL INFORMATION

Table 1.--*Listing of computer program*

```
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C                                                                            *
C                    TONGUE RIVER DISSOLVED SOLIDS MODEL                     *
C                                                                            *
C   PROGRAM TO COMPUTE DISSOLVED SOLIDS (SALINITY) CONDITIONS FOR FIVE       *
C   REACHES ON THE TONGUE RIVER, MONTANA FROM THE TONGUE RIVER DAM TO MILES  *
C   CITY, IN ADDITION TO HANGING WOMAN, OTTER, AND PUMPKIN CREEKS.           *
C   COMPUTATIONAL SCHEME IS MASS BALANCE OF HYDROLOGIC INPUTS AND OUTPUTS    *
C   IN ASSOCIATION WITH THEIR RESPECTIVE DISSOLVED SOLIDS CONCENTRATIONS.    *
C   TIME STEP IS MONTHLY. EACH SIMULATION RUN IS FOR ONE YEAR TIME PERIOD.   *
C                                                                            *
C   DEFINITION OF INPUT VARIABLES                                            *
C     SN = SIMULATION NUMBER, USE FOR IDENTIFICATION PURPOSES                *
C     MFD = MONTHLY FLOW DESIGNATOR , ENTER 1 FOR MEAN, 2 FOR PLUS ONE       *
C           STANDARD DEVIATION, 3 FOR MINUS ONE STANDARD DEVIATION, 4 FOR    *
C           HISTORIC HIGH, 5 FOR HISTORIC LOW, 6 FOR INSTREAM FLOW           *
C     INTDS = DESIGNATOR FOR DISSOLVED SOLIDS INPUT BY TONGUE RIVER DAM,     *
C             ENTER 0 FOR REGRESSION-DERIVED VALUES OR ENTER 1 FOR           *
C             USER-DEFINED VALUES                                            *
C     TRDTDS = USER-DEFINED MONTHLY VALUE FOR DISSOLVED SOLIDS INPUT BY      *
C              TONGUE RIVER DAM                                              *
C     AIT = AREA (ACRES) IRRIGATED ON EACH OF FIVE REACHES ON TONGUE RIVER   *
C     AIHW = AREA (ACRES) IRRIGATED ON HANGING WOMAN CREEK (ENTER ACRES      *
C            IN EXCESS OF 1225 ACRES PRESENTLY IRRIGATED)                    *
C     AIO = AREA (ACRES) IRRIGATED ON OTTER CREEK (ENTER ACRES IN EXCESS     *
C           OF 785 ACRES PRESENTLY IRRIGATED)                                *
C     AIP = AREA (ACRES) IRRIGATED ON PUMPKIN CREEK (ENTER ACRES IN          *
C           EXCESS OF 2875 ACRES PRESENTLY IRRIGATED)                        *
C     AMT = ACREAGE OF SURFACE COAL MINES ON EACH OF FIVE REACHES ON         *
C           TONGUE RIVER                                                     *
C     AMHW = ACREAGE OF SURFACE COAL MINES ON HANGING WOMAN CREEK            *
C     AMO = ACREAGE OF SURFACE COAL MINES ON OTTER CREEK                     *
C     AMP = ACREAGE OF SURFACE COAL MINES ON PUMPKIN CREEK                   *
C     DST = DISSOLVED SOLIDS CONCENTRATION (MG/L) OF LEACHATE FROM           *
C           SURFACE COAL MINES ON EACH OF FIVE REACHES ON TONGUE RIVER       *
C     DSHW = DISSOLVED SOLIDS CONCENTRATION (MG/L) OF LEACHATE FROM          *
C            SURFACE COAL MINES ON HANGING WOMAN CREEK                       *
C     DSO = DISSOLVED SOLIDS CONCENTRATION (MG/L) OF LEACHATE FROM           *
C           SURFACE COAL MINES ON OTTER CREEK                                *
C     DSP = DISSOLVED SOLIDS CONCENTRATION (MG/L) OF LEACHATE FROM           *
C           SURFACE COAL MINES ON PUMPKIN CREEK                              *
C     QOLT = OTHER WATER LOSSES FROM EACH OF FIVE REACHES ON TONGUE RIVER    *
C            (ACRE-FEET/YEAR)                                                *
C     QOLHW = OTHER WATER LOSSES FROM HANGING WOMAN CREEK (ACRE-FEET/YEAR)   *
C     QOLO = OTHER WATER LOSSES FROM OTTER CREEK (ACRE-FEET/YEAR)            *
C     QOLP = OTHER WATER LOSSES FROM PUMPKIN CREEK (ACRE-FEET/YEAR)          *
C                                                                            *
C   INPUT DATA CARD INSTRUCTIONS, SIX CARDS REQUIRED                         *
C     CARD 1 = SN,MFD                       FORMAT(A5,5X,12I2)               *
C     CARD 2 = INTDS,TRDTDS                 FORMAT(I1,4X,12F5.0)             *
C     CARD 3 = AIT,AIHW,AIO,AIP             FORMAT(8F6.0)                    *
C     CARD 4 = AMT,AMHW,AMO,AMP             FORMAT(8F6.0)                    *
C     CARD 5 = DST,DSHW,DSO,DSP             FORMAT(8F6.0)                    *
C     CARD 6 = QOLT,QOLHW,QOLO,QOLP         FORMAT(8F6.0)                    *
```

Table 1.--*Listing of computer program*--Continued

```
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *




CCCCC     SUBROUTINE MAIN --- READS INPUT DATA, WRITES SIMULATION CONDITIONS,
CCCCC     CALLS APPROPRIATE SUBROUTINES FOR PASSAGE OF DATA TO SUBROUTINE
CCCCC     SALINE, WRITES HEADINGS FOR OUTPUT OF MONTHLY RESULTS, PERFORMS
CCCCC     STATISTICAL ANALYSES OF MONTHLY RESULTS, WRITES HEADINGS AND
CCCCC     RESULTS FOR SIMULATION SUMMARY

      DIMENSION MFD(12),X(12),Y(12),M(12),Z(12),YMEAN(5),ZMEAN(5),
     *YMEANT(3)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      DATA M / 'JAN','FEB','MAR','APR','MAY','JUNE','JULY','AUG','SEPT',
     *'OCT','NOV','DEC'/

CCCCC     READ INPUT DATA FROM CARDS

      READ(5,5)SN,MFD
      READ(5,7)INTDS,TROTDS
      READ(5,10)AIT,AIHW,AIO,AIP
      READ(5,10)AMT,AMHW,AMO,AMP
      READ(5,10)DST,DSHW,DSO,DSP
      READ(5,10)QOLT,QOLHW,QOLO,QOLP
    5 FORMAT(A5,5X,12I2)
    7 FORMAT(I1,4X,12F5.0)
   10 FORMAT(8F6.0)
CCCCC     WRITE DESCRIPTION OF SIMULATION CONDITIONS
      WRITE(6,15) SN
   15 FORMAT('1TONGUE RIVER DISSOLVED SOLIDS MODEL --- SIMULATION NUMBER
     * ',A5//)
      IF(INTDS.EQ.0) WRITE(6,18)
      IF(INTDS.EQ.1) WRITE(6,20)
   18 FORMAT(' DESIGNATOR FOR DISSOLVED-SOLIDS INPUT BY TONGUE RIVER DAM
     * SET TO REGRESSION-DEFINED STATUS')
   20 FORMAT(' DESIGNATOR FOR DISSOLVED-SOLIDS INPUT BY TONGUE RIVER DAM
     * SET TO USER-DEFINED STATUS')
      WRITE(6,76)
      WRITE(6,78)
      WRITE(6,80)
      WRITE(6,82)
      WRITE(6,84)
      WRITE(6,86)
      WRITE(6,88)
      WRITE(6,90)
      WRITE(6,92)
      WRITE(6,94)
      WRITE(6,96)
      WRITE(6,22)
```

```
      22 FORMAT('OSTREAMFLOW STATUS DURING SIMULATION')
         WRITE(6,24)
      24 FORMAT(' ***********************************')
         WRITE(6,30)MFD(1),MFD(2)
         WRITE(6,32)MFD(3),MFD(4)
         WRITE(6,34)MFD(5),MFD(6)
         WRITE(6,36)MFD(7),MFD(8)
         WRITE(6,38)MFD(9),MFD(10)
         WRITE(6,40)MFD(11),MFD(12)
      30 FORMAT('0JAN   = ',I1,T13,'FEB   = ',I1,T30,'1 = MEAN')
      32 FORMAT(' MARCH = ',I1,T13,'APRIL = ',I1,T30,'2 = PLUS ONE STANDARD
        * DEVIATION')
      34 FORMAT(' MAY   = ',I1,T13,'JUNE  = ',I1,T30,'3 = MINUS ONE STANDAR
        *D DEVIATION')
      36 FORMAT(' JULY  = ',I1,T13,'AUG   = ',I1,T30,'4 = HISTORIC HIGH')
      38 FORMAT(' SEPT  = ',I1,T13,'OCT   = ',I1,T30,'5 = HISTORIC LOW')
      40 FORMAT(' NOV   = ',I1,T13,'DEC   = ',I1,T30,'6 = INSTREAM FLOW REQ
        *UIREMENTS')
         WRITE(6,42)
         WRITE(6,44)
      42 FORMAT('0IRRIGATED ACREAGE STATUS DURING SIMULATION')
      44 FORMAT(' ******************************************')
         WRITE(6,46)AIT(1),AIT(2),AIT(3),AIT(4)
         WRITE(6,48)AIT(5),AIHW,AIO,AIP
         WRITE(6,49)
      46 FORMAT('0REACH 1 = ',F6.0,T19,'REACH  2  = ',F6.0,T38,'REACH  3 =
        *',F6.0,T56,'REACH  4 = ',F6.0)
      48 FORMAT(' REACH 5 = ',F6.0,T19,'REACH HWC = ',F6.0,T38,'REACH OC =
        *',F6.0,T56,'REACH PC = ',F6.0)
      49 FORMAT('     NOTE - IRRIGATED ACRES ON REACHES HWC, OC, AND PC ARE
        *THOSE IN '/,'+   EXCESS OF PRESENTLY IRRIGATED ACRES (1225 ACRES O
        *N HWC, '/,'+   785 ACRES ON OC, 2875 ACRES ON PC)')
         WRITE(6,50)
         WRITE(6,52)
      50 FORMAT('OSURFACE COAL MINING STATUS DURING SIMULATION')
      52 FORMAT(' *********************************************')
         WRITE(6,54)
         WRITE(6,56)
         WRITE(6,58)
      54 FORMAT('0                 DISSOLVED SOLIDS                   DI
        *SSOLVED SOLIDS')
      56 FORMAT(' REACH  ACREAGE  (MG/L) OF LEACHATE    REACH  ACREAGE  (MG
        */L) OF LEACHATE')
      58 FORMAT(' -----  -------  -----------------    -----  -------  ---
        *---------------')
         WRITE(6,60)AMT(1),DST(1),AMT(2),DST(2)
         WRITE(6,62)AMT(3),DST(3),AMT(4),DST(4)
         WRITE(6,64)AMT(5),DST(5),AMHW,DSHW
         WRITE(6,66)AMO,DSO,AMP,DSP
      60 FORMAT('   1',T8,F7.0,T25,F5.0,T42,'2',T46,F7.0,T63,F5.0)
      62 FORMAT('   3',T8,F7.0,T25,F5.0,T42,'4',T46,F7.0,T63,F5.0)
      64 FORMAT('   5',T8,F7.0,T25,F5.0,T41,'HWC',T46,F7.0,T63,F5.0)
      66 FORMAT('  OC',T8,F7.0,T25,F5.0,T42,'PC',T46,F7.0,T63,F5.0)
         WRITE(6,68)
```

```
      WRITE(6,70)
   68 FORMAT('0OTHER WATER LOSSES (ACRE-FEET PER YEAR) DURING SIMULATION
     *')
   70 FORMAT(' ***********************************************************
     *')
      WRITE(6,72)QOLT(1),QOLT(2),QOLT(3),QOLT(4)
      WRITE(6,74)QOLT(5),QOLHW,QOLO,QOLP
   72 FORMAT('0REACH 1 = ',F6.0,T19,'REACH  2  = ',F6.0,T38,'REACH  3 =
     *',F6.0,T56,'REACH  4 = ',F6.0)
   74 FORMAT(' REACH 5 = ',F6.0,T19,'REACH HWC = ',F6.0,T38,'REACH OC =
     *',F6.0,T56,'REACH PC = ',F6.0)
   76 FORMAT('0REACH DESCRIPTIONS')
   78 FORMAT(' *****************')
   80 FORMAT('0 1  = TONGUE RIVER DAM (RIVER MILE 189.1) TO RIVER MILE 1
     *56.7')
   82 FORMAT('  2  = RIVER MILE 156.7 TO RIVER MILE 112.7 (INCLUDES HANG
     *ING WOMAN CREEK)')
   84 FORMAT('  3  = RIVER MILE 112.7 TO RIVER MILE  77.6 (INCLUDES OTTE
     *R CREEK)')
   86 FORMAT('  4  = RIVER MILE  77.6 TO RIVER MILE  20.0')
   88 FORMAT('  5  = RIVER MILE  20.0 TO RIVER MILE 8.1 AT MILES CITY GA
     *GE (INCLUDES PUMPKIN CREEK)')
   90 FORMAT(' HWC = HANGING WOMAN CREEK')
   92 FORMAT(' OC  = OTTER CREEK')
   94 FORMAT(' PC  = PUMPKIN CREEK')
   96 FORMAT(' TRD = TONGUE RIVER DAM DISCHARGE'//)

CCCCC     WRITE HEADINGS FOR MONTHLY RESULTS OF SIMULATION. RESULTS WILL BE
CCCCC     WRITTEN BY SUBROUTINE SALINE

      WRITE(6,100)SN
  100 FORMAT('1SIMULATION RESULTS -- SIMULATION NUMBER ',A5/,'+*********
     ************************************'/,'+',T17,'STREAMFLOW',T33,'DI
     *SSOLVED SOLIDS',T58,'PERCENT LOAD (PER',T88,'CUMULATIVE PERCENT'/,
     *'+',T17,'(ACRE-FEET)',T34,'LOAD',T44,'CONC',T60,'REACH) DUE TO',T9
     *1,'LOAD DUE TO'/,'+MONTH  REACH',T33,'(TONS)',T43,'(MG/L)',T56,'RE
     *TURN FLOW    MINING         RETURN FLOW    MINING'/,'+------  -----
     *    -----------  ---------  ----------    -----------  --------
     *         -----------   --------')

CCCCC     ZERO OUT ARRAYS FOR COMPUTATIONS OF IRRIGATION RETURN FLOW

      DO 112 I = 1,12
      SLADH(I)=0.0
      SLADO(I)=0.0
      SLADP(I)=0.0
      DO 111 J = 1,5
      SADX(I,J)=0.0
  111 CONTINUE
  112 CONTINUE

CCCCC     BASED ON VALUE OF MONTHLY FLOW DESIGNATOR(MFD), SUBROUTINE MAIN
CCCCC     CALLS APPROPRIATE SUBROUTINE FOR PASSING DATA TO SUBROUTINE SALINE

```

```
      DO 145 I = 1,12
      IMFD=MFD(I)
C  TEST FOR VALID MONTHLY FLOW DESIGNATOR
      IF(IMFD.LT.1.OR.IMFD.GT.6) GO TO 1000
      GO TO(115,120,125,130,135,140),IMFD
  115 CALL MEAN
      GO TO 145
  120 CALL PLS1SD
      GO TO 145
  125 CALL MIN1SD
      GO TO 145
  130 CALL HIGH
      GO TO 145
  135 CALL LOW
      GO TO 145
  140 CALL INSTRM
  145 CONTINUE

CCCCC     WRITE FIRST SET OF HEADINGS FOR SIMULATION SUMMARY

      WRITE(6,300) SN
  300 FORMAT('1SIMULATION SUMMARY -- SIMULATION NUMBER ',A5)
      WRITE(6,305)
  305 FORMAT(' ********************************************'////)
      WRITE(6,310)
  310 FORMAT('0',T20,'STREAMFLOW',T56,'DISSOLVED SOLIDS'/,'+',T20,'(ACRE
     *-FEET)',T44,'--------------------------------------------'/,'+',T4
     *6,'TONGUE RIVER DAM',T70,'MILES CITY GAGE'/,'+',T9,'--------------
     *------------------- --------------------- ----------------------'
     */,'+MONTH  TONGUE RIVER DAM  MILES CITY GAGE  LOAD(TON)  CONC(MG/L
     *)  LOAD(TON)  CONC(MG/L)'/,'+-----  ----------------  ------------
     *---  ---------  ----------  ---------  ----------')

CCCCC     WRITE RESULTS FOR SIMULATION SUMMARY

      DO 390 I=1,12
      Z(I)=YSLMC(I)/YQMC(I)/.00136
      WRITE(6,385) M(I),QD(I),YQMC(I),SD(I),CD(I),YSLMC(I),Z(I)
  385 FORMAT(1X,A5,T11,F10.0,T28,F10.0,T42,F10.0,T56,F7.0,T65,F10.0,T79,
     *F7.0)
  390 CONTINUE

CCCCC     WRITE SECOND SET OF HEADINGS FOR SIMULATION SUMMARY

      WRITE(6,400)
      WRITE(6,410)
      WRITE(6,420)
      WRITE(6,430)
  400 FORMAT('0',T10,'MONTHLY DISSOLVED SOLIDS CONC (MG/L)',T55,'MEAN PE
     *RCENT LOAD',T83,'MEAN CUMULATIVE PERCENT')
  410 FORMAT(' ',T10,'------------------------------------',T55,'PER REA
     *CH DUE TO',T69,'LOAD DUE TO')
  420 FORMAT(' ',T2,'REACH',T12,'MEAN',T20,'STD DEV',T31,'MIN',T40,'MAX'
     *,T53,'RETURN FLOW',T68,'MINING',T84,'RETURN FLOW',T99,'MINING')
```

Table 1.--*Listing of computer program*--Continued

```
  430 FORMAT(' ',T2,'-----',T11,'-------  -------  -------  -------',T53
     *,'----------   --------',T84,'----------   --------')

CCCCC     PERFORM STATISTICAL ANALYSIS OF DATA OUTPUT BY MONTHLY COMPUTATIONS
CCCCC     FOR FIVE REACHES OF TONGUE RIVER, WRITE RESULTS OF STATISTICAL
CCCCC     ANALYSES

      DO 500 J=1,5
      SUMX = 0
      SUMXSQ = 0
      SUMY = 0
      SUMZ = 0
      XMIN = 1.E20
      XMAX = -1.E20
      SUMU=0
      SUMV=0
      DO 470 I=1,12
      SUMX = SUMX + CT(I,J)
      SUMXSQ = SUMXSQ + CT(I,J) ** 2
      SUMY = SUMY + PTA(I,J)
      SUMZ = SUMZ + PTM(I,J)
      XMIN = AMIN1(XMIN,CT(I,J))
      XMAX = AMAX1(XMAX,CT(I,J))
      SUMU=SUMU+CPTA(I,J)
      SUMV=SUMV+CPTM(I,J)
  470 CONTINUE
      XMEAN = SUMX/12
      XSD = SQRT(12 * SUMXSQ - SUMX ** 2)/12
      YMEAN(J) = SUMY/12
      ZMEAN(J) = SUMZ/12
      UMEAN=SUMU/12
      VMEAN=SUMV/12
      WRITE(6,480) J,XMEAN,XSD,XMIN,XMAX,YMEAN(J),ZMEAN(J),UMEAN,VMEAN
  480 FORMAT(' ',T4,I1,T10,F6.0,T20,F6.0,T29,F6.0,T38,F6.0,T55,F7.4,T67,
     *F7.4,T87,F7.4,T98,F7.4)
  500 CONTINUE

CCCCC     PERFORM STATISTICAL ANALYSIS OF DATA OUTPUT BY MONTHLY COMPUTATIONS
CCCCC     FOR HANGING WOMAN, OTTER, AND PUMPKIN CREEKS, WRITE RESULTS OF
CCCCC     STATISTICAL ANALYSES

      DO 650 K=1,3
      SUMX = 0
      SUMXSQ = 0
      SUMY = 0
      XMIN = 1.E20
      XMAX = -1.E20
      DO 610 I=1,12
      IF(K.EQ.1) X(I) = CH(I)
      IF(K.EQ.2) X(I) = CO(I)
      IF(K.EQ.3) X(I) = CP(I)
      IF(K.EQ.1) Y(I) = PHM(I)
      IF(K.EQ.2) Y(I) = POM(I)
      IF(K.EQ.3) Y(I) = PPM(I)
```

Table 1.--*Listing of computer program*--Continued

```
          SUMX = SUMX + X(I)
          SUMXSQ = SUMXSQ + X(I)**2
          SUMY = SUMY + Y(I)
          XMIN = AMIN1(XMIN,X(I))
          XMAX = AMAX1(XMAX,X(I))
      610 CONTINUE
          XMEAN = SUMX/12
          XSD = SQRT(12 * SUMXSQ - SUMX ** 2)/12
          YMEANT(K) = SUMY/12
          GO TO(620,625,630),K
      620 WRITE(6,635)XMEAN,XSD,XMIN,XMAX,YMEANT(1)
          GO TO 650
      625 WRITE(6,640)XMEAN,XSD,XMIN,XMAX,YMEANT(2)
          GO TO 650
      630 WRITE(6,645)XMEAN,XSD,XMIN,XMAX,YMEANT(3)
      635 FORMAT('  HWC',T9,F7.0,T19,F7.0,T28,F7.0,T37,F7.0,T67,F7.4)
      640 FORMAT('  OC ',T9,F7.0,T19,F7.0,T28,F7.0,T37,F7.0,T67,F7.4)
      645 FORMAT('  PC ',T9,F7.0,T19,F7.0,T28,F7.0,T37,F7.0,T67,F7.4)
      650 CONTINUE
          WRITE(6,670)
      670 FORMAT('0     NOTE -- MEAN AND CUMULATIVE PERCENT VALUES DERIVED FR
         *OM 12 MONTHLY VALUES')
          GO TO 1020

CCCCC     WRITE ERROR MESSAGE FOR INVALID MONTHLY FLOW DESIGNATOR(MFD)

     1000 WRITE(6,1010) SN,I
     1010 FORMAT('0SIMULATION NUMBER ',A5,' TERMINATED DUE TO INVALID MONTHL
         *Y FLOW DESIGNATOR IN MONTH NUMBER ',I2)
     1020 STOP
          END

C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

CCCCC     SUBROUTINE BLOCK DATA --- CONTAINS DATA FOR SIX STREAMFLOW
CCCCC     CONDITIONS USED IN THE MODEL

          BLOCK DATA
          COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
         *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
         *FT(6,12)
          DATA QTRD / 10800.,13350.,8250.,15060.,4910.,9220.,10580.,15520.,5
         *640.,32880.,3160.,8330.,15390.,24560.,6220.,41550.,1400.,9220.,247
         *70.,37490.,12050.,57020.,6830.,6920.,63390.,95550.,31230.,166900.,
         *11970.,23700.,90450.,145350.,35550.,223300.,13980.,41640.,35170.,5
         *7010.,13330.,128100.,10390.,12790.,22560.,31220.,13900.,47190.,670
         *0.,9220.,18130.,25480.,10780.,40850.,7740.,8920.,16730.,24580.,888
         *0.,31320.,4740.,11680.,15120.,22820.,7430.,30110.,2420.,11300.,121
         *20.,15770.,8470.,19680.,5320.,9220./
          DATA PT/.049,.081,.018,.148,.007,.049,.047,.073,.02,.108,.007,.047
         *,.054,.09,.018,.153,.006,.054,.114,.196,.033,.352,.008,.114,.194,.
         *323,.066,.568,.02,.194,.232,.341,.123,.436,.07,.232,.123,.217,.03,
         *.376,.008,.123,.099,.192,.007,.333,.001,.099,.095,.18,.01,.335,.00
         *1,.095,.078,.178,.001,.526,.001,.078,.05,.093,.008,.18,.002,.05,.0
```

Table 1.--*Listing of computer program*--Continued

```
      *5,.088,.013,.148,.002,.05/
       DATA ET/.058,.05,.067,.042,.092,.058,.058,.05,.067,.042,.092,.058,
      *.117,.092,.142,.083,.175,.117,.217,.175,.258,.15,.325,.217,.358,.2
      *83,.433,.242,.533,.358,.45,.333,.567,.275,.842,.45,.575,.475,.667,
      *.408,.808,.575,.55,.45,.65,.425,.775,.55,.358,.292,.425,.233,.508,
      *.358,.258,.208,.308,.183,.383,.258,.117,.092,.142,.083,.175,.117,.
      *058,.05,.067,.042,.092,.058/
       DATA GHW / 175.,825.,88.,1300.,62.,175.,150.,525.,138.,1220.,64.,1
      *50.,413.,544.,262.,5730.,133.,413.,225.,325.,158.,1030.,117.,225.,
      *210.,375.,105.,6060.,67.,210.,183.,762.,125.,769.,88.,183.,225.,26
      *2.,88.,390.,27.,225.,85.,116.,38.,129.,10.,85.,45.,76.,34.,139.,16
      *.,45.,75.,92.,49.,186.,46.,75.,95.,162.,64.,182.,54.,95.,115.,191.
      *,74.,194.,58.,115./
       DATA QO / 300.,400.,233.,1850.,162.,300.,550.,650.,300.,1940.,154.
      *,550.,750.,1800.,500.,6550.,413.,750.,500.,600.,433.,1670.,270.,50
      *0.,525.,900.,375.,3270.,263.,525.,300.,500.,233.,936.,138.,300.,16
      *7.,350.,100.,549.,17.,167.,80.,200.,40.,259.,5.,80.,80.,150.,40.,2
      *43.,8.,80.,133.,200.,67.,272.,25.,133.,233.,300.,167.,364.,121.,23
      *3.,233.,300.,167.,432.,165.,233./
       DATA GP / 172.,257.,86.,1120.,1.,172.,600.,900.,200.,6770.,1.,600.
      *,800.,6000.,400.,18400.,25.,800.,900.,2100.,300.,5000.,12.,900.,80
      *0.,2000.,400.,12580.,1.,800.,300.,2100.,150.,3820.,1.,300.,200.,30
      *0.,100.,1110.,1.,200.,16.,30.,8.,344.,1.,16.,200.,300.,100.,3560.,
      *1.,200.,16.,30.,8.,72.,1.,16.,16.,30.,8.,158.,1.,16.,16.,30.,8.,45
      *.,1.,16./
       DATA YHW / .58,2.74,.29,2.74,.29,.58,.5,1.75,.46,1.75,.46,.5,1.37,
      *1.81,.87,1.81,.87,1.37,.75,1.08,.53,1.08,.53,.75,.7,1.25,.35,1.25,
      *.35,.7,.61,2.53,.42,2.53,.42,.61,.75,.87,.29,.87,.29,.75,.28,.39,.
      *13,.39,.13,.28,.15,.25,.11,.25,.11,.15,.25,.31,.16,.31,.16,.25,.32
      *,.54,.21,.54,.21,.32,.38,.63,.25,.63,.25,.38/
       DATA YO /.66,.88,.51,.88,.51,.66,1.22,1.44,.66,1.44,.66,1.22,1.66,
      *3.98,1.11,3.98,1.11,1.66,1.11,1.33,.96,1.33,.96,1.11,1.16,1.99,.83
      *,1.99,.83,1.16,.66,1.11,.51,1.11,.51,.66,.37,.77,.22,.77,.22,.37,.
      *18,.44,.09,.44,.09,.18,.18,.33,.09,.33,.09,.18,.29,.44,.15,.44,.15
      *,.29,.51,.66,.37,.66,.37,.51,.51,.66,.37,.66,.37,.51/
       DATA YP / .39,.58,.19,.58,.19,.39,1.35,2.02,.45,2.02,.45,1.35,1.79
      *,13.45,.9,13.45,.9,1.79,2.02,4.71,.67,4.71,.67,2.02,1.79,4.48,.9,4
      *.48,.9,1.79,.67,4.71,.34,4.71,.34,.67,.45,.67,.22,.67,.22,.45,.04,
      *.07,.02,.07,.02,.04,.45,.67,.22,.67,.22,.45,.04,.07,.02,.07,.02,.0
      *4,.04,.07,.02,.07,.02,.04,.04,.07,.02,.07,.02,.04/
       DATA AD / 18*0.,.06,.054,.066,.054,.066,.06,.94,.846,1.034,.846,1.
      *034,.94,1.14,1.026,1.254,1.026,1.254,1.14,1.52,1.368,1.672,1.368,1
      *.672,1.52,1.41,1.269,1.551,1.269,1.551,1.41,1.06,.954,1.166,.954,1
      *.166,1.06,.27,.243,.297,.243,.297,.27,12*0./
       DATA RF / .153,.138,.168,.138,.168,.153,.131,.118,.144,.118,.144,.
      *131,.103,.093,.113,.093,.113,.103,.091,.082,.1,.082,.1,.091,.372,.
      *335,.409,.335,.409,.372,.44,.396,.484,.396,.484,.44,.598,.538,.658
      *,.538,.658,.598,.594,.535,.653,.535,.653,.594,.504,.454,.554,.454,
      *.554,.504,.245,.221,.27,.221,.27,.245,.155,.14,.171,.14,.171,.155,
      *.155,.14,.171,.14,.171,.155/
       DATA QADT / 18*0.,.06,.054,.066,.054,.066,.06,.94,.846,1.034,.846,
      *1.034,.94,1.14,1.026,1.254,1.026,1.254,1.14,.76,.684,.836,.684,.83
      *6,.76,30*0./
       DATA QRFT / .049,.044,.054,.044,.054,.049,.046,.041,.051,.041,.051
```

Table 1.--*Listing of computer program*--Continued

```
     *,.046,.018,.016,.02,.016,.02,.018,.022,.02,.024,.02,.024,.022,.339
     *,.31,.37,.31,.37,.339,.413,.37,.45,.37,.45,.413,.305,.27,.34,.27,.
     *34,.305,.05,.04,.06,.04,.06,.05,.05,.04,.06,.04,.06,.05,.05,.04,.0
     *6,.04,.06,.05,.05,.04,.06,.04,.06,.05,.05,.04,.06,.04,.06,.05/
      END

C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

CCCCC     SUBROUTINE MEAN --- PASSES DATA ASSOCIATED WITH MEAN STREAMFLOW
CCCCC     TO SUBROUTINE SALINE

      SUBROUTINE MEAN
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      CALL SALINE (1)
      RETURN
      END

C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

CCCCC     SUBROUTINE PLS1SD --- PASSES DATA ASSOCIATED WITH PLUS ONE
CCCCC     STANDARD DEVIATION STREAMFLOW TO SUBROUTINE SALINE

      SUBROUTINE PLS1SD
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      CALL SALINE (2)
      RETURN
      END

C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

CCCCC     SUBROUTINE MIN1SD --- PASSES DATA ASSOCIATED WITH MINUS ONE
CCCCC     STANDARD DEVIATION STREAMFLOW TO SUBROUTINE SALINE

      SUBROUTINE MIN1SD
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
```

Table 1.--*Listing of computer program*--Continued

```
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      CALL SALINE (3)
      RETURN
      END
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
CCCCC     SUBROUTINE HIGH --- PASSES DATA ASSOCIATED WITH HISTORIC HIGH
CCCCC     STREAMFLOW TO SUBROUTINE SALINE
      SUBROUTINE HIGH
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      CALL SALINE (4)
      RETURN
      END
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
CCCCC     SUBROUTINE LOW --- PASSES DATA ASSOCIATED WITH HISTORIC LOW
CCCCC     STREAMFLOW TO SUBROUTINE SALINE
      SUBROUTINE LOW
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
     *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
     *),INTDS,TRDTDS(12),SD(12),CD(12)
      CALL SALINE (5)
      RETURN
      END
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
CCCCC     SUBROUTINE INSTRM --- PASSES DATA ASSOCIATED WITH INSTREAM
CCCCC     STREAMFLOW REQUIREMENTS TO SUBROUTINE SALINE
      SUBROUTINE INSTRM
      COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
     *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
     *FT(6,12)
      COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
     *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
     *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
```

```
      *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
      *),INTDS,TRDTDS(12),SD(12),CD(12)
       CALL SALINE (6)
       RETURN
       END

C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

CCCCC      SUBROUTINE SALINE --- CALCULATES HYDROLOGIC AND DISSOLVED SOLIDS
CCCCC      MASS BALANCES FOR FIVE REACHES OF THE TONGUE RIVER INCLUDING
CCCCC      HANGING WOMAN, OTTER, AND PUMPKIN CREEKS AND WRITES RESULTS
CCCCC      OF MONTHLY COMPUTATIONS

       SUBROUTINE SALINE (INDEX)
       COMMON / DATA / QTRD(6,12),PT(6,12),ET(6,12),QHW(6,12),QO(6,12),QP
      *(6,12),YHW(6,12),YO(6,12),YP(6,12),AD(6,12),RF(6,12),QADT(6,12),QR
      *FT(6,12)
       COMMON AIT(5),AMT(5),DST(5),QOLT(5),CT(12,5),PTA(12,5),PTM(12,5),C
      *H(12),CO(12),CP(12),PHM(12),POM(12),PPM(12),SN,AIHW,AIO,AIP,A
      *MHW,AMO,AMP,DSHW,DSO,DSP,QOLHW,QOLO,QOLP,YQMC(12),YSLMC(12),I,J,CP
      *TA(12,5),CPTM(12,5),QD(12),SADX(12,5),SLADH(12),SLADO(12),SLADP(12
      *),INTDS,TRDTDS(12),SD(12),CD(12)
       DIMENSION SCGW(5),RA(5),RL(5),AUT(5),GW(5),M(12),ND(12),QIR123(12)
      *,QIR4(12),QIR5(12),QIM(5)
       DIMENSION Q(5),QC(5),QPT(5),QET(5),QGW(5),QAD(5),QRF(5),QUT(5),QGT
      *(5),QI(5),QOL(5),SL(5),SLC(5),SGW(5),SAD(5),SRF(5),S(5),SUT(5),SGT
      *(5),SLMT(5),SOL(5),SC(5),SADP(12,5)
       DATA SCGW / 1150.,1125.,1100.,950.,800./
       DATA RA / 471.,640.,511.,838.,173./
       DATA RL / 32.4,44.,35.1,57.6,11.9/
       DATA AUT / 187520.,223360.,247680.,355200.,84480./
       DATA GW / .09,.67,.37,.41,.35/
       DATA M / 'JAN','FEB','MAR','APR','MAY','JUNE','JULY','AUG','SEPT',
      *'OCT','NOV','DEC'/
       DATA ND / 31,28,31,30,31,30,31,31,30,31,30,31/
       DATA QIR123 / .75,.75,9*0.,.5/
       DATA QIR4 / .75,1.,9*0.,.5/
       DATA QIR5 / 1.,1.,9*0.,.5/
       DATA QIM / 471.,1280.,1022.,1886.,433./
       DATA SADP / .12,.093,.075,.055,.033,.008,6*0.,.137,.109,.09,.064,
      *.036,.008,6*0.,.154,.125,.105,.074,.04,.009,6*0.,.171,.141,.12,
      *.084,.044,.009,6*0.,.189,.158,.135,.093,.048,.01,6*0./

CCCCC      CALCULATE HYDROLOGIC MASS BALANCE

       QD(I) = QTRD(INDEX,I)
       DO 1500 J = 1,5
       IF(ND(I).EQ.31) CV = 61.491
       IF(ND(I).EQ.30) CV = 59.504
       IF(ND(I).EQ.28) CV = 55.547
       IF(J.EQ.1) Q(J)=QTRD(INDEX,I)
       IF(J.GT.1) Q(J)=QC(J-1)
       QPT(J)=RA(J)*PT(INDEX,I)
       QET(J)=RA(J)*ET(INDEX,I)
```

Table 1.--*Listing of computer program*--Continued

```
      QGW(J)=RL(J)*GW(J)*ND(I)
      QAD(J)=AIT(J)*AD(INDEX,I)
      QRF(J)=AIT(J)*RF(INDEX,I)
      IF(J.EQ.1) YC=YHW(INDEX,I) * .001
      IF(J.EQ.2.OR.J.EQ.3) YC=YO(INDEX,I) * .001
      IF(J.EQ.4.OR.J.EQ.5) YC=YP(INDEX,I) * .001
      QUT(J)=AUT(J)*YC
      QGT(J)=0
      IF(J.EQ.2) QGT(J)=QHW(INDEX,I)
      IF(J.EQ.3) QGT(J)=QO(INDEX,I)
      IF(J.EQ.5) QGT(J)=QP(INDEX,I)
      GO TO (20,30,30,40,50),J
   20 QI(J)=RA(J)*.5*QIR123(I)
      GO TO 60
   30 QI(J)=RA(J)*QIR123(I)
      GO TO 60
   40 QI(J)=RA(J)*QIR4(I)
      GO TO 60
   50 QI(J)=RA(J)*QIR5(I)
   60 QOL(J)=QOLT(J)/12
      QOLTR=0
      IF(J.EQ.1) QOLTR=QOLHW/12
      IF(J.EQ.2) QOLTR=QOLO/12
      IF(J.EQ.4) QOLTR=QOLP/12

CCCCC      COMPUTE DISSOLVED SOLIDS MASS BALANCE

      C=.00136
      IF(J.EQ.1) ROCT=.186
      IF(J.EQ.2.OR.J.EQ.3) ROCT=.167
      IF(J.EQ.4.OR.J.EQ.5) ROCT=.409
      ROCH=.186
      ROCO=.167
      ROCP=.409
      IF(J.EQ.1.AND.INTDS.EQ.0) SL(J) = C*QTRD(INDEX,I)*13412.07*(QTRD(I
     *NDEX,I)**(-.3498))
      IF(J.EQ.1.AND.INTDS.EQ.1) SL(J) = TRDTDS(I)*QTRD(INDEX,I)*C
      SD(I)=SL(1)
      CD(I)=SL(1)/QD(I)/C
      IF(J.GT.1) SL(J)=SLC(J-1)
      SGW(J)=QGW(J)*SCGW(J)*C
      SAD(J)=QAD(J)*(SL(J)/Q(J))
      SADX(I,J) = SAD(J)
      SRF(J) = SAD(J)*.65+(SADX(1,J)+SADX(2,J)+SADX(3,J)+SADX(4,J)+SADX(
     *5,J)+SADX(6,J)+SADX(7,J)+SADX(8,J)+SADX(9,J)+SADX(10,J)+SADX(11,J)
     *+SADX(12,J)-SADX(I,J))*.04375+SADP(I,J)*AIT(J)
      IF(J.EQ.1) S(J)=2006.14-16.13*(QHW(INDEX,I)/CV)
      IF(J.EQ.2.OR.J.EQ.3) S(J)=2237.49-8.831*(QO(INDEX,I)/CV)
      IF(J.EQ.4.OR.J.EQ.5) S(J)=1610.64*(QP(INDEX,I)/CV)**(-.2543)
      SUT(J)=QUT(J)*S(J)*C
      SLMT(J)=DST(J)*.0001133*AMT(J)*(ROCT/12)
      SOL(J)=QOL(J)*(SL(J)/Q(J))
      SOLTR=0
      IF(J.EQ.1) SOLTR=QOLTR*(SL(J)/Q(J))
```

```
      IF(J.EQ.2) SOLTR=QOLTR*(SL(J)/Q(J))
      IF(J.EQ.4) SOLTR=QOLTR*(SL(J)/Q(J))

CCCCC     COMPUTE DISSOLVED SOLIDS MASS BALANCES FOR THREE TRIBUTARIES

      SGT(J)=0
      GO TO (400,100,200,400,300),J

CCCCC     COMPUTE DISSOLVED SOLIDS MASS BALANCE FOR HANGING WOMAN CREEK

  100 GO TO(110,120,130,140,140,140,140,140,140,140,140,140),I
  110 SGT(J)=C*QGT(J)*(-22.885*(QHW(INDEX,I)/CV)+2056.07)
      GO TO 150
  120 SGT(J)=C*QGT(J)*(-67.916*(QHW(INDEX,I)/CV)+1874.24)
      GO TO 150
  130 SGT(J)=C*QGT(J)*(-13.293*(QHW(INDEX,I)/CV)+1779)
      GO TO 150
  140 SGT(J)=C*QGT(J)*(-16.13*(QHW(INDEX,I)/CV)+2006.14)
  150 SLAD=AIHW*QADT(INDEX,I)*SGT(J)/QGT(J)
      SLADH(I) = SLAD
      SLA = SLAD*.65+(SLADH(1)+SLADH(2)+SLADH(3)+SLADH(4)+SLADH(5)+SLADH
     *(6)+SLADH(7)+SLADH(8)+SLADH(9)+SLADH(10)+SLADH(11)+SLADH(12)-SLADH
     *(I))*.04375
      SLMH=DSHW*.00011333*AMHW*(ROCH/12)
      QGT(J)=QGT(J)+AIHW*QRFT(INDEX,I)-AIHW*QADT(INDEX,I)
C  TEST FOR CALCULATED ZERO OR NEGATIVE STREAMFLOW
      IF(QGT(J).LE.0) QGT(J)=1.0
      SGT(J)=SLA-SLAD+SLMH+SGT(J)
      SCHW=SGT(J)/QGT(J)/C
      PSHM=SLMH/SGT(J)*100
      PHM(I)=PSHM
      CH(I)=SCHW
  180 FORMAT('                 Q IN HWC LESS THAN OR EQUAL TO ZERO')
  190 FORMAT('                 LOAD IN HWC LESS THAN OR EQUAL TO ZERO')
      GO TO 400

CCCCC     COMPUTE DISSOLVED SOLIDS MASS BALANCE FOR OTTER CREEK

  200 GO TO(210,220,230,220,220,220,220,220,240,220,220,220),I
  210 SGT(J)=C*QGT(J)*(-24.409*(QO(INDEX,I)/CV)+2678.99)
      GO TO 250
  220 SGT(J)=C*QGT(J)*(-8.831*(QO(INDEX,I)/CV)+2237.49)
      GO TO 250
  230 SGT(J)=C*QGT(J)*(-6.336*(QO(INDEX,I)/CV)+1829.06)
      GO TO 250
  240 SGT(J)=C*QGT(J)*(-94.326*(QO(INDEX,I)/CV)+2195.16)
  250 SLAD=AIO*QADT(INDEX,I)*SGT(J)/QGT(J)
      SLADO(I) = SLAD
      SLA = SLAD*.65+(SLADO(1)+SLADO(2)+SLADO(3)+SLADO(4)+SLADO(5)+SLADO
     *(6)+SLADO(7)+SLADO(8)+SLADO(9)+SLADO(10)+SLADO(11)+SLADO(12)-SLADO
     *(I))*.04375
      SLMO=DSO*.0001133*AMO*(ROCO/12)
      QGT(J)=QGT(J)+AIO*QRFT(INDEX,I)-AIO*QADT(INDEX,I)
C   TEST FOR CALCULATED ZERO OR NEGATIVE STREAMFLOW
```

```
      IF(QGT(J).LE.0) QGT(J)=1.0
      SGT(J)=SLA-SLAD+SLMO+SGT(J)
      SCO =SGT(J)/QGT(J)/C
      PSOM=SLMO/SGT(J)*100
      POM(I)=PSOM
      CO(I)=SCO
  280 FORMAT('                     Q IN OC LESS THAN OR EQUAL TO ZERO')
  290 FORMAT('                     LOAD IN OC LESS THAN OR EQUAL TO ZERO')
      GO TO 400

CCCCC     COMPUTE DISSOLVED SOLIDS MASS BALANCE FOR PUMPKIN CREEK

  300 GO TO(310,310,310,310,310,310,310,310,310,320,310,310),I
  310 SGT(J)=C*QGT(J)*(1610.64*(QP(INDEX,I)/CV)**(-.2543))
      GO TO 350
  320 SGT(J)=C*QGT(J)*(5172.22*(QP(INDEX,I)/CV)+42)
  350 SLAD=AIP*QADT(INDEX,I)*SGT(J)/QGT(J)
      SLADP(I) = SLAD
      SLA = SLAD*.65+(SLADP(1)+SLADP(2)+SLADP(3)+SLADP(4)+SLADP(5)+SLADP
     *(6)+SLADP(7)+SLADP(8)+SLADP(9)+SLADP(10)+SLADP(11)+SLADP(12)-SLADP
     *(I))*.04375
      SLMP=DSP*.0001133*AMP*(ROCP/12)
      QGT(J)=QGT(J)+AIP*QRFT(INDEX,I)-AIP*QADT(INDEX,I)
C   TEST FOR CALCULATED ZERO OR NEGATIVE STREAMFLOW
      IF(QGT(J).LE.0) QGT(J)=1.0
      SGT(J)=SLA-SLAD+SLMP+SGT(J)
      SCP=SGT(J)/QGT(J)/C
      PSPM=SLMP/SGT(J)*100
      PPM(I)=PSPM
      CP(I)=SCP
  380 FORMAT('                     Q IN PC LESS THAN OR EQUAL TO ZERO')
  390 FORMAT('                     LOAD IN PC LESS THAN OR EQUAL TO ZERO')

CCCCC     COMPUTE DISSOLVED SOLIDS MASS BALANCE AT DOWNSTREAM END OF REACH

  400 SLC(J)=SL(J)+SGW(J)-SAD(J)+SRF(J)+SUT(J)+SGT(J)-SOL(J)
     *+SLMT(J)-SOLTR

CCCCC     COMPUTE MASS BALANCE OF FLOW AT DOWNSTREAM END OF REACH

      QC(J)=Q(J)+QPT(J)-QET(J)+QGW(J)-QAD(J)+QRF(J)+QUT(J)+QGT(J)-QI(J)-
     *QOL(J)-QOLTR
      IF(I.EQ.3) QC(J)=QC(J)+QIM(J)
C   TEST FOR ZERO OR NEGATIVE STREAMFLOW
      IF(QC(J).LE.0) GO TO 2000

CCCCC     COMPUTE DISSOLVED SOLIDS CONCENTRATIONS, COMPUTE PERCENTAGE OF
CCCCC     DISSOLVED SOLIDS LOAD DUE TO MINING OR RETURN FLOW, COMPUTE
CCCCC     CUMULATIVE PERCENTAGE OF DISSOLVED SOLIDS LOAD DUE TO MINING
CCCCC     OR RETURN FLOW

      SC(J)=SLC(J)/QC(J)/C
      PSTA=SRF(J)/SLC(J)*100
      PSTM=SLMT(J)/SLC(J)*100
```

Table 1.--*Listing of computer program*--Continued

```
      IF(J.EQ.1) CSLM=SLMT(1)/SLC(1)
      IF(J.EQ.2) CSLM=(SLMT(1)+SLMT(2)+SLMH)/SLC(2)
      IF(J.EQ.3) CSLM=(SLMT(1)+SLMT(2)+SLMT(3)+SLMH+SLMO)/SLC(3)
      IF(J.EQ.4) CSLM=(SLMT(1)+SLMT(2)+SLMT(3)+SLMT(4)+SLMH+SLMO)/SLC(4)
      IF(J.EQ.5) CSLM=(SLMT(1)+SLMT(2)+SLMT(3)+SLMT(4)+SLMT(5)+SLMH+SLMO
     *+SLMP)/SLC(5)
      IF(J.EQ.1) CSRF=SRF(1)/SLC(1)
      IF(J.EQ.2) CSRF=(SRF(1)+SRF(2))/SLC(2)
      IF(J.EQ.3) CSRF=(SRF(1)+SRF(2)+SRF(3))/SLC(3)
      IF(J.EQ.4) CSRF=(SRF(1)+SRF(2)+SRF(3)+SRF(4))/SLC(4)
      IF(J.EQ.5) CSRF=(SRF(1)+SRF(2)+SRF(3)+SRF(4)+SRF(5))/SLC(5)

CCCCC     BUILD ARRAYS FOR LATER STATISTICAL ANALYSIS BY SUBROUTINE MAIN

      PTA(I,J)=PSTA
      PTM(I,J)=PSTM
      CT(I,J)=SC(J)
      CPSTA=CSRF*100
      CPSTM=CSLM*100
      CPTA(I,J)=CPSTA
      CPTM(I,J)=CPSTM

CCCCC     WRITE RESULTS OF REACH COMPUTATIONS FOR MONTH

      IF(J.EQ.5) YQMC(I)=QC(J)
      IF(J.EQ.5) YSLMC(I)=SLC(J)
      GO TO(500,600,700,800,900),J
  500 IF(INTDS.EQ.0) X=C*QTRD(INDEX,I)*13412.07*(QTRD(INDEX,I)**
     *(-.3498))
      IF(INTDS.EQ.0) Y=QTRD(INDEX,I)**(-.3498)*13412.07
      IF(INTDS.EQ.1) X=TRDTDS(I)*QTRD(INDEX,I)*C
      IF(INTDS.EQ.1) Y=TRDTDS(I)
      WRITE(6,1000) M(I),QTRD(INDEX,I),X,Y
      WRITE(6,1100) J,QC(1),SLC(1),SC(1),PSTA,PSTM,CPSTA,CPSTM
      GO TO 1500
  600 WRITE(6,1100) J,QC(2),SLC(2),SC(2),PSTA,PSTM,CPSTA,CPSTM
      WRITE(6,1200) QGT(2),SGT(2),SCHW,PSHM
      IF(QGT(2).LE.0) WRITE(6,180)
      IF(SGT(2).LE.0) WRITE(6,190)
      GO TO 1500
  700 WRITE(6,1100) J,QC(3),SLC(3),SC(3),PSTA,PSTM,CPSTA,CPSTM
      WRITE(6,1300) QGT(3),SGT(3),SCO,PSOM
      IF(QGT(3).LE.0) WRITE(6,280)
      IF(SGT(3).LE.0) WRITE(6,290)
      GO TO 1500
  800 WRITE(6,1100) J,QC(4),SLC(4),SC(4),PSTA,PSTM,CPSTA,CPSTM
      GO TO 1500
  900 WRITE(6,1100) J,QC(5),SLC(5),SC(5),PSTA,PSTM,CPSTA,CPSTM
      WRITE(6,1400) QGT(5),SGT(5),SCP,PSPM
      IF(QGT(5).LE.0) WRITE(6,380)
      IF(SGT(5).LE.0) WRITE(6,390)
      IF(I.EQ.6) WRITE(6,1450) SN
 1000 FORMAT(1X,A5,3X,'TRD',5X,F8.0,5X,F8.0,2X,F8.0)
 1100 FORMAT(10X,I1,6X,F8.0,5X,F8.0,2X,F8.0,T58,F7.4,T70,
```

Table 1.--*Listing of computer program*--Continued

```
     *F7.4,T58,F7.4,T100,F7.4)
 1200 FORMAT(9X,'HWC',5X,F8.0,5X,F8.0,2X,F8.0,T70,F7.4)
 1300 FORMAT(9X,'UC',6X,F8.0,5X,F8.0,2X,F8.0,T70,F7.4)
 1400 FORMAT(9X,'PC',6X,F8.0,5X,F8.0,2X,F8.0,T70,F7.4)
 1450 FORMAT('1SIMULATION RESULTS -- SIMULATION NUMBER ',A5/,'+**********
     ************************************'/,'+',T17,'STREAMFLOW',T33,'DI
     *SSOLVED SOLIDS',T58,'PERCENT LOAD (PER',T88,'CUMULATIVE PERCENT'/,
     *'+',T17,'(ACRE-FEET)',T34,'LOAD',T44,'CONC',T60,'REACH) DUE TO',T9
     *1,'LOAD DUE TO'/,'+MONTH  REACH',T33,'(TONS)',T43,'(MG/L)',T56,'RE
     *TURN FLOW    MINING        RETURN FLOW    MINING'/,'+-----  -----
     *  -----------  ---------  ----------    -----------  --------
     *      -----------  --------')
 1500 CONTINUE
 1550 RETURN

CCCCC     WRITE ERROR MESSAGE FOR ZERO OR NEGATIVE STREAMFLOW

 2000 WRITE(6,2100) SN,J,I
 2100 FORMAT('0SIMULATION NUMBER ',A5,' TERMINATED DUE TO ZERO OR NEGATI
     *VE STREAMFLOW IN REACH NUMBER ',I1,' DURING MONTH NUMBER ',I2)
      STOP
      END
```

Table 3.--*Definition of model variables*

AD	Irrigation water diversion rate (in acre-feet per acre) for Tongue River reaches
AIHW	Area (in acres) irrigated on Hanging Woman Creek
AIO	Area (in acres) irrigated on Otter Creek
AIP	Area (in acres) irrigated on Pumpkin Creek
AIT	Area (in acres) irrigated on Tongue River reaches
AMHW	Area (in acres) mined on Hanging Woman Creek
AMO	Area (in acres) mined on Otter Creek
AMP	Area (in acres) mined on Pumpkin Creek
AMT	Area (in acres) mined on Tongue River reaches
AUT	Area (in acres) of ungaged tributaries
C	Factor to convert dissolved-solids load (in tons per acre-foot) of streamflow into concentration (in milligrams per liter)
CD	Dissolved-solids load (in tons) input by Tongue River Reservoir
CH	Matrix of SCHW values
CO	Matrix of SCO values
CP	Matrix of SCP values
CPSTA	Cumulative percentage of dissolved-solids load in the Tongue River due to irrigation return flow
CPSTM	Cumulative percentage of dissolved-solids load in the Tongue River due to mining
CPTA	Matrix of CPSTA values
CPTM	Matrix of CPSTM values
CSLM	Cumulative ratio of dissolved-solids load (in tons) due to mining versus total load (in tons) of dissolved solids in the Tongue River
CSRF	Cumulative ratio of dissolved-solids load (in tons) due to irrigation return flow versus total load (in tons) of dissolved solids in the Tongue River
CT	Matrix of SC values
CV	Factor to convert monthly streamflow (in acre-feet) to mean daily streamflow (in cubic feet per second)
DSHW	Dissolved-solids concentration (in milligrams per liter) of mine-spoil leachates from Hanging Woman Creek
DSO	Dissolved-solids concentration (in milligrams per liter) of mine-spoil leachates from Otter Creek
DSP	Dissolved-solids concentration (in milligrams per liter) of mine-spoil leachates from Pumpkin Creek
DST	Dissolved-solids concentration (in milligrams per liter) of mine-spoil leachates from Tongue River reaches
ET	Evaporation rate (in feet)
GW	Ground-water inflow rate (in acre-feet per river mile per day)
I	Counter for monthly loop
IMFD	Monthly flow designator
INTDS	Option variable for initial input of dissolved-solids
J	Counter for Tongue River reaches loop
M	Name of month
MFD	Monthly flow designator
ND	Number of days in month

Table 3.--*Definition of model variables*--Continued

PHM	Matrix of PSHM values
POM	Matrix of PSOM values
PPM	Matrix of PSPM values
PSHM	Percentage of dissolved-solids load in Hanging Woman Creek due to mining
PSOM	Percentage of dissolved-solids load in Otter Creek due to mining
PSPM	Percentage of dissolved-solids load in Pumpkin Creek due to mining
PSTA	Percentage of dissolved-solids load in the Tongue River due to irrigation return flow
PSTM	Percentage of dissolved-solids load in the Tongue River due to mining
PT	Precipitation rate (in feet)
PTA	Matrix of PSTA values
PTM	Matrix of PSTM values
Q	Streamflow (in acre-feet) input to upstream end of reach
QAD	Volume (in acre-feet) of irrigation diversion for Tongue River reaches
QADT	Irrigation water diversion rate (in acre-feet per acre) for Hanging Woman, Otter, and Pumpkin Creeks
QC	Streamflow (in acre-feet) at downstream end of reach
QD	Streamflow (in acre-feet) input by Tongue River Reservoir
QET	Volume (in acre-feet) of evaporation
QGT	Volume (in acre-feet) of streamflow input to the Tongue River by Hanging Woman, Otter, and Pumpkin Creeks
QGW	Volume (in acre-feet) of ground water
QHW	Initial streamflow (in acre-feet) of Hanging Woman Creek
QI	Volume (in acre-feet) of ice removed from streamflow
QIM	Volume (in acre-feet) of streamflow input by ice breakup
QIR123	Ice removal rate (in feet) for Tongue River reaches 1 through 3
QIR4	Ice removal rate (in feet) for Tongue River reach 4
QIR5	Ice removal rate (in feet) for Tongue River reach 5
QO	Initial streamflow (in acre-feet) of Otter Creek
QOL	Volume (in acre-feet) of other water losses for Tongue River reaches
QOLHW	Other water losses rate (in acre-feet per year) for Hanging Woman Creek
QOLO	Other water losses rate (in acre-feet per year) for Otter Creek
QOLP	Other water losses rate (in acre-feet per year) for Pumpkin Creek
QOLT	Other water losses rate (in acre-feet per year) for Tongue River reaches
QOLTR	Volume (in acre-feet) of other water losses from Hanging Woman, Otter, and Pumpkin Creeks
QP	Initial streamflow (in acre-feet) of Pumpkin Creek
QPT	Volume (in acre-feet) of precipitation
QRF	Volume (in acre-feet) of irrigation return flow for Tongue River reaches
QRFT	Irrigation water return-flow rate (in acre-feet per acre) for Hanging Woman, Otter, and Pumpkin Creeks
QTRD	Initial streamflow (in acre-feet) input by Tongue River Reservoir
QUT	Volume (in acre-feet) of streamflow from ungaged tributaries
RA	Reach area (in acres)
RF	Irrigation water return-flow rate (in acre-feet per acre) for Tongue River reaches
RL	Reach length (in miles)
ROCT	Runoff coefficient (in inches per year) for Tongue River reaches

Table 3.--*Definition of model variables*--Continued

ROCH	Runoff coefficient (in inches per year) for Hanging Woman Creek
ROCO	Runoff coefficient (in inches per year) for Otter Creek
ROCP	Runoff coefficient (in inches per year) for Pumpkin Creek
S	Dissolved-solids concentration (in milligrams per liter) for ungaged tributaries
SAD	Dissolved-solids load (in tons) removed by irrigation water diversion
SADP	Dissolved-solids loading rate (in tons per acre) from previous year's irrigation
SADX	Matrix of SAD values
SC	Dissolved-solids concentration (in milligrams per liter) at downstream end of reach
SCGW	Dissolved-solids concentration (in milligrams per liter) of ground water
SCHW	Dissolved-solids concentration (in milligrams per liter) of Hanging Woman Creek
SCO	Dissolved-solids concentration (in milligrams per liter) of Otter Creek
SD	Dissolved-solids concentration (in milligrams per liter) input by Tongue River Reservoir
SCP	Dissolved-solids concentration (in milligrams per liter) of Pumpkin Creek
SGT	Dissolved-solids load (in tons) of Hanging Woman, Otter, and Pumpkin Creeks
SGW	Dissolved-solids load (in tons) from ground water
SL	Dissolved-solids load (in tons) input at upstream end of reach
SLA	Dissolved-solids load (in tons) due to irrigation water return flow in Hanging Woman, Otter, and Pumpkin Creeks
SLAD	Dissolved-solids load (in tons) removed by irrigation water diversion from Hanging Woman, Otter, and Pumpkin Creeks
SLADH	Matrix of SLAD values for Hanging Woman Creek
SLADO	Matrix of SLAD values for Otter Creek
SLADP	Matrix of SLAD values for Pumpkin Creek
SLC	Dissolved-solids load (in tons) at downstream end of reach
SLMH	Dissolved-solids load (in tons) due to mining on Hanging Woman Creek
SLMO	Dissolved-solids load (in tons) due to mining on Otter Creek
SLMP	Dissolved-solids load (in tons) due to mining on Pumpkin Creek
SLMT	Dissolved-solids load (in tons) due to mining on Tongue River reaches
SN	Simulation number
SOL	Dissolved-solids load (in tons) removed by other water losses from Tongue River reaches
SOLTR	Dissolved-solids load (in tons) removed by other water losses from Hanging Woman, Otter, and Pumpkin Creeks
SRF	Dissolved-solids load (in tons) due to irrigation water return flow on Tongue River reaches
SUMU	Summation of CPTA values
SUMV	Summation of CPTM values
SUMX	Summation of CT values or X values
SUMXSQ	Summation of CT values squared or X values squared
SUMY	Summation of PTA values or Y values
SUMZ	Summation of PTM values
SUT	Dissolved-solids load (in tons) from ungaged tributaries

Table 3.--*Definition of model variables*--Continued

TRDTDS	User-defined dissolved-solids concentrations (in milligrams per liter) input by Tongue River Reservoir
UMEAN	Mean of CPTA values
VMEAN	Mean of CPTM values
X	Matrix of CH or CO or CP values or dissolved-solids load (in tons) input by Tongue River Reservoir
XMAX	Maximum of CT values or X values
XMEAN	Mean of CT values or X values
XMIN	Minimum of CT values or X values
XSD	Standard deviation of CT values or X values
Y	Matrix of PHM or POM or PPM values or dissolved-solids concentration (in milligrams per liter) input by Tongue River Reservoir
YC	Runoff coefficient (in feet) for ungaged tributaries
YHW	Runoff coefficient (in feet) for Hanging Woman Creek
YMEAN	Mean of PTA values
YMEANT	Mean of PHM or POM or PPM values
YO	Runoff coefficient (in feet) for Otter Creek
YP	Runoff coefficient (in feet) for Pumpkin Creek
YQMC	Streamflow (in acre-feet) at Miles City
YSLMC	Dissolved-solids load (in tons) at Miles City
Z	Dissolved-solids concentration (in milligrams per liter) at Miles City
ZMEAN	Mean of PTM values

Table 5.--*Example of model output*

```
TONGUE RIVER DISSOLVED SOLIDS MODEL --- SIMULATION NUMBER   100

DESIGNATOR FOR DISSOLVED-SOLIDS INPUT BY TONGUE RIVER DAM SET TO USER-DEFINED STATUS

REACH DESCRIPTIONS
******************

 1  = TONGUE RIVER DAM (RIVER MILE 189.1) TO RIVER MILE 156.7
 2  = RIVER MILE 156.7 TO RIVER MILE 112.7 (INCLUDES HANGING WOMAN CREEK)
 3  = RIVER MILE 112.7 TO RIVER MILE  77.6 (INCLUDES OTTER CREEK)
 4  = RIVER MILE  77.6 TO RIVER MILE  20.0
 5  = RIVER MILE  20.0 TO RIVER MILE 8.1 AT MILES CITY GAGE (INCLUDES PUMPKIN CREEK)
HWC = HANGING WOMAN CREEK
OC  = OTTER CREEK
PC  = PUMPKIN CREEK
TRD = TONGUE RIVER DAM DISCHARGE


STREAMFLOW STATUS DURING SIMULATION
***********************************

JAN   = 1  FEB   = 1        1 = MEAN
MARCH = 2  APRIL = 2        2 = PLUS ONE STANDARD DEVIATION
MAY   = 3  JUNE  = 3        3 = MINUS ONE STANDARD DEVIATION
JULY  = 4  AUG   = 5        4 = HISTORIC HIGH
SEPT  = 6  OCT   = 1        5 = HISTORIC LOW
NOV   = 3  DEC   = 6        6 = INSTREAM FLOW REQUIREMENTS

IRRIGATED ACREAGE STATUS DURING SIMULATION
******************************************

REACH 1 =     50. REACH  2  =     50. REACH  3 =     80. REACH  4 =    60.
REACH 5 =     10. REACH HWC =      0. REACH OC =     10. REACH PC =    20.
   NOTE - IRRIGATED ACRES ON REACHES HWC, OC, AND PC ARE THOSE IN
   EXCESS OF PRESENTLY IRRIGATED ACRES (1225 ACRES ON HWC,
   785 ACRES ON OC, 2875 ACRES ON PC)

SURFACE COAL MINING STATUS DURING SIMULATION
********************************************

                 DISSOLVED SOLIDS                            DISSOLVED SOLIDS
REACH  ACREAGE  (MG/L) OF LEACHATE    REACH  ACREAGE  (MG/L) OF LEACHATE
-----  -------  ------------------    -----  -------  ------------------
  1       10.              900.         2       0.                0.
  3        0.                0.         4     100.              800.
  5       30.             1200.       HWC       0.                0.
 OC       10.              500.        PC       5.             1500.

OTHER WATER LOSSES (ACRE-FEET PER YEAR) DURING SIMULATION
*********************************************************

REACH 1 =      0. REACH  2  =      0. REACH  3 =     90. REACH  4 =     0.
REACH 5 =     50. REACH HWC =      0. REACH OC =     50. REACH PC =   150.
```

Table 5.--*Example of model output*--Continued

SIMULATION RESULTS -- SIMULATION NUMBER 100

MONTH	REACH	STREAMFLOW (ACRE-FEET)	DISSOLVED SOLIDS LOAD (TONS)	DISSOLVED SOLIDS CONC (MG/L)	PERCENT LOAD (PER REACH) DUE TO RETURN FLOW	PERCENT LOAD (PER REACH) DUE TO MINING	CUMULATIVE PERCENT LOAD DUE TO RETURN FLOW	CUMULATIVE PERCENT LOAD DUE TO MINING
JAN	TRD	10800.	7785.	530.				
	1	10826.	8222.	558.	0.0730	0.0002	0.0730	0.0002
	2	11580.	10538.	669.	0.0650	0.0	0.1219	0.0001
	HWC	175.	474.	1991.		0.0		
	3	12063.	12678.	773.	0.0972	0.0	0.1985	0.0002
	OC	300.	1044.	2556.		0.0008		
	4	12295.	13855.	829.	0.0741	0.0022	0.2557	0.0024
	5	12452.	14338.	847.	0.0132	0.0010	0.2603	0.0035
	PC	173.	290.	1233.		0.0100		
FEB	TRD	10580.	8130.	565.				
	1	10580.	8512.	592.	0.0546	0.0002	0.0546	0.0002
	2	11343.	10919.	708.	0.0499	0.0	0.0925	0.0001
	HWC	150.	345.	1691.		0.0		
	3	12174.	13958.	843.	0.0716	0.0	0.1440	0.0002
	OC	550.	1608.	2148.		0.0005		
	4	12463.	15380.	907.	0.0550	0.0020	0.1857	0.0022
	5	13116.	16357.	917.	0.0097	0.0008	0.1843	0.0031
	PC	601.	718.	878.		0.0040		
MAR	TRD	24560.	19273.	577.				
	1	25465.	20278.	586.	0.0185	0.0001	0.0185	0.0001
	2	29091.	25299.	639.	0.0178	0.0	0.0326	0.0001
	HWC	544.	1229.	1661.		0.0		
	3	33300.	32580.	719.	0.0258	0.0	0.0511	0.0001
	OC	1800.	4024.	1643.		0.0002		
	4	40687.	36786.	665.	0.0196	0.0008	0.0648	0.0009
	5	48382.	41801.	635.	0.0032	0.0003	0.0603	0.0012
	PC	6000.	4100.	502.		0.0007		
APR	TRD	37490.	28501.	559.				
	1	37791.	29169.	568.	0.0140	0.0001	0.0140	0.0001
	2	39308.	32237.	603.	0.0141	0.0	0.0268	0.0000
	HWC	325.	848.	1918.		0.0		
	3	40633.	35533.	643.	0.0231	0.0	0.0475	0.0001
	OC	600.	1753.	2149.		0.0004		
	4	43021.	37923.	648.	0.0181	0.0008	0.0626	0.0009
	5	45643.	40266.	649.	0.0031	0.0003	0.0620	0.0012
	PC	2099.	1858.	651.		0.0016		
MAY	TRD	31230.	20684.	487.				
	1	31182.	20992.	495.	0.1143	0.0001	0.1143	0.0001
	2	32116.	23210.	531.	0.1056	0.0	0.2090	0.0001
	HWC	105.	283.	1979.		0.0		
	3	32847.	25503.	571.	0.1655	0.0	0.3557	0.0001
	OC	368.	1103.	2202.		0.0007		
	4	33542.	26860.	589.	0.1269	0.0012	0.4646	0.0012
	5	34060.	27633.	597.	0.0213	0.0005	0.4729	0.0016
	PC	387.	534.	1016.		0.0054		
JUNE	TRD	35550.	12667.	262.				
	1	35469.	13009.	270.	0.1269	0.0001	0.1269	0.0001
	2	36265.	15032.	305.	0.1128	0.0	0.2227	0.0001
	HWC	125.	335.	1972.		0.0		
	3	36710.	16665.	334.	0.1831	0.0	0.3840	0.0001
	OC	225.	686.	2243.		0.0011		
	4	37108.	17775.	352.	0.1405	0.0017	0.5005	0.0019
	5	37307.	18203.	359.	0.0241	0.0008	0.5128	0.0028
	PC	134.	246.	1350.		0.0118		

Table 5.--*Example of model output*--Continued

SIMULATION RESULTS -- SIMULATION NUMBER 100

MONTH	REACH	STREAMFLOW (ACRE-FEET)	DISSOLVED SOLIDS LOAD (TONS)	DISSOLVED SOLIDS CONC (MG/L)	PERCENT LOAD (PER REACH) DUE TO RETURN FLOW	PERCENT LOAD (PER REACH) DUE TO MINING	CUMULATIVE PERCENT LOAD DUE TO RETURN FLOW	CUMULATIVE PERCENT LOAD DUE TO MINING
JULY	TRD	128100.	38850.	223.				
	1	128297.	39409.	226.	0.0407	0.0000	0.0407	0.0000
	2	129706.	42316.	240.	0.0385	0.0	0.0764	0.0000
	HWC	390.	1010.	1904.		0.0		
	3	130754.	45076.	253.	0.0617	0.0	0.1334	0.0001
	OC	545.	1608.	2170.		0.0005		
	4	131635.	46261.	258.	0.0478	0.0007	0.1778	0.0007
	5	132904.	47622.	263.	0.0079	0.0003	0.1806	0.0011
	PC	1102.	1163.	776.		0.0025		
AUG	TRD	6700.	2387.	262.				
	1	6405.	2589.	297.	0.8279	0.0006	0.8279	0.0006
	2	6805.	4066.	439.	0.5881	0.0	1.1152	0.0004
	HWC	10.	27.	2004.		0.0		
	3	6760.	4731.	515.	1.1487	0.0	2.1071	0.0005
	OC	6.	19.	2515.		0.0412		
	4	6785.	5695.	617.	0.8305	0.0054	2.5809	0.0058
	5	6771.	5849.	635.	0.1593	0.0024	2.6723	0.0086
	PC	2.	10.	3367.		0.2875		
SEPT	TRD	8920.	4780.	394.				
	1	8884.	4988.	413.	0.4640	0.0003	0.4640	0.0003
	2	9653.	6577.	501.	0.3688	0.0	0.7206	0.0002
	HWC	45.	122.	1994.		0.0		
	3	9962.	7507.	553.	0.6254	0.0	1.2566	0.0003
	OC	81.	229.	2092.		0.0034		
	4	10584.	8662.	602.	0.4492	0.0036	1.5383	0.0038
	5	10892.	9180.	620.	0.0770	0.0015	1.5285	0.0055
	PC	201.	326.	1191.		0.0089		
OCT	TRD	16730.	10921.	480.				
	1	16781.	11192.	490.	0.1041	0.0001	0.1041	0.0001
	2	17714.	12989.	539.	0.0929	0.0	0.1826	0.0001
	HWC	75.	203.	1986.		0.0		
	3	18221.	14214.	574.	0.1563	0.0	0.3232	0.0002
	OC	134.	405.	2232.		0.0019		
	4	18802.	15200.	594.	0.1192	0.0020	0.4214	0.0022
	5	18916.	15382.	598.	0.0210	0.0009	0.4374	0.0033
	PC	17.	34.	1472.		0.0851		
NOV	TRD	7430.	4951.	490.				
	1	7502.	5201.	510.	0.1213	0.0003	0.1213	0.0003
	2	8452.	6980.	607.	0.0947	0.0	0.1851	0.0002
	HWC	64.	173.	1989.		0.0		
	3	9038.	8351.	679.	0.1511	0.0	0.3057	0.0003
	OC	168.	506.	2222.		0.0016		
	4	9640.	9292.	709.	0.1126	0.0033	0.3873	0.0036
	5	9750.	9465.	714.	0.0201	0.0015	0.4003	0.0053
	PC	9.	33.	2639.		0.0877		
DEC	TRD	9220.	7009.	559.				
	1	9268.	7349.	583.	0.0859	0.0002	0.0859	0.0002
	2	10089.	9401.	685.	0.0703	0.0	0.1374	0.0002
	HWC	115.	309.	1976.		0.0		
	3	10597.	11090.	769.	0.1138	0.0	0.2302	0.0002
	OC	234.	702.	2212.		0.0011		
	4	10914.	12077.	814.	0.0866	0.0026	0.2980	0.0028
	5	10973.	12278.	823.	0.0155	0.0011	0.3086	0.0041
	PC	17.	53.	2300.		0.0545		

Table 5.--*Example of model output*--Continued

SIMULATION SUMMARY -- SIMULATION NUMBER 100

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	STREAMFLOW (ACRE-FEET)		DISSOLVED SOLIDS			
			TONGUE RIVER DAM		MILES CITY GAGE	
MONTH	TONGUE RIVER DAM	MILES CITY GAGE	LOAD(TON)	CONC(MG/L)	LOAD(TON)	CONC(MG/L)
JAN	10800.	12452.	7785.	530.	14338.	847.
FEB	10580.	13116.	8130.	565.	16357.	917.
MAR	24560.	48382.	19273.	577.	41801.	635.
APR	37490.	45643.	28501.	559.	40266.	649.
MAY	31230.	34060.	20684.	487.	27633.	597.
JUNE	35550.	37307.	12667.	262.	18203.	359.
JULY	128100.	132904.	38850.	223.	47622.	263.
AUG	6700.	6771.	2387.	262.	5849.	635.
SEPT	8920.	10892.	4780.	394.	9180.	620.
OCT	16730.	18916.	10921.	480.	15382.	598.
NOV	7430.	9750.	4951.	490.	9465.	714.
DEC	9220.	10973.	7009.	559.	12278.	823.

	MONTHLY DISSOLVED SOLIDS CONC (MG/L)				MEAN PERCENT LOAD PER REACH DUE TO		MEAN CUMULATIVE PERCENT LOAD DUE TO	
REACH	MEAN	STD DEV	MIN	MAX	RETURN FLOW	MINING	RETURN FLOW	MINING
1	466.	127.	226.	592.	0.1704	0.0002	0.1704	0.0002
2	539.	142.	240.	708.	0.1349	0.0	0.2602	0.0001
3	602.	169.	253.	843.	0.2353	0.0	0.4614	0.0002
4	632.	177.	258.	907.	0.1733	0.0022	0.5781	0.0024
5	638.	179.	263.	917.	0.0313	0.0010	0.5900	0.0034
HWC	1922.	114.	1661.	2004.		0.0		
OC	2199.	215.	1643.	2556.		0.0045		
PC	1448.	839.	502.	3367.		0.0466		

NOTE -- MEAN AND CUMULATIVE PERCENT VALUES DERIVED FROM 12 MONTHLY VALUES