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User's Manual for Stream Quality Model (QUAL-II)

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USER'S MANUAL

for the

STREAM QUALITY MODEL

QUAL-II

Prepared by

Larry A. Roesner
Paul R. Giguere
Donald E. Evenson

Prepared for

Southeast Michigan Council of Governments
Detroit, Michigan

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Environmental Research Laborabory
Office of Research and Development
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FOREWORD

QUAL-II/SEMCOG version was developed by Water Resources Engineers for the Southeast Michigan Council of Governments (SEMCOG) under Section 208 of PL 92-500. It represents a substantial improvement over previous versions of the model and is being made available through the Center for Water Quality Modeling as a service to interested users with the permission of SEMCOG. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency.

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I. INTRODUCTION

QUAL-II is a comprehensive and versatile stream water quality model. It can simulate up to 13 water quality constituents in any combination desired by the user. Constituents which can be simulated are:

1. Dissolved Oxygen
2. Biochemical Oxygen Demand
3. Temperature
4. Algae as Chlorophyll a
5. Ammonia
6. Nitrite
7. Nitrate
8. Phosphate
9. Coliforms
10. Arbitrary Nonconservative Constituent
11. Three Conservative Constituents

The model is applicable to dendritic streams which are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (longitudinal axis of the stream or canal). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow. It also has the capability to compute required dilution flows for flow augmentation to meet any prespecified dissolved oxygen level.

Hydraulically QUAL-II is limited to the simulation of time periods during which the stream flows in the river basin are essentially constant. Input waste loads must also be held constant over time. QUAL-II can be operated as a steady-state model or a dynamic model. Dynamic operation makes it possible to study water quality (primarily dissolved oxygen and temperature) as it is affected by diurnal variations in meteorological data. The basic theory and mechanics behind the development of QUAL-II are described in the Program Documentation Manual which is intended to supplement this User's Manual.

QUAL-II can be very helpful as a water quality planning tool. It can be used to study the impact of waste loads (magnitude, quality and location) on in-stream water quality. It could also be used in conjunction with a field sampling program to identify the magnitude and quality characteristics of nonpoint source waste loads. By operating the model dynamically, diurnal dissolved oxygen variations due to algae growth and respiration can be studied. Dynamic operation also makes it possible to trace the water quality impact of a slug loading, such as a spill, or of seasonal or periodic discharges.

HISTORY AND ACKNOWLEDGMENTS

QUAL-II/SEMCOG VERSION is a new release of QUAL-II which was developed by Water Resources Engineers, Inc. It includes modifications and refinements made in the model since its original development in 1972 and is intended to supersede all prior releases of the computer program. The significant differences between this program and earlier releases are:

1. Option of English or Metric units on input data.
2. Option for English or Metric output--choice is independent of input units.
3. Option to specify channel hydraulic properties in terms of trapezoidal channels or stage-discharge and velocity discharge curves.
4. Option to use Tsivoglou's computational method for stream reaeration.
5. Improved output display routines.
6. Improved steady-state temperature computation routines.

QUAL-II is an extension of the stream water quality model QUAL-I developed in 1970 by F. D. Masch and Associates and the Texas Water Development Board. The computer code was written by W. A. White. In

1972, WRE under contract to the U. S. Environmental Protection Agency, modified and extended QUAL-I to produce the first version of QUAL-II. Over the next three years, several different versions of the model evolved in response to specific client needs. In March of 1976, the Southeast Michigan Council of Governments (SEMCOG) contracted with WRE to make further modifications and to combine the best features of the existing versions of QUAL-II into a single model. QUAL-II/SEMCOG VERSION is that Model.

The authors greatly appreciate the cooperation and assistance provided to them by members of the SEMCOG 208 planning staff. In particular, we thank Peter G. Collins, 208 Technical Coordinator, and James W. Ridgway, Hydrologist, for their assistance in modifying the computer code and in testing, debugging and calibrating this program.

II. GENERAL MODEL SPECIFICATIONS

PROTOTYPE REPRESENTATION

QUAL-II permits any branching, one-dimensional stream system to be simulated. The first step involved in approximating the prototype is to subdivide the stream system into reaches, which are stretches of stream that have uniform hydraulic characteristics. Each reach is then divided into computational elements of equal length so that all computational elements in all reaches are the same length. Thus, all reaches must consist of an integer number of computational elements.

In total, there are seven different types of computational elements; these are:

1. Headwater element
2. Standard element
3. Element just upstream from a junction
4. Junction element
5. Last element in system
6. Input element
7. Withdrawal element

Headwater elements begin every tributary as well as the main river system, and as such, they must always be the first element in a reach. A standard element is one that does not qualify as one of the remaining six element types. Since incremental inflow is permitted in all element types, the only input permitted in a standard element is incremental inflow. A type 3 element is used to designate an element on the mainstem that is just upstream from a junction element (type 4) which is an element that has a simulated tributary entering it. Element type 5 identifies the last computational element in the river system; there should be only one element type 5. Element types 6 and 7 represent elements which have inputs (waste loads and unsimulated tributaries) and water withdrawals, respectively.

River reaches, which are aggregates of computational elements, are the basis of most data input. Hydraulic data, reaction rate coefficients, initial conditions, and incremental inflow data are constant for all computational elements within a reach.

MODEL LIMITATIONS

QUAL-II has been developed to be a relatively general program; however, certain dimensional limitations have been imposed upon it during program development. These limitations are as follows:

- Reaches: a maximum of 75
- Computational elements: no more than 20 per reach nor 500 in total
- Headwater elements: a maximum of 15
- Junction elements: a maximum of 15
- Input and withdrawal elements: a maximum of 90 in total

MODEL STRUCTURE AND SUBROUTINES

QUAL-II is structured as one main program, QUAL2, supported by 23 different subroutines. Figure II-1 graphically illustrates the functional relationships between the main program and the 23 subroutines. The original version of QUAL was structured to permit the addition of parameters easily through addition of subroutines. This basic concept, which proved to be an extremely valuable one, was maintained in the extension of the original version to QUAL-II. Thus, if it becomes desirable at some later time to add new parameters or modify existing parameter relationships, the changes can be made with a minimum of model restructuring.

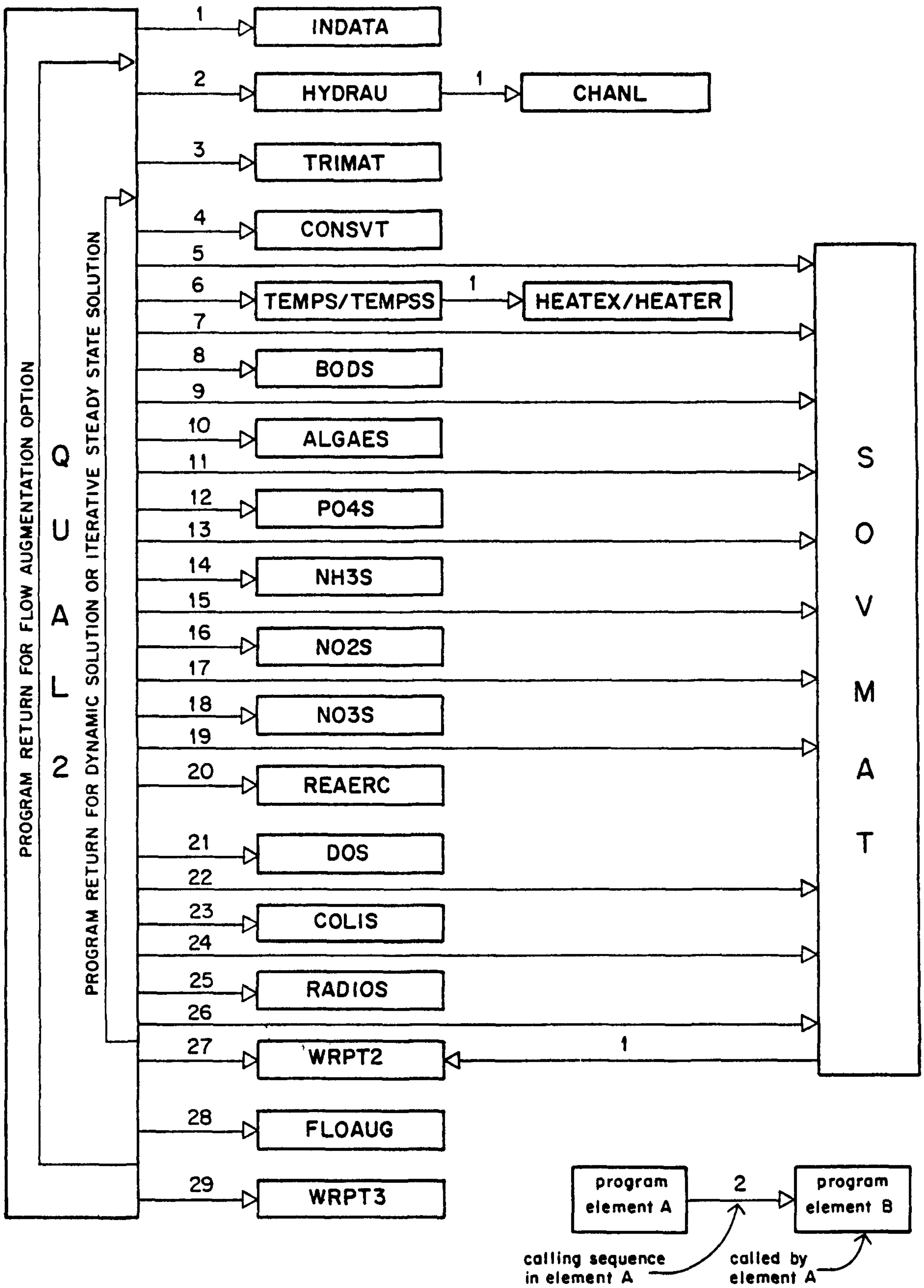

FIGURE II-1

GENERAL STRUCTURE OF QUAL-II

PROGRAM LANGUAGE AND OPERATING REQUIREMENTS

QUAL-II is written in FORTRAN IV and is compatible with the UNIVAC 1108, CDC 6400, and IBM 360 and 370 computer systems. The SEMCOG version of QUAL-II requires an average of 51,000 words of core storage. QUAL-II uses the system's 80 column card reader as the only input device and the system's line printer as the only output device.

TYPICAL EXECUTION TIMES

Execution time on any particular computer system is nearly linearly related to:

1. The number of water quality parameters simulated,
2. The number of computational elements in the system, and
3. The number of time steps simulated when the dynamic simulation option is used.

Approximate execution times for a UNIVAC and IBM computer are shown below.

	Execution Time	
Computer	Steady-State Simulation*	Dynamic Simulation**
UNIVAC 1108	0.02	0.01
IBM 360/40	0.15	0.05

* Seconds/water quality parameter/computational element
**Seconds/water quality parameter/computational element/time step

JOB CONTROL CONSIDERATIONS

If the system's normal FORTRAN input device unit is not unit 5 or the output unit is not unit 6, then the variables "NI" and "NJ" in the subroutine INDATA should be changed to reflect the system's I/O unit identifiers.

III. PROBLEM DEFINITION

Problem definition as used in this document is the gathering and subsequent reduction of basic data to the format required by QUAL-II. The user is required to generate a card deck containing the definition of the stream or channel reach which he desires to model.

The first step in the problem definition is to decide exactly which segments of a stream or canal system are to be simulated. A schematic diagram of a stream system is laid out as shown in Figure III-1. The next step is to decide what degree of detail is required. If one is familiar with the prototype system this decision should be fairly easy to make. It should be based on the amount and worth of the available data, changes in stream geometry, and the number and location of waste inputs or withdrawals. Once the amount of detail is decided upon, the stream can be broken down into reaches, which are portions of the stream system with nearly uniform characteristics. Reaches, headwaters, waste discharges or withdrawals, and junctions are ordered sequentially from the uppermost point of the system. This breakdown also determines the amount of data required by the program.

The final step is to decide upon the degree of resolution that is required. Again, this decision should be based on some feeling for how the prototype behaves. For example, if the dissolved oxygen concentration goes from saturated concentration to critical concentration and back to saturated concentration over an interval of about five (5) river miles, a degree of resolution of less than one (1) mile is appropriate. Once this decision has been made, each reach is then broken down into computational elements or control volumes.

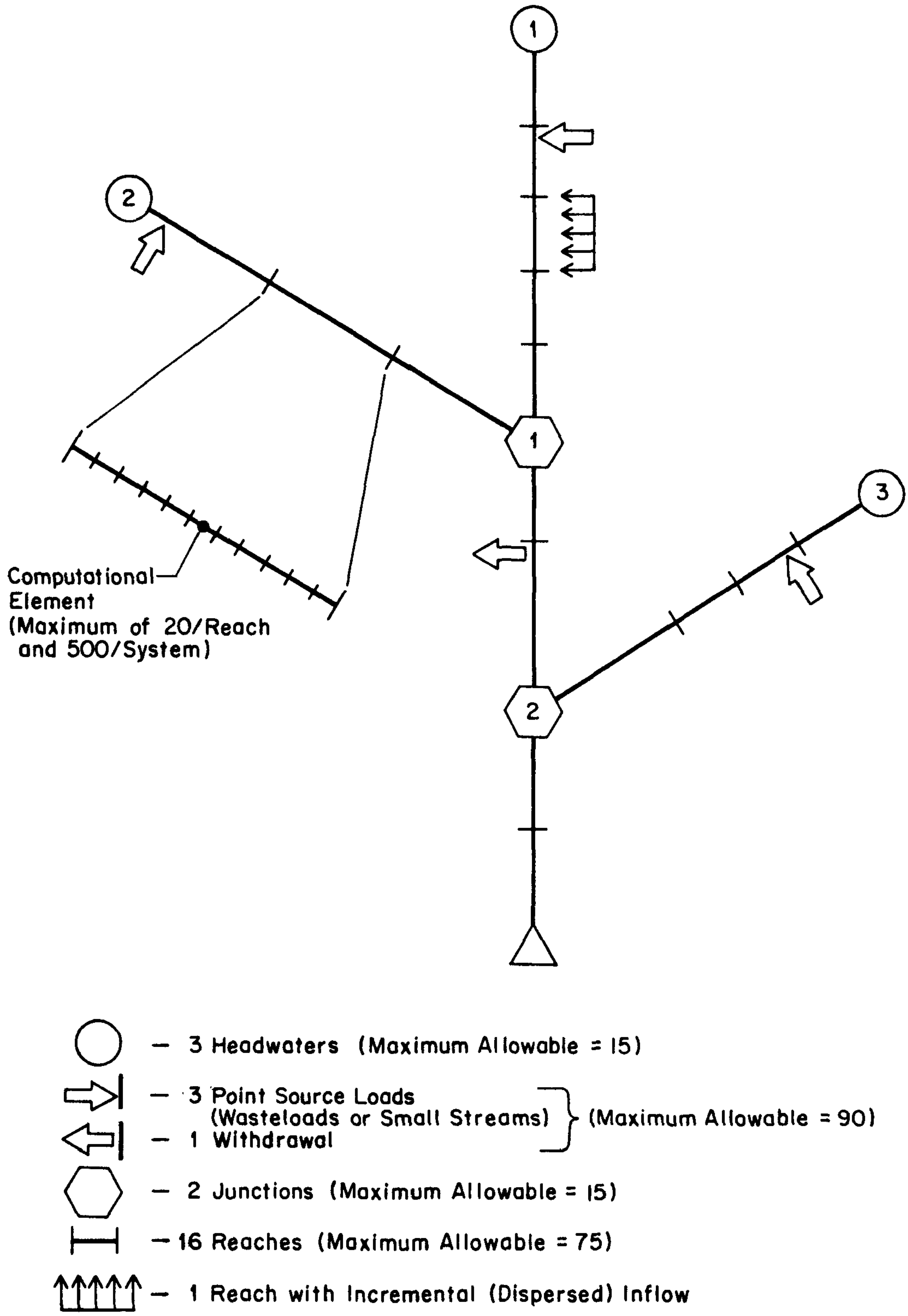

FIGURE III-1

A SCHEMATIC DIAGRAM OF A HYPOTHETICAL STREAM SYSTEM

The next section describes the data preparation for QUAL-II. A number of bio-chemical, stoichiometric, and rate parameters are required as input. Table III-1 summarizes these parameters and indicates the range of values typically used.

TABLE III-1
INPUT PARAMETERS FOR QUAL-II

INPUT PARAMETER NAME IN EQU.	NAME IN QUAL	DESCRIPTION	UNITS	RANGE OF VALUES	VARIABLE BY REACH	TEMPERATURE DEPENDENT	RELIABILITY
α_0	ALPHAØ	Ratio of chlorophyll a to algae biomass	$\frac{\mu g\ Chl\text{-}A}{mg\ A}$	50-100	Yes	No	Fair
α_1	ALPHA1	Fraction of algae biomass which is N	$\frac{mg\ N}{mg\ A}$	0.08-0.09	No	No	Good
α_2	ALPHA2	Fraction of algae biomass which is P	$\frac{mg\ P}{mg\ A}$	0.012-0.015	No	No	Good
α_3	ALPHA3	O_2 production per unit of algae growth	$\frac{mg\ O}{mg\ A}$	1.4-1.8	No	No	Good
α_4	ALPHA4	O_2 uptake per unit of algae respired	$\frac{mg\ O}{mg\ A}$	1.6-2.3	No	No	Fair
α_5	ALPHA5	O_2 uptake per unit of NH_3 oxidation	$\frac{mg\ O}{mg\ N}$	3.0-4.0	No	No	Good
α_6	ALPHA6	O_2 uptake per unit of NO_2 oxidation	$\frac{mg\ O}{mg\ N}$	1.0-1.14	No	No	Good
μ_{max}	GRØMAX	Maximum specific growth rate of algae	$\frac{1}{day}$	1.0-3.0	No	Yes	Good
ρ	RESPRT	Algae respiration rate	$\frac{1}{day}$	0.05-0.5	No	Yes	Fair
β_1	CKNH3	Rate constant for biological oxidation of $NH_3 \rightarrow NO_2$	$\frac{1}{day}$	0.1-0.5	Yes	Yes	Fair
β_2	CKNØ2	Rate constant for biological oxidation of $NO_2 \rightarrow NO_3$	$\frac{1}{day}$	0.5-2.0	Yes	Yes	Fair
σ_1	ALGSET	Local settling rate for algae	$\frac{ft}{day}$	0.5-6.0	Yes	No	Fair
σ_2	SPHØS	Benthos source rate for phosphorus	$\frac{mg\ P}{day\text{-}ft}$	*	Yes	No	Poor
σ_3	SNH3	Benthos source rate for NH	$\frac{mg\ N}{day\text{-}ft}$	*	Yes	No	Poor
K_1	CK1	Carbonaceous BOD decay rate	$\frac{1}{day}$	0.1-2.0	Yes	Yes	Poor
K_2	CK2	Reaeration rate	$\frac{1}{day}$	0.0-100	Yes	Yes	Good
K_3	CK3	Carbonaceous BOD sink rate	$\frac{1}{day}$	-0.36-0.36	Yes	No	Poor
K_4	CK4	Benthos source rate for BOD	$\frac{mg}{day\text{-}ft}$	*	Yes	No	Poor
K_5	CK5	Coliform die-off rate	$\frac{1}{day}$	0.5-4.0	Yes	Yes	Fair
K_6	CK6	Arbitrary nonconservative decay rate	$\frac{1}{day}$	*	Yes	Yes	*
K_N	CKN	Nitrogen half-saturation constant for algae growth	$\frac{mg}{\ell}$	0.2-0.4	No	No	Fair to Good
K_P	CKP	Phosphorus half-saturation constant for algae growth	$\frac{mg}{\ell}$	0.03-0.05	No	No	Fair to Good
K_L	CKL	Light half-saturation constant for algae growth	$\frac{Langleys}{min.}$	.03	No	No	Good

*Highly variable

IV. MODEL SETUP AND INPUT REQUIREMENTS

All the input data required by the program are in card form. The card data and input formats are itemized on the 19 input data forms attached to the back of this section. The following paragraphs give details of the data required, with suggested parameter limits and explanations of program requirements.

TITLE DATA CARDS (Form 1 of 19)

All 16 cards are required in the order shown. The first two cards are title cards, and columns 37 to 80 of card 2 can be used to describe the basin, i.e. name, date, season. Title cards 3 through 15 require either a YES or a NO in columns 10-12, right adjusted. The nitrogen series NH_3, NO_2, and NO_3 must be simulated as a group.

For each conservative mineral to be simulated enter the constituent name in columns 49-52 (e.g. IRON), enter the input data units (e.g. mg/l or μg/l) in columns 57-60. For the Arbitrary Nonconservative constituent, enter its name in columns 49-52 (e.g. FECL for fecal streptococci) and its input data units (e.g. N/ml) in columns 57-60).

Card 16 must read ENDTITLE.

NOTE: QUAL-II simulates *ULTIMATE* BOD in the general case; however, if the user wishes to use 5-day BOD for input and output, the program will make the conversions to ultimate BOD internally.* To use the 5-day BOD I-O option, write "5-DAY*b*BIØCHEMICAL*b*ØXYGEN*b*DEMAND*b*IN*b*MG/L" on the TITLE07 card beginning in column 22.

*The 5-day BOD is divided by a factor of 0.68, which is based on an assumed decay rate of 0.23 per day, base e.

PROGRAM ANALYSIS CONTROL DATA (Form 2 of 19)

The first five cards control program options. *If any characters other than those shown below are inserted in the first four columns of these cards, the action described will not occur.*

LIST - Card 1, list the input data

WRIT - Card 2, write the intermediate output report, WRPT2 (see SUBROUTINE WRPT2 IN THE DOCUMENTATION MANUAL)

FLOW - Card 3, use flow augmentation

STEA - Card 4, on Form 2 shows this is a steady-state simulation. If it is not to be a steady-state, write DYNAMIC SIMULATION and it is automatically a dynamic simulation.

TRAP - Card 5, cross-sectional data will be specified for each reach (see form 6A). If discharge coefficients are to be used for velocity and depth computations (see form 6), write DISCHARGE COEFFICIENTS, beginning in column 1.

Card 6 specifies whether the user will input and/or output his data in metric units or English units. The value of 1 in card column 35 specifies metric input. The value of 1 in card column 80 specifies metric units for the output. Any value less than or equal to zero will specify English units.

The next four cards describe the stream system. There are two data fields per card, columns 26-35 and 71-80.

Card 7 defines the number of reaches into which the stream is broken down and the number of stream junctions (confluences) within the system.

Card 8 shows the number of headwater sources and the number of inputs or withdrawals within the stream system. The inputs can be small streams, wasteloads, etc. Withdrawals can be municipal water supplies, canals, etc. NOTE: Withdrawals must have a minus sign ahead of the flow in type 11 data (see Form 17), and must be specified as withdrawals in type 4 data (see Form 5) by setting IFLAG = 7 for that element.

Card 9 contains the time step interval in hours and the length of the computational element in miles (kilometers). For steady-state computations leave the time step interval blank.

The maximum route time for dynamic simulations is on card 10, and represents the approximate time in hours required for a particle of water to travel from the most upstream point in the system to the most downstream point. In steady-state solutions enter the maximum number of iterations required for convergence. Thirty iterations should be sufficient in most cases. Also on card 10 is the time increment in hours for intermediate summary reports of concentration profiles (see Subroutine WRPT2 in the Documentation Manual). For the steady-state solutions, leave this blank.

The next four cards (cards 11-14) are required only if temperature is being simulated. The data fields are also columns 26-35 and 71-80. The basin latitude and longitude are entered in card 11 and represent mean values in degrees for the basin. On card 12 enter the standard meridian in degrees, and the day of the year the simulation is to begin. The evaporation coefficients are entered on card 13. (Typical values are AE = 6.8×10^{-4} ft/hour/in of Hg, and BE = 2.7×10^{-4} ft/hour/in of Hg/mph of wind.) On data card 14, enter the mean basin elevation in feet (meters) above MSL, and the dust attenuation coefficient (unitless) for solar radiation. The dust attenuation coefficient generally ranges between zero and 0.13.

The last card must read ENDATA1.

NONSPATIALLY VARIABLE A, N, AND P CONSTANTS (Form 2 of 19)

Six input data cards are required if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms or the arbitrary nonconservative constituent is to be simulated. Otherwise they may be deleted, except the ENDATA1A card. The data fields are columns 33-39 and 74-80. Card 1 inputs data on oxygen uptake per unit of ammonia oxidation, 3.5 mg O/mg N, and oxygen uptake per unit of nitrite oxidation, 1.14 mg O/mg N.

The next three cards concern algae. Card 2 contains data on oxygen production per unit of algae growth, usually 1.6 mg O/mg A, with a range of 1.4 to 1.8. It also contains data on oxygen update per unit of algae, usually 2.0 mg O/mg A respired, with a range of 1.6 to 2.3. The third card concerns the nitrogen content and phosphorus content of algae in mg per mg of algae. The fraction of algae biomass which is N is about 0.08 to 0.09, and the fraction of algae biomass which is P is about 0.012 to 0.015. Card 4 inputs the maximum specific growth rate of algae, which has a range of 1.0 to 3.0 per day. The respiration value of 0.05 is for pure streams, while 0.2 is used where the NO_3 and PO_4 concentrations are greater than twice the half saturation constants.

The nitrogen and phosphorus half saturation constants are entered on card 5 in mg/l. The range of the values for nitrogen is from 0.2 to 0.4 and the P value is 0.04.

Card 6 inputs solar radiation information. The light half saturation constant, in Langleys/minute, is 0.03. The total daily radiation is in Langleys.

This group of cards must end with ENDATA1A, even if no data are entered.

REACH IDENTIFICATION AND RIVER MILE DATA (Form 3 of 19)

The cards of this group identify the stream reach system by name and river mile by listing the stream reaches from the most upstream point in the system to the most downstream point. When a junction is reached, the order is continued from the upstream point of the tributary. There is one card per reach. The following information is on each card:

Reach order or number	Columns 16-20
Reach identification or name	Columns 26-40
River mile at head of reach	Columns 51-60
River mile at end of reach	Columns 71-80

A very useful feature of QUAL-II pertaining to modifications of reach identification once the system has been coded is: *reaches may be subdivided (or added) without renumbering the reaches for the whole system.* If, for example, it is desired to subdivide the river reach originally designated as REACH 3 into two reaches, the subdivision is made by calling the upstream portion REACH 3 and the "new reach" downstream REACH 3.1. Up to nine such subdivisions can be made per reach (3.1-3.9); thus REACH 3 (or any other reach) can be subdivided into as many as 10 reaches numbered 3, 3.1-3.9.

This group of cards must end with ENDATA2.

FLOW AUGMENTATION DATA (Form 4 of 19)

These cards except ENDATA 3 are required only if flow augmentation is to be used. The cards in this group contain data associated with determining flow augmentation requirements and available sources of flow augmentation. There must be as many cards in this group as in the reach identification group. The following information is on each card.

Reach order or number	Columns 26-30
Augmentation Sources (the number of headwater sources which are available for flow augmentation)	Columns 36-40
Target Level (minimum allowable dissolved oxygen concentration (mg/l) in this reach)	Columns 41-50
Order of Sources (order of available headwaters, starting at most upstream point)	Columns 51-80

This card group must end with ENDATA3.

COMPUTATIONAL ELEMENTS FLAG FIELD DATA (Form 5 of 19)

This group of cards identifies each type of computational element in each reach. These data allow the proper form of routing equations to be used by the program. There are seven element types allowed, they are listed below.

IFLAG	Type
1	Headwater source element
2	Standard element, incremental inflow only
3	Element on mainstream immediately upstream of a junction
4	Junction element
5	Most downstream element
6	Input element
7	Withdrawal element

Each card in this group (one for each reach), contains the following information:

Reach order or number	Columns 16-20
Number of elements in the reach	Columns 26-30
Element type (these are numbers of a set, identifying each element by type)	Columns 41-80

Remember that any of these reaches can be subdivided, if necessary, after the data has been coded without necessitating the renumbering of the reaches (see REACH IDENTIFICATION AND RIVER MILE DATA).

This card group must end with ENDATA4.

HYDRAULIC DATA (Form 6 of 19)

Two options are available to describe the hydrologic characteristics of the system. The first option utilizes a functional representation while the second option utilizes a geometric representation. The option desired must be specified on card 5 (TYPE 1 DATA) of Form 2.

If the first option is selected, velocity is calculated as $V = aQ^b$ and depth is found by $D = \alpha Q^\beta$. Each card represents one reach and contains the values of a, b, α, and β, as described below.

Reach order or number	Columns 16-20
a, coefficient for velocity	Columns 31-40
b, exponent for velocity	Columns 41-50
α, coefficient for depth	Columns 51-60
β, exponent for depth	Columns 61-70
Mannings "n" for reach (Default for Mannings "n" is 0.020)	Columns 71-80

The coefficients should be expressed to relate velocity, depth, and discharge units as follows:

System	PARAMETER UNITS Q	V	D
Metric	m^3/sec	m/sec	m
English	ft^3/sec	ft/sec	ft

If the second option is selected, each reach is represented as a trapezoidal channel. Form 6A is used to specify the trapezoidal cross-section (bottom width and side slope), the channel slope and the Manning's "n" corresponding to the reach. The program computes the velocity and depth from this data using Manning's Equation and the Newton Raphson (iteration) method. One card must be prepared for each reach as follows:

Reach order or number	Columns 16-20
Side slope 1(run/rise)	Columns 31-40
Side slope 2 (run/rise)	Columns 41-50
Bottom width of channel, feet (meters)	Columns 51-60
Channel slope, ft/ft (m/m)	Columns 61-70
Manning n (Default: 0.020)	Columns 71-80

This group of cards (TYPE 5 DATA) must end with ENDATA5.

BOD AND DO REACTION RATE CONSTANTS DATA (Form 7 of 19)

This group of cards includes reach information on the BOD rate coefficient and settling rate, as well as the method of computing the reaeration coefficient. Eight options for reaeration coefficient calculation are available. These are listed below.

K2OPT	Method
1	Read in values of K2
2	Churchill (1962)
3	O'Conner and Dobbins (1958)
4	Owens and Gibbs (1964)

5	Thackston and Krenkel (1966)
6	Langien and Durum (1967)
7	Use equation $K2 = aQ^b$
8	Tsivoglou-Wallace (1972)

One card is necessary for each reach, and contains the following information.

Reach order or number	Columns 16-20
BOD rate coefficient, per day	Columns 21-30
BOD removal rate by settling, per day	Columns 31-40
Option for K2 (1 to 8, as above)	Columns 41-50
K2 (option 1 only) reaeration coefficient	Columns 51-60
a, coefficient for K2 (option 7) or coefficient for Tsivoglou (option 8)	Columns 61-70
b, exponent for K2 (option 7) or slope of the energy gradient (option 8)	Columns 71-80

For option 8 (Tsivoglou's option), the energy gradient, S_e need not be specified if a Manning n value was assigned under HYDRAULIC DATA. S_e will be calculated from Manning's Equation using the wide channel approximation for hydraulic radius; however, it is suggested that the slope be specified rather than calculated by the program, if possible.

This group of cards must end with ENDATA6.

ALGAE, NITROGEN AND PHOSPHORUS CONSTANTS (Form 8 of 19)

This group of cards is required if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms or the arbitrary nonconservative constituent is to be simulated. Otherwise, they can be omitted. Each card of this group, one for each reach, contains the following information:

Reach order or number	Columns 26-30
Chlorophyll a to algae ratio, (μg chl a/mg Algae range of 50-100)	Columns 33-40
Algae settling rate, feet/day (m/day) (range of 0.5 to 6.0 ft/day)	Columns 41-48
Rate coefficient for ammonia oxidation, per day (range of 0.1 to 0.5, about equal to BOD rate coefficient)	Columns 49-56
Rate coefficient for nitrite oxidation, per day (range of 0.5 to 2.0, about five times BOD rate coefficient)	Columns 57-64
Benthos source rate for ammonia, mg/foot/day (mg/meter/day)	Columns 65-72
Benthos source rate for phosphorus, mg/foot/day (mg/meter/day)	Columns 73-80

Note that the benthos source data is expressed per unit length of stream. Rates per unit area are usually available ($mg/ft^2/day$); these values should be multiplied by the estimated width of the bottom benthos in each reach to determine the rate per unit length of stream.

This card group must end with ENDATA6A, even if no data are entered.

OTHER CONSTANTS (Form 9 of 19)

This group of cards is required if sediment oxygen demand, algae, the NH_3-NO_2-NO_3 series, PO_4, coliform or the arbitrary nonconservative constituent is to be simulated Otherwise, they may be deleted. Each card of the group, one for each reach, contains the following information.

Reach order or number	Columns 26-30
Benthos source rate for BOD, mg/foot/day (mg/meter/day)	Columns 33-40
Coliform decay rate, per day	Columns 41-48
Light extinction coefficient, per foot (per meter)	Columns 49-56
Nonconservative constituent decay rate, per day	Columns 57-64

This group of cards must end with ENDATA6B, even if no data are entered.

INITIAL CONDITIONS DATA (Form 10 of 19)

This card group, one card per reach, establishes the initial conditions of the system, with respect to temperature, dissolved oxygen concentrations, BOD concentrations, and conservative minerals. *Initial conditions for temperature must always be specified whether it is simulated or not.* The reason for this is: 1) if it is not simulated, the initial condition values are used to set the value of the temperature dependent rate constants; 2) for dynamic simulation the initial condition for temperature, plus every other parameter to be simulated, defines the state of the system at time zero; and 3) for steady-state simulations of temperature, an initial estimate of the temperature between freezing and boiling is required. Specifying 68°F or 20°C for all reaches is a sufficient initial condition for the steady-state temperature simulation case. The information is contained as follows:

Reach order or number	Columns 26-30
Temperature in degrees F or C	Columns 31-40
Dissolved Oxygen, mg/l	Columns 41-45
BOD, mg/l	Columns 46-50

Conservative mineral I*	Columns 51-60
Conservative mineral II*	Columns 61-70
Conservative mineral III*	Columns 71-80

*Units are those specified on the Title Card (Form I)

This group of cards must end with ENDATA7.

INITIAL CONDITIONS FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT (Form 11 of 19)

This group of cards, one per reach, is required only if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms, or the nonconservative constituent is to be simulated. Otherwise they may be deleted. The following information is on each card:

Reach order or number	Columns 20-24
Chlorophyll a, micrograms/l	Columns 25-32
Ammonia as N, mg/l	Columns 33-40
Nitrite as N, mg/l	Columns 41-48
Nitrate as N, mg/l	Columns 49-56
Phosphate as P, mg/l	Columns 57-64
Coliforms, no/100 ml	Columns 65-72
Nonconservative Constituent	Columns 73-80

This group of cards must end with ENDATA7A, even if no data are entered.

INCREMENTAL INFLOW DATA (Form 12 of 19)

This group of cards, one per reach, accounts for the additional flows into the system not represented by point source inflows or headwaters. These inflows which are assumed to be uniformly distributed over the reach are basically groundwater inflows and/or distributed surface runoff that can be assumed to be approximately constant through time. The flow rate, temperature of the flow and DO, BOD, and conservative mineral concentration of the flow is taken into account. Each card contains the following information:

Reach order or number	Columns 26-30
Incremental inflow, cfs (m^3/sec)	Columns 31-35
Temperature in degrees F or C	Columns 36-40
Dissolved Oxygen, mg/l	Columns 41-45
BOD, mg/l	Columns 46-50
Conservative I	Columns 51-60
Conservative II	Columns 61-70
Conservative III	Columns 71-80

This group of cards must end with ENDATA8.

INCREMENTAL INFLOW FOR ALGAE, N, P, COLIFORMS AND NONCONSERVATIVE CONSTITUENT (Form 13 of 19)

This card group is required if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms or the nonconservative constituent is to be simulated. Each card contains the following information:

Reach order or number	Columns 20-24
Chlorophyll a concentration, microgram/l	Columns 25-32
Ammonia as N, mg/l	Columns 33-40
Nitrite as N, mg/l	Columns 41-48
Nitrate as N, mg/l	Columns 49-56
Phosphate as P, mg/l	Columns 57-64
Coliforms as no/100 ml	Columns 65-72
Nonconservative Constituent	Columns 73-80

This group of cards must end with ENDATA8A, even if no data are entered.

STREAM JUNCTION DATA (Form 14 of 19)

This group of cards is required if there are junctions on confluences in the stream system being simulated. Otherwise they may be deleted. The junctions are ordered starting with the most upstream junction. For systems containing a junction(s) on a tributary, the junctions must be ordered in the manner indicated on Figure IV-1; that is, *the junctions must be ordered so that the element numbers just downstream of the junction are specified in ascending order*. In Figure IV-1, the downstream element numbers for Junctions 1, 2 and 3 are 29, 56, and 64, respectively. There is one card per junction, and the following information is on each card:

Junction order or number	Columns 21-25
Junction name or identification	Columns 35-50
Order number of the last element in the reach immediately upstream of the junction (see Figure IV-1). In the example, for Junction 1, the order number of the last element immediately upstream of the junction is number 17. *For Junction 2 it is number 49.* For Junction 3, it is number 43.	Columns 56-60
Order number of the first element in the reach immediately downstream from the junction. It is these numbers that must be arranged in ascending order. Thus for Figure IV-1 these order numbers are as follows:	Columns 66-70

Junction	Downstream Element No.
1	29
2	56
3	64

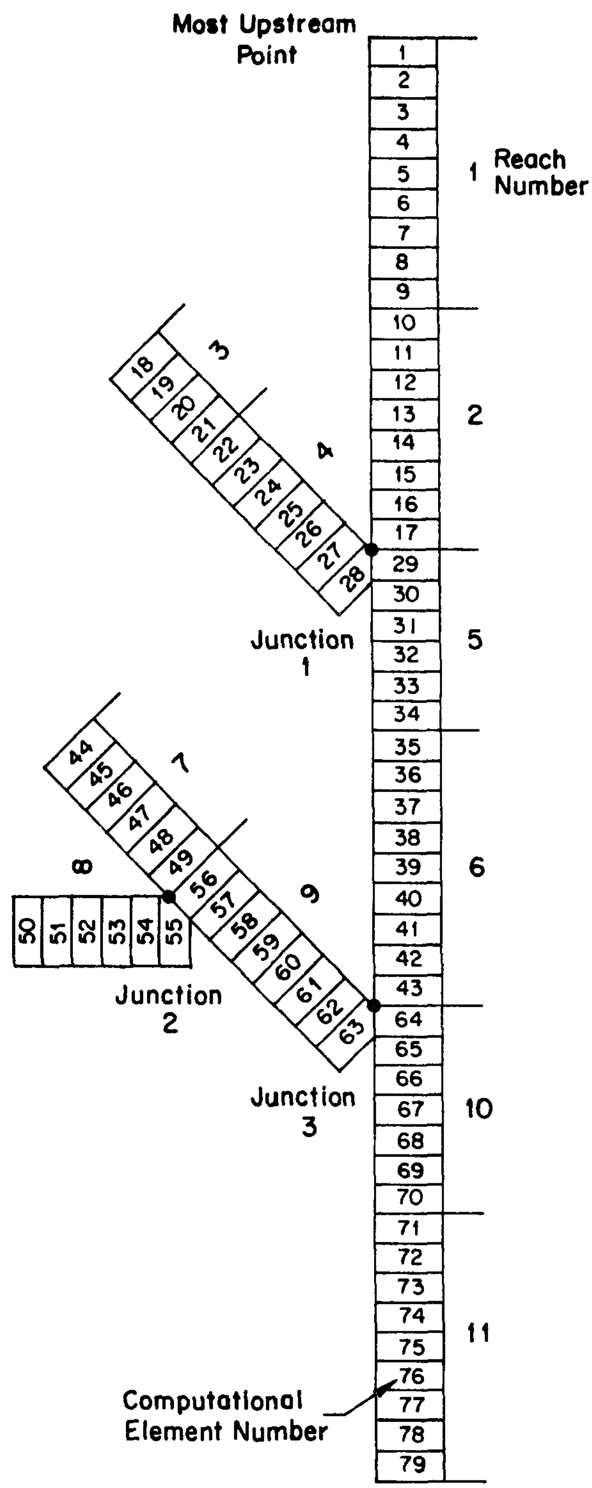

FIGURE IV-1
STREAM NETWORK EXAMPLE TO ILLUSTRATE DATA INPUT

Order number of the last element in the last reach of the tributary entering the junction. For Figure IV-1 these order numbers are Junctions 1, 2, and 3 are 28, 55, and 63, respectively.	Columns 76-80

This group of cards must end with ENDATA9, even if there are no junctions in the system.

HEADWATER SOURCES DATA (Form 15 of 19)

This group of cards, one per headwater, defines the flow, temperature, dissolved oxygen, BOD, and conservative mineral concentrations of the headwater. The following information is on each card:

Headwater order or number starting at most upstream point	Columns 16-20
Headwater name or identification	Columns 25-40
Flow in cfs (m^3/sec)	Columns 41-50
Temperature in degrees, F or C	Columns 51-55
Dissolved oxygen concentration, mg/l	Columns 56-60
BOD concentration, mg/l	Columns 61-65
Conservative Mineral I	Columns 66-70
Conservative Mineral II	Columns 71-75
Conservative Mineral III	Columns 76-80

This group of cards must end with ENDATA10.

HEADWATER SOURCES DATA FOR ALGAE, N, P, COLIFORMS AND NONCONSERVATIVE CONSTITUENT (Form 16 of 19)

This group of cards, one per headwater, is required only if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms, or the nonconservative constituent is to be simulated. Otherwise they may be omitted. The following information is on each card.

Headwater order or number	Columns 20-24
Chlorophyll a concentration, micrograms/l	Columns 25-32
Ammonia as N, mg/l	Columns 33-40
Nitrite as N, mg/l	Columns 41-48
Nitrate as N, mg/l	Columns 49-56
Phosphate as P, mg/l	Columns 57-64
Coliforms, no/100 ml	Columns 65-72
Nonconservative constituent	Columns 73-80

This group of cards must end with ENDATA10A, even if no data are to be entered.

POINT SOURCE INPUTS AND WITHDRAWALS DATA (Form 17 of 19)

This group of cards is used to define point source inputs to and point withdrawals from the stream system. Point sources include both *wasteloads* and *unsimulated tributary inflows.* One is required per inflow or withdrawal which describes the percent of treatment (for wastewater treatment), inflow or withdrawal, temperature, and dissolved oxygen, BOD, and conservative mineral concentrations. They must be ordered starting at the most upstream point. The following information is on each card:

Point load order number	Columns 11-15
Point load identification or name	Columns 20-35

Percent treatment (use only if influent BOD values are used)	Columns 36-40
Point load inflow or withdrawal in cfs or m^3/sec (a withdrawal must have a (-) sign).	Columns 41-50
Temperature, degrees F or C	Columns 51-55
Dissolved oxygen concentration, mg/l	Columns 56-60
BOD concentration, mg/l	Columns 61-65
Conservative Mineral I	Columns 66-70
Conservative Mineral II	Columns 71-75
Conservative Mineral III	Columns 76-80

This group of cards must end with ENDATA11.

POINT SOURCE DATA FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT (Form 18 of 19)

This group of cards, one per wasteload, is required only if algae, the NH_3-NO_2-NO_3 series, PO_4, coliforms, or the nonconservative constituent is to be simulated. Otherwise they may be deleted. The following information is on each card:

Point load order or number	Columns 20-24
Chlorophyll a concentration, microgram/l	Columns 25-32
Ammonia concentration, mg/l	Columns 33-40
Nitrite concentration, mg/l	Columns 41-48
Nitrate concentration, mg/l	Columns 49-56
Phosphate concentration, mg/l	Columns 57-64
Coliform, no/100 ml	Columns 65-72
Nonconservative Constituent	Columns 73-80

This group of cards must end with ENDATA11A, even if no data are to be entered.

LOCAL CLIMATOLOGICAL DATA (Form 19 of 19)

Climatologic data is required for the following cases:

1. Temperature simulations, both steady-state and dynamic;
2. Dynamic simulations where algae is being simulated but temperature is not.

If neither temperature nor dynamic algae are being simulated, these cards may be omitted.

For steady-state temperature simulation, only one card is required, which gives average values of the climatological data. For dynamic simulation, each card represents readings at three hour intervals, chronologically ordered. There must be a sufficient number of cards to cover the time period specified for the simulation. The following information is on each card:

Month	Columns 18-19
Day	Columns 21-22
Year (last two digits)	Columns 24-25
Hour of day	Columns 26-30
Net Solar Radiation[1], Langleys per hour	Columns 31-40
Cloudiness[2], fraction in tenths of cloud cover	Columns 41-48
Dry Bulb Temperature[2], degrees F or C	Columns 49-56
Wet Bulb Temperature[2], degrees F or C	Columns 57-64
Barometric pressure[2], inches Hg (mb)	Columns 65-72
Wind speed[2], ft/sec (m/sec)	Columns 73-80

There is no end card for this group.

---

[1]Required only if dynamic algae is simulated and temperature is not.

[2]Required if temperature is simulated.

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FORM (1) OF (19)

TITLE DATA

CARD TYPE (cols 1–9)	SIMULATE? YES or NO (cols 10–12)	ALPHANUMERIC NAME (cols 22–)	PARAMETER NAME (cols 49–52)	UNITS (cols 57–60)
TITLE01		TITLE ØF RUN		
TITLE02		NAME ØF BASIN		
TITLE03		CØNSERVATIVE MINERAL I		
TITLE04		CØNSERVATIVE MINERAL II		
TITLE05		CØNSERVATIVE MINERAL III		
TITLE06		TEMPERATURE		
TITLE07		BIØCHEMICAL ØXYGEN DEMAND IN MG/L		
TITLE08		ALGAE AS CHL A IN µG/L		
TITLE09		PHØSPHØRUS AS P IN MG/L		
E10		AMMØNIA AS N IN MG/L		
E11		NITRITE AS N IN MG/L		
E12		NITRATE AS N IN MG/L		
E13		DISSØLVED ØXYGEN IN MG/L		
TITLE14		CØLIFØRMS IN NØ/100 ML		
TITLE15		ARBITRARY NØN-CØNSERVATIVE		
ENDTITLE				

[illegible] (0A4)
[illegible] NH3, NO2, and NO3 must be simulated [illegible]

FORM ② OF ⑲

PROGRAM ANALYSIS CONTROL DATA

CARD TYPE (TYPE I DATA) (cols 1–25)	PARAMETER VALUE (cols 26–35)	(cols 36–45)	(cols 46–70)	PARAMETER VALUE (cols 71–80)
LIST DATA INPUT				
WRITE OPTIONAL SUMMARY				
NO FLOW AUGMENTATION				
STEADY STATE				
TRAPEZOIDAL X-SECTIONS				
INPUT METRIC (YES=1) =			OUTPUT METRIC (YES=1) =	
NUMBER OF REACHES =			NUMBER OF JUNCTIONS =	
NUM OF HEADWATERS =			NUMBER OF POINT LOADS =	
TIME STEP (HOURS) =			LNTH. COMP ELEMENT (MI)** =	
MAXIMUM ROUTE TIME (HRS) =			TIME INC. FOR RPT2 (HRS) =	
* LATITUDE OF BASIN (DEG) =			LONGITUDE OF BASIN (DEG) =	
* STANDARD MERIDIAN (DEG) =			DAY OF YEAR START TIME =	
* EVAP. COEF., (AE)** =			EVAP. COEF., (BE)** =	
* ELEV. OF BASIN (FEET)** =			DUST ATTENUATION COEF. =	
ENDATA1				

FORMAT (6A4, A1, F10.0, 10X, 6A4, A1, F10.0)
*NOTE 1: These cards may be deleted if temperature is not simulated.

**PARAMETER	ENGLISH UNITS	METRIC UNITS
Element Length	Miles	Kilometers
AE	(Ft/Hr)/In.Hg	M/Hr)/Millibar
BE	((Ft/Hr)/In.Hg)/(Mi/Hr)	((M/Hr)/Millibar)/(M/Sec)
Basin Elev.	Feet	Meters

NONSPATIALLY VARIABLE A, N, AND P CONSTANTS (SEE NOTE 2)

CARD TYPE (TYPE IA DATA) (cols 1–32)	PARAMETER VALUE (cols 33–39)	(cols 40–41)	(cols 42–73)	PARAMETER VALUE (cols 74–80)
O UPTAKE BY NH3 OXID(MG O/MG N) =			O UPTAKE BY NO2 OXID(MG O/MG N) =	
O PROD. BY ALGAE (MG O/MG A) =			O UPTAKE BY ALGAE (MG O/MG A) =	
N CONTENT OF ALGAE (MG N/MG A) =			P CONTENT OF ALGAE (MG P/MG A) =	
ALG MAX SPEC GROWTH RATE(1/DAY) =			ALGAE RESPIRATION RATE (1/DAY) =	
N HALF SATURATION CONST. (MG/L) =			P HALF SATURATION CONST. (MG/L) =	
LIGHT HALF SAT CONST(LNGLY/MIN) =			TOTAL DAILY RADIATION(LANGLEYS) =	
ENDATA1A				

FORMAT (8A4, F7 , 2X, 8A4, F7.0)
NOTE These cards (except ENDATA1A) may be deleted unless ALGAE, (NH3, NO2, NO3), PO4, [illegible] simulated

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ③ OF ⑲

REACH IDENTIFICATION DATA

CARD TYPE (TYPE 2 DATA)	REACH IDENTIFICATION			RIVER MILE* AT HEAD OF REACH		RIVER MILE* AT END OF REACH
	ORDER	ALPHANUMERIC NAME				
1–15	16–20	21–40	41–50	51–60	61–70	71–80
STREAM REACH		RCH=	FRØM		TØ	
↓		↓	↓		↓	
STREAM REACH		RCH=	FRØM		TØ	
ENDATA2						

FORMAT (3A4, 3X, F5.0, 5A4, 3X, A4, 3X, F10.0, 4X, A2, 4X, F10.0)
*For metric units enter river kilometer
NOTE: Once data has been coded, reaches may be subdivided without having to renumber the wh[illegible]

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ④ OF ⑲

FLOW AUGMENTATION DATA

CARD TYPE (TYPE 3 DATA) (cols 1–25)	ORDER OF REACH (cols 26–30)	(cols 31–35)	NO. OF AUGMENT SOURCES AVAIL. (cols 36–40)	TARGET LEVEL DISSOLVED OXYGEN (MG/L) (cols 41–50)	ORDER OF AVAILABLE AUGMENTATION SOURCES 1st (cols 51–55)	2nd (cols 56–60)	3rd (cols 61–65)	4th (cols 66–70)	5th (cols 71–75)	6th (cols 76–80)
FLØW AUGMT SØURCES RCH=		.								
FLØW AUGMT SØURCES RCH=										
ENDATA3										

FORMAT (5A4, 5X, F5.0, 5X, F5.0, F10.0, 6F5.0)
These cards (except ENDATA3) may be deleted if flow augmentation is not used.

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STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑤ OF ⑲

COMPUTATIONAL ELEMENT FLAG FIELD DATA

CARD TYPE (TYPE 4 DATA) (Cols. 1–15)	ORDER OF REACH (Cols. 16–20)	(Cols. 21–25)	NO. OF COMP ELEMENTS (Cols. 26–30)	(Cols. 31–40)	COMPUTATIONAL ELEMENT FLAGS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FLAG FIELD RCH=																								
FLAG FIELD RCH=																								
ENDATA4																								

FORMAT (2A4, A2, 5X, F5.0, 5X, F5.0, 10X, 20F2.0)

NOTE: If subdivision of reaches is necessary after initial system has been coded, it can be done without renumbering the entire system--see text under REACH IDENTIFICATION AND RIVER MILE DATA.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑥ OF ⑲

HYDROLOGIC DATA*

CARD TYPE (TYPE 5 DATA) (cols 1–15)	ORDER OF REACH (cols 16–20)	(cols 21–30)	COEFFICIENT OF FLOW FOR VELOCITY (cols 31–40)	EXPONENT OF FLOW FOR VELOCITY (cols 41–50)	COEFFICIENT OF FLOW FOR DEPTH (cols 51–60)	EXPONENT OF FLOW FOR DEPTH (cols 61–70)	MANNING'S "n" (cols 71–80)
HYDRAULICS RCH=							
↓							
HYDRAULICS RCH=							
ENDATA5							

FORMAT (2A4, A2, 5X, F5.0, 10X, 5F10.0)
**Skip this data set if trapezoidal cross-sections are used--see Form 6A.*

See text for units.

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HYDROLOGIC DATA*

FORM 6A OF 19

CARD TYPE (TYPE 5 DATA) (cols 1–15)	ORDER OF REACH (cols 16–20)	(cols 21–30)	SIDE SLOPE 1 (cols 31–40)	SIDE SLOPE 2 (cols 41–50)	WIDTH (FEET) (cols 51–60)	SLOPE (FT/FT) (cols 61–70)	MANNING'S "n" (cols 71–80)
HYDRAULICS RCH=							
↓							
HYDRAULICS RCH=							
ENDATA5A							

FORMAT (2A4, A2, 5X, F5.0, 10X, 5F10.0)
*Skip this data if discharge coefficients are used--see Form 6.
For metric input, use meters for feet.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (7) OF (19)

BOD AND DO REACTION RATE CONSTANTS DATA

CARD TYPE (TYPE 6 DATA)	ORDER OF REACH	DEOXYGENATION COEFFICIENT (1/DAY)	BOD REMOVAL DUE TO SETTLING (1/DAY)	OPTION FOR DETERMINATION OF K2	REAERATION COEFFICIENT (1/DAY)	COEQK2 TSIV COEF * FOR OPT 8	EXPQK2 OR SLOPE * FOR OPT 8
1–15	16–20	21–30	31–40	41–50	51–60	61–70	71–80
REACT CØEF RCH=							
REACT CØEF RCH=							
ENDATA6							

FORMAT (2A4, A2, 5X, F5.0, 6F10.0)
*For Tsivoglou option units are ft^{-1} (M^{-1}) and ft/ft (M/M) for TSIVCOEF and slope, respectively.

FORM (8) OF (19)

ALGAE, NITROGEN AND PHOSPHORUS CONSTANTS*

CARD TYPE (TYPE 6A DATA) (cols 1–25)	ORDER OF REACH (cols 26–30)	(cols 31–32)	CHLOR. A TO ALGAE RATIO (μG/MG) (cols 33–40)	ALGAE SETTLING RATE (FT/DAY) (cols 41–48)	RATE COEF. FOR NH3 OXIDATION (1/DAY) (cols 49–56)	RATE COEF FOR NH2 OXIDATION (1/DAY) (cols 57–64)	BENTHOS SOURCE RATE FOR NH3 (MG/FT/DAY) (cols 65–72)	BENTHOS SOURCE RATE FOR PO4 (MG/FT/DAY) (cols 73–80)
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ENDATA6A								

FORMAT (5A4, 5X, F5.0, 2X, 6F8.0)

*These cards (except ENDATA6A) may be deleted unless ALGAE, (NH3, NO2, NO3), PO4, coliforms or the nonconservative constituent are to be simulated

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM 9 OF 19

OTHER CONSTANTS*

CARD TYPE (TYPE 6B DATA)	ORDER OF REACH		BENTHOS SOURCE RATE FOR BOD (MG/FT/DAY)	COLIFORM DECAY RATE (1/DAY)	LIGHT EXTINCTION COEFFICIENT (1/FT)	NONCONS. DECAY RATE (1/DAY)		
1–25	26–30	31–32	33–40	41–48	49–56	57–64	65–72	73–80
ØTHER CØEFFICIENTS RCH=								
ØTHER CØEFFICIENTS RCH=								
ENDATA6B								

FORMAT (5A4, 5X, F5.0, 2X, 6F8.0)
*These cards (except ENDATA6B) may be deleted unless ALGAE, (NH3, NO2, NO3), PO4, Coliforms [illegible]
For metric units used meters where feet are indicated.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑩ OF ⑲

INITIAL CONDITIONS DATA

CARD TYPE (TYPE 7 DATA)	ORDER OF REACH	TEMPERATURE (°F)	DO (MG/L)	BOD (MG/L)	CONSERVATIVE MINERAL I	CONSERVATIVE MINERAL II	CONSERVATIVE MINERAL III
1–25	26–30	31–40	41–45	46–50	51–60	61–70	71–80
INITIAL CØNDITIØNS RCH =							
↓							
INITIAL CØNDITIØNS RCH =							
ENDATA7							

FORMAT (5A4, 5X, F5.0, F10.0, 2F5.0, 3F10.0)
NOTE: Use °C for metric input.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (11) OF (19)

INITIAL CONDITIONS FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT*

CARD TYPE (TYPE 7A DATA)	ORDER OF REACH	CHLOR. A (μG/L)	NH3 AS N (MG/L)	NO2 AS N (MG/L)	NO3 AS N (MG/L)	PO4 AS P (MG/L)	COLIFORMS (NO /100 ML)	NONCONS.
1–19	20–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
INITIAL CØND-2 RCH=								
↓								
INITIAL CØND-2 RCH=								
ENDATA7A								

FORMAT (3A4, A2, 5X, F5.0, 7F8.0)
*These cards may be deleted (except ENDATA7A) if none of the parameters on this sheet are to be simulated.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑫ OF ⑲

INCREMENTAL INFLOW DATA

CARD TYPE (TYPE 8 DATA)	ORDER OF REACH	INCRE-MENTAL FLOW (CFS)	TEMP (°F)	DO (MG/L)	BOD (MG/L)	CONSERVATIVE MINERAL I	CONSERVATIVE MINERAL II	CONSERVATIVE MINERAL III
1–25	26–30	31–35	36–40	41–45	46–50	51–60	61–70	71–80
INCREMENTAL INFLØW RCH=								
INCREMENTAL INFLØW RCH=								
ENDATA8								

FORMAT (5A4, 5X, 5F5.0, 3F10.0)
For metric input use M^3/sec and °C

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (13) OF (19)

INCREMENTAL INFLOW DATA FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT*

CARD TYPE (TYPE 8A DATA)	ORDER OF REACH	CHLOR. A (μG/L)	NH3 AS N (MG/L)	NO2 AS N (MG/L)	NO3 AS N (MG/L)	PO4 AS N (MG/L)	COLIFORMS (NO/100 ML)	NONCONS.
1–19	20–24	25–32	33–40	41–48	49–56	57–64	65–72	73–80
INCR INFLØW-2 RCH=								
↓								
INCR INFLØW-2 RCH=								
ENDATA8A								

*FORMAT (3A4, A2, 5X, F5.0, 7F8.0)
These cards (except ENDATA8A) may be deleted if none of the parameters shown are to be simulated

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (14) OF (19)

STREAM JUNCTION DATA

CARD TYPE (TYPE 9 DATA)	ORDER OF JUNCTION		JUNCTION IDENTIFICATION		ELEMENT TYPE: TYPE 3 NO. OF ELEMENT UPSTREAM OF JUNC.		ELEMENT TYPE: TYPE 4 NO. OF ELEMENT D'NSTREAM OF JUNC		ELEMENT TYPE: TYPE 2 NO OF ELEMENT ON TRIB.
1–20	21–25	26–30	31–50	51–55	56–60	61–65	66–70	71–75	76–80
STREAM JUNCTIØN			JNC=						
↓			↓						
STREAM JUNCTIØN			JNC=						
ENDATA9									

FORMAT (3A4, A3, 5X, F5.0, 5X, 5A4, 3(5X, F5.0)
NOTE: Junctions must be ordered so that type 4 element numbers (No. of element downstream of junction) are arranged in ascending order

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (15) OF (19)

HEADWATER SOURCES DATA

CARD TYPE (TYPE 10 DATA)	HEADWATER IDENTIFICATION		HEADWATER FLOW (CFS)	TEMP. (°F)	DO (MG/L)	BOD (MG/L)	CONS. MINERAL I	CONS. MINERAL II	CONS. MINERAL III
	ORDER	ALPHANUMERIC NAME							
1–15	16–20	21–40	41–50	51–55	56–60	61–65	66–70	71–75	76–80
HEADWATER		HDW=							
↓		↓							
HEADWATER		HDW=							
ENDATA10									

FORMAT (2A4, A2, 5X, F5.0, 5A4, F10.0, 6F5.0)
For metric input use M^3/sec and °C

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑯ OF ⑲

HEADWATER SOURCES DATA FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT*

CARD TYPE (TYPE 10A DATA) (cols 1-19)	ORDER OF HEAD-WATER (cols 20-24)	CHLOR. A (μG/L) (cols 25-32)	NH3 AS N (MG/L) (cols 33-40)	NO2 AS N (MG/L) (cols 41-48)	NO3 AS N (MG/L) (cols 49-56)	PO4 AS P (MG/L) (cols 57-64)	COLIFORMS (NO./100 ML) (cols 65-72)	NONCONS (cols 73-80)
HEADWATER-2 HDW=								
↓								
HEADWATER-2 HDW=								
ENDATA10A								

*FORMAT (3A4, A2, 5X, F5.0, 7F8.0)
These cards (except ENDATA10A) may be deleted if none of the parameters shown are to be simulated.

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (17) OF (19)

POINT SOURCE LOADINGS AND WITHDRAWALS DATA

CARD TYPE (TYPE 11 DATA)	POINT LOAD OR WITHDRAWAL IDENTIFICATION		PERCENT TREAT-MENT	INFLOW OR WITHDRAWAL (CFS)	TEMP. (°F)	DO (MG/L)	BOD (MG/L)	CONS MINERAL I	CONS MINERAL II	CONS MINERAL III
	ORDER	ALPHANUMERIC NAME								
1–10	11–15	16–35	36–40	41–50	51–55	56–60	61–65	66–70	71–75	76–80
PØINT LØAD		PTL=								
↓		↓								
PØINT LØAD		PTL=								
ENDATA11										

FORMAT (2A4, A2, F5.0, 5A4, F5.0, F10.0, 6F5.0)
For metric input use M^3/sec and °C

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM (18) OF (19)

POINT SOURCE DATA FOR ALGAE, N, P, COLIFORMS, AND NONCONSERVATIVE CONSTITUENT*

CARD TYPE (TYPE 11A DATA) (cols 1–19)	ORDER OF POINT LOAD (cols 20–24)	CHLOR A (μG/L) (cols 25–32)	NH3 AS N (MG/L) (cols 33–40)	NO2 AS N (MG/L) (cols 41–48)	NO3 AS N (MG/L) (cols 49–56)	PO4 AS N (MG/L) (cols 57–64)	COLIFORMS (NO/100 ML) (cols 65–72)	NONCONS. (cols 73–80)
PØINT LØAD-2 PTL=								
↓								
PØINT LØAD-2 PTL=								
ENDATA11A								

FORMAT (3A4, A2, 5X, F5.0, 7F8.0)
**These cards (except ENDATA11A) may be deleted if none of the parameters shown are to be simulated.*

WATER RESOURCES ENGINEERS, INC
STREAM QUALITY ROUTING MODEL / QUAL-II / SEMCOG VERSION

FORM ⑲ OF ⑲

LOCAL CLIMATOLOGICAL DATA*

CARD TYPE (TYPE 12 DATA)	MONTH, DAY AND YEAR	HOUR OF DAY	NET SOLAR RADIATION (LANGLEYS/HR)	CLOUDINESS	DRY BULB TEMPERATURE (°F)	WET BULB TEMPERATURE (°F)	BAROMETRIC PRESSURE (IN HG.)	WIND SPEED (FT/SEC)
1–17	18–25	26–30	31–40	41–48	49–56	57–64	65–72	73–80
LØCAL CLIMATØLØGY								
↓								
LØCAL CLIMATØLØGY								

50

*Must be chronologically ordered. FORMAT (30X, F10.0, 5F(8.0))
Net solar radiation is not required if temperature is simulated.
Only net solar radiation is required for algae simulation.
For metric input, use °C, millibars, and M/sec.

V. EXAMPLE PROBLEM

An example problem is presented here to demonstrate to the user a typical application of QUAL-II to a stream network. Since the preparation of the input data has been thoroughly explained in another part of this manual, many details of the data deck preparation are omitted in favor of highlighting potential trouble spots in the set-up of this example. The program output is also reviewed to familiarize the user with the types and formats of the output reports.

The example problem is a steady-state simulation of a river based on part of the River Rouge in Michigan. Modifications of the prototype were made so that more of the situations the user may be faced with are illustrated. Figure V-1 shows the example problem network. Constructing such a network representation early in the problem formulation is recommended. A useful exercise for the user would be to closely review this network in conjunction with the corresponding input data listing which follows the text of this section.

Special attention should be paid to the numbering of elements, particularly at junctions. Note that this network has a tributary on a tributary and how the number of the two junctions is by the order of the downstream (type 4) element at the junction. The point loads are numbered in the order of their elements, the withdrawal counting as a point load in the numbering scheme. It is important that this be done correctly since QUAL-II associates the first wasteload card with the first type 6 or 7 element in the flag field. The same is true of the order of the headwaters (type 1 flag). The river mile (or kilometer) data on the stream reach cards do not enter into any computations and may be numbered as the user chooses to identify the reaches. In the example, each tributary is numbered starting with 0 at the junction and increasing upstream.

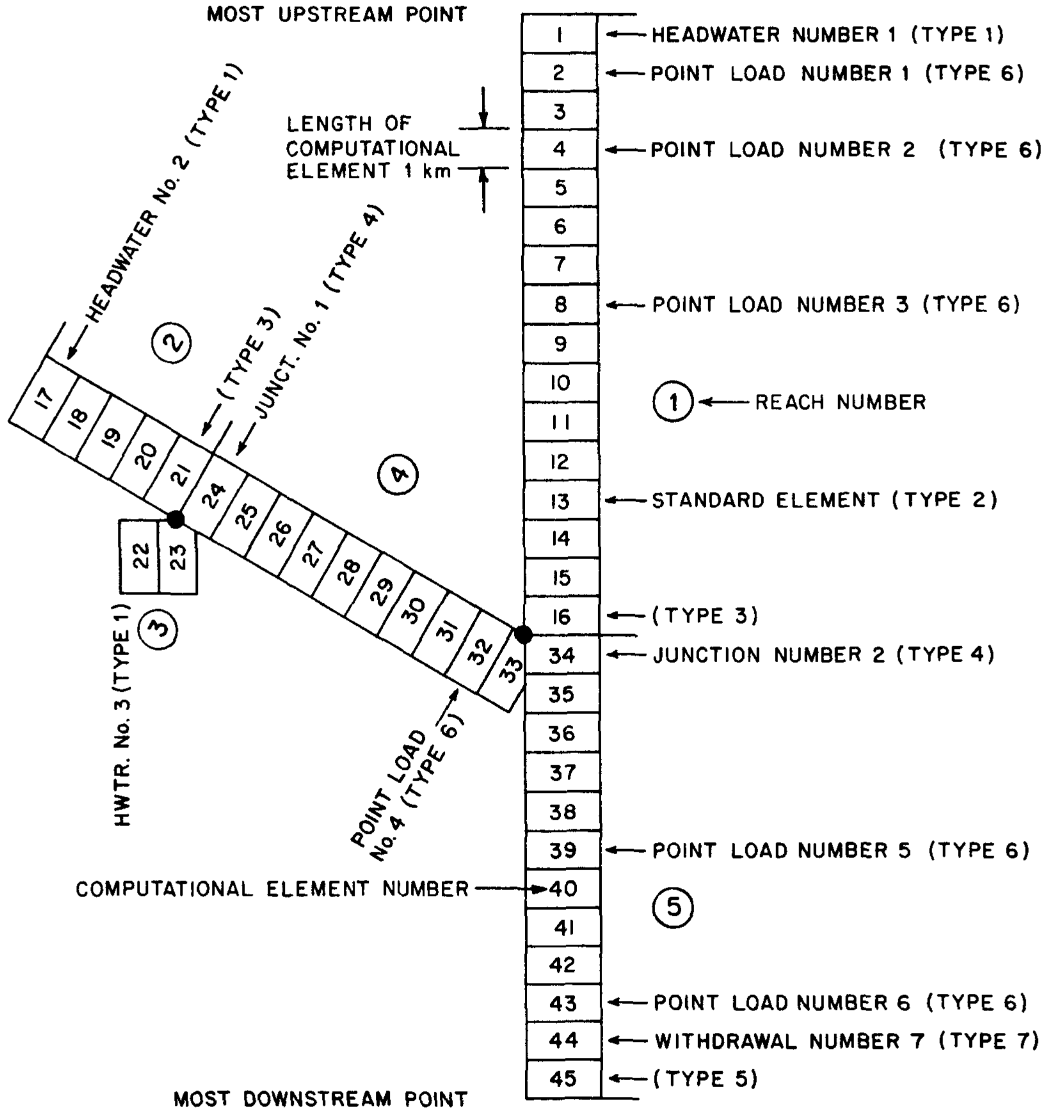

FIGURE V-1
EXAMPLE PROBLEM NETWORK

The type 1 data in the example problem includes values on the last four cards since temperature is simulated. The time step and time increment for RPT2 are omitted and the maximum route time is actually the number of iterations since this is a steady-state simulation. The various rate constants used are those found in common usage. The total daily radiation is not required or used since temperature is simulated. Hydraulic coefficients are used and the O'Connor and Dobbins method is employed for reaeration computations. Also of note is that the initial conditions of all constituents are set at zero, which is permissible since the steady-state conditions are independent of initial conditions. However, initial temperature, while it may not be necessary, is roughly estimated to avoid any possible instability in the steady-state temperature iterative solution. Finally, only one local climatology card is required, representing average steady-state conditions. Again, solar radiation is not required since temperature is simulated.

Following the data listing is the output from the example problem execution. The first part of this output is the echo print of the data as read by the input subroutine of QUAL-II. This should be reviewed to detect any keypunching or other errors in the data. If the incorrect number of cards of a particular card type is read, a message is printed and the execution terminates after all the data is echo printed. The next statements in the output, printed only if steady-state temperature is simulated, give the number of nonconverged elements, MM, at iteration number NITER. In the example, only two iterations were required, largely because of a good initial estimate. (The number of iterations will normally be a small number, and the execution is terminated if NITER reaches ten before all elements converge.) The next set of output gives the results of the algae growth rate convergence, and is, of course, output only if steady-state algae is simulated. Three iterations were required, out of a possible 30 (input by the user).

The optional summary (requested in data type 1) follows for each constituent. Each row contains the results for one reach, with element by element values from left to right. Finally, the standard output form is printed, given the same concentrations as the optional summary, but in a different format as well as additional information relating to hydraulics and to the rates of growth and decay in each element. This format lists the results in one row per element, ordered by element number. Since there is more information to be printed than can be fit horizontally, the form is repeated for all elements.

EXAMPLE PROBLEM
DATA LISTING

```
TITLE01                STREAM QUALITY MODEL--QUAL-II SEMCOG VERSION
TITLE02                ROUGE RIVER REACHES FOR EXAMPLE PROBLEM
TITLE03  YES           CONSERVATIVE MINERAL   I     TDS IN MG/L
TITLE04   NO           CONSERVATIVE MINERAL  II
TITLE05   NO           CONSERVATIVE MINERAL III
TITLE06  YES           TEMPERATURE
TITLE07  YES           5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES           ALGAE AS CHL.A IN UG/L
TITLE09  YES           PHOSPHORUS AS P IN MG/L
TITLE10  YES           AMMONIA AS N IN MG/L
TITLE11  YES           NITRITE AS N IN MG/L
TITLE12  YES           NITRATE AS N IN MG/L
TITLE13  YES           DISSOLVED OXYGEN IN MG/L
TITLE14  YES           FECAL COLIFORM IN NO./100 ML
TITLE15   NO           ARBITRARY NON-CONSERVATIVE
ENDTITLE
LIST DATA INPUT
WRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
NO TRAP CHANNELS
INPUT METRIC              =         1.        OUTPUT METRIC             =        1.
NUMBER OF REACHES         =         5.        NUMBER OF JUNCTIONS       =        2.
NUM OF HEADWATERS         =         3.        NUMBER OF POINT LOADS     =        7.
TIME STEP (HOURS)         =                   LNTH. COMP. ELEMENT (KM)=          1.
MAXIMUM ROUTE TIME (HRS)=          30.        TIME INC. FOR RPT2 (HRS)=
LATITUDE OF BASIN (DEG) =         42.5        LONGITUDE OF BASIN (DEG)=        83.3
STANDARD MERIDIAN (DEG) =          75.        DAY OF YEAR START TIME  =        180.
EVAP. COEF.,(AE)          =   .0000062        EVAP. COEF.,(BE)          =  .0000055
ELEV. OF BASIN (METERS) =          250.       DUST ATTENUATION COEF.    =      0.13
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)=     3.5  O UPTAKE BY NO2 OXID(MG O/MG N)=     1.20
O PROD. BY ALGAE (MG O/MG A)   =     1.6  O UPTAKE BY ALGAE (MG O/MG A)   =       2.
N CONTENT OF ALGAE (MG N/MG A) =    .085  P CONTENT OF ALGAE (MG P/MG A) =     .012
ALG MAX SPEC GROWTH RATE(1/DAY)=     2.5  ALGAE RESPIRATION RATE (1/DAY) =       .1
N HALF SATURATION CONST. (MG/L)=      .3  P HALF SATURATION CONST. (MG/L)=      .04
LIGHT HALF SAT CONST(LNGLY/MIN)=    .030  TOTAL DAILY RADIATION(LANGLEYS)=     400.
ENDATA1A
STREAM REACH     1. RCH= R.R. NW DETROIT   FROM          46.0     TO          30.0
STREAM REACH     2. RCH= U.R. FARMINGTON   FROM          15.0     TO          10.0
STREAM REACH     3. RCH= FICT. DRAIN       FROM           2.0     TO          00.0
STREAM REACH     4. RCH= U.R. FARMINGTON   FROM          10.0     TO          00.0
STREAM REACH     5. RCH= R.R. GM DIESEL    FROM          30.0     TO          18.0
ENDATA2
ENDATA3
FLAG FIELD RCH=  1.        16.          1.6.2.6.2.2.2.6.2.2.2.2.2.2.2.3.
FLAG FIELD RCH=  2.         5.          1.2.2.2.3.
FLAG FIELD RCH=  3.         2.          1.2.
FLAG FIELD RCH=  4.        10.          4.2.2.2.2.2.2.2.6.2.
FLAG FIELD RCH=  5.        12.          4.2.2.2.2.6.2.2.2.6.7.5.
ENDATA4
HYDRAULICS RCH=  1.               .25        .30        .44        .55        .040
HYDRAULICS RCH=  2.               .38        .37        .51        .61        .040
HYDRAULICS RCH=  3.               .28        .35        .48        .58        .040
HYDRAULICS RCH=  4.               .38        .37        .51        .61        .040
HYDRAULICS RCH=  5.               .22        .33        .43        .38        .040
ENDATA5
REACT COEF RCH=  1.        0.6        0.          3.
REACT COEF RCH=  2.        0.6        0.          3.
REACT COEF RCH=  3.        0.6        0.          3.
REACT COEF RCH=  4.        0.6        0.          3.
REACT COEF RCH=  5.        0.6        0.          3.
ENDATA6
ALGAE, N AND P COEF  RCH=  1.       50.      .15      .15     1.0       0.       0.
ALGAE, N AND P COEF  RCH=  2.       50.      .15      .15     1.0       0.       0.
ALGAE, N AND P COEF  RCH=  3.       50.      .15      .15     1.0       0.       0.
```

```
 67.   ALGAE, N AND P COEF  RCH=  4.       50.      .15      .15    1.0      0.       0.
 68.   ALGAE, N AND P COEF  RCH=  5.       50.      .15      .15    1.0      0.       0.
 69.   ENDATA6A
 70.   OTHER COEFFICIENTS   RCH=  1.      200.     1.5      3.8
 71.   OTHER COEFFICIENTS   RCH=  2.        0.     1.5      3.8
 72.   OTHER COEFFICIENTS   RCH=  3.        0.     1.5      3.8
 73.   OTHER COEFFICIENTS   RCH=  4.        0.     1.5      3.8
 74.   OTHER COEFFICIENTS   RCH=  5.     2000.     1.5      3.8
 75.   ENDATA6B
 76.   INITIAL CONDITIONS   RCH=  1.      20.
 77.   INITIAL CONDITIONS   RCH=  2.      20.
 78.   INITIAL CONDITIONS   RCH=  3.      20.
 79.   INITIAL CONDITIONS   RCH=  4.      20.
 80.   INITIAL CONDITIONS   RCH=  5.      20.
 81.   ENDATA7
 82.   INITIAL COND-2 RCH=  1.
 83.   INITIAL COND-2 RCH=  2.
 84.   INITIAL COND-2 RCH=  3.
 85.   INITIAL COND-2 RCH=  4.
 86.   INITIAL COND-2 RCH=  5.
 87.   ENDATA7A
 88.   INCREMENTAL INFLOW   RCH=  1.  .261 18.0  1.0 20.0       55.0
 89.   INCREMENTAL INFLOW   RCH=  2.  .008 18.0  1.0  5.0       55.0
 90.   INCREMENTAL INFLOW   RCH=  3.  .003 18.0  1.0  5.0       55.0
 91.   INCREMENTAL INFLOW   RCH=  4.  .015 18.0  1.0  5.0       55.0
 92.   INCREMENTAL INFLOW   RCH=  5.  .108 18.0  1.0 50.0       55.0
 93.   ENDATA8
 94.   INCR INFLOW-2   RCH=  1.      .0      .02      .0       .2       .0       0.
 95.   INCR INFLOW-2   RCH=  2.      .0      .02      .0       .2       .0       0.
 96.   INCR INFLOW-2   RCH=  3.      .0      .02      .0       .2       .0       0.
 97.   INCR INFLOW-2   RCH=  4.      .0      .02      .0       .2       .0       0.
 98.   INCR INFLOW-2   RCH=  5.      .0      .02      .0       .2       .0       0.
 99.   ENDATA8A
100.   STREAM JUNCTION       1.      JNC=FICT.-UPPER            21.       24.       23.
101.   STREAM JUNCTION       2.      JNC=UPPER-MAIN             16.       34.       33.
102.   ENDATA9
103.   HEADWATER         1. HDW= BIRMINGHAM GAGE      .960 22.   8.3  1.7 83.0
104.   HEADWATER         2. HDW= FARMINGTON GAGE      .180 21.   8.0  2.0 98.0
105.   HEADWATER         3. HDW= FICT. GAGE           .140 21.   8.0  2.0 98.0
106.   ENDATA10
107.   HEADWATER-2     HDW=  1.     10.      .03      .0       .5       .1      443.
108.   HEADWATER-2     HDW=  2.     10.      .02      .0       .5       .1      200.
109.   HEADWATER-2     HDW=  3.     10.      .02      .0       .5       .1      200.
110.   ENDATA10A
111.   POINT LOAD  1. PTL= PEBBLE CREEK               .220 20.0  8.0  2.0 120.
112.   POINT LOAD  2. PTL= TRIB KM42                  .220 20.0  8.0  2.0 120.
113.   POINT LOAD  3. PTL= EVANS DITCH                .160 22.3  7.9  2.0 143.
114.   POINT LOAD  4. PTL= BELL BRANCH                .410 20.6  7.4  2.0 122.
115.   POINT LOAD  5. PTL= GM DIESEL                  .040 20.0  5.0  6.0  50.
116.   POINT LOAD  6. PTL= ASHCROFT DRAIN             .020 20.0  5.0  5.0  95.
117.   POINT LOAD  7. PTL= WITHDRAWAL                -.20
118.   ENDATA11
119.   POINT LOAD-2    PTL=  1.     25.      .0       .0       .50      .10     300.
120.   POINT LOAD-2    PTL=  2.     25.      .02      .0       .50      .10     400.
121.   POINT LOAD-2    PTL=  3.     25.      .08      .0      2.0       .20     300.
122.   POINT LOAD-2    PTL=  4.     25.      .30      .0      1.0       .25     430.
123.   POINT LOAD-2    PTL=  5.      0.      .02      .0       .26      .10       0.
124.   POINT LOAD-2    PTL=  6.      0.      .18      .0       .20      .13       0.
125.   POINT LOAD-2    PTL=  7.
126.   ENDATA11A
127.   LOCAL CLIMATOLOGY                              .2      25.      20. 1000.      3.0
```

EXAMPLE PROBLEM
OUTPUT

```
                    WATER RESOURCES ENGINEERS, INC.

         * * * DATA LIST  STREAM QUALITY ROUTING MODEL * * *
               * * * QUAL-II/SEMCOG VERSION * * *

 $$$ (PROBLEM TITLES) $$$

CARD TYPE                            QUAL-II PROGRAM TITLES
TITLE01                STREAM QUALITY MODEL--QUAL-II SEMCOG VERSION
TITLE02                ROUGE RIVER REACHES FOR EXAMPLE PROBLEM
TITLE03  YES           CONSERVATIVE MINERAL   I    TDS IN MG/L
TITLE04   NO           CONSERVATIVE MINERAL  II
TITLE05   NO           CONSERVATIVE MINERAL III
TITLE06  YES           TEMPERATURE
TITLE07  YES           5-DAY BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES           ALGAE AS CHL.A IN UG/L
TITLE09  YES           PHOSPHORUS AS P IN MG/L
TITLE10  YES           AMMONIA AS N IN MG/L
TITLE11  YES           NITRITE AS N IN MG/L
TITLE12  YES           NITRATE AS N IN MG/L
TITLE13  YES           DISSOLVED OXYGEN IN MG/L
TITLE14  YES           FECAL COLIFORM IN NO./100 ML
TITLE15   NO           ARBITRARY NON-CONSERVATIVE
ENDTITLE

 $$$ DATA TYPE 1 (CONTROL DATA) $$$

CARD TYPE                                    CARD TYPE
LIST DATA INPUT             0.0                                           0.0
WRITE OPTIONAL SUMMARY      0.0                                           0.0
NO FLOW AUGMENTATION        0.0                                           0.0
STEADY STATE                0.0                                           0.0
NO TRAP CHANNELS            0.0                                           0.0
INPUT METRIC            =   1.00000          OUTPUT METRIC           =    1.00000
NUMBER OF REACHES       =   5.00000          NUMBER OF JUNCTIONS     =    2.00000
NUM OF HEADWATERS       =   3.00000          NUMBER OF POINT LOADS   =    7.00000
TIME STEP (HOURS)       =   0.0              LNTH. COMP. ELEMENT (KM)=    1.00000
MAXIMUM ROUTE TIME (HRS)=  30.00000          TIME INC. FOR RPT2 (HRS)=    0.0
LATITUDE OF BASIN (DEG) =  42.50000          LONGITUDE OF BASIN (DEG)=   83.29999
STANDARD MERIDIAN (DEG) =  75.00000          DAY OF YEAR START TIME  =  180.00000
EVAP. COEF.,(AE)        =   0.00001          EVAP. COEF.,(BE)        =    0.00001
ELEV. OF BASIN (METERS) = 250.00000          DUST ATTENUATION COEF.  =    0.13000
ENDATA1                     0.0                                           0.0

 $$$ DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS) $$$

CARD TYPE                                      CARD TYPE
O UPTAKE BY NH3 OXID(MG O/MG N)=    3.5000     O UPTAKE BY NO2 OXID(MG O/MG N)=    1.2000
O PROD. BY ALGAE (MG O/MG A)   =    1.6000     O UPTAKE BY ALGAE (MG O/MG A)  =    2.0000
```

```
N CONTENT OF ALGAE (MG N/MG A) =      0.0850          P CONTENT OF ALGAE (MG P/MG A) =      0.0120
ALG MAX SPEC GROWTH RATE(1/DAY)=      2.5000          ALGAE RESPIRATION RATE (1/DAY) =      0.1000
N HALF SATURATION CONST. (MG/L)=      0.3000          P HALF SATURATION CONST. (MG/L)=      0.0400
LIGHT HALF SAT CONST(LNGLY/MIN)=      0.0300          TOTAL DAILY RADIATION(LANGLEYS)=    400.0000
ENDATA1A                              0.0                                                  0.0

 $$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$

CARD TYPE           REACH ORDER AND IDENT                      R. MI/KM               R. MI/KM
STREAM REACH      1.0  RCH= R.R. NW DETROIT     FROM            46.0      TO            30.0
STREAM REACH      2.0  RCH= U.R. FARMINGTON     FROM            15.0      TO            10.0
STREAM REACH      3.0  RCH= FICT. DRAIN         FROM             2.0      TO             0.0
STREAM REACH      4.0  RCH= U.R. FARMINGTON     FROM            10.0      TO             0.0
STREAM REACH      5.0  RCH= R.R. GM DIESEL      FROM            30.0      TO            18.0
ENDATA2           0.0                                            0.0                     0.0

 $$$ DATA TYPE 3 (TARGET LEVEL DO AND FLOW AUGMENTATION SOURCES) $$$

CARD TYPE                     REACH  AVAIL HDWS TARGET     ORDER OF AVAIL SOURCES
ENDATA3                         0.        0.       0.0  0.   0.   0.   0.   0.   0.

 $$$ DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD) $$$

CARD TYPE         REACH ELEMENTS/REACH               COMPUTATIONAL FLAGS
FLAG FIELD          1.       16.          1.6.2.6.2.2.2.6.2.2.2.2.2.2.2.3.0.0.0.0.0.
FLAG FIELD          2.        5.          1.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          3.        2.          1.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          4.       10.          4.2.2.2.2.2.2.2.2.6.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          5.       12.          4.2.2.2.2.6.2.2.2.2.6.7.5.0.0.0.0.0.0.0.0.
ENDATA4             0.        0.          0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.

 $$$ DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH) $$$

CARD TYPE         REACH               COEFOV     EXPOOV     COEFOH     EXPOOH      CMANN
HYDRAULICS          1.                0.250      0.300      0.440      0.550       0.040
HYDRAULICS          2.                0.380      0.370      0.510      0.610       0.040
HYDRAULICS          3.                0.280      0.350      0.480      0.580       0.040
HYDRAULICS          4.                0.380      0.370      0.510      0.610       0.040
HYDRAULICS          5.                0.220      0.330      0.430      0.380       0.040
ENDATA5             0.                0.0        0.0        0.0        0.0         0.0

 $$$ DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION) $$$

CARD TYPE         REACH      K1         K3          K2OPT      K2      COEQK2, OR  EXPQK2,
                                                                        TSIV COEF   OR SLOPE
                                                                        FOR OPT 8   FOR OPT 8
REACT COEF          1.      0.60       0.0           3.       0.0       0.0          0.0
REACT COEF          2.      0.60       0.0           3.       0.0       0.0          0.0
REACT COEF          3.      0.60       0.0           3.       0.0       0.0          0.0
REACT COEF          4.      0.60       0.0           3.       0.0       0.0          0.0
REACT COEF          5.      0.60       0.0           3.       0.0       0.0          0.0
ENDATA6             0.      0.0        0.0           0.       0.0       0.0          0.0
```

$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHORUS CONSTANTS) $$$

CARD TYPE	REACH	ALPHAO	ALGSET	CKNH3	CKNO2	SNH3	SPO4
ALGAE, N AND P COEF	1.	50.0	0.15	0.15	1.00	0.0	0.0
ALGAE, N AND P COEF	2.	50.0	0.15	0.15	1.00	0.0	0.0
ALGAE, N AND P COEF	3.	50.0	0.15	0.15	1.00	0.0	0.0
ALGAE, N AND P COEF	4.	50.0	0.15	0.15	1.00	0.0	0.0
ALGAE, N AND P COEF	5.	50.0	0.15	0.15	1.00	0.0	0.0
ENDATA6A	0.	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$

CARD TYPE	REACH	CK4	CK5	EXCOEF	CK6
OTHER COEFFICIENTS	1.	200.00	1.50	3.80	0.0
OTHER COEFFICIENTS	2.	0.0	1.50	3.80	0.0
OTHER COEFFICIENTS	3.	0.0	1.50	3.80	0.0
OTHER COEFFICIENTS	4.	0.0	1.50	3.80	0.0
OTHER COEFFICIENTS	5.	2000.00	1.50	3.80	0.0
ENDATA6B	0.	0.0	0.0	0.0	0.0

$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
INITIAL CONDITIONS	1.	20.0	0.0	0.0	0.0	0.0	0.0
INITIAL CONDITIONS	2.	20.0	0.0	0.0	0.0	0.0	0.0
INITIAL CONDITIONS	3.	20.0	0.0	0.0	0.0	0.0	0.0
INITIAL CONDITIONS	4.	20.0	0.0	0.0	0.0	0.0	0.0
INITIAL CONDITIONS	5.	20.0	0.0	0.0	0.0	0.0	0.0
ENDATA7	0.	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	REACH	CHLORA	NH3/N	NO2/N	NO3/N	DOP	COLI	NONCON
INITIAL COND-2	1.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INITIAL COND-2	2.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INITIAL COND-2	3.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INITIAL COND-2	4.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INITIAL COND-2	5.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDATA7A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS) $$$

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
INCREMENTAL INFLOW	1.	0.261	18.0	1.0	20.0	55.0	0.0	0.0
INCREMENTAL INFLOW	2.	0.008	18.0	1.0	5.0	55.0	0.0	0.0
INCREMENTAL INFLOW	3.	0.003	18.0	1.0	5.0	55.0	0.0	0.0
INCREMENTAL INFLOW	4.	0.015	18.0	1.0	5.0	55.0	0.0	0.0
INCREMENTAL INFLOW	5.	0.108	18.0	1.0	50.0	55.0	0.0	0.0
ENDATA8	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	REACH	CHLORA	NH3/N	NO2/N	NO3/N	DOP	COLI	NONCON
INCR INFLOW-2	1.	0.0	0.02	0.0	0.20	0.0	0.0	0.0
INCR INFLOW-2	2.	0.0	0.02	0.0	0.20	0.0	0.0	0.0
INCR INFLOW-2	3.	0.0	0.02	0.0	0.20	0.0	0.0	0.0
INCR INFLOW-2	4.	0.0	0.02	0.0	0.20	0.0	0.0	0.0
INCR INFLOW-2	5.	0.0	0.02	0.0	0.20	0.0	0.0	0.0
ENDATA8A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC=FICT.-UPPER	21.	24.	23.
STREAM JUNCTION	2.	JNC=UPPER-MAIN	16.	34.	33.
ENDATA9	0.		0.	0.	0.

$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$

CARD TYPE	HDWATER ORDER AND IDENT		FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
HEADWATER	1.	HDW= BIRMINGHAM GAGE	0.960	22.00	8.30	1.70	83.00	0.0	0.0
HEADWATER	2.	HDW= FARMINGTON GAGE	0.180	21.00	8.00	2.00	98.00	0.0	0.0
HEADWATER	3.	HDW= FICT. GAGE	0.140	21.00	8.00	2.00	98.00	0.0	0.0
ENDATA10	0.		0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS, COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	HDWATER	CHLORA	NH3/N	NO2/N	NO3/N	DOP	COLI	NONCON
HEADWATER-2	1.	10.0	0.03	0.0	0.50	0.10	443.00	0.0
HEADWATER-2	2.	10.0	0.02	0.0	0.50	0.10	200.00	0.0
HEADWATER-2	3.	10.0	0.02	0.0	0.50	0.10	200.00	0.0
ENDATA10A	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS) $$$

CARD TYPE	POINT	SOURCE ORDER AND ID	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
POINT LOAD	1.	PTL= PEBBLE CREEK	0.0	0.220	20.00	8.00	2.00	120.00	0.0	0.0
POINT LOAD	2.	PTL= TRIB KM42	0.0	0.220	20.00	8.00	2.00	120.00	0.0	0.0
POINT LOAD	3.	PTL= EVANS DITCH	0.0	0.160	22.30	7.90	2.00	143.00	0.0	0.0
POINT LOAD	4.	PTL= BELL BRANCH	0.0	0.410	20.60	7.40	2.00	122.00	0.0	0.0
POINT LOAD	5.	PTL= GM DIESEL	0.0	0.040	20.00	5.00	6.00	50.00	0.0	0.0
POINT LOAD	6.	PTL= ASHCROFT DRAIN	0.0	0.020	20.00	5.00	5.00	95.00	0.0	0.0
POINT LOAD	7.	PTL= WITHDRAWAL	0.0	-0.200	0.0	0.0	0.0	0.0	0.0	0.0
ENDATA11	0.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$$ DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS, COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT) $$$

CARD TYPE	POINT SOURCE ORDER AND ID	CHLORA	NH3/N	NO2/N	NO3/N	DOP	COLI	NONCON
POINT LOAD-2	1. PTL= PEBBLE CREEK	25.000	0.0	0.0	0.50	0.10	300.00	0.0
POINT LOAD-2	2. PTL= TRIB KM42	25.000	0.02	0.0	0.50	0.10	400.00	0.0
POINT LOAD-2	3. PTL= EVANS DITCH	25.000	0.08	0.0	2.00	0.20	300.00	0.0
POINT LOAD-2	4. PTL= BELL BRANCH	25.000	0.30	0.0	1.00	0.25	430.00	0.0
POINT LOAD-2	5. PTL= GM DIESEL	0.0	0.02	0.0	0.26	0.10	0.0	0.0
POINT LOAD-2	6. PTL= ASHCROFT DRAIN	0.0	0.18	0.0	0.20	0.13	0.0	0.0
POINT LOAD-2	7. PTL= WITHDRAWAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDATA11A								

```
*** MM= ,   45 *** NITER =    1
*** MM= ,    0 *** NITER =    2
ITERATION      1
GROWTH RATE NON CONVERGENT IN  45 ELEMENTS
ITERATION      2
GROWTH RATE NON CONVERGENT IN  45 ELEMENTS
ITERATION      3
GROWTH RATE NON CONVERGENT IN   0 ELEMENTS
```

TEMPERATURE — ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	73.30	73.55	74.30	74.10	74.58	74.90	75.10	75.04	75.18	75.28	75.34	75.39	75.42	75.44	75.45	75.46				
2	73.87	75.11	75.49	75.61	75.64															
3	74.45	75.42																		
4	75.62	75.65	75.66	75.66	75.66	75.66	75.66	75.66	73.36	74.18										
5	75.23	75.35	75.43	75.49	75.53	75.48	75.52	75.55	75.57	75.55	75.57	75.58								

DISSOLVED OXYGEN IN MG/L — ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	8.19	8.08	8.00	7.94	7.87	7.81	7.75	7.71	7.67	7.62	7.58	7.54	7.51	7.47	7.44	7.42				
2	8.19	8.21	8.19	8.18	8.18															
3	8.20	8.20																		
4	8.18	8.16	8.15	8.15	8.14	8.14	8.14	8.15	7.88	7.95										
5	7.58	7.57	7.55	7.53	7.51	7.46	7.45	7.43	7.42	7.39	7.38	7.37								

5-DAY BIOCHEMICAL OXYGEN DEMAND — ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.94	2.14	2.30	2.39	2.51	2.62	2.73	2.75	2.84	2.92	2.99	3.06	3.13	3.20	3.26	3.31				
2	1.95	1.90	1.85	1.80	1.76															
3	1.92	1.84																		
4	1.74	1.69	1.65	1.62	1.58	1.54	1.51	1.47	1.73	1.70										
5	2.92	3.00	3.08	3.15	3.23	3.33	3.40	3.46	3.51	3.58	3.64	3.70								

AMMONIA AS N IN MG/L — ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03				
2	0.02	0.02	0.02	0.02	0.02															
3	0.02	0.02																		
4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.17	0.17										
5	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06								

NITRITE AS N IN MG/L — ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
2	0.00	0.00	0.00	0.00	0.00															
3	0.00	0.00																		
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00										
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01								

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                  NITRATE AS N IN MG/L                                             ITERATION  3
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

   1  0.49  0.49  0.49  0.49  0.48  0.48  0.48  0.62  0.61  0.61  0.60  0.60  0.60  0.59  0.59  0.59
   2  0.50  0.49  0.49  0.49  0.49
   3  0.50  0.49
   4  0.49  0.49  0.48  0.48  0.48  0.48  0.48  0.48  0.76  0.76
   5  0.63  0.63  0.63  0.63  0.63  0.62  0.62  0.62  0.62  0.61  0.61  0.61

                  PHOSPHORUS AS P IN MG/L                                          ITERATION  3
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

   1  0.10  0.10  0.10  0.10  0.09  0.09  0.09  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.09
   2  0.10  0.10  0.10  0.10  0.10
   3  0.10  0.10
   4  0.10  0.10  0.10  0.09  0.09  0.09  0.09  0.09  0.18  0.18
   5  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.11  0.11  0.11  0.11  0.11

                  ALGAE AS CHL.A IN UG/L                                           ITERATION  3
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

   1  9.77 12.34 12.12 13.86 13.64 13.43 13.23 14.18 14.00 13.83 13.65 13.49 13.32 13.16 13.00 12.84
   2  9.64  9.29  8.96  8.65  8.35
   3  9.41  8.87
   4  8.40  8.25  8.11  7.97  7.84  7.70  7.57  7.45 16.94 16.88
   5 13.94 13.86 13.78 13.71 13.63 13.35 13.27 13.19 13.12 12.95 12.88 12.80

                  FECAL COLIFORM IN NO./100 ML                                     ITERATION  3
RCH/CL      1          2          3          4          5          6          7          8          9         10
   1     4.03E 05   3.54E 05   3.25E 05   3.11E 05   2.87E 05   2.65E 05   2.44E 05   2.31E 05   2.14E 05   1.98E 05
     CL     11         12         13         14         15         16         17         18         19         20
         1.83E 05   1.69E 05   1.57E 05   1.45E 05   1.34E 05   1.24E 05
RCH/CL      1          2          3          4          5          6          7          8          9         10
   2     1.80E 05   1.62E 05   1.46E 05   1.31E 05   1.18E 05
RCH/CL      1          2          3          4          5          6          7          8          9         10
   3     1.73E 05   1.49E 05
RCH/CL      1          2          3          4          5          6          7          8          9         10
   4     1.18E 05   1.09E 05   1.00E 05   9.20E 04   8.46E 04   7.78E 04   7.15E 04   6.58E 04   2.52E 05   2.37E 05
     CL     11         12         13         14         15         16         17         18         19         20

RCH/CL      1          2          3          4          5          6          7          8          9         10
   5     1.47E 05   1.37E 05   1.28E 05   1.19E 05   1.11E 05   1.02E 05   9.48E 04   8.84E 04   8.24E 04   7.63E 04
     CL     11         12         13         14         15         16         17         18         19         20
         7.13E 04   6.64E 04

                  CONSERVATIVE MINERAL   I    TDS IN MG/L                          ITERATION  3
RCH/CL  1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20

   1 82.53 88.96 88.51 92.86 92.45 92.04 91.64 96.15 95.75 95.37 94.99 94.62 94.25 93.90 93.54 93.20
   2 97.62 97.25 96.88 96.52 96.17
   3 97.54 97.10
   4 96.35 96.17 95.98 95.80 95.62 95.44 95.26 95.09109.63109.52
   5 97.79 97.65 97.50 97.35 97.21 96.36 96.22 96.08 95.94 95.80 95.67 95.52
```

ALGAE GROWTH RATES IN PER DAY ARE ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.30	0.28	0.29	0.27	0.27	0.27	0.27	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.27	0.27				
2	0.42	0.43	0.43	0.43	0.43															
3	0.44	0.45																		
4	0.39	0.39	0.39	0.39	0.39	0.39	0.38	0.38	0.40	0.41										
5	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29								

PHOTOSYNTHESIS-RESPIRATION RATIOS ARE ITERATION 3

RCH/CL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2.12	1.97	1.95	1.83	1.82	1.80	1.78	1.92	1.90	1.89	1.87	1.86	1.84	1.83	1.81	1.80				
2	2.90	2.88	2.86	2.85	2.83															
3	2.99	2.97																		
4	2.58	2.57	2.56	2.55	2.55	2.54	2.53	2.52	2.78	2.78										
5	1.95	1.94	1.94	1.93	1.93	1.91	1.90	1.90	1.89	1.88	1.91	1.91								

STREAM QUALITY SIMULATION
QUAL II STREAM QUALITY ROUTING MODEL

OUTPUT PAGE NUMBER 1
WRE/SEMCOG VERSION

***** STEADY STATE SIMULATION *****

RCH NUM	ELT NUM	FROM KILO	TO KILO	FLOW (CMS)	POINT SOURCE	INCR FLOW	TEMP DEG C	DO (MG/L)	BOD (MG/L)	NH3-N (MG/L)	NO3-N (MG/L)	DIS-O-P (MG/L)	CHL A (UG/L)	COLI /100ML	( )	TDS (MG/L)	( )	( )
1	1	1	46.0	45.0	0.98	0.0	0.02	22.94	8.19	1.94	0.03	0.49	0.10	9.77	403.	0.0	82.53	0.0	0.0
2	1	2	45.0	44.0	1.21	0.22	0.02	23.08	8.08	2.14	0.02	0.49	0.10	12.34	354.	0.0	88.96	0.0	0.0
3	1	3	44.0	43.0	1.23	0.0	0.02	23.50	8.00	2.30	0.02	0.49	0.10	12.12	325.	0.0	88.51	0.0	0.0
4	1	4	43.0	42.0	1.47	0.22	0.02	23.39	7.94	2.39	0.02	0.49	0.10	13.86	311.	0.0	92.86	0.0	0.0
5	1	5	42.0	41.0	1.48	0.0	0.02	23.66	7.87	2.51	0.02	0.48	0.09	13.64	287.	0.0	92.45	0.0	0.0
6	1	6	41.0	40.0	1.50	0.0	0.02	23.83	7.81	2.62	0.02	0.48	0.09	13.43	265.	0.0	92.04	0.0	0.0
7	1	7	40.0	39.0	1.51	0.0	0.02	23.95	7.75	2.73	0.02	0.48	0.09	13.23	244.	0.0	91.64	0.0	0.0
8	1	8	39.0	38.0	1.69	0.16	0.02	23.91	7.71	2.75	0.03	0.62	0.10	14.18	231.	0.0	96.15	0.0	0.0
9	1	9	38.0	37.0	1.71	0.0	0.02	23.99	7.67	2.84	0.03	0.61	0.10	14.00	214.	0.0	95.75	0.0	0.0
10	1	10	37.0	36.0	1.72	0.0	0.02	24.04	7.62	2.92	0.03	0.61	0.10	13.83	198.	0.0	95.37	0.0	0.0
11	1	11	36.0	35.0	1.74	0.0	0.02	24.08	7.58	2.99	0.03	0.60	0.10	13.65	183.	0.0	94.99	0.0	0.0
12	1	12	35.0	34.0	1.76	0.0	0.02	24.11	7.54	3.06	0.03	0.60	0.10	13.49	169.	0.0	94.62	0.0	0.0
13	1	13	34.0	33.0	1.77	0.0	0.02	24.12	7.51	3.13	0.03	0.60	0.10	13.32	157.	0.0	94.25	0.0	0.0
14	1	14	33.0	32.0	1.79	0.0	0.02	24.13	7.47	3.20	0.03	0.59	0.10	13.16	145.	0.0	93.90	0.0	0.0
15	1	15	32.0	31.0	1.80	0.0	0.02	24.14	7.44	3.26	0.03	0.59	0.10	13.00	134.	0.0	93.54	0.0	0.0
16	1	16	31.0	30.0	1.82	0.0	0.02	24.15	7.42	3.31	0.03	0.59	0.09	12.84	124.	0.0	93.20	0.0	0.0
17	2	1	15.0	14.0	0.18	0.0	0.00	23.26	8.19	1.95	0.02	0.50	0.10	9.64	180.	0.0	97.62	0.0	0.0
18	2	2	14.0	13.0	0.18	0.0	0.00	23.95	8.21	1.90	0.02	0.49	0.10	9.29	162.	0.0	97.25	0.0	0.0
19	2	3	13.0	12.0	0.18	0.0	0.00	24.16	8.19	1.85	0.02	0.49	0.10	8.96	146.	0.0	96.88	0.0	0.0
20	2	4	12.0	11.0	0.19	0.0	0.00	24.23	8.18	1.80	0.02	0.49	0.10	8.65	131.	0.0	96.52	0.0	0.0
21	2	5	11.0	10.0	0.19	0.0	0.00	24.25	8.18	1.76	0.02	0.49	0.10	8.35	118.	0.0	96.17	0.0	0.0
22	3	1	2.0	1.0	0.14	0.0	0.00	23.58	8.20	1.92	0.02	0.50	0.10	9.41	173.	0.0	97.54	0.0	0.0
23	3	2	1.0	-0.0	0.14	0.0	0.00	24.12	8.20	1.84	0.02	0.49	0.10	8.87	149.	0.0	97.10	0.0	0.0
24	4	1	10.0	9.0	0.33	0.0	0.00	24.24	8.18	1.74	0.02	0.49	0.10	8.40	118.	0.0	96.35	0.0	0.0
25	4	2	9.0	8.0	0.33	0.0	0.00	24.25	8.16	1.69	0.02	0.49	0.10	8.25	109.	0.0	96.17	0.0	0.0
26	4	3	8.0	7.0	0.34	0.0	0.00	24.25	8.15	1.65	0.02	0.48	0.10	8.11	100.	0.0	95.98	0.0	0.0
27	4	4	7.0	6.0	0.34	0.0	0.00	24.26	8.15	1.62	0.02	0.48	0.09	7.97	92.	0.0	95.80	0.0	0.0
28	4	5	6.0	5.0	0.34	0.0	0.00	24.26	8.14	1.58	0.02	0.48	0.09	7.84	85.	0.0	95.62	0.0	0.0
29	4	6	5.0	4.0	0.34	0.0	0.00	24.26	8.14	1.54	0.02	0.48	0.09	7.70	78.	0.0	95.44	0.0	0.0
30	4	7	4.0	3.0	0.34	0.0	0.00	24.26	8.14	1.51	0.02	0.48	0.09	7.57	72.	0.0	95.26	0.0	0.0
31	4	8	3.0	2.0	0.34	0.0	0.00	24.26	8.15	1.47	0.02	0.48	0.09	7.45	66.	0.0	95.09	0.0	0.0
32	4	9	2.0	1.0	0.75	0.41	0.00	22.98	7.88	1.73	0.17	0.76	0.18	16.94	252.	0.0	109.63	0.0	0.0
33	4	10	1.0	0.0	0.76	0.0	0.00	23.43	7.95	1.70	0.17	0.76	0.18	16.88	237.	0.0	109.52	0.0	0.0
34	5	1	30.0	29.0	2.59	0.0	0.01	24.02	7.58	2.92	0.07	0.63	0.12	13.94	147.	0.0	97.79	0.0	0.0
35	5	2	29.0	28.0	2.59	0.0	0.01	24.08	7.57	3.00	0.07	0.63	0.12	13.86	137.	0.0	97.65	0.0	0.0
36	5	3	28.0	27.0	2.60	0.0	0.01	24.13	7.55	3.08	0.07	0.63	0.12	13.78	128.	0.0	97.50	0.0	0.0
37	5	4	27.0	26.0	2.61	0.0	0.01	24.16	7.53	3.15	0.07	0.63	0.12	13.71	119.	0.0	97.35	0.0	0.0
38	5	5	26.0	25.0	2.62	0.0	0.01	24.18	7.51	3.23	0.07	0.63	0.12	13.63	111.	0.0	97.21	0.0	0.0
39	5	6	25.0	24.0	2.67	0.04	0.01	24.15	7.46	3.33	0.07	0.62	0.12	13.35	102.	0.0	96.36	0.0	0.0
40	5	7	24.0	23.0	2.68	0.0	0.01	24.18	7.45	3.40	0.06	0.62	0.12	13.27	95.	0.0	96.22	0.0	0.0
41	5	8	23.0	22.0	2.69	0.0	0.01	24.19	7.43	3.46	0.06	0.62	0.11	13.19	88.	0.0	96.08	0.0	0.0
42	5	9	22.0	21.0	2.70	0.0	0.01	24.21	7.42	3.51	0.06	0.62	0.11	13.12	82.	0.0	95.94	0.0	0.0
43	5	10	21.0	20.0	2.73	0.02	0.01	24.19	7.39	3.58	0.06	0.61	0.11	12.95	76.	0.0	95.80	0.0	0.0
44	5	11	20.0	19.0	2.54	0.20	0.01	24.20	7.38	3.64	0.06	0.61	0.11	12.88	71.	0.0	95.67	0.0	0.0
45	5	12	19.0	18.0	2.54	0.0	0.01	24.21	7.37	3.70	0.06	0.61	0.11	12.80	66.	0.0	95.52	0.0	0.0

STREAM QUALITY SIMULATION
QUAL II STREAM QUALITY ROUTING MODEL

OUTPUT PAGE NUMBER 2
WRE/SEMCOG VERSION

***** STEADY STATE SIMULATION *****

	RCH ORD	ELT NUM	FROM KILO	TO KILO	STREAM VEL (MPS)	STREAM DEPTH (M)	OXYGEN REAIR (1/DY)	BOD DECAY (1/DY)	NH3 DECAY (1/DY)	NO2 DECAY (1/DY)	COLI DECAY (1/DY)	ALGAE GROWTH (1/DY)	ALGAE RESPR (1/DY)
1	1	1	46.0	45.0	0.248	0.43	7.20	0.69	0.17	1.14	1.72	0.30	0.11
2	1	2	45.0	44.0	0.265	0.49	6.73	0.69	0.17	1.15	1.73	0.28	0.12
3	1	3	44.0	43.0	0.266	0.49	6.25	0.70	0.18	1.17	1.76	0.29	0.12
4	1	4	43.0	42.0	0.280	0.54	5.86	0.70	0.18	1.17	1.75	0.27	0.12
5	1	5	42.0	41.0	0.281	0.55	5.52	0.71	0.18	1.18	1.77	0.27	0.12
6	1	6	41.0	40.0	0.282	0.55	5.49	0.72	0.18	1.19	1.79	0.27	0.12
7	1	7	40.0	39.0	0.283	0.55	5.46	0.72	0.18	1.20	1.80	0.27	0.12
8	1	8	39.0	38.0	0.293	0.59	5.25	0.72	0.18	1.20	1.80	0.29	0.12
9	1	9	38.0	37.0	0.293	0.59	5.04	0.72	0.18	1.20	1.80	0.29	0.12
10	1	10	37.0	36.0	0.294	0.59	5.01	0.72	0.18	1.20	1.81	0.28	0.12
11	1	11	36.0	35.0	0.295	0.60	4.98	0.72	0.18	1.21	1.81	0.28	0.12
12	1	12	35.0	34.0	0.296	0.60	4.95	0.72	0.18	1.21	1.81	0.28	0.12
13	1	13	34.0	33.0	0.297	0.60	4.92	0.73	0.18	1.21	1.81	0.28	0.12
14	1	14	33.0	32.0	0.298	0.61	4.89	0.73	0.18	1.21	1.81	0.28	0.12
15	1	15	32.0	31.0	0.298	0.61	4.86	0.73	0.18	1.21	1.81	0.27	0.12
16	1	16	31.0	30.0	0.299	0.61	4.84	0.73	0.18	1.21	1.81	0.27	0.12
17	2	1	15.0	14.0	0.202	0.18	24.45	0.70	0.17	1.16	1.74	0.42	0.12
18	2	2	14.0	13.0	0.203	0.18	24.64	0.72	0.18	1.20	1.80	0.43	0.12
19	2	3	13.0	12.0	0.203	0.18	24.57	0.73	0.18	1.21	1.82	0.43	0.12
20	2	4	12.0	11.0	0.204	0.18	24.44	0.73	0.18	1.21	1.82	0.43	0.12
21	2	5	11.0	10.0	0.205	0.18	24.29	0.73	0.18	1.22	1.82	0.43	0.12
22	3	1	2.0	1.0	0.141	0.15	25.89	0.71	0.18	1.18	1.77	0.44	0.12
23	3	2	1.0	-0.0	0.142	0.16	26.02	0.73	0.18	1.21	1.81	0.45	0.12
24	4	1	10.0	9.0	0.253	0.26	20.53	0.73	0.18	1.21	1.82	0.39	0.12
25	4	2	9.0	8.0	0.253	0.26	15.95	0.73	0.18	1.22	1.82	0.39	0.12
26	4	3	8.0	7.0	0.254	0.26	15.90	0.73	0.18	1.22	1.82	0.39	0.12
27	4	4	7.0	6.0	0.254	0.26	15.84	0.73	0.18	1.22	1.82	0.39	0.12
28	4	5	6.0	5.0	0.255	0.26	15.79	0.73	0.18	1.22	1.82	0.39	0.12
29	4	6	5.0	4.0	0.255	0.26	15.74	0.73	0.18	1.22	1.82	0.39	0.12
30	4	7	4.0	3.0	0.255	0.26	15.69	0.73	0.18	1.22	1.82	0.38	0.12
31	4	8	3.0	2.0	0.256	0.27	15.64	0.73	0.18	1.22	1.82	0.38	0.12
32	4	9	2.0	1.0	0.342	0.43	11.96	0.69	0.17	1.15	1.72	0.40	0.11
33	4	10	1.0	0.0	0.343	0.43	8.66	0.70	0.18	1.17	1.76	0.41	0.12
34	5	1	30.0	29.0	0.301	0.62	5.77	0.72	0.18	1.20	1.80	0.29	0.12
35	5	2	29.0	28.0	0.301	0.62	4.77	0.72	0.18	1.21	1.81	0.29	0.12
36	5	3	28.0	27.0	0.302	0.62	4.76	0.73	0.18	1.21	1.81	0.29	0.12
37	5	4	27.0	26.0	0.302	0.62	4.76	0.73	0.18	1.21	1.82	0.29	0.12
38	5	5	26.0	25.0	0.302	0.62	4.75	0.73	0.18	1.21	1.82	0.29	0.12
39	5	6	25.0	24.0	0.304	0.62	4.73	0.73	0.18	1.21	1.82	0.29	0.12
40	5	7	24.0	23.0	0.305	0.63	4.71	0.73	0.18	1.21	1.82	0.29	0.12
41	5	8	23.0	22.0	0.305	0.63	4.71	0.73	0.18	1.21	1.82	0.29	0.12
42	5	9	22.0	21.0	0.305	0.63	4.70	0.73	0.18	1.21	1.82	0.29	0.12
43	5	10	21.0	20.0	0.306	0.63	4.69	0.73	0.18	1.21	1.82	0.29	0.12
44	5	11	20.0	19.0	0.299	0.61	4.75	0.73	0.18	1.21	1.82	0.29	0.12
45	5	12	19.0	18.0	0.299	0.61	4.81	0.73	0.18	1.21	1.82	0.29	0.12

VI. APPLICATION AND CALIBRATION

This chapter outlines a general approach for calibrating QUAL-II. The procedure has evolved from the many applications of earlier versions of the model and, if followed, can save the user many hours and much frustration in getting the model to satisfactorily represent his system.

QUANTITY CALIBRATION

Once the system has been discretized into reaches, the next step is to specify the discharge coefficients α, β, a and b, or the channel cross-section for each reach (see HYDRAULIC DATA input specifications). Care should be taken here to see that *the coefficients or channel section specified are typical for the entire reach.* A mistake that is often made, especially when discharge coefficients are used, is to use the discharge curves, or cross-section at a gaging station to represent the reach. The problem with using these data is that the gaging station is generally located at a control section in the stream and thus is atypical of the reach.

After the hydraulics data for the reach has been specified, a run should be made to "rough check" the system. All headwater sources, and known point source inputs should be specified so that the only inflows not simulated are incremental inflows. The output from this simulation can be checked quickly by hand for continuity. If flow continuity is not satisfied, the system is not properly specified upstream of the point where the continuity problem occurs. In such a case the input data should be checked for proper ordering of reaches, tributaries and point source loads. Examine carefully the Flag Field Data and the Junction Data with respect to these specifications. Most often the problem is in one of these two input data types.

Once the continuity check has been made the Incremental Inflows to the reaches can be computed. These inflows are generally groundwater inflows and/or minor amounts of distributed surface runoff, which is not accounted for in the point source data. In order to properly specify these incremental inflows *the flow data must be taken from a period(s) of record when the discharge varied less than 15 percent over a period equal to the travel time through the stream system.* Incremental inflows are calculated from this data as follows. Starting with the uppermost headwater, the difference between this flow and the flow at the first gage downstream is due to point sources and incremental inflow (there may be another headwater(s) contributing also if the first gage is below a junction(s)). Once the incremental inflow is calculated, it can be apportioned over the reaches between the flow gage and the headwater(s) on an inflow per mile basis, or inflow per square mile of tributary area basis (better) or some other hydrologically defensible method. *Note: To insure that incremental inflows are properly distributed among the reaches, there is no substitute for familiarity with the hydrologic characteristics of the basin.* Once the upstream portion of the system has been balanced, the next lower portion can be calibrated in a similar manner. The process is continued until the bottom of the stream system is reached. After the incremental inflows are calculated, a simulation run should be made. The computed flows at the gage locations should be the same as the recorded values. Make adjustments as necessary.

When the flow balance is achieved, *check the velocity and depth in every element of every reach.* Adjust discharge coefficients or channel cross sections as appropriate to achieve reasonable values for velocity and depth. This aspect of the calibration is often ignored with the result that "strange" water quality responses are simulated on certain river reaches. Detailed examination of the "strange" reaches reveals simulated velocities that are high (or low) in reaches that the user thought (or knows) are slow (fast) in the prototype. Similarly, shallow (deep) depths may be computed for reaches that are actually deep (shallow).

Often a stream system will have a low head dam with a shallow (10-20 ft.) impoundment behind it. For nonstratified impoundments these stream segments may be represented as follows. The channel depth is taken as the average depth of the reservoir and the velocity as the flow divided by the average cross-sectional area. If discharge coefficients are used, set β and b to 1.0. Calculate α as D/Q. Then compute a as $a = V/Q = (Q/wD)/Q = 1/wD$ where w is the mean width of the reservoir. *Change these coefficients (α and a) every time the input flows (headwaters, point sources or incremental inflows) are changed.*

If trapezoidal cross sections are used, select a section most representative of the reservoir. Use the mean depth D that occurs for a flow Q through the reservoir. Using this value of D and the specifications of the cross section, compute the cross sectional area A of the flow and the hydraulic radius R. The energy slope, S_e for the reservoir, can then be computed as

$$S_e = \left(\frac{n}{1.486} \frac{Q}{A\ R^{2/3}} \right)^2 \qquad \text{V-1}$$

Use the computed slope S_e as the channel slope for the reservoir reach. This will produce a representation of the reservoir as a trapezoidal channel with a cross section as specified and a depth D at discharge Q.

Be sure to check the simulated depth and discharge in each reservoir for reasonableness. Make adjustments as necessary.

QUALITY CALIBRATION

It is assumed here that the user has 1) a working knowledge of water quality relationships in streams and 2) reads and understands Chapters II and III--General Model Formulation, and Constituent Reactions and Interrelationships, respectively. The user should also be familiar with the air-water interface energy transfer relationships in Chapter IV, if temperature is to be simulated. Familiarity with the computation of radiation (solar, atmospheric, and longwave back radiation) is desirable but not mandatory.

There is no required order in which the water quality parameters must be calibrated; however, if the order suggested is followed, a much faster calibration of the whole model can generally be achieved. The suggested order of constituent calibration is:

1. Conservative Constituents
2. Temperature
3. BOD, Coliforms, and the Arbitrary Nonconservative Constituent
4. Algae, NH_3, NO_2, NO_3, and PO_4
5. DO

The rational for the order shown is that we wish to calibrate those constituents whose concentrations are independent of other constituent concentrations first. The last constituents to be simulated are the most interdependent constituents. The following sections provide some pointers on calibration of these parameter groups.

Conservative Constituents

These parameters should be calibrated first, especially if constituents such as chlorides, total dissolved solids, or heavy metal(s) are included. Since there is no decay rate, calibration consists only of adjusting input loads in headwaters, from point sources and from incremental inflows. Thus this calibration becomes an excellent tool for locating previously unidentified waste sources.

Temperature

This parameter is calibrated next because once the point waste sources are all identified the only factor that affects temperature is the heat transfer through the air-water interface. Temperature, on the other hand, affects the value of nearly all the rate constants.

To calibrate temperature, first make sure that the Climatological Data (Type 12 data) is specified as accurately as possible. Windspeed along the river--channeled by a canyon or sheltered by high vegetation growths on the banks--may be significantly different than the value measured at the Class A weather station. Take this into account as much as possible. Secondly, cloud cover should be carefully estimated and adjustments should be made if necessary between cloud cover at the observation point and cloud cover over the river. Furthermore, a tree-lined river flowing in a North-South direction will be partially or wholly shaded. The only way to effectively account for this condition is to increase the cloud cover as appropriate.

Once the climatological data have been adjusted to the user's satisfaction, the remaining calibration parameters are the dust attenuation coefficient and the evaporation coefficients _a_ and _b_. Of these three parameters, temperature is most sensitive to the coefficient _b_. It should be possible to calibrate the temperature by varying _b_ over acceptable ranges with the dust attenuation coefficient and the evaporation coefficient _a_ set at their recommended values. If this is not possible within accepted ranges of coefficient _b_, then recheck the meteorological input data, i.e. the data on the last four Type 1 Data Cards. If these data are correct, then adjust the dust attenuation coefficient and lastly the evaporation coefficient _a_.

BOD, Coliforms, and the Arbitrary Nonconservative Constituent

Coliforms and the arbitrary nonconservative constituent should be calibrated next since they are affected only by waste input strength and decay rate. Coliform inputs will be headwaters, point sources, and incremental inflows if it is surface runoff. The trick here is to get the concentration of the incremental inflow correct. A high incremental inflow load plus a high decay rate will produce the same in-stream concentration as a low incremental inflow rate and a low decay rate. This relationship applies to all three constituents.

In the case of BOD, another parameter that affects the concentration is the sedimentation rate, K_3. When calibrating BOD, keep in mind that $d(BOD)/dt = K \cdot BOD$ where $K = K_1 + K_3$. Thus for an observed in-stream loss rate, K and an assumed BOD decay rate, K_1, the value of K_3 is $K - K_1$. Keep in mind that $K_1 \cdot BOD$ is the oxygen uptake rate by suspended BOD. $K_3 \cdot BOD$ is a loss of BOD to the stream, but it does not exert an oxygen demand per se.

Algae, NH_3, NO_2, NO_3, and PO_4

Each of these variables are related to one or more of the others, thus the calibration of this set of constituents can be time consuming. The following pointers will save some time. First, calibrate PO_4 as a conservative constituent. Do not spend too much time on this initial calibration; keep in mind that algae takes up PO_4 for growth and produces it through respiration. Remember benthos deposits as well as wasteloads and incremental inflows may also be a source of PO_4.

Next calibrate NH_3 and NO_3. Don't worry about calibrating NO_2; use a high decay rate that will keep concentrations low. This is the phenomenon that is observed in natural waters. Nitrite serves only as the intermediate product of the $NH_3 \rightarrow NO_3$ nitrification process and its oxidation to NO_3 is rapid. The process which actually controls the rate of $NH_3 \rightarrow NO_3$ oxidation process is the ammonia decay rate. Calibrate NH_3 and NO_3 initially ignoring algae. Calibrate NH_3 on the low side to account for algae respiration and NO_3 a little high to provide for NO_3 uptake by algae growth (keep in mind that one mg of algae growth or respiration uses or produces only 0.12 mg of NO_3 or NH_3 as N). Note that the only loss of

NO_3 from the system is by algae growth. If simulated values of NO_3 are too high it is probably because the ammonia decay rate is too high. Recall that benthos deposits can be a source of ammonia to the system.

In some river systems it may happen that simulated values of NH_3 and/or NO_3 and PO_4 are too high and cannot be reduced to observed values through realistic adjustment of rate and uptake coefficients. In such cases, one might suspect the presence of macrophytes and benthic algae. These plants can take up significant quantities of NH_3 and PO_4 from the stream. If such a situation appears probable a stream visit is probably in order.

Once PO_4 and the nitrogen series have been initially calibrated, then algae may be simulated. The primary calibration parameter here is the algae specific growth rate which can vary from 1.0 to 3.5 per day. The recommended values for the nitrogen and phosphorus content of algae and the half saturation constants (see the test problem) should not be changed unless the user has a defendable argument for doing so. The algae respiration rate can also be varied. Another factor that affects the algae concentration is the light extinction coefficient. The value can be initially estimated as follows. The 10 percent light level is about three times the Secchi disc reading (call it Z_s). Thus we can say at the 10 percent light depth:

$$\frac{I}{I_o} = 0.10 = e^{-\lambda(3Z_s)} \qquad \text{(V-2a)}$$

or

$$L_n\ 0.10 = -2.3 = -\lambda 3Z_s \qquad \text{(V-2b)}$$

or

$$\lambda = \frac{2.3}{3\ Z_s} \qquad \text{(V-2c)}$$

where λ is the light extinction coefficient. In clear water Z_s could be ten feet or more; in turbid water it would be quite small. If algae concentrations are around 1.0 mg/l, Z_s will probably be one to two feet.

Algae can also be lost to the system by settling. This might occur in a small reservoir and possibly in very sluggish river reaches. For velocities over 1.5 ft/sec. algae settling will probably not occur.

Dissolved Oxygen

If everything else has been calibrated satisfactorily, the dissolved oxygen (DO) calibration should be relatively straightforward. Do not change the algae O_2 uptake or respiration constants unless there is a biologically defensible reason. This leaves basically only the reaeration constants and the benthic oxygen demand to adjust.

If the user has no preference with respect to the reaeration option to use, we suggest Tsivoglou's formulation be selected. The reaeration constant can be adjusted reach by reach.

In some reaches the river may be fast flowing possibly with white water resulting in high reaeration rates. The user may wish to specify option 1 for such reaches and enter a reaeration rate for that reach as input data.

Finally, the spillway on many low head dams serves as an "in-stream" aeration device causing DO levels just downstream of the spillway to be much higher (probably near saturation) than those in the reservoir just upstream of the spillway. For these cases the user may want to define a reach, just below the spillway, that is one computational element long and which has a high K_2 value specified as input data.

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