COMPUTER PROGRAM DOCUMENTATION

for the

STREAM QUALITY MODEL QUAL-II

AN INTERMEDIATE TECHNICAL REPORT

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prepared for

THE ENVIRONMENTAL PROTECTION AGENCY SYSTEMS DEVELOPMENT BRANCH

WASHINGTON, D.C.

Contract No 68-01-0742 Iowa And Cedar River Basins Model Project

MAY, 1973

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SECTION I
BACKGROUND AND INTRODUCTION

BACKGROUND

Beginning on June 13, 1972, the Environmental Protection Agency (EPA) awarded Water Resources Engineers, Inc. (WRE) a series of four contracts to modify and apply certain water quality models to four river basins in the United States. These four contracts and the project titles are:

	Project Title	EPA Contract No.
1.	Chattahoochee-Flint River Basin Mathematical Model Project	68-01-0708
2.	Upper Mississippi River Basin Mathematical Model Project	68-01-0713
3.	Iowa and Cedar River Basins Model Project	68-01-0742
4.	Santee River Basin Model Project	68-01-0739

An element of work common to all four projects is the modification and application of the mathematical model QUAL-I to simulate steady-state water quality levels in selected river reaches in each basin.

QUAL-I

QUAL-I is a computer program originally designed to simulate the dynamic behavior of conservative minerals, temperature, biochemical oxygen demand, and dissolved oxygen levels in streams. The program simulates this

dynamic behavior by numerical integration of the one-dimensional form of the advection-dispersion transport equation. The following two reports by F. D. Masch and Associates and the Texas Water Development Board contain detailed descriptions of both the theory and structure of the model:

1. Simulation of Water Quality in Streams and Canals, Theory and Description of the QUAL-I Mathematical Modeling System. Prepared by Frank D. Masch and Associates and the Texas Water Development Board, Report 128, The Texas Water Development Board, May 1971.

2. Simulation of Water Quality in Streams and Canals, Program Documentation and User's Manual. Prepared by the Systems Engineering Division of the Texas Water Development Board. September 1970.

QUAL MODIFICATIONS: QUAL-II

Within the four projects, WRE modified QUAL-I to simulate both the steady-state and dynamic behavior of the following constituents:

- Chlorophyll a
- Nitrogen
  - Ammonia
  - Nitrite
  - Nitrate
- Phosphorus
- Carbonaceous BOD
- Benthic Oxygen Demand
- Dissolved Oxygen
- Coliforms
- Radioactive Material*
- Conservative Substances

*The version of the program documented herein does not contain a solution subroutine for Radionuclides; however, the Input-Output routines are set up to accommodate the subroutine once it is programmed. Radionuclines will be included in the program documented in the Upper Mississippi River Basin Project.

The temperature simulation capability of the program was *not* modified to simulate steady-state temperature directly. The modified program will, as before, simulate dynamic changes in temperature. The modified version of QUAL-I is referred to in this report as QUAL-II.

DOCUMENTATION REPORT

The theoretical considerations and program structure, which are discussed in Sections II and III, respectively, are intended to supplement Report 128 referenced above. The diagram documentation and user's manual which comprises Sections IV through VII, is self contained, i.e., these sections replace the existing QUAL-I Program Documentation and User's Manual. To the extent possible, this documentation uses the same symbols and terminology that were used in the previous reports and program code. The reason for making the program documentation and user's manual self contained was to avoid the possibility of confusing program users by requiring them to use two documents to set up and use QUAL-II.

The following section of this documentation report presents the theoretical foundation of the modified model. Section III describes the overall capabilities, limitations, and structure of QUAL-II. Subroutine descriptions, including theory, flowcharts and listings are presented in Section IV, while Section V defines the program variables. Section VI contains users information on input data preparation. Input data and output reports for an example problem are presented in Section VII, which concludes the documentation report.

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SECTION II
THEORETICAL CONSIDERATIONS

INTRODUCTION

Basically, QUAL-II numerically integrates the advection-dispersion mass transport equation for all water quality constituents to be modeled. This equation includes the effects of advection, dispersion, individual constituent changes, and sources and sinks; for any constituent, c, this equation can be written as

$$(A_x dx)\frac{\partial c}{\partial t} = \frac{\partial(A_x D_L \frac{\partial c}{\partial x})}{\partial x} dx - \frac{\partial(A_x \bar{u} c)}{\partial x} dx + (A_x dx)\frac{dc}{dt} \pm s \quad \text{. . . . . II-1}$$

where

- c = concentration (M/L^3)
- x = distance (L)
- t = time (T)
- A_x = cross-sectional area (L^2)
- D_L = dispersion coefficient (L^2/T)
- $\bar{u}$ = stream velocity (L/T)
- s = source or sink (M/T)

There are two terms in this equation that deserve special attention; these are the two derivatives that describe the local gradients and individual constituent changes. Under steady-state conditions, the local derivative becomes equal to zero; in other words

$$\frac{\partial c}{\partial t} = 0 \quad \text{. . . . . II-2}$$

Changes that occur to individual constituents or particles independent of advection, dispersion and waste inputs are defined by the term

$$\frac{dc}{dt} = \text{individual constituents changes} \quad \ldots\ldots \quad \text{II-3}$$

These changes include the physical, chemical, and biological reactions and interactions that occur in the stream. Examples of these changes are reaeration, algal respiration and photosynthesis, and coliform die-off.

The basic differences between QUAL-I in its original form and the version documented in this report is that QUAL-II can now solve steady-state problems directly plus it includes all the complex reactions and interactions of the nonconservative constituents listed in Section I. In order to differentiate between the original and modified versions of QUAL, the latter version is referred to in this report as QUAL-II.

GENERAL MODEL RELATIONSHIPS

QUAL-I in its original form had the capability to simulate conservative constituents. Thus, the necessary modifications were directed toward the development of a model that could simulate the nonconservative constituents listed in Section I. Of this list, QUAL-I already had the capability to simulate carbonaceous BOD and dissolved oxygen as dependent constituents with first order kinetics.

To accommodate the other constituents, WRE modified QUAL-I to include the major interactions of the nutrient cycles, algae production, benthic oxygen demand, carbonaceous oxygen uptake and their effect on the behavior of dissolved oxygen. Figure II-1 illustrates the conceptualization of this model. It should be noted that the arrows on this figure indicate the direction of normal system progression in a moderately polluted environment; the directions may be reversed in some circumstances for some constituents. As an example of process reversal, consider that under normal conditions oxygen will be transferred from the atmosphere into solution and thus into the oxygen resources of the stream. Under conditions of oxygen

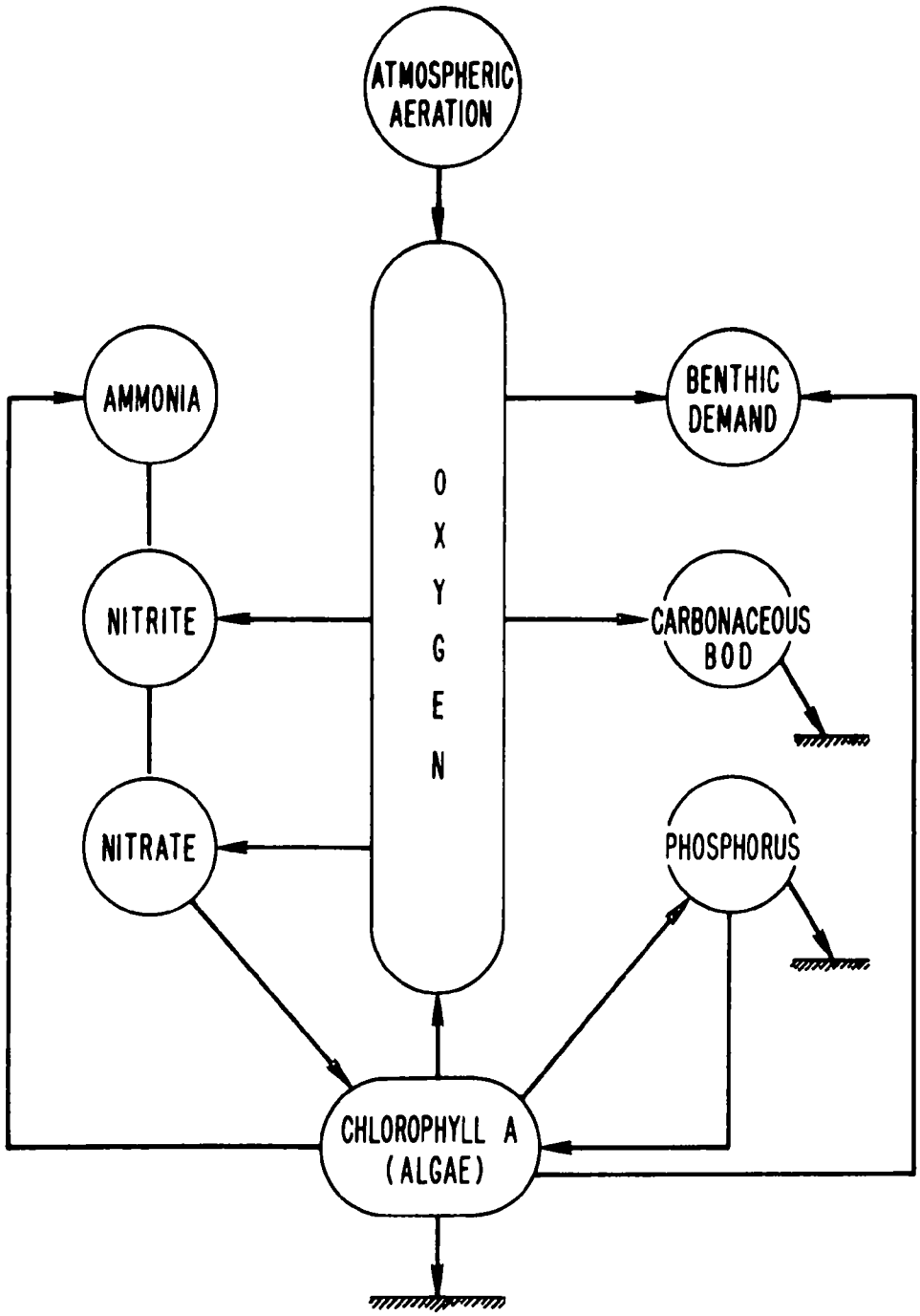

FIGURE II-1

GENERAL MODEL STRUCTURE FOR QUAL-II

supersaturation, however, which might occur as a result of algal photosynthesis, oxygen might actually be driven from solution, opposite to the indicated direction of the flow path.

CONSTITUENT REACTIONS AND INTERACTIONS

The following paragraphs define the mathematical relationships that describe the individual reactions and interactions among the constituents treated.

CHLOROPHYLL a (PHYTOPLANKTONIC ALGAE)

Chlorophyll a was considered to be directly proportional to the concentration of phytoplanktonic algal biomass. For the purposes of this model algal biomass was converted to chlorophyll a by the simple relationship

$$C = \alpha_0 A \quad \text{. . . . . .} \quad \text{II-4}$$

where

- C = chlorophyll a concentration
- A = algal biomass concentration
- α_0 = a conversion factor

The differential equation that governs the growth and production of algae (chlorophyll a) is formulated according to the following relationship

$$\frac{dA}{dt} = \mu A - \rho A - \frac{\sigma_1}{D} A \quad \text{. . . . . .} \quad \text{II-5}$$

where

- A = algal biomass
- t = time
- μ = the local specific growth rate of algae as defined below, which is temperature dependent
- ρ = the local respiration rate of algae, which is temperature dependent

σ_1 = the local settling rate for algae

D = average stream depth

Now, the local specific growth rate of algae is known to be coupled to availability of required nutrients and light. The standard formulation for the local specific growth rate in a stream takes the form

$$\mu = \hat{\mu} \frac{N_3}{N_3 + K_N} \cdot \frac{P}{P + K_P} \cdot \frac{1}{\lambda D} \ln \frac{K_L + L}{K_L + Le^{-\lambda D}} \quad \text{. . . . . II-6}$$

where

$\hat{\mu}$ = the maximum specific growth rate

N_3 = the local concentration of nitrate nitrogen

P = the local concentration of orthophosphate

L = the local intensity of light

λ = the light extinction coefficient in the river

K_N, K_P, K_L = empirical half-saturation constants (temperature dependent)

It should be noted that Equation II-6 couples algal production to the available nutrient supply, and thus algae and chlorophyll a can be expected to vary in time and space as nutrients are added to the stream. It should also be noted that Equation II-6 includes light intensity. Thus, other factors remaining equal, algal production will be increased during daylight hours and will cease at night, although respiration will continue at night as indicated in Equation II-5. Finally, the growth and respiration constants will be temperature dependent and will be formulated, along with all other temperature dependent systems variables, according to the procedure explained in a later paragraph of this section.

NITROGEN CYCLE

The nitrogen cycle in QUAL-II contains three components as shown in Figure II-1. The differential equations governing transformation of nitrogen from one form to another are given below.

Ammonia Nitrogen

$$\frac{dN_1}{dt} = \alpha_1 \rho A - \beta_1 N_1 + \alpha_3/A_X \quad \text{. . . . . .} \quad \text{II-7}$$

where

N_1 = the concentration of ammonia nitrogen as nitrogen

β_1 = rate constant for the biological oxidation of ammonia nitrogen, temperature dependent

α_1 = the fraction of respired algal biomass which is resolubilized as ammonia nitrogen by bacterial action

α_3 = the benthos source rate for ammonia nitrogen

A_X = average stream cross-sectional area

and other terms are as previously defined.

Nitrite Nitrogen

$$\frac{dN_2}{dt} = \beta_1 N_1 - \beta_2 N_2 \quad \text{. . . . . .} \quad \text{II-8}$$

where

N_2 = the concentration of nitrite nitrogen as nitrogen

β_2 = rate constant for the oxidation of nitrite nitrogen temperature dependent

and other terms are as previously defined.

Nitrate Nitrogen

$$\frac{dN_3}{dt} = \beta_2 N_2 - \alpha_1 \mu A \quad \text{. . . . . .} \quad \text{II-9}$$

Note the coupling that exists between the conversion of nitrate and the production of algae to close the loop indicated in Figure II-1.

PHOSPHORUS CYCLE

The formulation of the phosphorus cycle is less complex than the nitrogen cycle because the model considers only the interaction of phosphorus and algae plus a sink term. Correspondingly, the differential equation describing the distribution can be written as

$$\frac{dP}{dt} = \alpha_2 \rho A - \alpha_2 \mu A + \sigma_2 / A_X \quad \text{. . . . . .} \quad \text{II-10}$$

where

P = the concentration of orthophosphate as phosphorus

α_2 = the fraction of algal biomass that is phosphorus

σ_2 = the benthos source rate for phosphorus

and all other terms are as previously defined.

CARBONACEOUS BOD

The rate of change of carbonaceous BOD in the stream is formulated as a first order reaction according to the formula

$$\frac{dL_1}{dt} = - K_1 L_1 - K_3 L_1 \quad \text{. . . . . .} \quad \text{II-11}$$

where

L_1 = the concentration of carbonaceous BOD

K_1 = the rate of decay of carbonaceous BOD (temperature dependent)

K_3 = the rate of loss of carbonaceous BOD due to settling

Note that while the change in BOD is expressed by Equation II-11, the oxygen demand exerted as a result of the change is only $K_1 L_1$. The BOD which settles becomes a benthic oxygen demand.

BENTHIC OXYGEN DEMAND

The benthic oxygen demand is considered to be a fixed demand, i.e.

$$\frac{dL_2}{dt} = K_4/A_x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{II-12}$$

where

L_2 = benthic oxygen demand

K_4 = constant benthic uptake

DISSOLVED OXYGEN

The differential equation that describes the rate of change of oxygen in the model is written in the form

$$\frac{dO}{dt} = K_2(O^* - O) + (\alpha_3\mu - \alpha_4\rho)\,A - K_1\,L_1 - K_4/A_x - \alpha_5\,\beta_1\,N_1 - \alpha_6\,\beta_2\,N_2 \quad \ldots \quad \text{II-13}$$

where

O = the concentration of dissolved oxygen

O^* = the saturation concentration of dissolved oxygen at the local temperature and pressure

α_3 = the rate of oxygen production per unit of algae (photosynthesis)

α_4 = the rate of oxygen uptake per unit of algae respired

α_5 = the rate of oxygen uptake per unit of ammonia oxidation

α_6 = the rate of oxygen uptake per unit of nitrite nitrogen oxidation

K_2 = the aeration rate in accordance with the Fickian diffusion analogy

COLIFORMS

The differential equation that describes the die-off of coliforms in the stream is

$$\frac{dF}{dt} = -K_5F \quad \text{II-14}$$

where

F = the concentration of coliforms,

K_5 = coliform die-off rate.

RADIONUCLIDES (NOT PROGRAMMED)

This portion of the model will be completed in the Upper Mississippi River Basin Project, and the documentation will be updated at the time that project is completed. However, it is tentatively envisioned that the differential equation to describe the changes in radionuclides will be written as

$$\frac{dR}{dt} = -K_rR - K_aR \quad \text{II-15}$$

where

R = concentration of radionuclides,

K_r = radioactive decay rate

K_a = radioactive adsorption rate

SUMMARY OF MATHEMATICAL RELATIONSHIPS

Table II-1 summarizes the complete set of equations solved by QUAL-II with the exception of the temperature relationships. The equations that describe the temperature routing as well as the associated relationships for all the heat budget terms can be found in the report by F. D. Masch and Associates and the Texas Water Development Board. The equations presented in Table II-1 include the effects of dispersion, advection, constituent reactions and interactions, and a source term. The following chapter of this documentation describes how QUAL-II is structured to solve these equations.

TABLE II-1

SUMMARY OF DIFFERENTIAL EQUATIONS TO BE SOLVED BY QUAL-II

Conservative mineral (c)	$\frac{\partial c}{\partial t} = \frac{\partial(A_x D_L \frac{\partial c}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uc)}{A_x \partial x} + \frac{S_c}{A_x dx}$
Algae (A)	$\frac{\partial A}{\partial t} = \frac{\partial(A_x D_L \frac{\partial A}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uA)}{A_x \partial x} + \frac{S_A}{A_x dx} + (\mu - \rho - \frac{\sigma_1}{}) A$
Ammonia nitrogen (N_1)	$\frac{\partial N_1}{\partial t} = \frac{\partial(A_x D_L \frac{\partial N_1}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uN_1)}{A_x \partial x} + \frac{S_{N_1}}{A_x dx} + (\alpha_1 \rho A - \beta_1 N_1 + \frac{\alpha_3}{A_x})$
Nitrite nitrogen (N_2)	$\frac{\partial N_2}{\partial t} = \frac{\partial(A_x D_L \frac{\partial N_2}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uN_2)}{A_x \partial x} + \frac{S_{N_2}}{A_x dx} + (\alpha_5 N_1 - \beta_2 N_2)$
Nitrate nitrogen (N_3)	$\frac{\partial N_3}{\partial t} = \frac{\partial(A_x D_L \frac{\partial N_3}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uN_3)}{A_x \partial x} + \frac{S_{N_3}}{A_x dx} + (\beta_2 N_2 - \alpha_1 \mu A)$
Phosphate phosphorus (P)	$\frac{\partial P}{\partial t} = \frac{\partial(A_x D_L \frac{\partial P}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uP)}{A_x \partial x} + \frac{S_P}{A_x dx} + (\alpha_2(\rho - \mu)A - \frac{\sigma_2}{A_x})$
Biochemical oxygen demand (L)	$\frac{\partial L}{\partial t} = \frac{\partial(A_x D_L \frac{\partial L}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uL)}{A_x \partial x} + \frac{S_L}{A_x dx} - (K_1 + K_3)L$
Dissolved oxygen (ϕ)	$\frac{\partial \phi}{\partial t} = \frac{\partial(A_x D_L \frac{\partial \phi}{\partial x})}{A_x \partial x} - \frac{\partial(A_x u\phi)}{A_x \partial x} + \frac{S_\phi}{A_x dx} + [K_2(\phi^* - \phi) + (\alpha_3 \mu - \alpha_4 \rho)A - K_1 L - \frac{K_4}{A_x} - \alpha_5 \beta_1 N_1 - \alpha_6 \beta_2 N_2]$
Coliform (F)	$\frac{\partial F}{\partial t} = \frac{\partial(A_x D_L \frac{\partial F}{\partial x})}{A_x \partial x} - \frac{\partial(A_x uF)}{A_x \partial x} - \frac{S_F}{A_x dx} - K_5 F$
Radioactive material (R)	$\frac{\partial R}{\partial t} = \frac{\partial(A_x D_L \frac{\partial R}{\partial x}}{A_x \partial x} - \frac{\partial(A_x uR)}{A_x \partial x} - \frac{S_R}{A_x dx} - K_r R - K_a$

REACTION RATES AND PHYSICAL CONSTANTS

INPUT PARAMETERS

The chemical and biological reactions that are simulated by QUAL-II are represented by a complex set of equations (3, 4) that contain many system parameters: some are constants, some are spatially variable, and some are temperature dependent. Table II-2 lists these system parameters and gives the possible range of values, units, types of variation, and reliability of the ranges for each parameter. References (5) and (6) give detailed discussions of the basic sources of data, ranges and reliabilities of each of these parameters. Final selection of the values for many of these system parameters will be made during model calibration and verification.

TEMPERATURE DEPENDENCE

All rate constants and other factors (except the saturation concentration of oxygen) that are known to be temperature dependent are formulated according to the relationship

$$X_T = X_{T_s} \theta^{(T-T_s)} \quad \text{. . . . . .} \quad \text{II-16}$$

where

X_T = the value of the variable at the local temperature, T

X_{T_s} = the value of the variable at the standard temperature, T_s

θ = an empirical constant for each system variable

REFERENCES

1. Frank D. Masch and Associates and the Texas Water Development Board, *Simulation of Water Quality in Streams and Canals, Theory and Description of the QUAL-I Mathematical Modeling System*, Report 128, the Texas Water Development Board, May 1971.

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SECTION III
MODEL DESCRIPTION

INTRODUCTION

This section of the report describes (1) how the prototype river system is approximated in the model; (2) the numerical procedures used to integrate the differential equations presented in Section II and applied to the prototype representation; (3) the general limitations of the model; and (4) the overall model structure and subroutines.

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 runoff 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

QUAL-II can be used to simulate any combination of the following parameters or groups of parameters:

1. Conservative minerals
2. Temperature
3. BOD
4. Chlorophyll a
5. Phosphorous
6. Ammonia, nitrite and nitrate
7. Dissolved oxygen
8. Coliforms, and
9. Radioactive material

The only limitation placed on the parameters to be simulated is that temperature can only be simulated under dynamic conditions. All other parameters can be simulated under either steady-state or dynamic conditions. If either phosphorus or the nitrogen cycle are not being simulated, the model presumes they will not limit algal growth.

NUMERICAL PROCEDURES

The complete set of equations that must be solved have been presented in Table II-1. QUAL-II numerically integrates this set of differential equations using a wholly implicit numerical scheme. Report 128, Simulation of Water Quality in Streams and Canals, prepared by F. D. Masch and Associates and the Texas Water Development Board (1) describes the numerical formulation and method of solution. The only difference between the original version of QUAL and the version documented herein is that all terms that describe the local derivative (e.g., reaeration and decay rates) are now described implicitly rather than explicitly.

MODEL STRUCTURE AND SUBROUTINES

QUAL-II is structured as one main program, QUAL2, supported by 20 different subroutines. Figure III-1 graphically illustrates the functional relationships between the main program and the 20 subroutines. The original version of QUAL, as programmed by William A. White, 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.

The following section of this documentation describes, in detail, the main program, QUAL2, and its 20 subroutines.

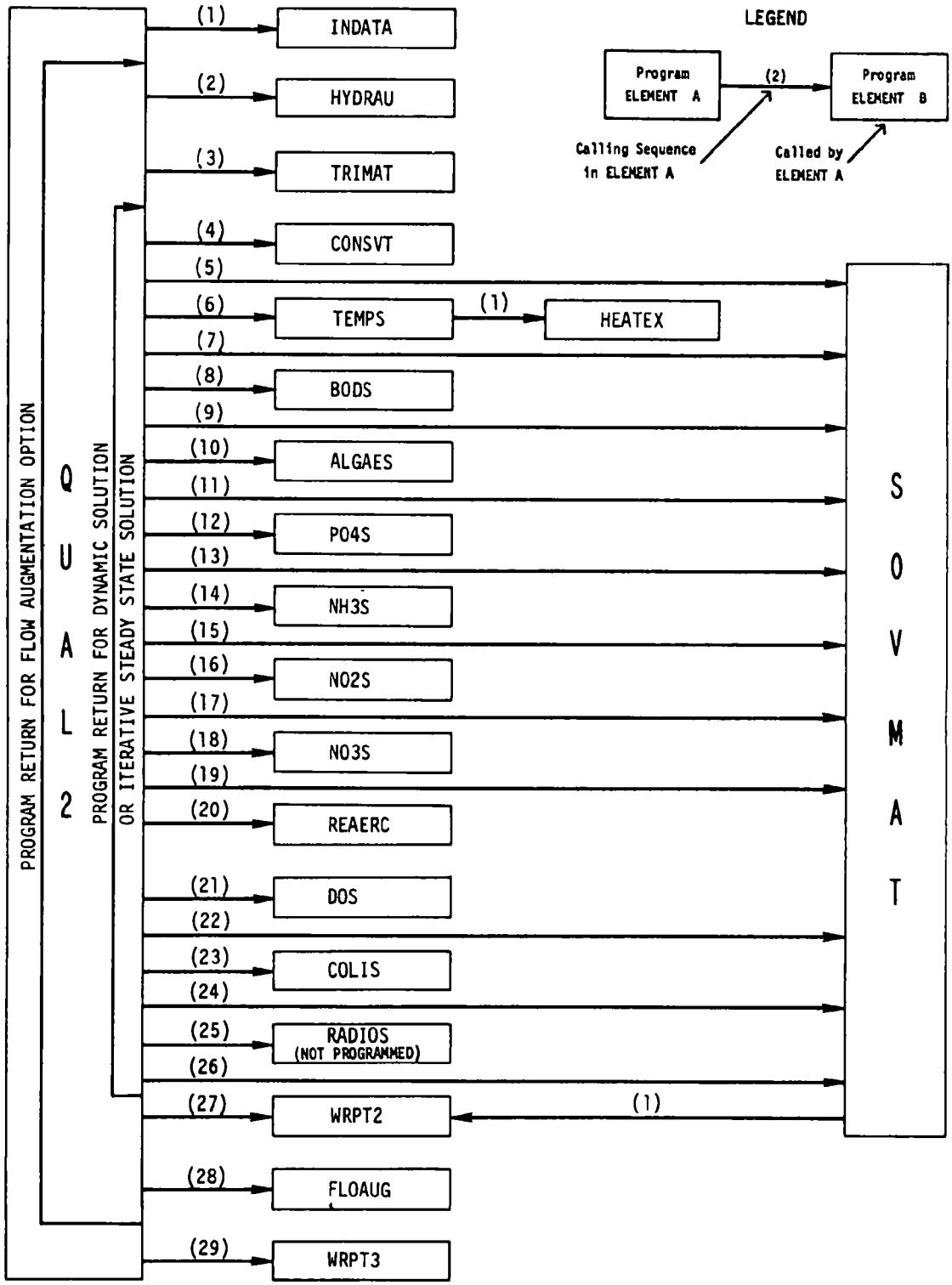

FIGURE III-1 GENERAL STRUCTURE OF QUAL-II

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SECTION IV
PROGRAM DESCRIPTIONS

This chapter describes the main program QUAL2, and its 20 subroutines. Each program description contains: (1) a brief written description of what the program does, including mathematical relationships; (2) a program flow chart; and (3) a program listing. Section V contains definitions of all program variables in COMMON storage.

MAIN PROGRAM QUAL2

QUAL2 is the main program of QUAL-II; it calls most of the subroutines, computes some miscellaneous constants, sets up the initial conditions, performs the convergence checks when a steady-state problem is being solved, and controls the printing of the output reports. The only subroutine not called by the main program is HEATEX, which is called by Subroutine TEMPS.

After QUAL2 calls INPUT, which reads in the input data, and computes some miscellaneous constants, it sets up the initial conditions for each computational element. Initial conditions for each reach are read in and used to define the initial conditions for all computational elements within a reach. QUAL2 then calls the subroutines necessary to simulate the water quality parameters specified on the title cards.

The input Title Data Cards (see Section VI) prescribe which water quality parameters QUAL-II will simulate. Whenever a Title Data Card indicates a parameter is to be simulated, the program assigns a positive integer to an internal variable (MODOPT) that indicates which model options are to be used. The correspondence between internal model options and parameters is as follows.

Model Option	Parameter(s) to be Simulated
MODOPT (1)	Conservative Constituents
MODOPT (2)	Temperature
MODOPT (3)	Biochemical Oxygen Demand
MODOPT (4)	Chlorophyll a
MODOPT (5)	Phosphorus (as P)
MODOPT (6)	Ammonia, Nitrite and Nitrate (as N)
MODOPT (7)	Dissolved Oxygen
MODOPT (8)	Coliforms
MODOPT (9)	Radionuclides (not programmed)

Any combination of the above options will work. However, it should be noted that if chlorophyll a is to be simulated when either phosphorus or the nitrogen cycle or both are not to be simulated, the program assumes they will not limit algae growth. Also, when chlorophyll a is to be simulated under steady-state conditions, QUAL2 uses an iterative numerical scheme to converge on a solution. Basically the procedure works as follows:

1. Calculate an algae growth rate based on the initial conditions for the first iteration.
2. Compute the resulting phosphorus and nitrate concentrations.
3. Recompute the growth rate based on the newly computed phosphorus and nitrate levels.
4. Compare the previous and newly computed growth rates.
5. If all growth rates have not changed by at least 0.05 per day, the problem is considered solved. If the growth rate change in any one computational element exceeds 0.05 per day, steps 2 through 5 are repeated.

Upon completion of the stream quality computations, QUAL2 selectively reports the results and execution is terminated.

The flow chart for QUAL2 is illustrated in Figure IV-1 and is followed by the program listing. All program variables contained in COMMON are described in Section V.

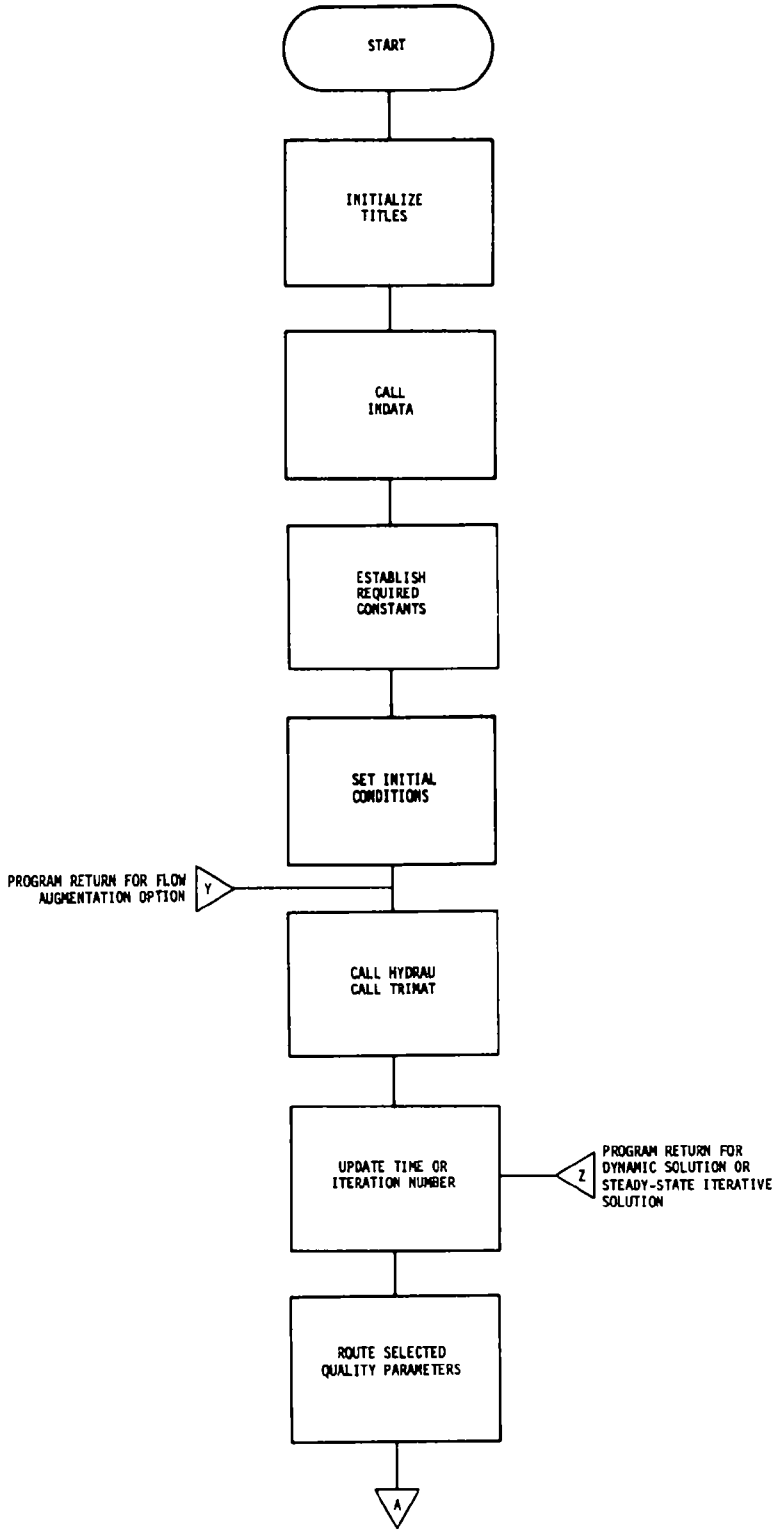

FIGURE IV-1 FLOW CHART FOR MAIN PROGRAM QUAL2

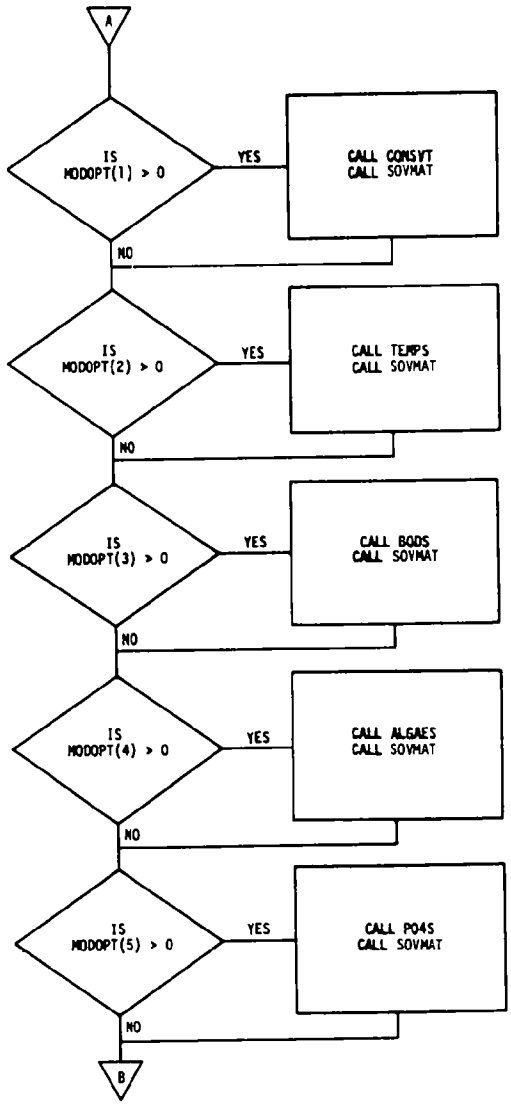

FIGURE IV-1 (cont.) FLOW CHART FOR MAIN PROGRAM QUAL2

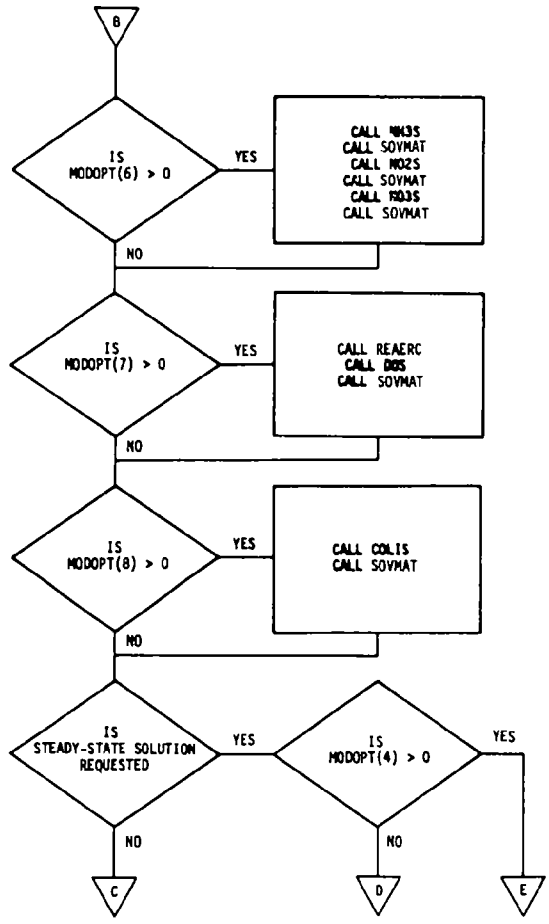

FIGURE IV-1 (cont.) FLOW CHART FOR MAIN PROGRAM QUAL2

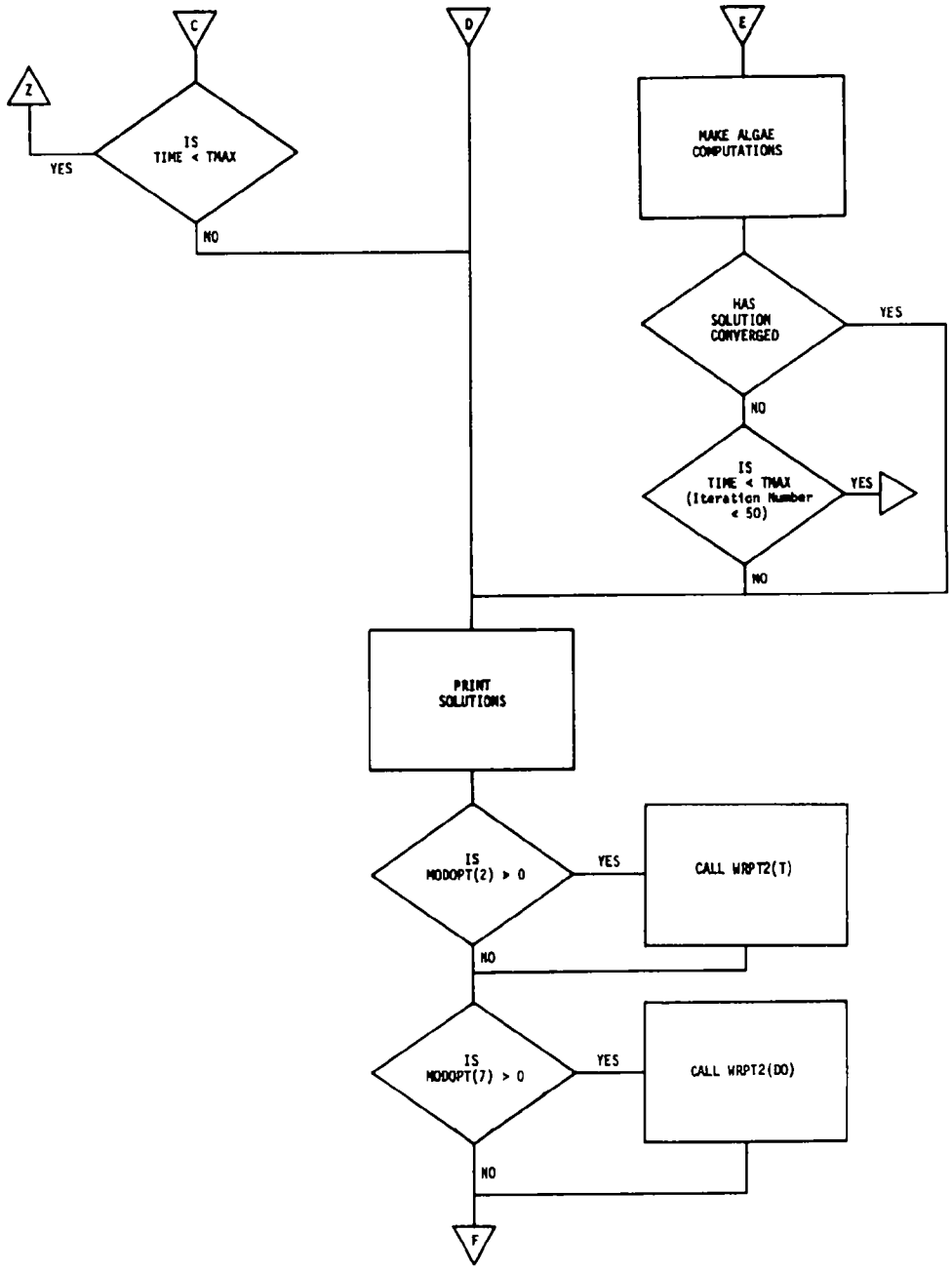

FIGURE IV-1 (cont.) FLOW CHART FOR MAIN PROGRAM QUAL2

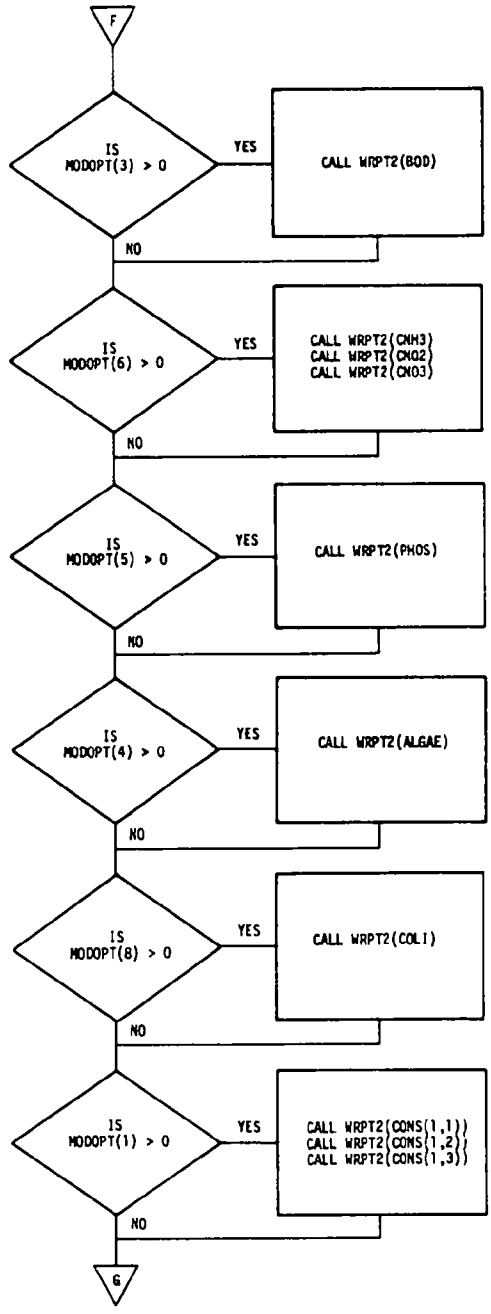

FIGURE IV-1(cont.) FLOW CHART FOR MAIN PROGRAM QUAL2

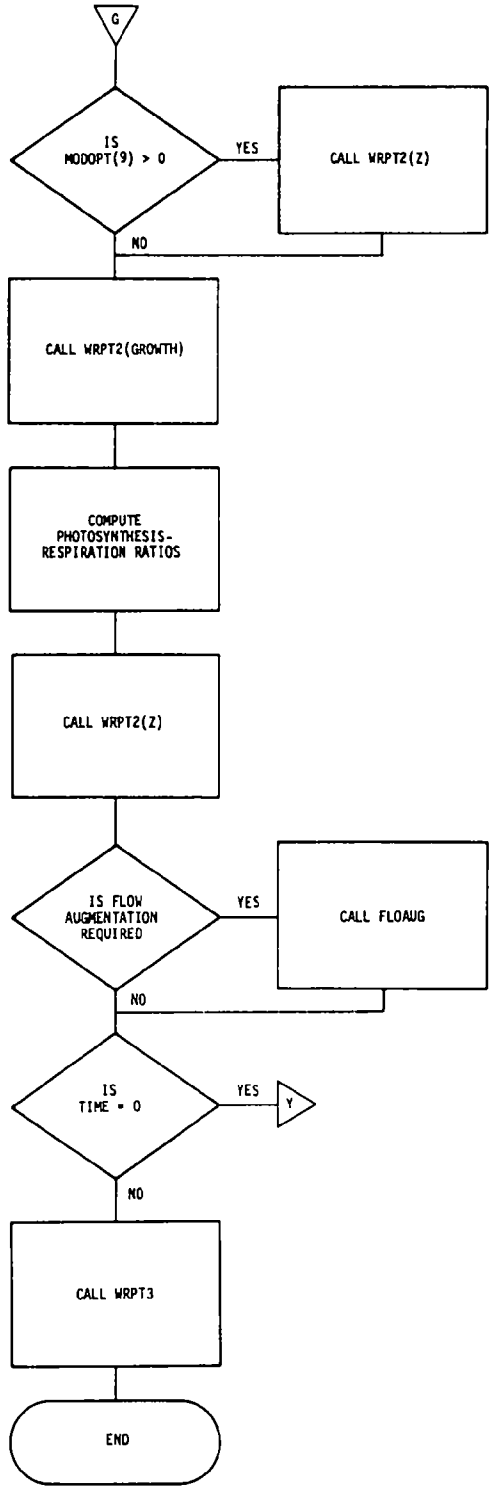

FIGURE IV-1 (cont.) FLOW CHART FOR MAIN PROGRAM QUAL2

```
C       PROGRAM QUAL-2                                                  *NEW
C                                                                       *NEW
C                               QUAL-2 IS A SET OF INTERRELATED STREAM  *NEW
C                                QUALITY ROUTING MODELS. IT HAS THE     **-3
C                                CAPABILITY TO ROUTE TEMP.,BOD/DO,
C                                NITROGEN SERIES, PHOSPHATE, ALGAE,
C                                COLIFORMS, RADIO NUCLIDE, AND
C                                UP TO THREE CONSERVATIVE MINERALS
C                                THROUGH A FULLY-MIXED STREAM SYSTEM.
C                                THESE PARAMETERS CAN BE ROUTED ON AN
C                                INDIVIDUAL BASIS OR SIMULTANEOUSLY IN
C                                SUCH A COMBINATION AS THE USER MAY
C                                DESIRE. QUAL-1 ALSO HAS THE CAPABILITY
C                                TO COMPUTE THE FLOW AUGMENTATION REQED.
C                                TO MEET PRESELECTED MIMIMUM DO LEVELS.
C                                HYDRAULICS ARE CONSIDERED STEADY-STATE.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),
     *       ICLORD(75,20),COEFOV(75),EXPOOV(75),COEFOH(75),EXPOOH(75),
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TREACT(90),WSFLOW(90),
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,
     *       NHBTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,
     *       LAT,LSM,LLM,ELEV,DAT,AF,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS
C
C
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),
     *       CKN,CKP,CKL,ALPHAO(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),
     *       MODOPT(10),IRCHNO(750),EXCOFF(75)
C
C
      COMMON/SSTATE/ X(500),ISS
C
C
      COMMON/RADION/ CK6(75),RADNIT(75),RADMI(75),HWRADN(15),WSRADN(90)
C
      DIMENSION TITL19(15),TITL20(15)
      REAL K1,K2,LAT,LLM,LSM,JUNCID
```

```
      DATA TITL19                /4H ALG,4HAF G,4HROWT,4HH RA,4HTES ,4HIM
     *P,4HEN D,4HAY A,4HRE  ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    /
      DATA TITL20                /4H PHO,4HTOSY,4HNTHE,4HSIS-,4HRESP,4HIRA
     *T,4HION ,4HRATI,4HOS A,4HPE  ,4H    ,4H    ,4H    ,4H    ,4H    /
C                                                                       00003400
C                                                                       00005900
C                                         STEP 1-0                      00003500
C                                         INITIALIZE CERTAIN PARAMETERS 00003600
      DO 10 J=6,20
      I=J-5
      TITLE(19,J)=TITL19(I)
      TITLE(20,J)=TITL20(I)
   10 CONTINUE
C                                                                       00005900
C                                         STEP 2-0                      00006000
C                                         READ IN TITLES                00006100
C                                                                       00008300
C                                         STEP 3-0                      00008400
C                                         READ IN ALL DATA REQUIRED FOR OP00008500
C                                         OF THE MODELS.                00008600
C
C                                         STEP 4-0                      00064600
C                                         IF THE CORRECT NO. OF DATA CARDS00064700
C                                         NOT BEEN READ IN, THE PROGRAM WI00064800
C                                         TERMINATE.                    00064900
C                                                                       00065000
      CALL INDATA(ILIST,IRPT1,IAUGOP,TMAX,NCELLS)
C                                         STEP 5-0                      00066500
C                                         ESTABLISH REQUIRED CONSTANTS. 00066600
C                                                                       00066700
      DELX=DELX*5280.0                                                  00066800
      IF (ISS) 901,901,900
  900 D1LT = 1.0/24.0
      D2LT = 1.0
      DELT = 3600.0
      IF (PTIME.LE.0.) PTIME=TMAX                                                    *NEW
      GO TO 902
  901 D1LT = DELT/24.0
      D2LT=DELT                                                         00067000
      DELT=DELT*3600.0                                                  00067100
      TMAX=TMAX-0.01                                                    00067200
  902 CONTINUE
      DT2DX2=DELT/(DELX*DELX)                                           00067300
      DT2DX=2.0*DELT/DELX                                               00067400
C                                                                       00067500
C                                         STEP 6-0                      00067600
C                                         SET INITIAL CONDITIONS.       00067700
C                                                                       00067800
  998 CALL HYDRAU                                                       00070800
      CALL TRIMAT                                                       00070900
C                                         CONVERSION OF CKL TO LANGLEYS/HR
      CKL=CKL*60.
C                                         CONVERSION TO BTU/SQ.FT./HR
      IF (MODOPT(2).GT.0) CKL=CKL*3.685
C                                         THE FOLLOWING COMPUTES THE
C                                         AVERAGE LIGHT INTENSITY FOR
C                                         STEADY-STATE COMPUTATION
      IF (ISS.LE.0) GO TO 110
      FUNCT=0.0
      IF (SOLFT.LT.1.0E-4) GO TO 51
```

```
      NDLH=14
      DLH=FLOAT(NDLH)
      SOAVE=SONET/DLH
      DO 50 M=1,NDLH
      FM=M
      TOT=SOAVE*(1.0-COS(6.28*FM/DLH))
   50 FUNCT=FUNCT+(TOT/(CKL+TOT))
   51 CONTINUE
      FUNCT=FUNCT/24.
      SONNEN=CKL*FUNCT/(1.-FUNCT)
  110 CONTINUE
      DO 915 I=1,NREACH                                                 00067900
      NCELR=NCELRH(I)                                                   00068000
      DO 915 J=1,NCELR                                                  00068100
      IOR=ICLORD(I,J)                                                   00068200
      T(IOR)=TINIT(I)                                                   00068300
      DO(IOR)=DOINIT(I)                                                 00068400
      BOD(IOR)=BOINIT(I)                                                00068500
      CONS(IOR,1)=COINIT(I,1)                                           00068600
      CONS(IOR,2)=COINIT(I,2)                                           00068700
      CONS(IOR,3)=COINIT(I,3)                                           00068800
      ALGAE(IOR)=ALGIT(I)
      PHOS(IOR)=PHOSIT(I)
      CNH3(IOR)=CNH3IT(I)
      CNO2(IOR)=CNO2IT(I)
      CNO3(IOR)=CNO3IT(I)
      COLI(IOR)=COLIIT(I)
      IF(MODOPT(4).EQ.0)  GO TO 915
      TC=0.556*(T(IOR)-68.0)
      EXPT=EXP(-EXCOEF(I)*DEPTH(IOR))
      TLOG=ALOG((CKL+SONNEN)/(CKL+SONNEN*EXPT))
      GROWTH(IOR)=GROMAX*TLOG/(EXCOEF(I)*DEPTH(IOR))
      GROWTH(IOR)=GROWTH(IOR)*1.047**TC
  915 CONTINUE                                                          00068900
      DO 922 NWS=1,NWASTE                                               00069000
      EFLBOD=1.0-TREACT(NWS)                                            00069100
      WSBOD(NWS)=EFLBOD*WSBOD(NWS)                                      00069200
  922 CONTINUE                                                          00069300
C                                                                       00069400
C                                       STEP 7-0                        00069500
C                                       BEGIN COMPUTATIONS AND OPERATE U00069600
C                                       STEADY-STATE CONDITIONS ARE REAC00069700
C                                       WHICH IS THE TIME (TMAX) REQUIRE00069800
C                                       WATER PARTICLE AT THE UPPERMOST 00069900
C                                       IN THE SYSTEM TO REACH THE END 000070000
C                                       THE SYSTEM.                     00070100
C                                                                       00070200
C                                       STEP 7-1                        00070300
C                                       CALL SUBROUTINES TO PERFORM HYDR00070400
C                                       BALANCE ON SYSTEM AND ESTABLISH 00070500
C                                       COEFFICIENT MATRIX.             00070600
C                                                                       00070700
  999 TIME=TIME+D2LT                                                    00071000
      TPRINT=TPRINT+D2LT                                                00071100
C                                                                       00071200
C                                       STEP 7-2                        00071300
C                                       ROUTE SELECTED QUALITY PARAMETER00071400
C                                                                       00071500
C                                       MODOPT(1)    CONSERVATIVE
C                                       MODOPT(2)    TEMPERATURE
```

```
C                                       MODOPT(3)   BOD
C                                       MODOPT(4)   CHLOROPHYLL A
C                                       MODOPT(5)   PHOSPHOROUS
C                                       MODOPT(6)   NH3,NO2,NO3
C                                       MODOPT(7)   OXYGEN
C                                       MODOPT(8)   COLIFORMS
C                                       MODOPT(9)   RADIOACTIVE
C                                                                          00072300
      IF (MODOPT(1).EQ.0) GO TO 702
  701 NT=3                                                                 00072500
      DO 777 NC=1,NCS                                                      00072600
      CALL CONSVT                                                          00072700
      CALL SOVMAT                                                          00072800
      NT=NT+1                                                              00072900
      DO 888 I=1,NCELLS                                                    00073000
      CONS(I,NC)=Z(I)                                                      00073100
  888 CONTINUE                                                             00073200
  777 CONTINUE                                                             00073300
C
  702 IF (MODOPT(2).EQ.0) GO TO 703
C******** RUN 1, 1973  STEADY STATE TEMP SOLUTION NOT OPERABLE                    *NEW
      IF (ISS.GT.0) GO TO 703                                                     *NEW
      NT = 6
      CALL TEMPS                                                           00073500
      CALL SOVMAT                                                          00073600
      DO 800 I=1,NCELLS                                                    00073700
      T(I)=Z(I)                                                            00073800
  800 CONTINUE                                                             00073900
C
  703 IF (MODOPT(3).EQ.0) GO TO 704
      NT = 7
      CALL BODS                                                            00074100
      CALL SOVMAT                                                          00074200
      DO 802 I=1,NCELLS                                                    00074300
      BOD(I)=Z(I)                                                          00074400
  802 CONTINUE                                                             00074500
C
  704 IF (MODOPT(4).EQ.0) GO TO 705
      NT = 8
      CALL ALGAES
      CALL SOVMAT
      DO 804 I=1,NCELLS
      ALGAE(I) = Z(I)
      IF (ALGAE(I).GT.50.) ALGAE(I)=50.
  804 CONTINUE
C
  705 IF (MODOPT(5).EQ.0) GO TO 706
      NT = 9
      CALL PO4S
      CALL SOVMAT
      DO 805 I=1,NCELLS
      PHOS(I) = Z(I)
  805 CONTINUE
C
  706 IF (MODOPT(6).EQ.0) GO TO 707
      NT = 10
      CALL NH3S
      CALL SOVMAT
      DO 806 I=1,NCELLS
      CNH3(I) = Z(I)
```

```
  806 CONTINUE
      NT = 11
      CALL NO2S
      CALL SOVMAT
      DO 816 I=1,NCELLS
      CNO2(I) = Z(I)
  816 CONTINUE
      NT = 12
      CALL NO3S
      CALL SOVMAT
      DO 826 I=1,NCELLS
      CNO3(I) = Z(I)
  826 CONTINUE
C
  707 IF (MODOPT(7).EQ.0) GO TO 708
      NT = 13
      CALL PEAERC                                                       00074700
      CALL DOS                                                          00074800
      CALL SOVMAT                                                       00074900
      DO 803 I=1,NCELLS                                                 00075000
      DO(I)=Z(I)                                                        00075100
  803 CONTINUE                                                          00075200
  708 IF (MODOPT(8).EQ.0) GO TO 799
      NT = 14
      CALL COLIS
      CALL SOVMAT
      DO 807 I=1,NCELLS
      COLI(I) = Z(I)
  807 CONTINUE
  799 CONTINUE                                                          00079000
      IF (TPRINT.LT.PTIME) GO TO 997                                    00079100
      TPRINT=0.0                                                        00079200
  997 CONTINUE                                                          00079300
C                                                                       00079400
C                                       STEP 7-3                        00079500
C                                       IF STEADY-STATE CONDITION HAS N00079600
C                                       REACHED, CONTINUE ROUTING.      00079700
C                                                                       00079800
      IF(ISS) 9996,9996,9990
 9990 IF (MODOPT(4)) 1001,1001,9992                                                *NEW
 9992 NUM = 0                                                                      **-1
      ITER = ITER + 1
      WRITE (NU,7779) ITER
 7779 FORMAT (12H ITERATION  ,I5)
      DO 9994 JJ=1,NREACH
      NCELR=NCELPH(JJ)
      DO 9994 KK=1,NCELR
      T=TCLOPD(JJ,KK)
      TC=0.556*(T(I)-68.0)
      EXPT=EXP(-EXCOEF(JJ)*DEPTH(I))
      TLOC=ALOG((CKL+SONNEN)/(CKL+SONNEN*EXPT))
      XGROW=GROMAX*TLOG/(EXCOEF(JJ)*DEPTH(I))
      XGROW=XGROW*1.047**TC
      TT = DELX/(VEL(I)*86400.)
      TGROW = XGROW
      IF (MODOPT(5).EQ.0) GO TO 9820
      DGDP = -1.0/(ALPHA2*ALGAE(I)*TT)
      XA = DGDP
      XB = GROWTH(I)*(CKP+PHOS(I))*DGDP-XGROW
      XC = GROWTH(I)*(CKP+PHOS(I))-XGROW*PHOS(I)
```

```
      ROOT = SQRT(XB*XB-4.0*XA*XC)
      DPHOS=-0.5*XB/XA + 0.5*ROOT/ABS(XA)
      PHOS(I) = PHOS(I)+DPHOS
      IF (PHOS(I).LT.0.0) PHOS(I) = 0.0
      TCROW = XCROW*PHOS(I)/(CKP+PHOS(I))
 9820 IF (MODOPT(6).EQ.0) GO TO 9840
      DGDN = -1.0/(ALPHA1*ALGAE(I)*TT)
      XA = DGDN
      XB = GROWTH(I)+(CKN+CNO3(I))*DGDN-XGROW
      XC = GROWTH(I)*(CKN+CNO3(I))-XGROW*CNO3(I)
      ROOT = SQRT(XB*XB-4.0*XA*XC)
      DCNO3=-0.5*XB/XA + 0.5*ROOT/ABS(XA)
      CNO3(I) = CNO3(I) + DCNO3
      IF (CNO3(I).LT.0.0) CNO3(I) = 0.0
      TCROW = TCROW*CNO3(I)/(CKN+CNO3(I))
 9840 CONTINUE
      DG = TCROW - GROWTH(I)
      IF (ABS(DG).LT.0.05) GO TO 8994
      NUM = NUM + 1
 8994 GROWTH(I) = GROWTH(I) + 0.7*DG
 9994 CONTINUE
      WRITE (NU,7780) NUM
 7780 FORMAT (30H GROWTH RATE NON CONVERGENT IN,I4,9H ELEMENTS)
      IF (NUM) 1001,1001,9996
 9996 IF(TIME .LT. TMAX) GO TO 999
      IF (ISS) 9998,9998,1001
 1001 CONTINUE
      IF (MODOPT(2)) 1011,1011,1002
 1002 NT=6
C********JULY 1, 1973  STEADY STATE TEMP SOLUTION NOT OPERABLE                    *NEW
      GO TO 1011                                                                  *NEW
      CALL WRPT2(T)
 1011 CONTINUE
      IF (MODOPT(7)) 1021,1021,1012
 1012 NT=13
      CALL WRPT2(DO)
 1021 CONTINUE
      IF (MODOPT(3)) 1031,1031,1022
 1022 NT=7
      CALL WRPT2(BOD)
 1031 CONTINUE
      IF (MODOPT(6)) 1041,1041,1032
 1032 NT=10
      CALL WRPT2(CNH3)
      NT=11
      CALL WRPT2 (CNO2)
      NT=12
      CALL WRPT2 (CNO3)
 1041 CONTINUE
      IF (MODOPT(5)) 1051,1051,1042
 1042 NT=9
      CALL WRPT2 (PHOS)
 1051 CONTINUE
      IF (MODOPT(4)) 1061,1061,1052
 1052 NT=8
      CALL WRPT2 (ALGAE)
 1061 CONTINUE
      IF (MODOPT(8)) 1071,1071,1062
 1062 NT=14
      CALL WRPT2 (COLT)
```

```
 1071 CONTINUE
      IF (MODOPT(1)) 1081,1081,1072
 1072 NT=3
      DO 1075 NC=1,NCS
      CALL WRPT2 (CONS(1,NC))
 1075 NT=NT+1
 1081 CONTINUE
      IF (MODOPT(9)) 1091,1091,1082
 1082 NT=15
C        THIS DATE JAN 12, 1973 NO PROVISION FOR RADIONUCLIDES
      CALL WRPT2 (Z)
 1091 CONTINUE
 9998 CONTINUE
      IF (MODOPT(4).EQ.0) GO TO 9965                                    *NEW
C
      NT=19
      CALL WRPT2 (GROWTH)
C
      XTEMP = ALPHA3/ALPHA4
      DO 9960 I=1,NCELLS
      Z(I) = XTEMP*GROWTH(I)/RESPRR(I)
 9960 CONTINUE
      NT = 20
      CALL WRPT2 (Z)
 9965 CONTINUE                                                          *NEW
C
C                                                                 00080000
C                                        STEP 8-0                 00080100
C                                        IF FLOW AUGMENTATION IS DESIRED,00080200
C                                        HOW MUCH IS REQUIRED, AUGMENT T00080300
C                                        NECESSARY HEADWATER FLOWS AND ST00080400
C                                        ROUTING AGAIN AT TIME = ZERO.   00080500
C                                                                 00080600
      IF (IAUGOP.EQ.0) GO TO 9999                                 00080700
      CALL FLOAUG                                                 00080800
      IF (TIME.EQ.0.0) GO TO 998                                  00080900
 9999 CONTINUE                                                    00081000
      IF(IRPT1.EQ.1)  CALL WRPT3
      STOP                                                        00081500
      END                                                         00081600
```

SUBROUTINE ALGAES*

Subroutine ALGAES completes the setup of the equations necessary to calculate algal biomass concentrations in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations. In addition, solar radiation is read at three hour intervals if a dynamic simulation is being performed.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computation element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i - (\mu_i - \rho - \sigma_1)\Delta t$
7. Withdrawal	$b_i = x_i - (\mu_i - \rho - \sigma_1)\Delta t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The growth rate, μ_i, is computed according to Equation II-6 as

$$\mu_i = \mu_{max} \frac{N_3}{N_3 + K_N}_i \frac{P}{P + K_P}_i \frac{1}{\lambda_i D_i} \ln \frac{K_L + L}{K_L + Le^{-\lambda_i D_i}}$$

For dynamic simulation, nitrate (N_3) and phosphorus (P) values from the previous time period are used to calculate the growth rate; for steady-state simulation, values from the previous iteration are used.

If, under the program options, algal concentrations are being simulated and either nitrate or phosphorus or both are <u>not</u> being simulated, the program assumes that the parameter or parameters not simulated are not limiting. For example, if both nitrate and phosphorus are <u>not</u> being simulated the growth rate would be computed as

$$\mu_i = \hat{\mu} \frac{1}{\lambda_i D_i} \ln \frac{K_L + L}{K_L + Le^{-\lambda_i D_i}}$$

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = A_i^* + q_i' A_i' \frac{\Delta t}{v_i} - a_i A_h$
6. Waste Input	$S_i = A_i^* + q_i' A_i' \frac{\Delta t}{v_i} + q_w A_w \frac{\Delta t}{v_i}$
All Others	$S_i = A_i^* + q_i' A_i' \frac{\Delta t}{v_i}$

For steady-state simulation, the only difference is that the value from the previous time step, A_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-2 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

*All symbols used are defined at the end of this section of the Documentation Report.

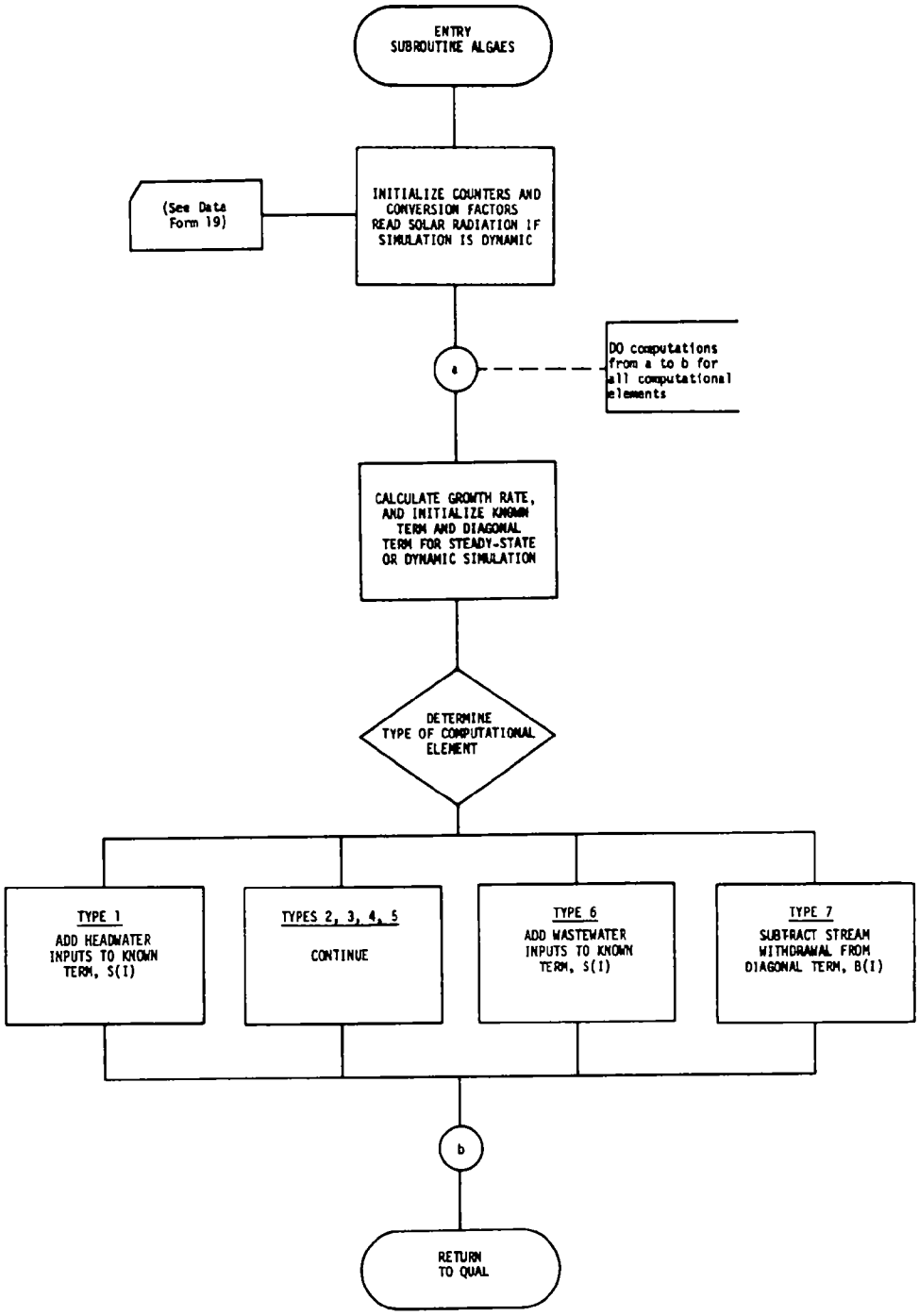

FIGURE IV-2 FLOW CHART FOR SUBROUTINE ALGAES

```
      SUBROUTINE ALGAES
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),TAUGOR(75,6),NCFLRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       BO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BF,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       AIRPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *NEW
C                                                                                *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),               *NEW
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,                 *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                   *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),                 *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),                 *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                   *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),               *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),              *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),                 *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),               *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                   *NEW
C                                                                                *-29
      COMMON/SSTATE/X(500),ISS
C
C                                INITIALIZE COUNTERS
C
      NHW=0
      NWS=0
C
C                                          READ SOLAR RADIATION DATA IF REQD
C
      IF(ISS .GT. 0 .OR. MODOPT(2) .GT. 0) GO TO 20
      IF(TRLCD) 10,10,15
   10 READ(NI,11) SONET
   11 FORMAT(30X,F10.0)
      TRLCD=3.0
   15 TRLCD=TRLCD-D2LT
   20 CONTINUE
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELR=NCFLRH(I)
      CNCELR=NCELR
      ALGIJ = QI(I)/CNCELR*ALGI(I)
      DO 100 J=1,NCELR
```

```
      IOR=ICLORD(I,J)
C
C                                COMPUTE ALGAE GROWTH RATES
C
      TC = 0.556*(T(IOR)-68.0)
      RESPRR(IOP)=RESPRT*1.047**TC
      ALSINK = ALGSFT(I)/(CNCELR*DEPTH(IOP))
      IF (ISS.GT.0) GO TO 52
      EXPT=EXP(-EXCOEF(I)*DEPTH(IOP))
      TLOG=ALOG((CKL+SONET )/(CKL+SONET *EXPT))
      GROWTH(IOP)=GROMAX*TLOG/(EXCOEF(I)*DEPTH(IOP))
      GROWTH(IOP)=GROWTH(IOR)*1.047**TC
      IF (MODOPT(5).EQ.0) GO TO 50
      GROWTH(IOR) = GROWTH(IOR)*PHOS(IOR)/(CKP+PHOS(IOR))
   50 IF (MODOPT(6).EQ.0) GO TO 52
      GROWTH(IOR) = GROWTH(IOR)*CNO3(IOR)/(CKN+CNO3(IOR))
   52 CONTINUE
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      REACT=GROWTH(IOP)-RESPRR(IOR)-ALSINK
      B(IOR)=X(IOR)-REACT*D1LT
      S(IOR)=ALGAE(IOR)
      IF(ISS.GT.1) S(IOR)=0.0
      S(IOR) = S(IOR)+ALGIJ*DTOVCL(IOR)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      IFL=IFLAG(I,J)
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR) = S(IOR) - A(IOR)*HWALG(NHW)
      GO TO 100
  103 NWS=NWS+1
      S(IOR) = S(IOR) + WSFLOW(NWS)*WSALG(NWS)*DTOVCL(IOR)
      GO TO 100
  104 NWS=NWS+1
      B(IOR) = B(IOR) - WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE BODS*

Subroutine BODS completes the setup of the equations necessary to calculate BOD levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i + (K_1 + K_3)\Delta t$
7. Withdrawal	$b_i = x_i + (K_1 + K_3)\Delta t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = L_i^* + q_i' L_i' \frac{\Delta t}{v_i} - a_i L_h$
6. Waste Input	$S_i = L_i^* + q_i' L_i' \frac{\Delta t}{v_i} + q_w L_w \frac{\Delta t}{v_i}$
All Others	$S_i = L_i^* + q_i' L_i' \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, L_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-3 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

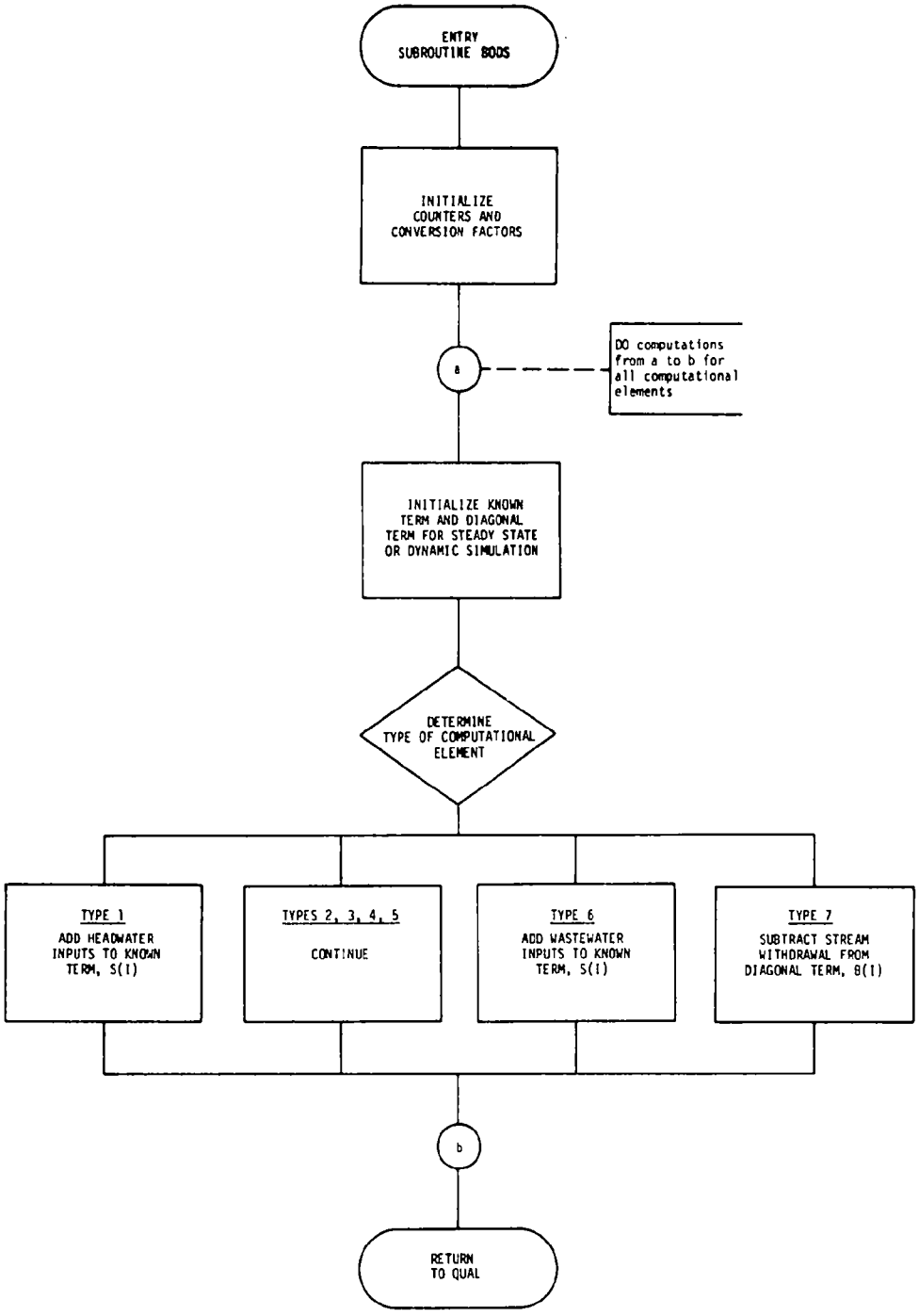

FIGURE IV-3 FLOW CHART FOR SUBROUTINE BODS

```
      SUBROUTINE BODS
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CHANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TREACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SOMFT,NI,NJ,TRLCC,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
C
      COMMON/SSTATE/X(500),ISS
      REAL K1,K3                                                          00002300
C                                                                         00002400
C                                INITIALIZE COUNTERS
C                                                                         00002800
      NHW=0                                                               00002900
      NWS=0                                                               00003000
C                                                                         00003100
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C                                                                         00003600
      DO 100 I=1,NREACH                                                   00003700
      NCELR=NCELRH(I)                                                     00003800
      CNCELR=NCELR                                                        00003900
      BODIJ=QI(I)/CNCELR*BODI(I)                                          00004000
      DO 100 J=1,NCELR                                                    00004100
      IOR=ICLORD(I,J)                                                     00004200
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      TC=0.555*(T(IOR)-68.0)                                              00004300
      K1(IOR)=CK1(I)*1.047**TC                                            00004400
      K3=CK3(I)                                                           00004500
      REACT=D1LT*(K1(IOR)+K3)
      B(IOR)=X(IOR)+REACT
      S(IOR)=BOD(IOR)
      IF(ISS.GT.1) S(IOR)=0.0
      S(IOR)=S(IOR)+BODIJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)                                                      00004700
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C                                                                         00005300
  101 NHW=NHW+1                                                           00005400
      S(IOR)=S(IOR)-X(IOR)*HWBOD(NHW)
```

```
      GO TO 100                                                         00005600
  103 NWS=NWS+1                                                         00006900
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSBOD(NWS)*DTOVCL(IOR)
      GO TO 100                                                         00007100
  104 NWS=NWS+1                                                         00007700
      P(IOR)=P(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE                                                          00007900
      RETURN                                                            00008000
      END                                                               00008100
```

SUBROUTINE COLIS*

Subroutine COLIS completes the setup of the equations necessary to calculate coliform levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i + K_5 \Delta t$
7. Withdrawal	$b_i = x_i + K_5 \Delta t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = E_i^* + q_i' E_i' \frac{\Delta t}{v_i} - a_i E_h$
6. Waste Input	$S_i = E_i^* + q_i' E_i' \frac{\Delta t}{v_i} + q_w E_w \frac{\Delta t}{v_i}$
All Others	$S_i + E_i^* + q_i' E_i' \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, E_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-4 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

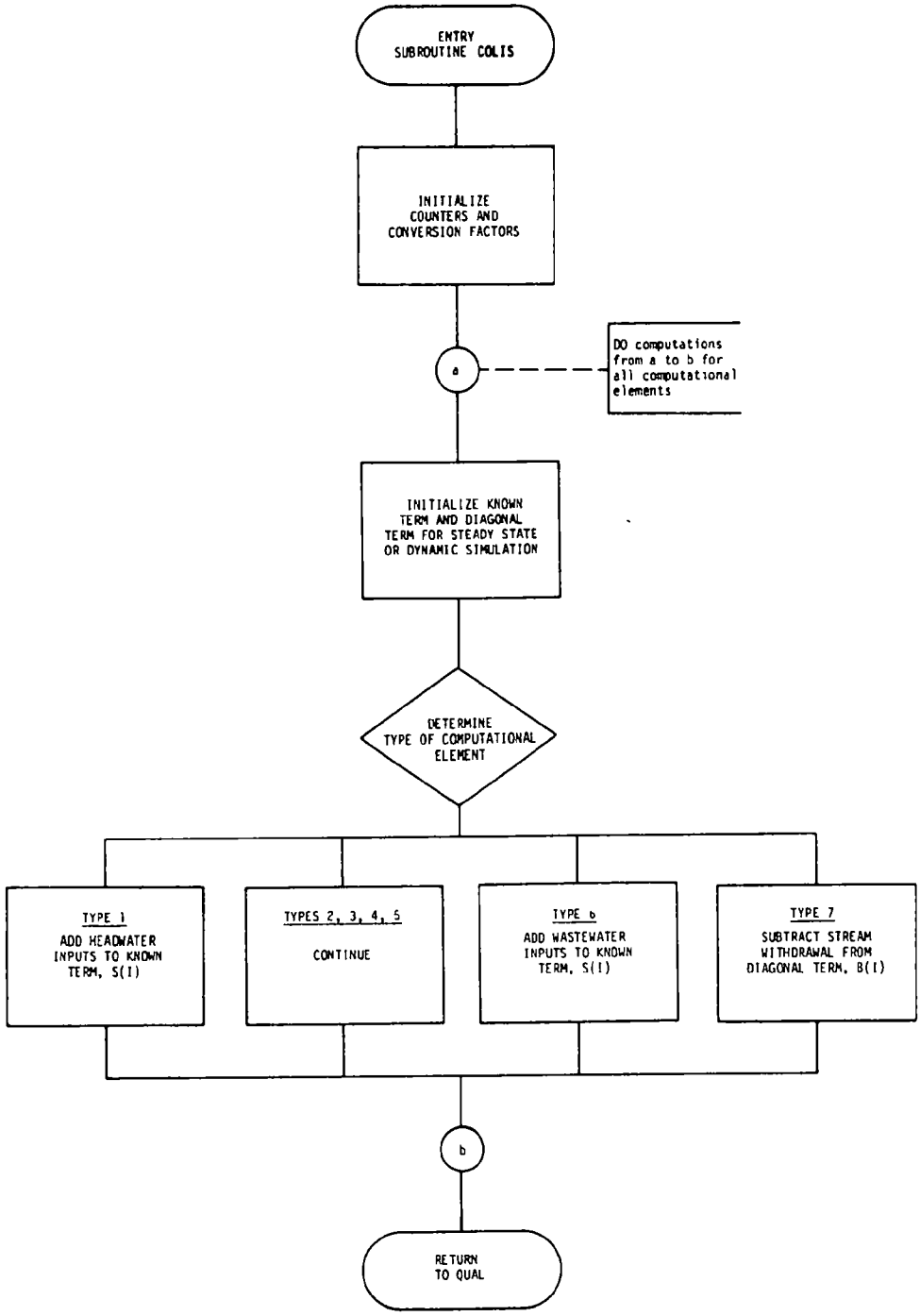

FIGURE IV-4 FLOW CHART FOR SUBROUTINE COLIS

```
      SUBROUTINE COLIS
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),        *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                  *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),        *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),           *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),          *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),          *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),           *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),        *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),             *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),            *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),        *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),             *NEW
     *       DO(500),POD(500),CONS(500,3),PTIME,TPRINT,DELX,                   *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,          *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,            *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS          *NEW
C                                                                              *NEW
C                                                                              *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),             *NEW
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,               *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                 *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),               *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),               *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                 *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),             *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),            *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),               *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),             *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                 *NEW
C                                                                              *-29
C
      COMMON/SSTATE/X(500),ISS
      REAL K5
C
C                                INITIALIZE COUNTERS
C
      NHW=0
      NWS=0
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELR=NCELRH(I)
      CNCELR=NCELR
      COLIJ=QI(I)/CNCELR*COLIR(I)
      DO 100 J=1,NCELR
      IOR=ICLORD(I,J)
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      TC=0.556*(T(IOR)-68.0)
      K5=CK5(I)*1.047**TC
      REACT=D1LT*K5
```

```
      B(IOR)=X(IOR)+REACT
      S(IOR)=COLI(IOR)
      IF (ISS.GT.0) S(IOR)=0.0
      S(IOR)=S(IOR)+COLIJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR)=S(IOR)-A(IOR)*HWCOLI(NHW)
      GO TO 100
C
  103 NWS=NWS+1
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSCOLI(NWS)*DTOVCL(IOR)
      GO TO 100
C
  104 NWS=NWS+1
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE CONSVT*

Subroutine CONSVT completes the setup of the equations necessary to calculate concentrations of a conservative constituent level in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i$
7. Withdrawal	$b_i = x_i - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = C_i^* + q_i' C_i' \frac{\Delta t}{v_i} - a_i C_h$
6. Waste Input	$S_i = C_i^* + q_i' C_i' \frac{\Delta t}{v_i} - q_w C_w \frac{\Delta t}{v_i}$
All Others	$S_i = C_i^* + q_i' C_i' \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, C_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-5 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

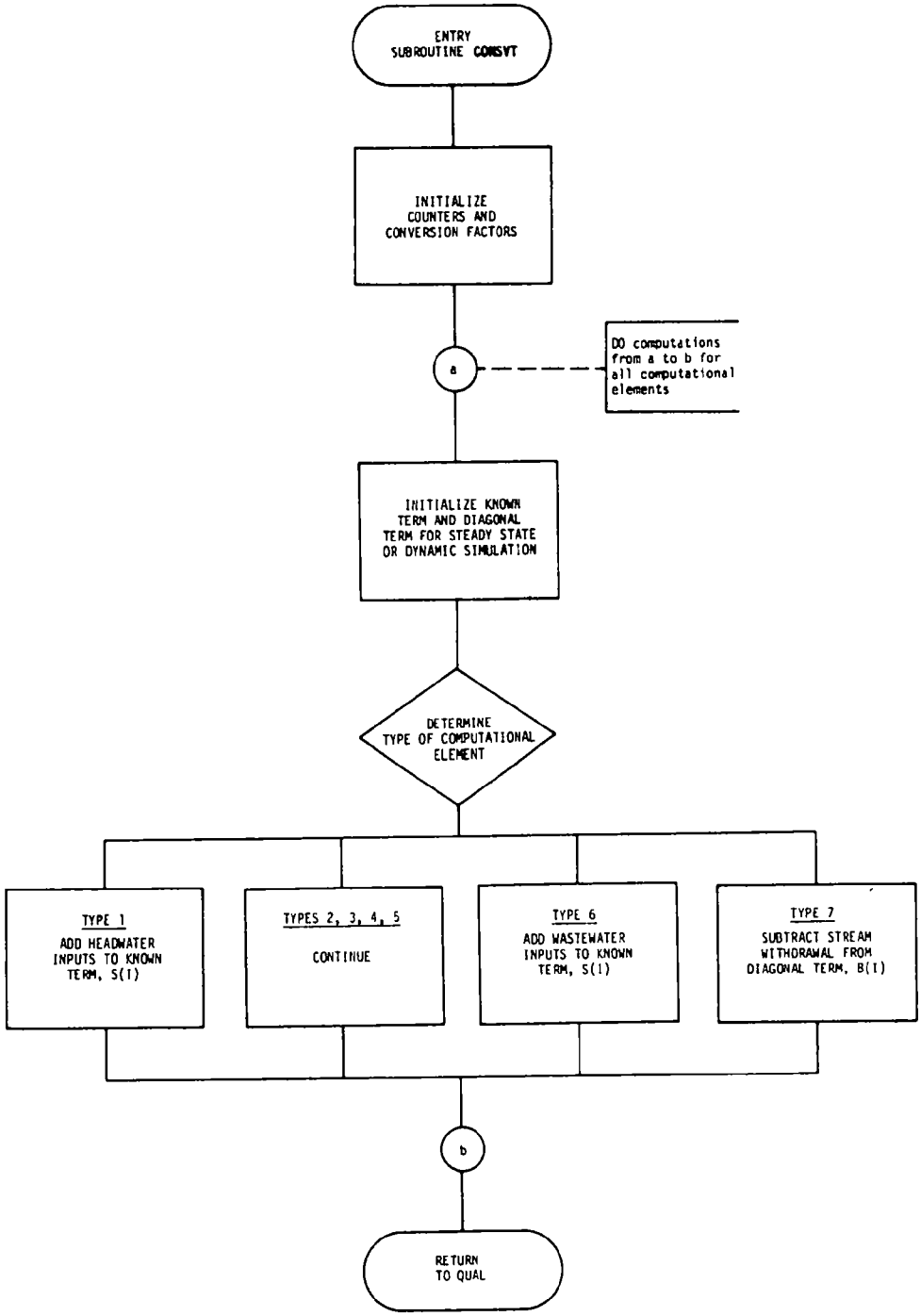

FIGURE IV-5 FLOW CHART FOR SUBROUTINE CONSVT

```
      SUBROUTINE CONSVT
C
C                                CONSVT PERFORMS A CONSERVATIVE MINERAL
C                                BALANCE FOR EACH COMPUTATIONAL ELEMENT
C                                IN THE SYSTEM.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DFPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,ELM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
      COMMON/SSTATE/X(500),ISS
C                                                                     00002300
C                                INITIALIZE COUNTERS
C                                                                     00002700
      NHW=0                                                           00002800
      NJS=0                                                           00002900
C                                                                     00003000
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C                                                                     00003500
      DO 100 I=1,NREACH                                               00003600
      NCELR=NCELRH(I)                                                 00003700
      CNCELR=NCELR                                                    00003800
      CONSIJ=QI(I)/CNCELR*CONSI(I,NC)                                 00003900
      DO 100 J=1,NCELR                                                00004000
      IOR=ICLORD(I,J)                                                 00004100
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      B(IOR)=X(IOR)
      S(IOR)=CONS(IOR,NC)
      IF(ISS.GT.1) S(IOR)=0.0
      S(IOR)=S(IOR)+CONSIJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)                                                  00004200
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C                                                                     00004400
  101 NHW=NHW+1                                                       00004900
      S(IOR)=S(IOR)-A(IOR)*HWCONS(NHW,NC)
      GO TO 100                                                       00005100
C                                                                     00005200
```

```
  103 NWS=NWS+1                                                         00006400
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSCONS(NWS,NC)*DTOVCL(IOR)
      GO TO 100                                                         00006700
C                                                                       00006800
  104 NWS=NWS+1                                                         00007300
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE                                                          00007500
      RETURN                                                            00007600
      END                                                               00007700
```

SUBROUTINE DOS*

Subroutine DOS completes the setup of the equations necessary to calculate dissolved oxygen levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i + (K_2)_i \Delta t$
7. Withdrawal	$b_i = x_i + (K_2)_i \Delta t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT and the reaeration rate reaeration constant, $(K_2)_i$, is determined in Subroutine REAERC.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

$$S_i = \phi_i^* + q_i'\phi_i' \frac{\Delta t}{v_i} + (\alpha_3\mu_i - \alpha_4\rho) A_i\Delta t - \alpha_5(K_7N_1)_i \Delta t$$

$$- \alpha_6(K_8N_2) \Delta t - K_4\Delta x \frac{\Delta t}{v_i} + (K_2C_5)_i \Delta t - K_1L_i\Delta t$$

and is corrected for headwater conditions or a waste input as follows:

*All symbols used are defined at the end of this section of the Documentation Report.

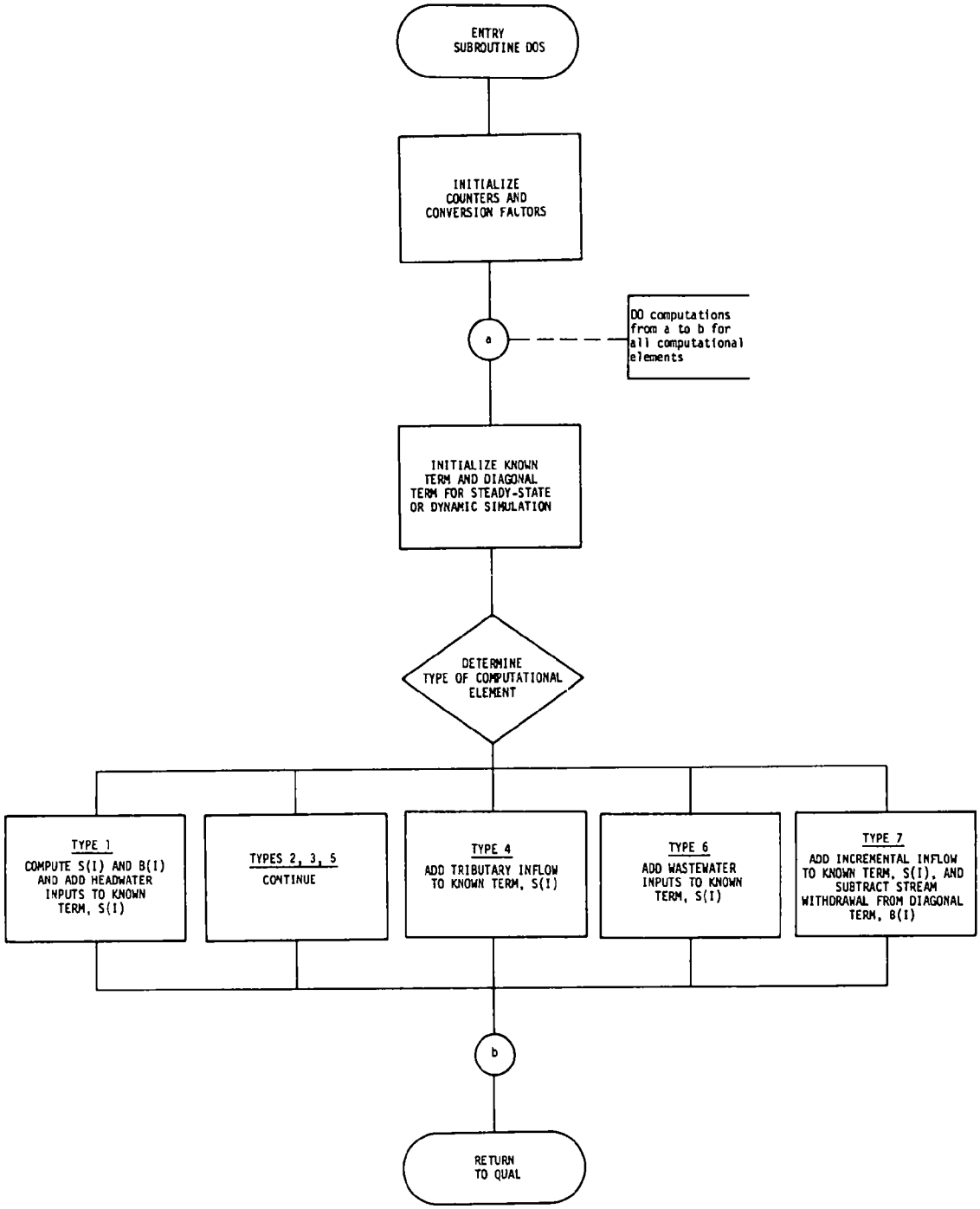

FIGURE IV-6 FLOW CHART FOR SUBROUTINE DOS

```
      SUBROUTINE COS
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),
     *       TARGDO(75),IAUGOR(75,6),NCFLRH(75),IFLAG(75,20),
     *       ICLORD(75,20),COEFOV(75),EXPOOV(75),COEFOH(75),EXPOOH(75),
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),
     *       EXPOK2(75),TINIT(75),DOINIT(75),ROINIT(75),COINIT(75,3),
     *       QI(75),TI(75),DOI(75),ROOI(75),CONSI(75,3),JUNCID(15,5),
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),
     *       HWROD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),
     *       WSTEMP(90),WSDO(90),WSROD(90),WSCONS(90,3),QATOT(15),
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),
     *       HSNET(500),DL(500),VHW(15),DFPHW(15),DLHW(15),T(500),
     *       DO(500),ROD(500),CONS(500,3),PTIME,TPRINT,DELX,
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,
     *       LAT,LSM,LLM,ELEV,DAT,AE,BF,DAYOFY,DRYBLB,WETBLB,DEWPT,
     *       ATMPR,WIND,CLOUD,SONFT,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS
C
C
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),
     *       CKN,CKP,CKL,ALPHAO(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),
     *       MODOPT(10),IRCHND(750),EXCOEF(75)
C
C
      COMMON/SSTATE/X(500),ISS
      REAL K1,K2,KO                                                     00002300
      REAL KNH3,KNO2
      DATA UROD/4H BIO/
C-.....
C.....CONVERT BETWEEN ULTIMATE AND 5-DAY BOD BASED ON AN ASSUMED
C.....LAB DECAY RATE OF 0.23/DAY (BASE E ).........WRN......
C.....
      IF( TITLE(7,6)  .EQ. UROD ) GO TO 50
      CFBOD = 1.0 - EXP( -5.0*0.23 )
      IVERT = 0
   10 IVERT = IVERT + 1
      IF( NHWTRS .LE. 0 ) GO TO 25
      DO 20 J = 1, NHWTRS
      HWBOD(J) = HWROD(J) / CFBOD
   20 CONTINUE
   25 IF( NWASTE .LE. 0 ) GO TO 35
      DO 30 J = 1, NWASTE
      WSBOD(J) = WSROD(J) / CFBOD
   30 CONTINUE
   35 DO 45 J = 1, NREACH
      BODT(J) = ROUT(J) / CFBOD
```

```
      NCELR = NCELRH(J)
      DO 40 K = 1, NCELR
      IOR = ICLORD(J,K)
      BOD(IOR) = BOD(IOR) / CFBOD
   40 CONTINUE
   45 CONTINUE
      IF( IVERT .GE. 2 ) RETURN
      CFBOD = 1.0 / CFBOD
C                                                                       00002400
C                                INITIALIZE COUNTERS
C                                                                       00002900
   50 CONTINUE
      NHW=0                                                             00003000
      NWS=0                                                             00003100
      IJUNC=0                                                           00003200
      FACT = 1.0 / (28.3 * 86400.0)
C                                                                       00003300
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C                                                                       00003800
      DO 100 I=1,NREACH                                                 00003900
      NCELR=NCELRH(I)                                                   00004000
      CNCELR=NCELR                                                      00004100
      DOIJ=QI(I)/CNCELR*DOI(I)                                          00004200
C     RATIO=1.0/(1.0-EXP(-5.0*CK1(I)))                                  00004300
      DO 100 J=1,NCELR                                                  00004400
      IOR=ICLORD(I,J)                                                   00004500
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      S(IOR)=DO(IOR)
      IF (ISS.GT.1) S(IOR)=0.0
      IF (MODOPT(4).LT.1) GO TO 90
      AREACT=(ALPHA3*GROWTH(IOR)-ALPHA4*RESPRR(IOR))*D1LT
      S(IOR) = S(IOR) + AREACT*ALGAE(IOR)
   90 IF (MODOPT(6).LT.1) GO TO 92
      S(IOR) = S(IOR) - (ALPHA5*KNH3(IOR)*CNH3(IOR)+
     1                   ALPHA6*KNO2(IOR)*CNO2(IOR))*D1LT
   92 S(IOR) = S(IOR) - CK4(I)*DELX*DTOVCL(IOR)*FACT
      TC=0.556*(T(IOR)-68.0)                                            00004600
C     K1(IOR)=K1(IOR)*RATIO                                             00004700
      DOSAT=24.69-0.4259*T(IOR)+0.003734*T(IOR)**2-0.00001328*T(IOR)**3 00004800
      IF (DO(IOR).GT.DOSAT) DO(IOR) = DOSAT                             00004900
      IFL=IFLAG(I,J)                                                    00005000
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,102,102,104,102,103,105), IFL                          00005100
C                                                                       00005200
  101 NHW=NHW+1                                                         00005700
      KO=K2(IOR)*1.0159**TC                                             00005800
      REACT=D1LT*(KO*DOSAT-K1(IOR)*BOD(IOR))
      S(IOR)=S(IOR)+REACT+DOIJ*DTOVCL(IOR)-A(IOR)*HWDO(NHW)
      B(IOR)=X(IOR)+D1LT*KO
      GO TO 100                                                         00006100
C                                                                       00006200
  102 KO=(0.5*(K2(IOR-1)+K2(IOR)))*1.0159**TC                           00006700
      REACT=D1LT*(KO*DOSAT-K1(IOR)*BOD(IOR))
      S(IOR)=S(IOR)+REACT+DOIJ*DTOVCL(IOR)
      B(IOR)=X(IOR)+D1LT*KO
      GO TO 100                                                         00007000
```

```
C                                                                       00007100
  107   S=NWS+1                                                         00007600
      KO=(0.5*(K2(IOR-1)+K2(IOR)))*1.0159**TC                           00007700
      REACT=FILT*(KO*DOSAT-K1(IOR)*BOD(IOR))
      S(IOR)=S(IOR)+REACT+(DOIJ+WSFLOW(NWS)*WSDO(NWS))*DTOVCL(IOR)
      B(IOR)=X(IOR)+DILT*KO
      GO TO 100                                                         00008000
C                                                                       00008100
  104 IJUNC=IJUNC+1                                                     00008600
      NS=1                                                              00008700
      NN=JUNC(IJUNC,NS)                                                 00008800
      KO=(0.25*(K2(IOR-1)+K2(NN)+2.0*K2(IOR)))*1.0159**TC               00008900
      REACT=FILT*(KO*DOSAT-K1(IOR)*BOD(IOR))
      S(IOR)=S(IOR)+REACT+DOIJ*DTOVCL(IOR)
      B(IOR)=X(IOR)+DILT*KO
      GO TO 100                                                         00009200
C                                                                       00009300
  105 NWS=NWS+1                                                         00009800
      KO=(0.5*(K2(IOR-1)+K2(IOR)))*1.0159**TC                           00009900
      REACT=FILT*(KO*DOSAT-K1(IOR)*BOD(IOR))
      S(IOR)=S(IOR)+REACT+DOIJ*DTOVCL(IOR)
      B(IOR)=X(IOR)+DILT*KO-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE                                                          00010200
      IF( TITLE(7,6)  .EQ. UBOD ) RETURN
      GO TO 10                                                                  *NEW
      END                                                               00010400
```

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = S_i - a_i\phi_h$
6. Waste Input	$S_i = S_i + q_w\phi_w \frac{\Delta t}{v_i}$

For steady-state simulation, the only difference is that the value from the previous time step, ϕ_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-6 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

SUBROUTINE FLOAUG

Subroutine FLOAUG remains unchanged from the original version of QUAL as documented by the Texas Water Development Board (2). According to reference (2):

> *After steady-state conditions have been reached, FLOAUG checks the calculated dissolved oxygen concentration against the pre-specified target levels for dissolved oxygen in each reach. If the computed dissolved oxygen is below the target level, the routine then searches all of the upstream headwaters for those sources that the user has specified to have dilution water. Dilution water is then added equally from all sources and calculations are repeated. This sequence continues until all target levels are satisfied, whereupon a summary is written.*

The flow chart for FLOAUG shown in Figure IV-7 is taken from reference (2). The program listing follows the figure.

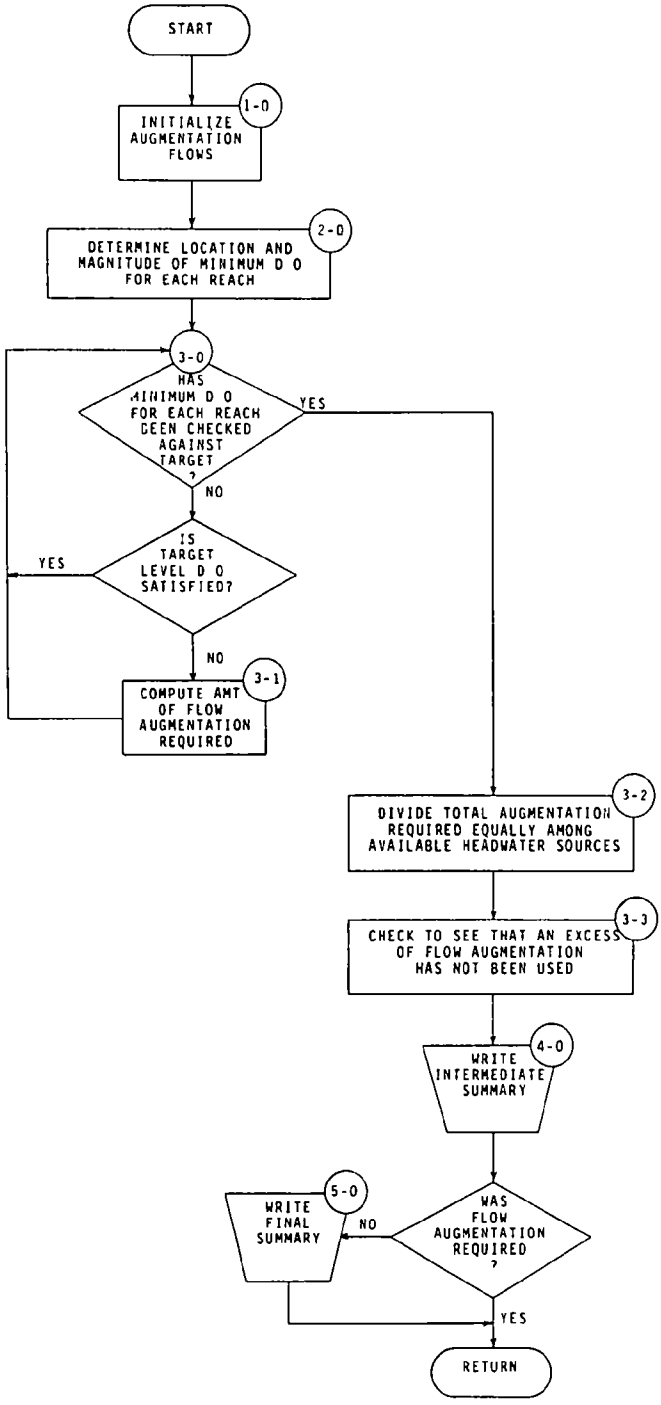

FIGURE IV-7 FLOW CHART FOR SUBROUTINE FLOAUG

```
      SUBROUTINE FLOAUG
C
C
C                                FLOAUG SEARCHES THROUGH THE SYSTEM BY
C                                REACH TO DETERMINE THE MINIMUM DO LEVEL
C                                WITHIN EACH REACH. EACH OF THESE MINIMUM
C                                DO LEVELS IS CHECKED AGAINST A SELECTED
C                                TARGET LEVEL. IF FLOW AUGMENTATION IS
C                                REQUIRED, THIS FLOW IS DISTRIBUTED
C                                EQUALLY AMONG THE HEADWATER SOURCES THAT
C                                ARE AVAILABLE TO A GIVEN REACH.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
C
      DIMENSION IORMIN(75),RMILE(75),DOMIN(75),IORDER(75),QAUG(15)               *NEW
C                                                                                **-1
C                                                                       00002900
C                                        STEP 1-0                       00003000
C                                        INITIALIZE AUMENTATION FLOWS   00003100
      DO 5 NHW=1,NHWTRS                                                 00003200
      QAUG(NHW)=0.0                                                     00003300
    5 CONTINUE                                                          00003400
C                                                                       00003500
C                                                                       00003600
C                                        STEP 2-0                       00003700
C                                        LOOP THROUGH SYSTEM OF NREACH RE00003800
C                                        AND NCELR COMPUTATIONAL ELEMENTS00003900
C                                        REACH TO DETERMINE MINIMUM DO LE00004000
C                                        REACH AND ITS LOCATION BY RIVER 00004100
C                                                                       00004200
      DO 50 I=1,NRLACH                                                  00004300
      DOMIN(I)=100.0                                                    00004400
      IF(NHWWAR(I).EQ.0) GO TO 50                                       00004500
      NCELR=NCELRH(I)                                                   00004600
      DO 100 J=1,NCELR                                                  00004700
      IOR=ICLORD(I,J)                                                   00004800
      IF (DO(IOR).GE.DOMIN(I)) GO TO 100                                00004900
      DOMIN(I)=DO(IOR)                                                  00005000
      IORMIN(I)=IOR                                                     00005100
```

```
      XMIN=J                                                            00005200
      RMILE(I)=RMTHOR(I)-XMIN*DELX/5280.0                               00005300
  100 CONTINUE                                                          00005400
   50 CONTINUE                                                          00005500
      NBTARG=0                                                          00005600
C                                                                       00005700
C                                       STEP 3-0                        00005800
C                                       LOOP THROUGH NREACH REACHES TO 500005900
C                                       MINIMUM DO LEVEL IS BELOW TARGET00006000
C                                                                       00006100
      DO 25 I=1,NREACH                                                  00006200
      IF (DOMIN(I).GE.TARGDO(I)) GO TO 25                               00006300
C                                                                       00006400
C                                       STEP 3-1                        00006500
C                                       IF TARGET LEVEL IS NOT MET, COMP00006600
C                                       AMOUNT OF FLOW AUGMENTATION REQU00006700
C                                                                       00006800
      NBTARG=NBTARG+1                                                   00006900
      IORDER(NBTARG)=I                                                  00007000
      IOR=IORMIN(I)                                                     00007100
      RMILE(NBTARG)=RMILE(I)                                            00007200
      DOREQD=TARGDO(I)-DOMIN(I)+0.1                                     00007300
      QREQD = FLOW(IOR)*(DOREQD/TARGDO(I) + 0.15*                       00007400
     *(DOREQD/TARGDO(I))**2)                                            00007500
      QSUM=0.0                                                          00007600
      NHWAR=NHWWAR(I)                                                   00007700
      DO 350 J=1,NHWAR                                                  00007800
      NHW=IAUGOR(I,J)                                                   00007900
      QSUM=QSUM+QAUG(NHW)                                               00008000
  350 CONTINUE                                                          00008100
C                                                                       00008200
C                                       STEP 3-2                        00008300
C                                       DIVIDE TOTAL AUGMENTATION REQUIR00008400
C                                       EQUALLY AMONG THE UPSTREAM HEADW00008500
C                                       SOURCES AVAILABLE TO A GIVEN REA00008600
C                                 GIVEN REACH.                          00008700
C                                                                       00008800
      QAUD=QREQD/NHWWAR(I)                                              00008900
C                                                                       00009000
C                                       STEP 3-3                        00009100
C                                       CHECK TO SEE THAT AN EXCESS OF F00009200
C                                       AUGMENTATION HAS NOT BEEN USED. 00009300
C                                                                       00009400
      IF (QREQD.LT.QSUM) GO TO 25                                       00009500
      NHWAR=NHWWAR(I)                                                   00009600
      DO 375 J=1,NHWAR                                                  00009700
      NHW=IAUGOR(I,J)                                                   00009800
      QAUG(NHW)=QAUD                                                    00009900
  375 CONTINUE                                                          00010000
   25 CONTINUE                                                          00010100
      IF (NBTARG.EQ.0) GO TO 300                                        00010200
C                                                                       00010300
C                                       STEP 4-0                        00010400
C                                       WRITE SUMMARY OF FLOW AUG'MT. RE00010500
C                                                                       00010600
      WRITE (NJ,200)                                                    00010700
  200 FORMAT (1H1,3AX,39H* * * REACHES WITH OXYGEN DEFICIT * * *,//,23X,00010800
     *        52HREACH NO.     REACH IDENTIFICATION       MINIMUM DO.,  00010900
     *        15H     RIVER MILE,/)                                     00011000
      TIME=0.0                                                          00011100
```

```
      DO 250 K=1,NOTARS                                                 00011200
      I=IORDER(K)                                                       00011300
      WRITE (NJ,255) I,(RCHID(I,J),J=1,5),DOMIN(I),RMILE(I)             00011400
  255 FORMAT (22X,I5,10X,5A4,7X,F5.1,11X,F6.1)                          00011500
  250 CONTINUE                                                          00011600
      WRITE (NJ,260)                                                    00011700
  260 FORMAT (1H0,30X,38H* * * FLOW AUGMENTATION REQUIRED * * *,//,     00011800
     *        5X,100HHEADWATER NO.      HEADWATER IDENTIFICATION     EXIS00011900
     *TING HEADWATER FLOW (CFS)      AUG. REQUIRED (CFS),/)             00012000
      DO 270 NHW=1,NHWTRS                                               00012100
      WRITE (NJ,275) NHW,(HWTRID(NHW,J),J=1,5),HWFLOW(NHW),QAUG(NHW)    00012200
  275 FORMAT (8X,I5,12X,5A4,16X,F10.1,20X,F10.1)                        00012300
  270 CONTINUE                                                          00012400
      DO 380 NHW=1,NHWTRS                                               00012500
      HWFLOW(NHW) = HWFLOW(NHW) + QAUG(NHW)                             00012600
  380 CONTINUE                                                          00012700
      GO TO 310                                                         00012800
  300 CONTINUE                                                          00012900
C                                                                       00013000
C                                        STEP 5-0                       00013100
C                                        WRITE FINAL SUMMARY OF FLOW    00013200
C                                        AUGMENTATION REQUIREMENTS.     00013300
C                                                                       00013400
      WRITE (NJ,261)                                                    00013500
  261 FORMAT (1H0,33X,32HTOTAL FLOW AUGMENTATION REQUIRED.//,           00013600
     *5X,101HHEADWATER NO.      HEADWATER IDENTIFICATION      INITIAL  HE00013700
     *ADWATER FLOW (CFS)      AUG. REQUIRED (CFS),/)                   00013800
      DO 305 NHW=1,NHWTRS                                               00013900
      HWFLOI=QATOT(NHW)                                                 00014000
      QATOT(NHW)=HWFLOW(NHW)-HWFLOI                                     00014100
      HWFLOW(NHW)=HWFLOI                                                00014200
      WRITE (NJ,275) NHW,(HWTRID(NHW,J),J=1,5),HWFLOW(NHW),QATOT(NHW)   00014300
  305 CONTINUE                                                          00014400
  310 CONTINUE                                                          00014500
      RETURN                                                            00014600
      END                                                               00014700
```

SUBROUTINE HEATEX

Subroutine HEATEX remains unchanged from the original version of QUAL as documented by the Texas Water Development Board (2). According to reference (2):

> *This routine computes the net amount of heat radiation flux being transferred across the air-water interface. It is based on an energy budget which considers solar radiation, atmospheric radiation, back radiation, conduction, and evaporation.*

Detailed equations for all of the heat budget terms are presented in Report 128 of the Texas Water Development Board (1).

The flow chart for Subroutine HEATEX shown in Figure IV-8 is taken from reference (2). The program listing follows the figure.

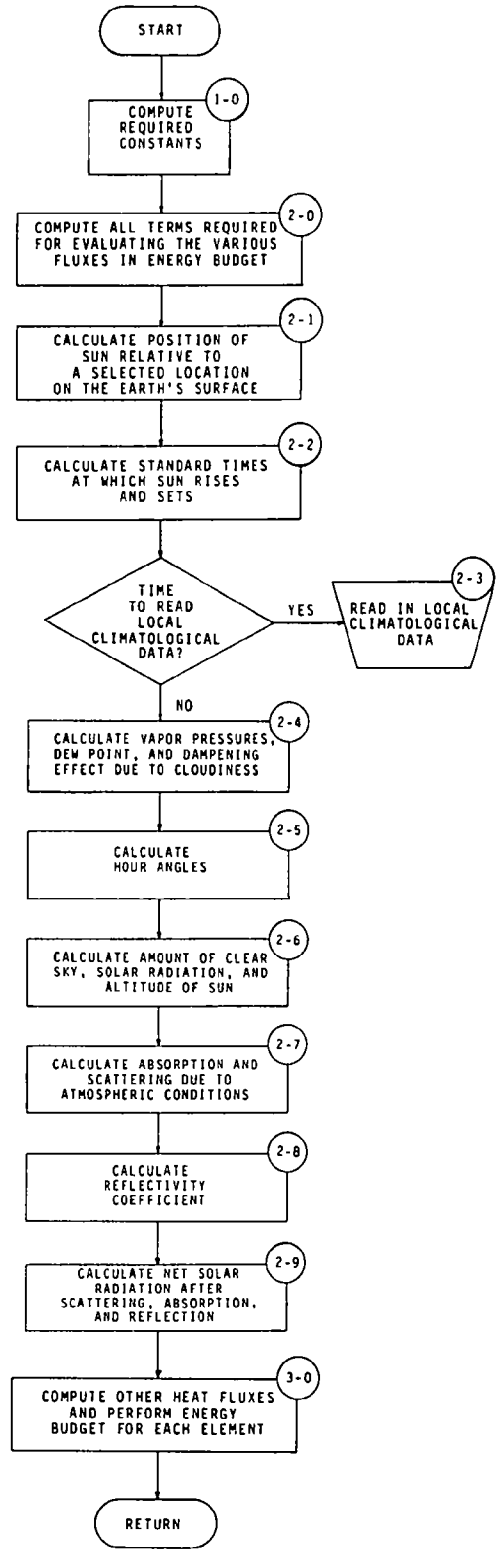

FIGURE IV-8 FLOW CHART FOR SUBROUTINE HEATEX

```
      SUBROUTINE HEATEX
C
C                                HEATEX COMPUTES THE NET AMOUNT OF HEAT
C                                RADIATION FLUX BEING TRANSFERRED ACROSS
C                                THE AIR-WATER INTERFACE BASED ON AN
C                                ENERGY BUDGET WHICH CONSIDERS SOLAR
C                                RADIATION, ATMOSPHERIC RADIATION, BACK
C                                RADIATION, CONDUCTION, AND EVAPORATION.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAP(15),          *NEW
     *       TAPGDO(75),IAUGOR(75,6),NCFLRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),RODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWROD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSRDO(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),ROD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,RE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
      REAL LLM,LSM,LAT                                                   00002600
C                                                                        00002700
C                                        STEP 1-0                        00002800
C                                        COMPUTE REQUIRED CONSTANTS      00002900
C                                                                        00003000
      PI=3.141628                                                        00003100
      CON1=2.0*PI/365.0                                                  00003200
      CON2=PI/180.0*LAT                                                  00003300
      CON3=180.0/PI                                                      00003400
      CON4=23.45*PI/180.0                                                00003500
      CON5=PI/12.0                                                       00003600
      CON6=12.0/PI                                                       00003700
      DELTSL=(LLM-LSM)/15.0                                              00003800
      SOLCON=438.0                                                       00003900
      ELEXP=EXP(-ELEV/2532.0)                                            00004000
C                                                                        00004100
C                                        STEP 2-0                        00004200
C                                        COMPUTE ALL TERMS REQUIRED FOR  00004300
C                                        EVALUATING THE VARIOUS FLUXES IN00004400
C                                        ENERGY BUDGET                   00004500
C                                                                        00004600
      IF (TOFDAY.NE.0.0) GO TO 77                                        00004700
C                                                                        00004800
C                                        STEP 2-1                        00004900
C                                        COMPUTE SEASONAL AND DAILY POSIT00005000
C                                        SUN RELATIVE TO A SELECTED LOCAT00005100
C                                        THE EARTH'S SURFACE.            00005200
C                                                                        00005300
      RLARTH=1.0+0.017*COS(CON1*(186.0-DAYOFY))                          00005400
```

```
      DECLIN=CON4*COS(CON1*(172.0-DAYOFY))                              00005500
      RR=EARTH**2                                                       00005600
      EQTIME=0.000121-0.12319*SIN(CON1*(DAYOFY-1.0)-0.07014)            00005700
     *       -0.16549*SIN(2.0*CON1*(DAYOFY-1.0)+0.3088)                 00005800
      DECLON=ABS(DECLIN)                                                00005900
      ACS=TAN(CON2)*TAN(DECLON)                                         00006000
      IF (ACS.EQ.0.0) GO TO 8                                           00006100
      X=SQRT(1.0-ACS*ACS)                                               00006200
      X=X/ACS                                                           00006300
      ACS=ATAN(X)                                                       00006400
      IF (DECLIN.GT.0.0) ACS=PI-ACS                                     00006500
      GO TO 9                                                           00006600
    8 ACS=PI/2.0                                                        00006700
    9 CONTINUE                                                          00006800
C                                                                       00006900
C                                       STEP 2-2                        00007000
C                                       COMPUTE STANDARD TIMES AT WHICH 00007100
C                                       RISES AND SETS.                 00007200
C                                                                       00007300
      STR=12.0-CON6*ACS+DELTSL                                          00007400
      STS=24.0-STR+2.0*DELTSL                                           00007500
      STB=0.0                                                           00007600
      STE=STB+D2LT                                                      00007700
      GO TO 78                                                          00007800
   77 STB=STR+D2LT                                                      00007900
      STE=STB+D2LT                                                      00008000
   78 CONTINUE                                                          00008100
C                                                                       00008200
C                                       STEP 2-3                        00008300
C                                       READ IN LOCAL CLIMATALOGICAL DAT00008400
C                                       AT DESIRED TIME INTERVAL (MINIMU00008500
C                                       INTERVAL IS THREE HOURS).       00008600
C                                                                       00008700
      IF (TRLCD.NE.0.0) GO TO 82                                        00008800
      READ 12, CLOUD,DRYBLB,WETBLB,ATMPR,WIND                           00008900
   12 FORMAT(40X,5F8.0)
      WIND=WIND*1.151                                                   00009100
C                                                                       00009200
C                                       STEP 2-4                        00009300
C                                       COMPUTE VAPOR PRESSURES, DEW POI00009400
C                                       DAMPENING EFFECT OF CLOUDINESS. 00009500
C                                                                       00009600
      VPWB=0.1001*EXP(0.03*WETBLB)-0.0837                               00009700
      VPAIR=VPWB-0.000367*ATMPR*(DRYBLB-WETBLB)                         00009800
     *      *(1.0+(WETBLB-32.0)/1571.0)                                 00009900
      DEWPT=ALOG((VPAIR+0.0837)/0.1001)/0.03                            00010000
      CS=1.0-0.65*CLOUD**2                                              00010100
      IF (CLOUD.GT.0.9) CS=0.50                                         00010200
      CNL=CLOUD*10.0+1.0                                                00010300
      NL=CNL                                                            00010400
   82 CONTINUE                                                          00010500
      TRLCD=TRLCD+D2LT                                                  00010600
      IF (TRLCD.LT.2.9) GO TO 84                                        00010700
      TRLCD=0.0                                                         00010800
   84 CONTINUE                                                          00010900
      IF (STS.LE.STR.OR.STR.GE.STE) GO TO 35                            00011000
      IF(STR.GT.STB.AND.STR.LT.STE) GO TO 41                            00011100
      IF (STS.LT.STE.AND.STS.GT.STB) GO TO 42                           00011200
C                                                                       00011300
C                                       STEP 2-5                        00011400
```

```
C                                       COMPUTE HOUR ANGLES
C
      TB=STB-12.0-DELTSL+EQTIME
      TE=STE-12.0-DELTSL+EQTIME
      GO TO 43
   41 TB=STB-12.0-DELTSL+EQTIME
      TE=STE-12.0-DELTSL+EQTIME
      GO TO 43
   42 TB=STB-12.0-DELTSL+EQTIME
      TE=STS-12.0-DELTSL+EQTIME
   43 CONTINUE
      TALT=(TB+TE)/2.0
C
C                                       STEP 2-6
C                                       COMPUTE AMT OF CLEAR SKY, SOLAR
C                                       RADIATION, AND ALTITUDE OF SUN.
C
      SOLAR=SOLCON/RR*(SIN(CON2)*SIN(DECLIN)*(TE-TB)+CON6*COS(CON2)*
     *       COS(DECLIN)*(SIN(CON5*TE)-SIN(CON5*TB)))
      ALPHA=SIN(CON2)*SIN(DECLIN)+COS(CON2)*COS(DECLIN)*COS(CON5*TALT)
      IF (ABS(ALPHA).EQ.1.0) GO TO 4
      Y=SQRT(1.0-ALPHA*ALPHA)
      Y=ALPHA/Y
      ALPHA=ATAN(Y)
      GO TO 5
    4 IF (ALPHA.EQ.-1.0) GO TO 6
      ALPHA=PI/2.0
      GO TO 5
    6 ALPHA=-PI/2.0
    5 CONTINUE
      IF (ALPHA.LT.0.01) GO TO 35
C
C                                       STEP 2-7
C                                       COMPUTE ABSORPTION AND SCATTERIN
C                                       DUE TO ATMOSPHERIC CONDITIONS.
C
      PWC=0.00614*EXP(0.0489*DEWPT)
      OAM=ELEXP/(SIN(ALPHA)+0.15*(ALPHA*CON3+3.885)**(-1.253))
      A1=EXP(-(0.465+0.0408*PWC)*(0.129+0.171*EXP(-0.880*OAM))*OAM)
      A2=EXP(-(0.465+0.0408*PWC)*(0.179+0.171*EXP(-0.721*OAM))*OAM)
C
C                                       STEP 2-8
C                                       COMPUTE REFLECTIVITY COEFFICIENT
C
      GO TO (30,31,31,31,31,31,32,32,32,32,33), NL
   30 AR=1.18
      BR=-0.77
      GO TO 34
   31 AR=2.20
      BR=-0.97
      GO TO 34
   32 AR=0.95
      BR=-0.75
      GO TO 34
   33 AR=0.35
      BR=-0.45
   34 CONTINUE
      RS=AR*(CONS*ALPHA)**BR
      RTC=(A2+0.5*(1.0-A1-DAT))/(1.0-0.5*RS*(1.0-A1+DAT))
C
```

```
C                                       STEP 2-9                        00017500
C                                       COMPUTE NET SOLAR RADIATION AFTE00017600
C                                       SCATTERING, ABSORPTION, AND REFL00017700
C                                                                       00017800
      SONET=SOLAR*ATC*CS*(1.0-RS)                                       00017900
      GO TO 36                                                          00018000
   35 SONET=0.0                                                         00018100
   36 CONTINUE                                                          00018200
      CLC=1.0+0.17*CLOUD**2                                             00018300
C                                                                       00018400
C                                       STEP 3-0                        00018500
C                                       COMPUTE OTHER HEAT FLUXES AND PE00018600
C                                       ENERGY BUDGET FOR EACH COMPUTATI00018700
C                                       ELEMENT.                        00018800
C                                                                       00018900
      HA=0.97*1.73E-09*2.89E-06*(DRYBLB+460.0)**6*CLC*D2LT              00019000
      DO 70 I=1,NPEACH                                                  00019100
      NCELR=NCELRH(I)                                                   00019200
      DO 70 J=1,NCELR                                                   00019300
      IOR=ICLORD(I,J)                                                   00019400
      VPW=0.1001*EXP(0.03*T(IOR))-0.0837                                00019500
      HB=0.97*1.73E-09*(T(IOR)+460.0)**4*D2LT                           00019600
      EVAP=62.4*(AE+BE*WIND)                                            00019700
      HE=EVAP*(VPW-VPAIR)*(1084.0-0.5*T(IOR))*D2LT                      00019800
      HC=0.01*EVAP*(DRYBLB-T(IOR))*(1084.0-0.5*T(IOR))*D2LT             00019900
      HV=EVAP*T(IOR)*D2LT                                               00020000
      HSNET(IOR)=SONET+HA-HB+HC-HE-HV                                   00020100
   70 CONTINUE                                                          00020200
      TOFDAY=TOFDAY+D2LT                                                00020300
      IF (TOFDAY.LT.23.9) GO TO 85                                      00020400
      TOFDAY=0.0                                                        00020500
      DAYOFY=DAYOFY+1.0                                                 00020600
   85 CONTINUE                                                          00020700
      RETURN                                                            00020800
      END                                                               00020900
```

SUBROUTINE HYDRAU

Subroutine HYDRAU remains unchanged from the original version of QUAL as documented by the Texas Water Development Board (2). According to reference (2):

> *This routine performs a hydrologic balance for a branching stream or canal system based on continuity of flow. It then computes velocities, volumes, and dispersion coefficients for every computational element in the system.*

The flow chart for Subroutine HYDRAU shown in Figure IV-9 is taken from reference (2). The program listing follows the figure.

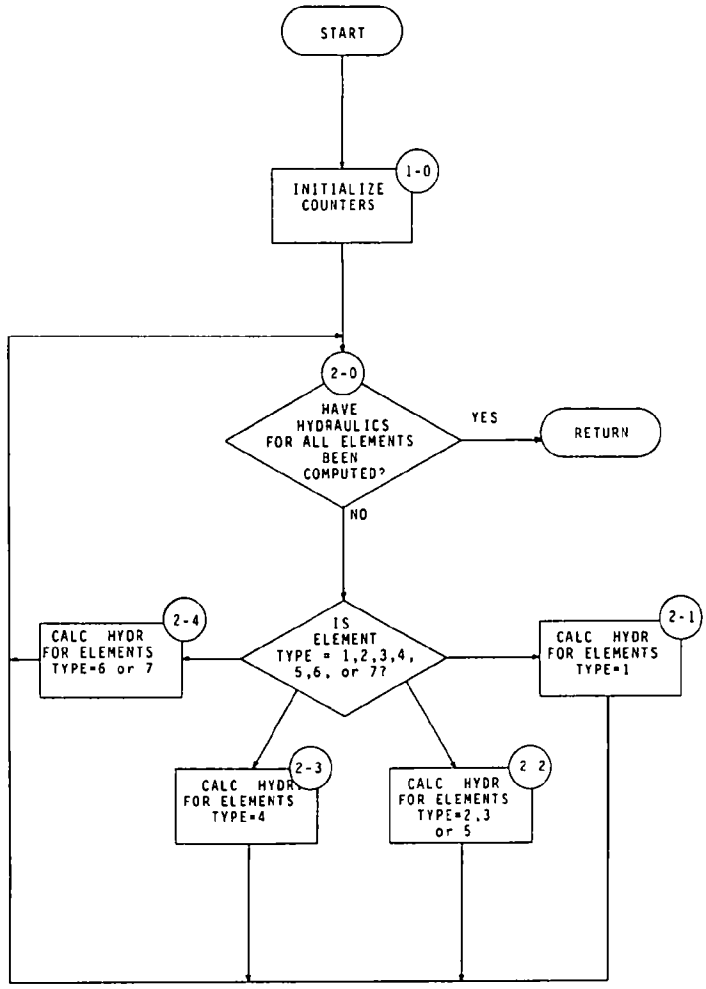

FIGURE IV-9 FLOW CHART FOR SUBROUTINE HYDRAU

```
      SUBROUTINE HYDRAU
C
C
C                                HYDRAU PERFORMS A HYDROLOGIC BALANCE ON
C                                THE SYSTEM BASED ON CONTINUITY. IT
C                                COMPUTES THE FLOW, VELOCITY, VOLUME,
C                                DEPTH, AND DISPERSION COEFFICIENT FOR
C                                EVERY ELEMENT IN THE SYSTEM.
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),TAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFOV(75),EXPOOV(75),COEFOH(75),EXPOOH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEOK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TREACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),DATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DFPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,PE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
C                                                                      00002500
C                                        STEP 1-0                      00002600
C                                        INITIALIZE COUNTERS FOR HEADWATE00002700
C                                        WASTE INPUTS OR WITHDRAWLS, AND 00002800
C                                        JUNCTIONS.                    00002900
C                                                                      00003000
      NHW=0                                                            00003100
      NWS=0                                                            00003200
      IJUNC=0                                                          00003300
C                                                                      00003400
C                                        STEP 2-0                      00003500
C                                        LOOP THROUGH SYSTEM OF NREACH RE00003600
C                                        AND NCELR COMPUTATIONAL ELEMENTS00003700
C                                        REACH.                        00003800
C                                                                      00003900
      DO 100 I=1,NREACH                                                00004000
      NCELR=NCELRH(I)                                                  00004100
      CNCELR=NCELR                                                     00004200
      QK=QI(I)/CNCELR                                                  00004300
      DO 100 J=1,NCELR                                                 00004400
      IOP=ICLORD(I,J)                                                  00004500
      IFL=IFLAG(I,J)                                                   00004600
      GO TO (101,102,102,103,102,104,104), IFL                         00004700
C                                                                      00004800
C                                        STEP 2-1                      00004900
C                                        COMPUTE HYDRAULICS FOR AN ELEMEN00005000
C                                        TYPE 1.                       00005100
C                                                                      00005200
  101 NHW=NHW+1                                                        00005300
      FLOW(IOP)=HWFLOW(NHW)+QK                                         00005400
```

```
      VHW(NHW)=COEFQV(I)*HWFLOW(NHW)**EXPOQV(I)                         00005500
      DEPHW(NHW)=COEFQH(I)*HWFLOW(NHW)**EXPOQH(I)                       00005600
      DLHW(NHW)=22.6*CMANN(I)*VHW(NHW)*DEPHW(NHW)**0.833                00005700
      VEL(IOR)=COEFQV(I)*FLOW(IOR)**EXPOQV(I)                           00005800
      DTOVEL(IOR)=DT2ODX/(HWFLOW(NHW)/VHW(NHW)+FLOW(IOR)/VEL(IOR))      00005900
      GO TO 105                                                         00006000
C                                                                       00006100
C                                         STEP 2-2                      00006200
C                                         COMPUTE HYDRAULICS FOR ELEMENTS 00006300
C                                         2,3, OR 5.                    00006400
C                                                                       00006500
  102 FLOW(IOR)=FLOW(IOR-1)+QR                                          00006600
      VEL(IOR)=COEFQV(I)*FLOW(IOR)**EXPOQV(I)                           00006700
      DTOVEL(IOR)=DT2ODX/(FLOW(IOR-1)/VEL(IOR-1)+FLOW(IOR)/VEL(IOR))    00006800
      GO TO 105                                                         00006900
C                                                                       00007000
C                                         STEP 2-3                      00007100
C                                         COMPUTE HYDRAULICS FOR AN ELEMEN00007200
C                                         TYPE 4.                       00007300
C                                                                       00007400
  103 IJUNC=IJUNC+1                                                     00007500
      NS=1                                                              00007600
      NN=JUNC(IJUNC,NS)                                                 00007700
      FLOW(IOR)=FLOW(IOR-1)+FLOW(NN)+QR                                 00007800
      VEL(IOR)=COEFQV(I)*FLOW(IOR)**EXPOQV(I)                           00007900
      DTOVEL(IOR)=DT2ODX/(FLOW(IOR-1)/VEL(IOR-1)+FLOW(IOR)/VEL(IOR)+    00008000
     *            FLOW(NN)/VEL(NN))                                     00008100
      GO TO 105                                                         00008200
C                                                                       00008300
C                                         STEP 2-4                      00008400
C                                         COMPUTE HYDRAULICS FOR ELEMENTS 00008500
C                                         6 OR 7.                       00008600
C                                                                       00008700
  104 NWS=NWS+1                                                         00008800
      FLOW(IOR)=FLOW(IOR-1)+WSFLOW(NWS)+QR                              00008900
      VEL(IOR)=COEFQV(I)*FLOW(IOR)**EXPOQV(I)                           00009000
      DTOVEL(IOR)=DT2ODX/(FLOW(IOR-1)/VEL(IOR-1)+FLOW(IOR)/VEL(IOR))    00009100
  105 DEPTH(IOR)=COEFQH(I)*FLOW(IOR)**EXPOQH(I)                         00009200
      DL(IOR)=22.6*CMANN(I)*VEL(IOR)*DEPTH(IOR)**0.833                  00009300
  100 CONTINUE                                                          00009400
      RETURN                                                            00009500
      END                                                               00009600
```

SUBROUTINE INDATA

Subroutine INDATA reads and prints all data required by the model except the climatological data which is read in Subroutine HEATEX and/or ALGAES. INDATA reads a set of title cards and 11 different types of data that are prepared on 19 different data forms. Seven of the data forms are optional depending on the parameters to be simulated. Chapter V contains additional details concerning data preparation, descriptions of data forms and an example data set. If INDATA detects any data inconsistencies, it prints an error message and terminates execution.

Figure IV-10 illustrates the flow chart for INDATA and the following pages contain the program listing. All program variables in COMMON are defined in Section V.

```
      SUBROUTINE INDATA(ILIST,IRPT1,IAUGOR,IMAX,NCELLS)
C
C
C                                THIS SUBROUTINE READS IN ALL DATA
C                                REQUIRED FOR THE OPERATION OF THE
C                                MODEL EXCEPT THE CLIMATOLOGICAL
C                                DATA FOR TEMPERATURE SIMULATION.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),        *NEW
     *       TARGOD(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                  *NEW
     *       ICLOSD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),        *NEW
     *       CMANN(75),CK1(75),CK3(75),K20PT(75),CK2(75),COEQK2(75),           *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),          *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),          *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),           *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),        *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),             *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),            *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),        *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),             *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                   *NEW
     *       NMETRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,          *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,PE,DAYOFY,DRYBLB,WETBLB,DEWPT,            *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS          *NEW
C                                                                              *NEW
C                                                                              *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),             *NEW
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,               *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                 *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),               *NEW
     *       ALGAF(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),               *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                 *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),             *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),            *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),               *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),             *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                 *NEW
C                                                                              *-29
C
      COMMON/RADION/ CK6(75),RADNIT(75),RADNI(75),HWRADN(15),WSRADN(90)        *NEW
C                                                                              **-1
C
      COMMON/SSTATE/ Y(500),ISS
C
C
      DIMENSION DATA(91,25),CODE(12),CODE2(6)                                  *NEW
C                                                                              **-1
      REAL K1,K2,LAT,LLM,LSM,JUNCID                                   00003300
C                                                                     00003400
      DATA FIRST/4HEMPT/ , ENDA/4HENDA/ , YES/4H YES/
      DATA CODE/4HLIST,4HWRIT,4HFLOW,4HSTEA,4HNUMB,4HNUM ,4HTIME,
     *          4HMAT,4HLAT,4HSTAN,4HEVAP,4HELEV/
      DATA CODE2/4HO UP,4HO PR,4HN CO,4HALG ,4HN HA,4HLIGH/
C                                                                     00005900
C                                    STEP 1-0                         00003500
```

```
C                                       INITIALIZE CERTAIN PARAMETERS   00003600
C                                                                       00003700
      DO 1000 I=1,250
 1000 IPCHO(I)=0
      ILIST=0                                                           00003800
      IRP11=0                                                           00003900
      IAUGOP =0                                                         00004000
      ISS=0
      LAT=0.0                                                           00004100
      LLM=0.0                                                           00004200
      LSM=0.0                                                           00004300
      DAYOFY=0.0                                                        00004400
      AE=0.0                                                            00004500
      BF=0.0                                                            00004600
      ELEV=0.0                                                          00004700
      DAT=0.0                                                           00004800
      NERROR=0                                                          00004900
      TLAF=0.0                                                          00005000
      TPPINT=0.0                                                        00005100
      TOFDAY=0.0                                                        00005200
      TRLCD=0.0                                                         00005300
      CKL=0.0
      NI=5                                                              00005400
      NJ=6                                                              00005500
C                                                                       00005900
C                                       STEP 2-0                        00006000
C                                       READ IN TITLES                  00006100
C                                                                       00006200
      DO 30 I=1,16
      READ (NI,31) (TITLE(I,J),J=1,20)                                  00006400
   31 FORMAT (20A4)                                                     00006500
      IF (TITLE(I,1)-ENDT) 30,35,30                                     00006600
   30 CONTINUE                                                          00006700
      NERROR=1                                                          00006800
   34 I=I+1                                                             00006900
      READ (NI,31) (TITLE(I,J),J=1,20)                                  00007000
      IF (TITLE(I,1)-ENDT)34,39,34                                      00007100
   39 N=I-16
      WRITE (NJ,32) N                                                   00007300
   32 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) TITLE CARDS READ)      00007400
      GO TO 33                                                          00007500
   35 IF (I.GT.16) GO TO 33
      NERROR=1                                                          00007700
      N=16-I
      WRITE (NJ,36) N                                                   00007900
   36 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) TITLE CARDS READ)       00008000
   33 CONTINUE                                                          00008100
      NTITLE=I                                                          00008200
C                                       STEP 2-1
C                                       SET PARAMETER LIST TO BE SIMULATED
C                                       INTO MODEL OPTION ARRAY (MODOPT)
C
      DO 1700 I=1,9
 1700 MODOPT(I)=0
      IF(TITLE(3,3) .EQ. YES) MODOPT(1)=1
      DO 1710 I=6,9
      IF(TITLE(I,3) .EQ. YES) MODOPT(I-4)=1
 1711 CONTINUE
      IF(TITLE(10,3) .EQ. YES) MODOPT(6)=1
      DO 1720 I=13,15
```

DALE CHANGED TO '6'?

```
      IF(TITLE(I,3) .EQ. YES) MODOPT(I-6)=1
 1720 CONTINUE
C                                          STEP 2-2
C                                          SET NCS (NUMBER OF CONSERVATIVE
C                                          CONSTITUENTS
C
      NCS=0
      IF(MODOPT(1) .LT. 1) GO TO 1730
      NCS=1
      IF(TITLE(4,3) .EQ. YES) NCS=2
      IF(TITLE(5,3) .EQ. YES) NCS=3
 1730 CONTINUE
C                                                                        00008300
C                                          STEP 3-0                      00008400
C                                          READ IN ALL DATA REQUIRED FOR 0P00008500
C                                          OF THE MODELS.                00008600
C                                                                        00008700
C                                          STEP 3-1                      00008800
C                                          READ IN DATA TYPE 1 (MODEL CONTR00008900
C                                                                        00009000
      IDATA=0
      IF(MODOPT(4) .GT. 0) IDATA=1
      IF(MODOPT(5) .GT. 0) IDATA=1
      IF(MODOPT(6) .GT. 0) IDATA=1
      IF(MODOPT(8) .GT. 0) IDATA=1
      NCARDS=13
      DO 20 I=1,NCARDS
      READ (NI,21) (DATA(I,K),K=1,16)                                    00009200
   21 FORMAT (6A4,A1,F10.0,10X,6A4,A1,F10.0)                             00009300
      IF (DATA(I,1)-ENDA)20,25,20                                        00009400
   20 CONTINUE                                                           00009500
      NERROR=1                                                           00009600
   24 I=I+1                                                              00009700
      READ (NI,21) (DATA(I,K),K=1,16)                                    00009800
      IF (DATA(I,1)-ENDA)24,29,24                                        00009900
   29 N=I-NCARDS
      WRITE (NU,22) N                                                    00010100
   22 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA1 CARDS READ)       00010200
      GO TO 23                                                           00010300
   25 IF (I.GE.NCARDS) GO TO 23
      IF(MODOPT(2)) 1920,1920,1930
 1920 IF(I .EQ. 9) GO TO 23
 1930 NERROR=1
      NERROR=1                                                           00010500
      N=NCARDS-I
      WRITE (NU,26) N                                                    00010700
   26 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA1 CARDS READ)        00010800
   23 CONTINUE                                                           00010900
      NCRES=1
      N=I-1                                                              00011000
      DO 16 I=1,N                                                        00011200
      DO 16 J=1,12
      IF (DATA(I,1)-CODE(J)) 16,4,16                                     00011400
    4 GO TO (5,6,7,8,9,10,11,12,13,14,15,18), J
    5 ILTST = 1                                                          00011600
      GO TO 16                                                           00011700
    6 IRPT1 = 1                                                          00011800
      GO TO 16                                                           00011900
    7 IAUGOP = 1                                                         00012000
      GO TO 16                                                           00012100
```

WATER RESOURCES ENGINEERS, INC /TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 1 OF 19

TITLE DATA

CARD TYPE	Simulate ? Write Yes Or No	ALPHANUMERIC NAME
TITLE01		TWDB/WRE EXPANDED VERSIØN ØF QUAL-I
TITLE02		NAME ØF BASIN =
TITLE03		CØNSERVATIVE MINERAL I IN MG/L
TITLE04		CØNSERVATIVE MINERAL II IN MG/L
TITLE05		CØNSERVATIVE MINERAL III IN MG/L
TITLE06		TEMPERATURE IN DEGREES FAHRENHEIT
TITLE07		BIØCHEMICAL ØXYGEN DEMAND IN MG/L
TITLE08		ALGAE AS CHL A IN µG/L
TITLE09		PHØSPHØRØUS AS P IN MG/L
TITLE10		AMMØNIA AS N MG/L
TITLE11		NITRITE AS N MG/L
TITLE12		NITRATE AS N MG/L
TITLE13		DISSØLVED ØXYGEN IN MG/L
TITLE14		CØLIFØRMS AS MPN
TITLE15	NO	RADIØNUCLIDE (NOT PROGRAMMED)
ENDTITLE		

FORMAT (20A4)
NOTE 1 NH3, NO2, and NO3 must be simulated as a group or not simulated as a group.

16x

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 2 OF 19

PROGRAM ANALYSIS CONTROL DATA

CARD TYPE (TYPE 1 DATA)	PARAMETER VALUE			PARAMETER VALUE
LIST DATA INPUT				
WRITE FINAL SUMMARY				
NØ FLØW AUGMENTATIØN				
STEADY STATE				
NUMBER ØF REACHES =			NUMBER ØF JUNCTIØNS =	
NUM ØF HEADWATERS =			NUMBER ØF WASTE LØADS =	
TIME STEP (HØURS) =			LNTH COMP ELEMENT (MI) =	
MAXIMUM RØUTE TIME (HRS) =			TIME INC FØR RPT2 (HRS) =	
* LATITUDE ØF BASIN (DEG) =			LØNGITUDE ØF BASIN (DEG) =	
* STANDARD MERIDIAN (DEG) =			DAY ØF YEAR START TIME =	
* EVAP CØEF., (AE) =			EVAP CØEF, (BE) =	
* ELEV ØF BASIN (FEET) =			DUST ATTENUATIØN CØEF =	
ENDATAI				

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

NON-SPACIALLY VARIABLE A, N, and P CONSTANTS (SEE NOTE 2)

CARD TYPE (TYPE 1A DATA)	PARAMETER VALUE			PARAMETER VALUE
Ø UPTAKE BY NH3 ØXID(MG Ø/MG N) =			Ø UPTAKE BY NØ2 ØXID(MG Ø/MG/N) =	
Ø PRØD BY ALGAE (MG Ø/MG A) =			Ø UPTAKE BY ALGAE (MG Ø/MG A) =	
N CØNTENT ØF ALGAE (MG N/MG A) =			P CØNTENT ØF ALGAE (MG P/MG A) =	
ALG MAX SPEC GROWTH RATE(I/DAY) =			ALGAE RESPIRATION RATE (I/DAY) =	
N HALF SATURATION CONST (MG/L) =			P HALF SATURATION CONST. (MG/L) =	
LIGHT HALF SAT CONST(LNGLY/MIN) =			TOTAL DAILY RADIATION(LANGLEYS) =	
ENDATAIA				

FORMAT (8A4, F7.0, 2X, 8A4, F7.0)
NOTE 2 These cards (except ENDATAIA) may be deleted unless ALGAE, (NH3, NO2, NO3), PO4, Coliforms or adionuclides are to be simulated

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 3 OF 19

REACH IDENTIFICATION AND RIVER MILE DATA*

CARD TYPE (TYPE 2 DATA)	REACH IDENTIFICATION ORDER	REACH IDENTIFICATION ALPHANUMERIC NAME					RIVER MILE AT HEAD OF REACH			RIVER MILE AT HEAD OF REACH
STREAM REACH		RCH=				FRØM		.	TØ	.
STREAM REACH	.	RCH=				FRØM		.	TØ	.
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH	.	RCH=				FRØM		.	TØ	.
STREAM REACH	.	RCH=				FRØM		.	TØ	
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH		RCH=				FRØM		.	TØ	.
STREAM REACH	.	RCH=				FRØM		.	TØ	
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH	.	RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH		RCH=				FRØM			TØ	.
STREAM REACH	.	RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM			TØ	
STREAM REACH		RCH=				FRØM		.	TØ	.
STREAM REACH	.	RCH=				FRØM			TØ	
ENDATA2										

*This is an unmodified QUAL-1 form (See form B of E)
FORMAT (3A4, 3X, F5.0, 5A4, 3X, A4, 3X, F10.0, 4X, A2, 4X, F10.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM (4) OF (19)

FLOW AUGMENTATION DATA*

CARD TYPE (TYPE 3 DATA)				ORDER OF REACH		#Of Aug. Sources Available	TARGET LEVEL DISSOLVED OXYGEN		ORDER OF AVAILABLE AUGMENTATION SOURCES					
									1 st	2 nd	3 rd	4 th	5 th	6 th
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
FLØW	AUGMT	SØURCES	RCH =											
ENDATA3														

This is an unmodified QUAL-1 form (See form B of E)
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.

Number of forms per pad may vary slightly

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 5 OF 19

COMPUTATIONAL ELEMENT FLAG FIELD DATA*

CARD TYPE (TYPE 4 DATA)	ORDER OF REACH		Num Of Comp. Elements		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 =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
FLAG FIELD RCH =					
ENDATA					

*This is an unmodified QUAL-1 form (See form B)
FORMAT (2A4, A2, 5X, F5.0, 5X, F5.0, 10X, 20F2.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
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FORM 6 OF 19

HYDROLOGIC DATA*

CARD TYPE (TYPE 5 DATA)	ORDER OF REACH		COEFFICIENT OF FLOW FOR VELOCITY	EXPONENT OF FLOW FOR VELOCITY	COEFFICIENT OF FLOW FOR DEPTH	EXPONENT OF FLOW FOR DEPTH	MANNING'S "n"
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
HYDRAULICS	RCH =						
ENDATA5							

This is an unmodified QUAL-1 form (See form C)
FORMAT (2A4, A2, 5X, F5.0, 10X, 5F10.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
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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)	COEFFICIENT OF FLOW FOR K2	EXPONENT OF FLOW FOR K2
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
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REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
REACT CØEF RCH=							
ENDATA6							

*This is an unmodified QUAL-1 form (See form C)
FORMAT (2A4, A2, 5X, F5.0, 6F10.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 8 OF 19

ALGAE, NITROGEN AND PHOSPHOROUS CONSTANTS*

CARD TYPE (TYPE 6A DATA)	ORDER OF REACH		CHLOR A TO ALGAE RATIO μG/MG	Algae Settling Rate (FT/Day)	Rate Coef For NH3 Oxidation (1/Day)	Rate Coef For NH2 Oxidation (1/Day)	Benthos Source Rate For NH3 MG/FT/Day)	Benthos Source Rate For PO4 MG/FT/Day)
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
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ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ALGAE, N AND P CØEF RCH=								
ENDATA6A								

*FORMAT (5A4, 5X, F5.0, 2X, 5F8.0)
These cards (except EnDATA6A) may be deleted unless ALGAE, (NH3, NO2, NO3), PO4, Coliforms or the Radionuclides are to be simulated

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

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.)	RADIO-NUCLIDE DECAY RATE		
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	CØEFFICIENTS	RCH=								
Ø	THER	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 or Radionuclides are to be simulated.

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

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 MG/L	CONSERVATIVE MINERAL II MG/L	CONSERVATIVE MINERAL III MG/L
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
INITIAL CØNDITIØNS	RCH =							
ENDATA7								

*This is an unmodified QUAL-1 form (See form C)
FORMAT (5A4, 5X, F5.0, F10.0, 2F5.0, 3F10.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 11 OF 19

INITIAL CONDITIONS FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES *

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 (MPN)	RADIO-NUCLIDE
INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
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INITIAL CØND-2 RCH=								
INITIAL CØND-2 RCH=								
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 /TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 12 OF 19

INCREMENTAL RUNOFF DATA*

CARD TYPE (TYPE 8 DATA)			ORDER OF REACH	Incremental Flow (CFS)	TEMP (°F)	DO (MG/L)	BOD (MG/L)	CONSERVATIVE MINERAL I (MG/L)	CONSERVATIVE MINERAL II (MG/L)	CONSERVATIVE MINERAL III (MG/L)
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
RUNØFF	CØNDITIØNS	RCH =								
ENDATA8										

*This is an unmodified QUAL-1 form (See form D)
FORMAT (5A4, 5X, 5F5.0, 3F10.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 13 OF 19

INCREMENTAL RUNOFF DATA FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES*

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 (MPN)	RADIO-NUCLIDE
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
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RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-2 RCH=								
RUNØFF CØND-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./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM (14) OF (19)

STREAM JUNCTION DATA*

CARD TYPE (TYPE 9 DATA)	ORDER OF JUNCTION		JUNCTION IDENTIFICATION		No. Of Element Upstream Of Junc.		No Of Element Downstrm Of Junc.		No Of Element On Tributary
STREAM JUNCTION			JNC =						
STREAM JUNCTION			JNC =						
STREAM JUNCTION			JNC =						
STREAM JUNCTION			JNC =						
STREAM JUNCTION			JNC =						
ENDATA9									

*This is an unmodified QUAL-1 form (See form D)
FORMAT (3A4, A3, 5X, F5.0, 5X, 5A4, 3(5X, F5.0)

WATER RESOURCES ENGINEERS, INC /TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 15 OF 19

HEADWATER SOURCES DATA*

CARD TYPE (TYPE 10 DATA)	HEADWATER IDENTIFICATION		HEADWATER FLOW (CFS)	TEMP (F)	D O (MG/L)	B O D (MG/L)	CONS MINERAL I (MG/L)	CONS MINERAL II (MG/L)	CONS. MINERAL III (MG/L)
	ORDER	ALPHANUMERIC NAME							
HEADWATER		HWD =							
HEADWATER		HWD =							
HEADWATER		HWD =							
HEADWATER		HWD =							
HEADWATER		HWD =							
ENDATA10									

This is an unmodified QUAL-1 form (See form D)
FORMAT (2A4, A2, 5X, F5.0, 5A4, F10.0, 6F5.0)

FORM 16 OF 19

HEADWATER SOURCES DATA FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES *

CARD TYPE (TYPE 10A DATA)	Order Of Head-water	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 (MPN)	RADIO-NUCLIDE
HEADWATER-2 HWD =								
HEADWATER-2 HWD =								
HEADWATER-2 HWD =								
HEADWATER-2 HWD =								
HEADWATER-2 HWD =								
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./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM 17 OF 19

WASTE LOADINGS AND WITHDRAWALS DATA*

CARD TYPE (TYPE II DATA)	WASTELOAD OR WITHDRAWAL IDENTIFICATION		PERCENT TREAT-MENT	WASTELOAD OR WITHDRAWAL (CFS)	TEMP (°F)	DO (MG/L)	BOD (MG/L)	CONS. MINERAL I (MG/L)	CONS. MINERAL II (MG/L)	CONS. MINERAL III (MG/L)
	ORDER	ALPHANUMERIC NAME								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
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WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
WASTELØAD		WSL =								
ENDATAII										

This is an unmodified QUAL-1 form.
FORMAT (2A4, A2, F5.0, 5A4, F5.0, F10.0, 6F5.0)

WATER RESOURCES ENGINEERS, INC./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

FORM (18) OF (19)

WASTELOAD DATA FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES*

CARD TYPE (TYPE IIA DATA)	Order Of Waste-Load	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 (MPN)	RADIO-NUCLIDE
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
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WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
WASTELØAD-2 WSL =								
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./TEXAS WATER DEVELOPMENT BOARD
STREAM QUALITY ROUTING MODEL
QUAL-II

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 TEMP (°F)	WET BULB TEMP (°F)	BAROMETRIC PRESS (IN HG)	WIND SPEED KNOTS
LØCAL CLIMATØLØGY	-	-	300						
LØCAL CLIMATØLØGY	-	-	600						
LØCAL CLIMATØLØGY	-	-	900						
LØCAL CLIMATØLØGY	-	-	1200						
LØCAL CLIMATØLØGY	-	-	1500						
LØCAL CLIMATØLØGY	-	-	1800						
LØCAL CLIMATØLØGY	-	-	2100						
LØCAL CLIMATØLØGY	-	-	2400						
LØCAL CLIMATØLØGY	-	-	300						
LØCAL CLIMATØLØGY	-	-	600						
LØCAL CLIMATØLØGY	-	-	900						
LØCAL CLIMATØLØGY	-	-	1200						
LØCAL CLIMATØLØGY	-	-	1500						
LØCAL CLIMATØLØGY	-	-	1800						
LØCAL CLIMATØLØGY	-	-	2100						
LØCAL CLIMATØLØGY	-	-	2400						
LØCAL CLIMATØLØGY	-	-	300						
LØCAL CLIMATØLØGY	-	-	600						
LØCAL CLIMATØLØGY	-	-	900						
LØCAL CLIMATØLØGY	-	-	1200						
LØCAL CLIMATØLØGY	-	-	1500						
LØCAL CLIMATØLØGY	-	-	1800						
LØCAL CLIMATØLØGY	-	-	2100						
LØCAL CLIMATØLØGY	-	-	2400						

*Must be chronologically ordered. FORMAT (30X, F10.0, 5F(8.0))
Net solar radiation is not required if temperate is simulated.
Only net solar radiation is required for algae simulation.

3

STREAM REACH	6.0	RCH= REACH 6	FROM	40.0	TO	20.0
ENDATA2	.0			.0		.0

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

4

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

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

5

CARD TYPE	REACH	ELEMENTS/REACH	COMPUTATIONAL FLAGS
FLAG FIELD	1.	20.	1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD	2.	14.	2.2.2.2.2.6.2.2.2.2.2.2.2.3.**********
FLAG FIELD	3.	12.	1.2.2.2.2.2.2.2.2.2.2.2.2.**********
FLAG FIELD	4.	15.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.**********
FLAG FIELD	5.	16.	4.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.********
FLAG FIELD	6.	20.	2.2.2.2.2.2.2.2.2.2.2.2.2.2.7.2.2.2.2.5.
ENDATA4	0.	0.	**********

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

6

CARD TYPE	REACH	COEFQV	EXPOQV	COEFQH	EXPOQH	CMANN
HYDRAULICS	1.	.120	.400	.350	.600	.035
HYDRAULICS	2.	.120	.400	.350	.600	.035
HYDRAULICS	3.	.360	.400	.300	.600	.000
HYDRAULICS	4.	.360	.400	.300	.600	.000
HYDRAULICS	5.	.360	.400	.250	.600	.035
HYDRAULICS	6.	.480	.400	.250	.600	.035
ENDATA5	0.	.000	.000	.000	.000	.000

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

7

CARD TYPE	REACH	K1	K3	K2OPT	K2	COEQK2	EXPQK2
REACT COEF	1.	.60	.00	3.	.00	.000	.000
REACT COEF	2.	.60	.00	3.	.00	.000	.000
REACT COEF	3.	.60	.00	3.	.00	.000	.000
REACT COEF	4.	.60	.00	3.	.00	.000	.000
REACT COEF	5.	.60	.00	3.	.00	.000	.000
REACT COEF	6.	.60	.00	3.	.00	.000	.000
ENDATA6	0.	.00	.00	0.	.00	.000	.000

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

8

CARD TYPE	REACH	ALPHAO	ALGSET	CKNH3	CKNO2	SNH3	SPO4
ALGAE, N AND P COEF	1.	50.0	.50	.15	1.00	.0	.0
ALGAE, N AND P COEF	2.	50.0	.50	.15	1.00	.0	.0
ALGAE, N AND P COEF	3.	50.0	.50	.15	1.00	.0	.0
ALGAE, N AND P COEF	4.	50.0	.50	.15	1.00	.0	.0
ALGAE, N AND P COEF	5.	50.0	.50	.15	1.00	.0	.0
ALGAE, N AND P COEF	6.	50.0	.50	.15	1.00	.0	.0
ENDATA6A	0.	.0	.00	.00	.00	.0	.0

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

9

CARD TYPE	REACH	CK4	CK5	EXCOEF	CK6
OTHER COEFICIENTS	1.	.00	1.50	.15	.00
OTHER COEFICIENTS	2.	.00	1.50	.15	.00
OTHER COEFICIENTS	3.	.00	1.50	.15	.00
OTHER COEFICIENTS	4.	.00	1.50	.15	.00
OTHER COEFICIENTS	5.	.00	1.50	.15	.00

9

OTHER COEFICIENTS	6.	.00	1.50	.15	.00
ENDATA6E	0.	.00	.00	.00	.00

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

10

CARD TYPE	REACH	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
INITIAL CONDITIONS	1.	65.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	2.	65.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	3.	65.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	4.	65.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	5.	65.0	.0	.0	.0	.0	.0
INITIAL CONDITIONS	6.	65.0	.0	.0	.0	.0	.0
ENDATA7	0.	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROPHYLL A, NITROGEN, PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

11

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
INITIAL COND-2	1.	.0	.00	.00	.00	.00	.0	.00
INITIAL COND-2	2.	.0	.00	.00	.00	.00	.0	.00
INITIAL COND-2	3.	.0	.00	.00	.00	.00	.0	.00
INITIAL COND-2	4.	.0	.00	.00	.00	.00	.0	.00
INITIAL COND-2	5.	.0	.00	.00	.00	.00	.0	.00
INITIAL COND-2	6.	.0	.00	.00	.00	.00	.0	.00
ENDATA7A	0.	.0	.00	.00	.00	.00	.0	.00

$$$ DATA TYPE 8 (RUNOFF CONDITIONS) $$$

12

CARD TYPE	REACH	Q	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
RUNOFF CONDITIONS	1.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	2.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	3.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	4.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	5.	.0	.0	.0	.0	.0	.0	.0
RUNOFF CONDITIONS	6.	.0	.0	.0	.0	.0	.0	.0
ENDATA8	0.	.0	.0	.0	.0	.0	.0	.0

$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FOR NITROGEN,PHOSPHOROUS, COLIFORM AND RADIONUCLIDE) $$$

13

CARD TYPE	REACH	CHLORA	NH3	NO2	NO3	PO4	COLI	RADN
RUNOFF COND-2	1.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	2.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	3.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	4.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	5.	.0	.00	.00	.00	.00	.0	.00
RUNOFF COND-2	6.	.0	.00	.00	.00	.00	.0	.00
ENDATA8A	0.	.0	.00	.00	.00	.00	.0	.00

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

14

CARD TYPE	JUNCTION ORDER AND IDENT		UPSTRM	JUNCTION	TRIB
STREAM JUNCTION	1.	JNC= TRIB-MAINSTEM	34.	62.	61.
ENDATA9	0.		0.	0.	0.

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

15

CARD TYPE	HDWATER ORDER AND IDENT	FLOW	TEMP	D.O.	BOD	CM-I	CM-II	CM-III
HEADWATER	1. HDW= MAINSTEM	100.0	65.0	8.4	3.0	27.0	.0	.0
HEADWATER	2. HDW= TRIBUTARY	50.0	70.0	10.5	2.0	15.0	.0	.0

TEXAS WATER DEVELOPMENT BOARD/WATER RESOURCES ENGINEERS, INC.

* * * DATA LIST FOR MODIFIED QUAL1 STREAM QUALITY ROUTING MODEL * * *

FORM 1

$$$ (PROBLEM TITLES) $$$

CARD TYPE		QUAL-I PROGRAM TITLES
TITLE01		TWDB/WRE EXPANDED VERSION OF QUAL-I
TITLE02		HYPOTHETICAL BASIN
TITLE03	YES	CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)
TITLE04	NO	CONSERVATIVE MINERAL II
TITLE05	NO	CONSERVATIVE MINERAL III
TITLE06	NO	TEMPERATURE IN DEGREES FAHRENHEIT
TITLE07	YES	BIOCHEMICAL OXYGEN DEMAND IN MG/L
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 AS 1000/100 ML
TITLE15	NO	RADIONUCLIDE
ENDTITLE		

1

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

CARD TYPE			CARD TYPE		
LIST DATA INPUT		.00000			.00000
WRITE FINAL SUMMARY		.00000			.00000
NO FLOW AUGMENTATION		.00000			.00000
STEADY STATE SIMULATION		.00000			.00000
NUMBER OF REACHES	=	6.00000	NUMBER OF JUNCTIONS	=	1.00000
NUM OF HEADWATERS	=	2.00000	NUMBER OF WASTE LOADS	=	2.00000
TIME STEP (HOURS)		.00000	LNTH. COMP ELEMENT (MI)	=	1.00000
MAXIMUM ROUTE TIME (HRS)	=	30.00000	TIME INC. FOR RPT2 (HRS)	=	.00000
LATITUDE OF BASIN (DEG)	=	.00000	LONGITUDE OF BASIN (DEG)	=	.00000
STANDARD MERIDIAN (DEG)	=	.00000	DAY OF YEAR START TIME	=	.00000
EVAP. COEF.,(AF)	=	.00000	EVAP. COEF.,(BE)	=	.00000
ELEV. OF BASIN (FEET)	=	.00000	DUST ATTENUATION COEF.	=	.00000
ENDATA1		.00000			.00000

2

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

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 PRO . 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) =	.0850	P CONTENT OF ALGAE (MG P/MG A) =	.0120
ALG MAX SPEC GROWTH RATE(1/DAY) =	1.5000	ALGAE RESPIRATION RATE (1/DAY) =	.1000
N HALF SATURATION CONS (MG/L) =	.3000	P HALF SATURATION CONST (MG/L) =	.0400
LIGHT HALF SAT CONST(LNGLY/MIN) =	.0300	TOTAL DAILY RADIATION(LANGLEYS) =	400.0000
ENDATA1A	.0000		.0000

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

3

CARD TYPE		REACH ORDER AND IDENT		R. MILE		R. MILE
STREAM REACH	1.0	RCH= REACH 1	FROM	90.0	TO	70.0
STREAM REACH	2.0	RCH= REACH 2	FROM	70.0	TO	56.0
STREAM REACH	3.0	RCH= REACH 3 TRIB	FROM	27.0	TO	15.0
STREAM REACH	4.0	RCH= REACH 4 TRIB	FROM	15.0	TO	.0
STREAM REACH	5.0	RCH= REACH 5	FROM	56.0	TO	40.0

```
ENDATA10          0.                                  .0    .0    .0    .0    .0    .0    .0

 $$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL,NITROGEN, PHOSPHOROUS,
                    COLIFORM AND RADIONUCLIDE) $$$

CARD TYPE              HDWATER CHLORA    NH3     NO2     NO3     PO4    COLI    RADN
HEADWATER-2                1.    10.0  1.00     .05     .30     .20      .5     .00
HEADWATER-2                2.     5.0   .50     .01     .10     .05      .0     .00
ENDATA10A                  0.      .0   .00     .00     .00     .00      .0     .00

 $$$ DATA TYPE 11 (WASTE LOADINGS) $$$

CARD TYPE  WASTE LOAD ORDER AND IDENT  FEE      FLOW  TEMP  D.O.   BOD CM-I  CM-II CM-III
WASTELOAD    1.  WSL= INDUSTRIAL LOAD  .00      10.0  80.0   5.0  75.0 100.0    .0     .0
WASTELOAD    2.  WSL= WITHDRAWAL       .00     -80.0    .0    .0    .0    .0    .0     .0
ENDATA11     0.                        .00        .0    .0    .0    .0    .0    .0     .0

 $$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS -  ALGAE,NITROGEN,PHOSPHOROUS,
                    COLIFORMS AND RADIONUCLIDES) $$$

CARD TYPE       WASTE LOAD ORDER AND IDENT    CHL. A      NH3       NO2       NO3       PO4      COLI      RADN
WASTELOAD-2       1. WSL= INDUSTRIAL LOAD       .00     15.00       .50     10.00     20.00    600.00       .00
WASTELOAD-2       2. WSL= WITHDRAWAL            .00       .00       .00       .00       .00       .00       .00
ENDATA11A
```

```
    8 ISS = 2
      GO TO 16                                                          00012300
    9 NREACH = DATA(I,8)                                                00012400
      NJUNC = DATA(I,16)                                                00012500
      GO TO 16                                                          00012600
   10 NWATER = DATA(I,8)                                                00012700
      NWASTE = DATA(I,16)                                               00012800
      GO TO 16                                                          00012900
   11 DELT = DATA(I,8)                                                  00013000
      DELX = DATA(I,16)                                                 00013100
      GO TO 16                                                          00013200
   12 TMAX = DATA(I,8)                                                  00013300
      DTIME = DATA(I,16)                                                00013400
      GO TO 16                                                          00013500
   13 LAT = DATA(I,8)                                                   00013600
      LIM = DATA(I,16)                                                  00013700
      GO TO 16                                                          00013800
   14 LSM = DATA(I,8)                                                   00013900
      DAYOFY = DATA(I,16)                                               00014000
      GO TO 16                                                          00014100
   15 AE = DATA(I,8)                                                    00014200
      BE = DATA(I,16)                                                   00014300
      GO TO 16                                                          00014400
   18 ELEV=DATA(I,8)                                                    00014500
      DAT=DATA(I,16)                                                    00014600
      GO TO 16                                                          00014700
   16 CONTINUE                                                          00014900
      IF(NREACH-75) 610,610,620
  620 WRITE(NJ,515)  NREACH
  515 FORMAT(1H0,5X,'*****',I5,'REACHES EXCEED THE PROGRAM DIMENSIONS'
     *       ' OF 75')
      NERROR=1
  610 CONTINUE
      IF(NWASTE-75) 630,630,640
  640 WRITE(NJ,516)  NWASTE
  516 FORMAT(1H0,5X,'*****',I5,'WASTE LOADS EXCEED THE PROGRAM'
     *       ' DIMENSIONS OF 75')
      NERROR=1
  630 CONTINUE
      IF (ILIST.EQ.0) GO TO 200                                         00015000
      WRITE (NJ,501)                                                    00015100
  501 FORMAT(1H1,20X,29HTEXAS WATER DEVELOPMENT BOARD,32H/WATER RESOURCE
     *S ENGINEERS, INC.,//17X,34H* * * DATA LIST FOR MODIFIED QUAL1,
     * 35H STREAM QUALITY ROUTING MODEL * * *)
      WRITE (NJ,502)                                                    00015500
  502 FORMAT (1H0,10X,24H$$$ (PROBLEM TITLES) $$$,/)                    00015600
      WRITE (NJ,201)                                                    00015700
  201 FORMAT (10X,9HCARD TYPE,29X,21HQUAL-I PROGRAM TITLES)             00015800
      WRITE (NJ,503) ((TITLE(I,J),J=1,20),I=1,NTITLE)                   00015900
  503 FORMAT (10X,20A4)                                                 00016000
      WRITE (NJ,504)                                                    00016100
  504 FORMAT (1H0,10X,34H$$$ DATA TYPE 1 (CONTROL DATA) $$$,/)          00016200
      WRITE (NJ,203)                                                    00016300
  203 FORMAT (10X,9HCARD TYPE,36X,9HCARD TYPE)                          00016400
      WRITE (NJ,103) ((DATA(I,J),J=1,16),I=1,NCRDS)                     00016500
  103 FORMAT (2(10X,6A4,A1,F10.5))                                      00016600
  200 CONTINUE                                                          00016700
C
C                                        STEP 3-1A
C                                        READ IN DATA TYPE 1A (ALGAE PRODUCTION
```

```
C                                        AND NITROGEN OXIDATION CONSTANTS).
C
      DO 1003 I=1,7
      READ (NI,1001) (DATA(I,J),J=1,18)
 1001 FORMAT (8A4,F7.0,2X,8A4,F7.0)
      IF (DATA(I,1)-ENDA) 1003,1021,1003
 1003 CONTINUE
      NERROR=1
 1005 I=I+1
      READ (NI,1001) (DATA(I ,J),J=1,18)
      IF (DATA(I,1)-ENDA) 1005,1007,1005
 1007 N=I-7
      WRITE (NU,1020) N
 1020 FORMAT (1H0,5X,16H***** TOO MANY (,I3,20H) DATA 1A CARDS READ)
      GO TO 1004
 1021 IF (I.GE.7) GO TO 1004
      IF(IDATA) 1024,1024,1025
 1024 NCRDS=1
      GO TO 1020
 1025 NERROR=1
      N=7-I
      WRITE (NU,1022) N
 1022 FORMAT (1H0,5X,15H***** TOO FEW (,I3,20H) DATA 1A CARDS READ)
 1004 CONTINUE
      N=I-1
      NCRDS=1
      DO 1006 I=1,N
      DO 1006 J=1,6
      IF(DATA(I,1)-CODE2(J))1006,1008,1006
 1008 GO TO (1009,1010,1011,1012,1013,1014), J
 1009 ALPHA5=DATA(I,9)
      ALPHA6=DATA(I,18)
      GO TO 1006
 1010 ALPHA3=DATA(I,9)
      ALPHA4=DATA(I,18)
      GO TO 1006
 1011 ALPHA1=DATA(I,9)
      ALPHA2=DATA(I,18)
      GO TO 1006
 1012 GROMAX=DATA(I,9)
      RESPRT=DATA(I,18)
      GO TO 1006
 1013 CKN=DATA(I,9)
      CKP=DATA(I,18)
      GO TO 1006
 1014 CKL=DATA(I,9)
      SONFT=DATA(I,18)
      IF(MODOPT(2) .GT. 0) CKL=CKL*0.1532
 1006 CONTINUE
 1026 IF (ILIST .LE. 0) GO TO 1015
      WRITE (NU,1016)
 1016 FORMAT (1H0,10X,66H$$$DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN
     *OXIDATION CONSTANTS ,4H)$$$,/)
      WRITE (NU,1017)
 1017 FORMAT (10X,9HCARD TYPE,36X,9HCARD TYPE)
      WRITE (NU,1018) ((DATA(I,J),J=1,18),I=1,NCRDS)
 1018 FORMAT(2(10X,8A4,F10.4))
 1015 CONTINUE
C                                                                        00016800
C                                        STEP 3-2                        00016900
```

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C                                       RFAD IN DATA TYPE 2 (REACH IDENT00017000
C                                       RIVER MILE AT HEAD AND END OF RF00017100
C                                                                       00017200
      II = NREACH+1                                                     00017300
      DO 50 I=1,II                                                      00017400
      READ (NI,51) (DATA(I,J),J=1,13)                                   00017500
   51 FORMAT (3A4,3X,F5.0,5A4,3X,A4,3X,F10.0,4X,A2,4X,F10.0)            00017600
      IF (DATA(I,1)-ENDA) 50,55,50                                      00017700
   50 CONTINUE                                                          00017800
      NERROR=1                                                          00017900
   54 I=I+1                                                             00018000
      READ (NI,51) (DATA(I,J),J=1,13)                                   00018100
      IF (DATA(I,1)-ENDA) 54,59,54                                      00018200
   59 N=I-II                                                            00018300
      WRITE (NJ,52) N                                                   00018400
   52 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA2 CARDS READ)      00018500
      GO TO 53                                                          00018600
   55 IF (I.GE.II) GO TO 53                                             00018700
      NERROR = 1                                                        00018800
      N=II-I                                                            00018900
      WRITE (NJ,56) N                                                   00019000
   56 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA2 CARDS READ)       00019100
   53 CONTINUE                                                          00019200
      NCRDS=I                                                           00019300
      IMAX=0
      DO 1050 I=1,NREACH
      IRCH=IFIX(DATA(I,4)*10.+0.0001)
      IRCHNO(IRCH)=1
      IMAX=MAX0(IMAX,IRCH)
 1050 CONTINUE
      IORDER=0
      DO 1055 IRCH=1,IMAX
      IF (IRCHNO(IRCH)) 1055,1055,1052
 1052 IORDER=IORDER+1
      IRCHNO(IRCH)=IORDER
 1055 CONTINUE
      DO 57 I=1,NREACH                                                  00019400
      IPCH=IFIX(DATA(I,4)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      DO 58 J=5,9                                                       00019600
      K = J-4                                                           00019700
      RCHID(NRCH,K) = DATA(I,J)                                         00019800
   58 CONTINUE                                                          00019900
      RMTHOR(NRCH) = DATA(I,11)                                         00020000
      RMTFOR(NRCH) = DATA(I,13)                                         00020100
   57 CONTINUE                                                          00020200
      IF (ILIST.EQ.0) GO TO 425                                         00020300
      WRITE (NJ,505)                                                    00020400
  505 FORMAT (1H0,10X,42H$$$ DATA TYPE 2 (REACH IDENTIFICATION) $$$,/)  00020500
      WRITE (NJ,205)                                                    00020600
  205 FORMAT (10X,9HCARD TYPE,11X,21HREACH ORDER AND IDENT,             00020700
     *        15X,7HR. MILE,13X,7HR. MILE)                              00020800
      WRITE (NJ,401) ((DATA(I,J),J=1,13),I=1,NCRDS)                     00020900
  401 FORMAT (10X,3A4,3X,F5.1,2X,5A4,3X,A4,3X,F10.1,4X,A2,4X,F10.1)
  425 CONTINUE                                                          00021100
C                                                                       00021200
C                                       STEP 3-3                        00021300
C                                       RFAD IN DATA TYPE 3 (TARGET LEVE00021400
C                                       AVAILARLE FLOW AUGMENTATION SOUR00021500
C                                                                       00021600
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      DO 60 I=1,II                                                      00021700
      READ (NI,61) (DATA(I,J),J=1,14)                                   00021800
   61 FORMAT (5A4,3X,F5.0,5X,F5.0,F10.0,6F5.0)                          00021900
      IF (DATA(I,1)-FNDA) 60,65,60                                      00022000
   60 CONTINUE                                                          00022100
      JERROR = 1                                                        00022200
   64 I=I+1                                                             00022300
      READ (NI,61) (DATA(I,J),J=1,14)                                   00022400
      IF (DATA(I,1)-FNDA) 64,69,64                                      00022500
   69 N=I-II                                                            00022600
      WRITE (NJ,62) N                                                   00022700
   62 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA3 CARDS READ)      00022800
      GO TO 63                                                          00022900
   65 IF (I.GE.II) GO TO 63                                             00023000
      IF(IAUGOP) 8623,8623,8624
 8623 NCRDS=1
      GO TO 8625
 8624 JERROR=1
      N=II-1                                                            00023200
      WRITE (NJ,66) N                                                   00023300
   66 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA3 CARDS READ)       00023400
   63 CONTINUE                                                          00023500
      NCRDS=I                                                           00023600
      DO 67 I=1,NREACH                                                  00023700
      IRCH=IFIX(DATA(I,6)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      NHWAR = DATA(I,7)                                                 00023900
      NHWWAR(NRCH) = NHWAR                                              00024000
      TARGDO(NRCH)=DATA(I,8)                                            00024100
      DO 68 J=9,14                                                      00024200
      K = J-8                                                           00024300
      IAUGOR(NRCH,K) = DATA(I,J)                                        00024400
   68 CONTINUE                                                          00024500
   67 CONTINUE                                                          00024600
 8625 IF (ILIST.EQ.0) GO TO 426
      WRITE (NJ,506)                                                    00024800
  506 FORMAT (1H0,10X,36H$$$ DATA TYPE 3 (TARGET LEVEL DO AND,          00024900
     *                 31H FLOW AUGMENTATION SOURCES) $$$,/)            00025000
      WRITE (NJ,206)                                                    00025100
  206 FORMAT (10X,9HCARD TYPE,18X,24HREACH  AVAIL HDWS TARGET,          00025200
     *          5X,22HORDER OF AVAIL SOURCES)                           00025300
      WRITE (NJ,402) ((DATA(I,J),J=1,14),I=1,NCRDS)                     00025400
  402 FORMAT (10X,5A4,5X,F5.0,5X,F5.0,F10.1,6F5.0)                      00025500
  426 CONTINUE                                                          00025600
C                                                                       00025700
C                                       STEP 3-4                        00025800
C                                       READ IN DATA TYPE 4 (COMPUTATION00025900
C                                       ELEMENT FLAG FIELD)             00026000
C                                            1  =  ELEMENT WHICH REPRESEN00026100
C                                                  HEADWATER SOURCE.    00026200
C                                            2  =  AN ELEMENT WITH NO EXT00026300
C                                                  INPUTS OTHER THAN INCR00026400
C                                            3  =  AN ELEMENT ON THE MAIN00026500
C                                                  IMMEDIATELY UPSTREAM F00026600
C                                                  JUNCTION.            00026700
C                                            4  =  AN ELEMENT WHICH REPRE00026800
C                                                  A STREAM JUNCTION.   00026900
C                                            5  =  AN ELEMENT WHICH REPRE00027000
C                                                  THE LAST COMPUTATIONAL00027100
C                                                  IN THE SYSTEM.       00027200
```

```
C                                          S  =  AN ELEMENT WITH A WAS
C                                          /  =  AN ELEMENT WITH A WITH
C
      DO 70 I=1,II
      READ (NI,71) (DATA(I,J),J=1,25)
   71 FORMAT (2A4,A2,5X,F5.0,5X,F5.0,10X,20F2.0)
      IF (DATA(I,1)-END A) 70,75,70
   70 CONTINUE
      NERROR=1
   74 I=I+1
      READ (NI,71) (DATA(I,J),J=1,25)
      IF (DATA(I,1)-END A) 74,79,74
   79 N=I-II
      WRITE (NJ,72) N
   72 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA4 CARDS READ)
      GO TO 73
   75 IF (I.GE.II) GO TO 73
      NERROR = 1
      N=II-I
      WRITE (NJ,76) N
   76 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA4 CARDS READ)
   73 CONTINUE
      NCRDS=I
      DO 77 I=1,NREACH
      IRCH=IFIX(DATA(I,4)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      NCELR = DATA(I,5)
      NCELRH(NRCH)=NCELR
      DO 76 J=6,25
      K = J-5
      IFLAG(NRCH,K)=DATA(I,J)
   76 CONTINUE
   77 CONTINUE
      IF (ILIST.EQ.0) GO TO 427
      WRITE (NJ,507)
  507 FORMAT (1H0,10X,36H$$$ DATA TYPE 4 (COMPUTATIONAL REACH,
     *                16H FLAG FIELD) $$$,/)
      WRITE (NJ,207)
  207 FORMAT (10X,9HCARD TYPE,8X,20HREACH ELEMENTS/REACH,
     *        13X,19HCOMPUTATIONAL FLAGS)
      WRITE (NJ,403) ((DATA(I,J),J=1,25),I=1,NCRDS)
  403 FORMAT (10X,2A4,A2,5X,F5.0,5X,F5.0,10X,20F2.0)
  427 CONTINUE
      IOR=0
      DO 28 I=1,NREACH
      NCELR=NCELRH(I)
      DO 28 J=1,NCELR
      IOR=IOR+1
      ICLORD(I,J)=IOR
   28 CONTINUE
      NCELLS=IOR
C
C                                     STEP 3-5
C                                     READ IN DATA TYPE 5 (HYDRAULIC C
```

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C                                       FOR COMPUTING VELOCITY AND DEPTH00032600
C                                                                       00032700
      DO 80 I=1,II                                                      00032800
      READ (NI,81) (DATA(I,J),J=1,9)                                    00032900
   81 FORMAT (2A4,A2,5X,F5.0,10X,5F10.0)                                00033000
      IF (DATA(I,1)-ENDA) 80,85,80                                      00033100
   80 CONTINUE                                                          00033200
      NERROR = 1                                                        00033300
   84 I=I+1                                                             00033400
      READ (NI,81) (DATA(I,J),J=1,9)                                    00033500
      IF (DATA(I,1)-ENDA) 84,89,84                                      00033600
   89 N=I-II                                                            00033700
      WRITE (NU,82) N                                                   00033800
   82 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA5 CARDS READ)      00033900
      GO TO 83                                                          00034000
   85 IF (I.GE.II) GO TO 83                                             00034100
      NERROR = 1                                                        00034200
      N=II-I                                                            00034300
      WRITE (NU,86) N                                                   00034400
   86 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA5 CARDS READ)       00034500
   83 CONTINUE                                                          00034600
      NCHLS=1                                                           00034700
      DO 87 I=1,NREACH                                                  00034800
      IRCH=IFIX(DATA(I,4)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      COEFQV(NRCH) = DATA(I,5)                                          00035000
      EXPOQV(NRCH) = DATA(I,6)                                          00035100
      COEFQH(NRCH) = DATA(I,7)                                          00035200
      EXPOQH(NRCH) = DATA(I,8)                                          00035300
      CMANN(NRCH) = DATA(I,9)                                           00035400
   87 CONTINUE                                                          00035500
      IF (ILIST.EQ.0) GO TO 428                                         00035600
      WRITE (NU,508)                                                    00035700
  508 FORMAT (1H0,10X,39H$$$ DATA TYPE 5 (HYDRAULIC COEFFICIENTS,       00035800
     *                40H FOR DETERMINING VELOCITY AND DEPTH) $$$,/)    00035900
      WRITE (NU,205)                                                    00036000
  205 FORMAT (10X,9HCARD TYPE,8X,5HREACH,13X,16HCOEFQV    EXPOQV,       00036100
     *        4X,26HCOEFQH    EXPOQH     CMANN)                         00036200
      WRITE (NU,404) ((DATA(I,J),J=1, 9),I=1,NCRDS)                     00036300
  404 FORMAT (10X,2A4,A2,5X,F5.0,10X,5F10.3)                            00036400
  428 CONTINUE                                                          00036500
C                                                                       00036600
C                                       STEP 3-6                        00036700
C                                       READ IN DATA TYPE 6 (REACTION C000036800
C                                       DEOXYGENATION AND REAERATION).  00036900
C                                                                       00037000
      DO 90 I=1,II                                                      00037100
      READ (NI,91) (DATA(I,J),J=1,10)                                   00037200
   91 FORMAT (2A4,A2,5X,F5.0,6F10.0)                                    00037300
      IF (DATA(I,1)-ENDA) 90,95,90                                      00037400
   90 CONTINUE                                                          00037500
      NERROR = 1                                                        00037600
   94 I=I+1                                                             00037700
      READ (NI,91) (DATA(I,J),J=1,10)                                   00037800
      IF (DATA(I,1)-ENDA) 94,99,94                                      00037900
   99 N=I-II                                                            00038000
      WRITE (NU,92) N                                                   00038100
   92 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA6 CARDS READ)      00038200
      GO TO 93                                                          00038300
   95 IF (I.GE.II) GO TO 93                                             00038400
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      IERROR = 1                                                        00038500
      N=II-I                                                            00038600
      WRITE (NO,96) N                                                   00038700
   96 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA6 CARDS READ)       00038800
   97 CONTINUE                                                          00038900
      NCRDS=I                                                           00039000
      DO 97 I=1,NREACH                                                  00039100
      IRCH=IFIX(DATA(I,4)*10.+0.0001)
      NRCH=IRCHRD(IRCH)
      CK1(NRCH) = DATA(I,5)                                             00039300
      CK3(NRCH) = DATA(I,6)                                             00039400
      K2OPT(NRCH) = DATA(I,7)                                           00039500
      CK2(NRCH) = DATA(I,8)                                             00039600
      COEQK2(NRCH) = DATA(I,9)                                          00039700
      EXPQK2(NRCH) = DATA(I,10)                                         00039800
   97 CONTINUE                                                          00039900
      IF (ILIST.EQ.0) GO TO 429                                         00040000
      WRITE (NO,509)                                                    00040100
  509 FORMAT (1H0,10X,38H$$$ DATA TYPE 6 (REACTION COEFFICIENTS,        00040200
     *                    38H FOR DEOXYGENATION AND REAERATION) $$$,/)  00040300
      WRITE (NO,209)                                                    00040400
  209 FORMAT (10X,9HCARD TYPE,8X,12HREACH     K1,8X,2HK3,8X,5HK2OPT,    00040500
     *          5X,23HK2     COEQK2     EXPQK2)                         00040600
      WRITE (NO,405) ((DATA(I,J),J=1,10),I=1,NCRDS)                     00040700
  405 FORMAT (10X,2A4,A2,5X,F5.0,2F10.2,F10.0,F10.2,2F10.3)             00040800
  429 CONTINUE                                                          00040900
C
C                                        STEP 3-6A
C                                        READ IN DATA TYPE 6A (ALGAE, NITROGEN,
C                                        AND PHOSPHOROUS COEF.)
C
      DO 1100 I=1,II
      READ(NI,1101) (DATA(I,J),J=1,12)
 1101 FORMAT(5A4,5X,F5.0,2X,6F8.0)
      IF (DATA(I,1)-ENDA) 1100,1105,1100
 1100 CONTINUE
      NERROR=1
 1104 I=I+1
      READ(NI,1101) (DATA(I,J),J=1,12)
      IF (DATA(I,1)-ENDA)1104,1109,1104
 1109 N=I-II
      WRITE (NO,1102) N
 1102 FORMAT (1H0,5X,16H***** TOO MANY (,I3,19H) DATA6A CARDS READ)
      GO TO 1103
 1105 IF(I.GE.II) GO TO 1103
      IF(IDATA) 1120,1120,1130
 1120 NCRDS=1
      GO TO 1140
 1130 NERROR=1
      N=II-I
      WRITE (NO,1106) N
 1106 FORMAT (1H0,5X,15H***** TOO FEW (,I3,19H) DATA6A CARDS READ)
 1103 CONTINUE
      NCRDS=I
      DO 1107 I=1,NREACH
      IRCH=IFIX(DATA(I,6)*10.+0.0001)
      NRCH=IRCHRD(IRCH)
      ALPHAD(NRCH)=DATA(I,7)
      ALGSET(NRCH)=DATA(I,8)
      CKNRS(NRCH)=DATA(I,9)
```

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      CKNO2(NRCH)=DATA(I,10)
      SNH3(NRCH)=DATA(I,11)
      SPHOS(NRCH)=DATA(I,12)
 1107 CONTINUE
 1140 IF(TLIST .EQ. 0) GO TO 1199
      WRITE(NJ,1110)
 1110 FORMAT(1H0,10X,65H$$$ DATA TYPE 6A (ALGAE, NITROGEN, AND PHOSPHORO
     $US CONSTANTS) $$$,/)
      WRITE(NJ,1111)
 1111 FORMAT(10X,9HCARD TYPE,17X,6H REACH,2X,6HALPHAO,3X,6HALGSET,3X,
     *  5HCKNH3,4X,5HCKNO2,4X,4HSNH3,7X,4HSPO4)
      WRITE(NJ,1112) ((DATA(I,J), J=1,12), I=1,NCRDS)
 1112 FORMAT(10X,5A4,2X,F8.0,F8.1,1X,2F8.2,1X,F9.2,2F10.1)
 1199 CONTINUE
C
C                                        STEP 3-6B
C                                        READ IN DATA TYPE 6B (OTHER COEF.)
C
      DO 1200 I=1,II
      READ(NI,1201) (DATA(I,J),J=1,12)
 1201 FORMAT(5A4,5X,F5.0,2X,6F8.0)
      IF (DATA(I,1)-ENDA) 1200,1205,1200
 1200 CONTINUE
      NERROR=1
 1204 I=I+1
      READ(NI,1201) (DATA(I,J),J=1,12)
      IF (DATA(I,1)-ENDA)1204,1209,1204
 1209 N=I-II
      WRITE (NJ,1202) N
 1202 FORMAT (1H0,5X,16H***** TOO MANY (,I3,19H) DATA6B CARDS READ)
      GO TO 1203
 1205 IF(I.GE.II) GO TO 1203
      IF(IDATA) 1220,1220,1230
 1220 NCRDS=1
      GO TO 1250
 1230 NERROR=1
      N=II-I
      WRITE (NJ,1206) N
 1206 FORMAT (1H0,5X,15H***** TOO FEW (,I3,19H) DATA6B CARDS READ)
 1203 CONTINUE
      NCRDS=I
      DO 1207 I=1,NREACH
      IRCH=IFIX(DATA(I,6)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      CK4(NRCH)=DATA(I,7)
      CK5(NRCH)=DATA(I,8)
      EXCOEF(NRCH)=DATA(I,9)
      CK6(NRCH)=DATA(I,10)
 1207 CONTINUE
 1250 IF(TLIST.EQ.0) GO TO 1299
      WRITE(NJ,1210)
 1210 FORMAT(1H0,10X,41H$$$ DATA TYPE 6B (OTHER COEFFICIENTS) $$$,/)
      WRITE(NJ,1211)
 1211 FORMAT(10X,9HCARD TYPE,18X,6H REACH,4X,3HCK4,6X,3HCK5,6X,6HEXCOEF,
     *3X,3HCK6)
      WRITE(NJ,1212) ((DATA(I,J), J=1,10), I=1,NCRDS)
 1212 FORMAT(10X,5A4,2X,F9.0,4F9.2)
 1299 CONTINUE
C                                                                       00041000
C                                        STEP 3-7                       00041100
```

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C                                       READ IN DATA TYPE 7 (INITIAL CO00041200
C                                                                       00041300
      DO 110 I=1,II                                                     00041400
      READ (NI,111) (DATA(I,J),J=1,12)                                  00041500
  111 FORMAT (5A4,5X,F5.0,F10.0,2F5.0,3F10.0)                           00041600
      IF (DATA(I,1)-ENDA) 110,115,110                                   00041700
  110 CONTINUE                                                          00041800
      NERROR=1                                                          00041900
  114 I=I+1                                                             00042000
      READ (NI,111) (DATA(I,J),J=1,12)                                  00042100
      IF (DATA(I,1)-ENDA) 114,119,114                                   00042200
  119 N=I-II                                                            00042300
      WRITE (NJ,112) N                                                  00042400
  112 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA7 CARDS READ)      00042500
      GO TO 113                                                         00042600
  115 IF (I.GE.II) GO TO 113                                            00042700
      NERROR = 1                                                        00042800
      N=II-I                                                            00042900
      WRITE (NJ,116) N                                                  00043000
  116 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA7 CARDS READ)       00043100
  113 CONTINUE                                                          00043200
      NCRDS=I                                                           00043300
      DO 117 I=1,NREACH                                                 00043400
      IRCH=IFIX(DATA(I,6)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      TINIT(NRCH) = DATA(I,7)                                           00043600
      DOINIT(NRCH) = DATA(I,8)                                          00043700
      BOINIT(NRCH) = DATA(I,9)                                          00043800
      COINIT(NRCH,1)=DATA(I,10)                                         00043900
      COINIT(NRCH,2)=DATA(I,11)                                         00044000
      COINIT(NRCH,3)=DATA(I,12)                                         00044100
  117 CONTINUE                                                          00044200
      IF (ILIST.EQ.0) GO TO 430                                         00044300
      WRITE (NJ,510)                                                    00044400
  510 FORMAT (1H0,10X,40H$$$ DATA TYPE 7 (INITIAL CONDITIONS) $$$,/)    00044500
      WRITE (NJ,210)                                                    00044600
  210 FORMAT (10X,9HCARD TYPE,18X,23HREACH    TEMP  D.O. BOD.           00044700
     *          6X,26HCM-I       CM-II       CM-III)                   00044800
      WRITE (NJ,406) ((DATA(I,J),J=1,12),I=1,NCRDS)                     00044900
  406 FORMAT (19X,5A4,5X,F5.0,F10.1,2F5.1,3F10.1)                       00045000
  430 CONTINUE                                                          00045100
C
C                                       STEP 3-7A
C                                       READ IN DATA TYPE7A (INITIAL CONDITIONS
C                                       FOR CHLOROPHYLL,NITROGEN,PHOSPHOROUS,
C                                       COLIFORM,AND RADIONUCLIDE)
C
      DO 1302 I=1,II
      READ(NI,1301) (DATA(I,J), J=1,12)
 1301 FORMAT(3A4,A2,5X,F5.0,7F8.0)
      IF (DATA(I,1)-ENDA) 1302,1303,1302
 1302 CONTINUE
      NERROR=1
 1304 I=I+1
      READ(NI,1301) (DATA(I,J), J=1,12)
      IF (DATA(I,1)-ENDA) 1304,1305,1304
 1305 N=I-II
      WRITE (NJ,1306) N
 1306 FORMAT (1H0,5X,16H***** TOO MANY (,I3,20H) DATA 7A CARDS READ)
      GO TO 1307
```

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1303 IF (I.GE.II) GO TO 1307
     IF(IDATA) 1321,1321,1330
1321 NCRDS=1
      GO TO 1350
1330 NERROR=1
     N=II-1
     WRITE (NJ,1308) N
1308 FORMAT (1H0,5X,15H***** TOO FEW (,I3,20H) DATA 7A CARDS READ)
1307 CONTINUE
     NCRDS=I
     DO 1309 I=1,NREACH
     IRCH=IFIX(DATA(I,5)*10.+0.0001)
     NRCH=IRCHNO(IRCH)
     ALGIT(NRCH)=DATA(I,6)/ALPHAO(NRCH)
     CNH3IT(NRCH)=DATA(I,7)
     CNO2IT(NRCH)=DATA(I,8)
     CNO3IT(NRCH)=DATA(I,9)
     PHOSIT(NRCH)=DATA(I,10)
     COLIIT(NRCH)=DATA(I,11)
     RADNIT(NRCH)=DATA(I,12)
1309 CONTINUE
1350 IF (ILIST.EQ.0) GO TO 1320
     WRITE (NJ,1310)
1310 FORMAT(1H0,10X,48H$$$ DATA TYPE 7A (INITIAL CONDITIONS FOR CHLOROP
    * 30HHYLL A, NITROGEN, PHOSPHOROUS,/,29X,30HCOLIFORM AND RADIONUCLI
    *DE) $$$ ,/)
     WRITE (NJ,1311)
1311 FORMAT (10X,9HCARD TYPE,15X,5HREACH,1X,6HCHLORA,4X,3HNH3,5X,3HNO2,
    *5X,3HNO3,5X,3HPO4,4X,4HCOLI,4X,4HRADN)
     WRITE(NJ,1312) ((DATA(I,J), J=1,12), I=1,NCRDS)
1312 FORMAT(10X,3A4,A2,8X,F6.0,2X,F6.1,F6.2,3F8.2,F10.1,F6.2)
1320 CONTINUE
C                                                                       00045200
C                                        STEP 3-8                       00045300
C                                        READ IN DATA TYPE 8 (INCREMENTAL00045400
C                                        CONDITIONS).                   00045500
C                                                                       00045600
     DO 120 I=1,II                                                      00045700
     READ (NI,121) (DATA(I,J),J=1,13)                                   00045800
 121 FORMAT (5A4,5X,5F5.0,3F10.0)                                       00045900
     IF (DATA(I,1)-ENDA) 120,125,120                                    00046000
 120 CONTINUE                                                           00046100
     NERROR=1                                                           00046200
 124 I=I+1                                                              00046300
     READ (NI,121) (DATA(I,J),J=1,13)                                   00046400
     IF (DATA(I,1)-ENDA) 124,129,124                                    00046500
 129 N=I-II                                                             00046600
     WRITE (NJ,122) N                                                   00046700
 122 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA8 CARDS READ)       00046800
     GO TO 123                                                          00046900
 125 IF (I.GE.II) GO TO 123                                             00047000
     NERROR = 1                                                         00047100
     N=II-1                                                             00047200
     WRITE (NJ,126) N                                                   00047300
 126 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA8 CARDS READ)        00047400
 123 CONTINUE                                                           00047500
     NCRDS=I                                                            00047600
     DO 127 I=1,NREACH                                                  00047700
     IRCH=IFIX(DATA(I,6)*10.+0.0001)
     NRCH=IRCHNO(IRCH)
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      QI(NRCH) = DATA(I,7)                                              00047900
      TI(NRCH) = DATA(I,8)                                              00048000
      DOI(NRCH) = DATA(I,9)                                             00048100
      BODI(NRCH) = DATA(I,10)                                           00048200
      CONSI(NRCH,1)=DATA(I,11)                                          00048300
      CONSI(NRCH,2)=DATA(I,12)                                          00048400
      CONSI(NRCH,3)=DATA(I,13)                                          00048500
  127 CONTINUE                                                          00048600
      IF (ILIST.EQ.0) GO TO 431                                         00048700
      WRITE (NJ,511)                                                    00048800
  511 FORMAT (1H0,10X,39H$$$ DATA TYPE A (RUNOFF CONDITIONS) $$$,/)     00048900
      WRITE (NJ,211)                                                    00049000
  211 FORMAT (10X,9HCARD TYPE,18X,23HREACH Q  TEMP  D.O. BOD.           00049100
     *        6X,26HCM-I      CM-II      CM-III)                       00049200
      WRITE (NJ,407) ((DATA(I,J),J=1,13),I=1,NCRDS)                     00049300
  407 FORMAT (10X,5A4,5X,F5.0,4F5.1,3F10.1)                             00049400
  431 CONTINUE                                                          00049500
C
C                                        STEP 3-8A
C                                        READ IN DATA TYPE 8A (INCREMENTAL FLOW
C                                        CONDITIONS FOR CHLOROPHYLL, NITROGEN,
C                                        PHOSPHOROUS, COLIFORM AND RADIONUCLIDE)
C
      DO 1400 I=1,II
      READ(NI,1401) (DATA(I,J), J=1,12)
 1401 FORMAT(3A4,A2,5X,F5.0,7F8.0)
      IF (DATA(I,1)-ENDA) 1400,1402,1400
 1400 CONTINUE
      NERROR=1
 1403 I=I+1
      READ(NI,1401) (DATA(I,J), J=1,12)
      IF (DATA(I,1)-ENDA) 1403,1404,1403
 1404 N=I-II
      WRITE (NJ,1405) N
 1405 FORMAT (1H0,5X,16H***** TOO MANY (,I3,20H) DATA 8A CARDS READ)
      GO TO 1406
 1402 IF (I.GE.II) GO TO 1406
      IF(IDATA)1420,1420,1430
 1420 NCRDS=1
      GO TO 1450
 1430 NERROR=1
      N=II-I
      WRITE (NJ,1407) N
 1407 FORMAT (1H0,5X,15H***** TOO FEW (,I3,20H) DATA 8A CARDS READ)
 1406 CONTINUE
      NCRDS=I
      DO 1408 I=1,NREACH
      IRCH=IFIX(DATA(I,5)*10.+0.0001)
      NRCH=IRCHNO(IRCH)
      ALGI(NRCH)=DATA(I,6)/ALPHAO(NRCH)
      CNH3I(NRCH)=DATA(I,7)
      CNO2I(NRCH)=DATA(I,8)
      CNO3I(NRCH)=DATA(I,9)
      PHOSI(NRCH)=DATA(I,10)
      COLIR(NRCH)=DATA(I,11)
      RADNI(NRCH)=DATA(I,12)
 1408 CONTINUE
 1450 IF(ILIST .EQ.0) GO TO 1409
      WRITE (NJ,1410)
 1410 FORMAT(1H0,10X,48H$$$ DATA TYPE 8A (INCREMENTAL FLOW CONDITIONS FO
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     * 23HC NITROGEN,PHOSPHOROUS, /,29X,30HCOLIFORM AND RADIONUCLIDE) $$
     *$,/)
      WRITE (NJ,1411)
 1411 FORMAT (10X,9HCARD TYPE,15X,5HREACH,1X,6HCHLORA,4X,3HNH3,5X,3HNO2,
     * 5X,3HNO3,5X,3HPO4,4X,4HCOLI,4X,4HRADN)
      WRITE(NJ,1412) ((DATA(I,J), J=1,12), I=1,NCRDS)
 1412 FORMAT(10X,3A4,A2,8X,F6.0,2X,F6.1,F6.2,3F8.2,F10.1,F6.2)
 1409 CONTINUE
C                                                                       00049600
C                                          STEP 3-9                     00049700
C                                          READ IN DATA TYPE 9 (STREAM JUNC00049800
C                                          IDENTIFICATION AND THE ORDER OF 00049900
C                                          CONNECTING ELEMENTS TAKEN CLOCKW00050000
C                                          AROUND THE JUNCTION).        00050100
C                                                                       00050200
      II=NJUNC+1                                                        00050300
      DO 130 I=1,II                                                     00050400
      READ (NI,131) (DATA(I,J),J=1,13)                                  00050500
  131 FORMAT (3A4,A3,5X,F5.0,5X,5A4,3(5X,F5.0))                         00050600
      IF (DATA(I,1)-ENDA) 130,135,130                                   00050700
  130 CONTINUE                                                          00050800
      NERROR=1                                                          00050900
  134 I=I+1                                                             00051000
      READ (NI,131) (DATA(I,J),J=1,13)                                  00051100
      IF (DATA(I,1)-ENDA) 134,139,134                                   00051200
  139 N=I-II                                                            00051300
      WRITE (NJ,132) N                                                  00051400
  132 FORMAT (1H0,5X,16H***** TOO MANY (,I3,18H) DATA9 CARDS READ)      00051500
      GO TO 133                                                         00051600
  135 IF (I.GE.II) GO TO 133                                            00051700
      NERROR = 1                                                        00051800
      N=II-I                                                            00051900
      WRITE (NJ,136) N                                                  00052000
  136 FORMAT (1H0,5X,15H***** TOO FEW (,I3,18H) DATA9 CARDS READ)       00052100
  133 CONTINUE                                                          00052200
      NCRDS=I                                                           00052300
      DO 137 I=1,NJUNC                                                  00052400
      IJUNC = DATA(I,5)                                                 00052500
      DO 138 J=6,10                                                     00052600
      K = J-5                                                           00052700
      JUNCID(IJUNC,K)=DATA(I,J)                                         00052800
  138 CONTINUE                                                          00052900
      JUNC(IJUNC,1) = DATA(I,11)                                        00053000
      JUNC(IJUNC,2) = DATA(I,12)                                        00053100
      JUNC(IJUNC,3) = DATA(I,13)                                        00053200
  137 CONTINUE                                                          00053300
      IF (ILIST.EQ.0) GO TO 432                                         00053400
      WRITE (NJ,512)                                                    00053500
  512 FORMAT (1H0,10X,38H$$$ DATA TYPE 9 (STREAM JUNCTIONS) $$$,/)      00053600
      WRITE (NJ,212)                                                    00053700
  212 FORMAT (10X,9HCARD TYPE,14X,24HJUNCTION ORDER AND IDENT,          00053800
     *          9X,25HUPSTRM   JUNCTION    TRIB)                        00053900
      WRITE (NJ,408) ((DATA(I,J),J=1,13),I=1,NCRDS)                     00054000
  408 FORMAT (10X,3A4,A3,5X,F5.0,5X,5A4,5X,F5.0,5X,F5.0,5X,F5.0)        00054100
  432 CONTINUE                                                          00054200
C                                                                       00054300
C                                          STEP 3-10                    00054400
C                                          READ IN DATA TYPE 10 (HEADWATER 00054500
C                                          AND THEIR CHARACTERISTICS).  00054600
C                                                                       00054700
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      II = NHWTPS+1                                                     00054800
      DO 140 I=1,II                                                     00054900
      READ (NI,141) (DATA(I,J),J=1,16)                                  00055000
  141 FORMAT (2A4,A2,5X,F5.0,5A4,F10.0,6F5.0)                           00055100
      IF (DATA(I,1)-ENDA) 140,145,140                                   00055200
  140 CONTINUE                                                          00055300
      NERROR=1                                                          00055400
  144 I=I+1                                                             00055500
      READ (NI,141) (DATA(I,J),J=1,16)                                  00055600
      IF (DATA(I,1)-ENDA) 144,149,144                                   00055700
  149 N=I-II                                                            00055800
      WRITE (NJ,142) N                                                  00055900
  142 FORMAT (1H0,5X,16H***** TOO MANY (I3,19H) DATA10 CARDS READ)      00056000
      GO TO 143                                                         00056100
  145 IF (I.GE.II) GO TO 143                                            00056200
      NERROR = 1                                                        00056300
      N=II-I                                                            00056400
      WRITE (NJ,146) N                                                  00056500
  146 FORMAT (1H0,5X,15H***** TOO FEW (,I3,19H) DATA10 CARDS READ)      00056600
  143 CONTINUE                                                          00056700
      NCRDS=I                                                           00056800
      DO 147 I=1,NHWTPS                                                 00056900
      NHW = DATA(I,4)                                                   00057000
      DO 148 J=5,9                                                      00057100
      K = J-4                                                           00057200
      HWTRID(NHW,K) = DATA(I,J)                                         00057300
  148 CONTINUE                                                          00057400
      HWFLOW(NHW) = DATA(I,10)                                          00057500
      HWTEMP(NHW) = DATA(I,11)                                          00057600
      HWDO(NHW) = DATA(I,12)                                            00057700
      HWBOD(NHW) = DATA(I,13)                                           00057800
      HWCONS(NHW,1)=DATA(I,14)                                          00057900
      HWCONS(NHW,2)=DATA(I,15)                                          00058000
      HWCONS(NHW,3)=DATA(I,16)                                          00058100
      QATOT(NHW)=HWFLOW(NHW)                                            00058200
  147 CONTINUE                                                          00058300
      IF (ILIST.EQ.0) GO TO 433                                         00058400
      WRITE (NJ,513)                                                    00058500
  513 FORMAT (1H0,10X,40H$$$ DATA TYPE 10 (HEADWATER SOURCES) $$$,/)    00058600
      WRITE (NJ,213)                                                    00058700
  213 FORMAT (10X,9HCARD TYPE,10X,23HHDWATER ORDER AND IDENT,           00058800
     *          6X,41HFLOW  TEMP  D.O.   BOD CM-I  CM-II CM-III)        00058900
      WRITE (NJ,409) ((DATA(I,J),J=1,16),I=1,NCRDS)                     00059000
  409 FORMAT (10X,2A4,A2,5X,F5.0,2X,5A4,F10.1,6F6.1)                    00059100
  433 CONTINUE                                                          00059200
C
C                                        STEP 3-10A
C                                        READ IN DATA TYPE 10A (HEADWATER
C                                        CHLOROPHYLL, NITROGEN, PHOSPHORUS
C                                        COLIFORM AND RADIONUCLIDE CONDITIONS)
C
      DO 1500 I=1,II
      READ(NI,1501) (DATA(I,J), J=1,12)
 1501 FORMAT(3A4,A2,5X,F5.0,7F8.0)
      IF (DATA(I,1)-ENDA) 1500,1502,1500
 1500 CONTINUE
      NERROR=1
 1503 I=I+1
      READ(NI,1501) (DATA(I,J), J=1,12)
      IF (DATA(I,1)-ENDA) 1503,1504,1503
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1504 N=I-II
     WRITE (NJ,1505) N
1505 FORMAT (1H0,5X,16H***** TOO MANY (,I3,21H) DATA 10A CARDS READ)
     GO TO 1506
1502 IF (I.GE.II) GO TO 1506
     IF(IDATA) 1520,1520,1530
1520 NCRDS=1
     GO TO 1550
1530 NERROR=1
     N=II-I
     WRITE (NJ,1507) N
1507 FORMAT (1H0,5X,15H***** TOO FEW (,I3,21H) DATA 10A CARDS READ)
1506 CONTINUE
     NCRDS=I
     DO 1508 I=1,NHWTRS
     NHW=DATA(I,5)
     HWALG(NHW)=DATA(I,6)/ALPHAO(1)
     HWNH3(NHW)=DATA(I,7)
     HWNO2(NHW)=DATA(I,8)
     HWNO3(NHW)=DATA(I,9)
     HWPHOS(NHW)=DATA(I,10)
     HWCOLI(NHW)=DATA(I,11)
     HWRADN(NHW)=DATA(I,12)
1508 CONTINUE
1550 IF(ILIST .EQ. 0) GO TO 1509
     WRITE (NJ,1510)
1510 FORMAT(1H0,10X,44H$$$ DATA TYPE 10A (HEADWATER CONDITIONS FOR
    * 34HCHLOROPHYLL,NITROGEN, PHOSPHOROUS,/,30X,30HCOLIFORM AND RADION
    *UCLIDE) $$$,/)
     WRITE (NJ,1511)
1511 FORMAT(10X,9HCARD TYPE,13X,7HHDWATER,7H CHLORA,7H    NH3,
    * 8H     NO2,8H     NO3,8H     PO4,8H    COLI,8H    RADN)
     WRITE(NJ,1512) ((DATA(I,J), J=1,12), I=1,NCRDS)
1512 FORMAT(10X,3A4,A2,8X,F6.0,2X,F6.1,F6.2,3F8.2,F10.1,F6.2)
1509 CONTINUE
C                                                                       00059300
C                                        STEP 3-11                      00059400
C                                        READ IN DATA TYPE 11 (WASTE INPU00059500
C                                        WITHDRAWLS AND THEIR CHARACTERIS00059600
C                                                                       00059700
      II = NWASTE+1                                                     00059800
      DO 150 I=1,II                                                     00059900
      READ (NI,151) (DATA(I,J),J=1,17)                                  00060000
  151 FORMAT (2A4,A2,F5.0,5A4,F5.0,F10.0,6F5.0)                         00060100
      IF (DATA(I,1)-ENDA) 150,155,150                                   00060200
  150 CONTINUE                                                          00060300
      NERROR=1                                                          00060400
  154 I=I+1                                                             00060500
      READ (NI,151) (DATA(I,J),J=1,17)                                  00060600
      IF (DATA(I,1)-ENDA) 154,159,154                                   00060700
  159 N=I-II                                                            00060800
      WRITE (NJ,152) N                                                  00060900
  152 FORMAT (1H0,5X,16H***** TOO MANY (,I3,19H) DATA11 CARDS READ)     00061000
      GO TO 153                                                         00061100
  155 IF (I.GE.II) GO TO 153                                            00061200
      NERROR = 1                                                        00061300
      N=II-I                                                            00061400
      WRITE (NJ,156) N                                                  00061500
  156 FORMAT (1H0,5X,15H***** TOO FEW (,I3,19H) DATA11 CARDS READ)      00061600
  153 CONTINUE                                                          00061700
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      NCRDS=1                                                           00061800
      DO 157 I=1,NWASTE                                                 00061900
      NWS = DATA(I,4)                                                   00062000
      DO 158 J=5,9                                                      00062100
      K = J-4                                                           00062200
      WASTID(NWS,K)=DATA(I,J)                                           00062300
  158 CONTINUE                                                          00062400
      TREACT(NWS) = DATA(I,10)                                          00062500
      WSFLOW(NWS) = DATA(I,11)                                          00062600
      WSTEMP(NWS) = DATA(I,12)                                          00062700
      WSDO(NWS) = DATA(I,13)                                            00062800
      WSBOD(NWS) = DATA(I,14)                                           00062900
      WSCONS(NWS,1)=DATA(I,15)                                          00063000
      WSCONS(NWS,2)=DATA(I,16)                                          00063100
      WSCONS(NWS,3)=DATA(I,17)                                          00063200
  157 CONTINUE                                                          00063300
      IF (ILIST.EQ.0) GO TO 434                                         00063400
      WRITE (NJ,514)                                                    00063500
  514 FORMAT (1H0,10X,37H$$$ DATA TYPE 11 (WASTE LOADINGS) $$$,/)       00063600
      WRITE (NJ,214)                                                    00063700
  214 FORMAT (10X,9HCARD TYPE,2X,31HWASTE LOAD ORDER AND IDENT  EFF.    00063800
     *          6X,41HFLOW  TEMP  D.O.   BOD CM-I  CM-II CM-III)        00063900
      WRITE (NJ,410) ((DATA(I,J),J=1,17),I=1,NCRDS)                     00064000
  410 FORMAT (10X,2A4,A2,F5.0,2X,5A4,F5.2,F10.1,6F6.1)                  00064100
  434 CONTINUE                                                          00064200
C
C                                        STEP 3-11A
C                                        READ IN DATA TYPE 11A (WASTE INPUT
C                                        CHARACTERISTICS ALGAE, NITROGEN,
C                                        PHOROPHOROUS COLIFORMS AND RADIONUCLIDE)
      DO 1602 I=1,II
      READ(NI,1601) (DATA(I,J), J=1,12)
 1601 FORMAT(3A4,A2,5X,F5.0,7F8.0)
      IF (DATA(I,1)-ENDA) 1602,1621,1602
 1602 CONTINUE
      NERROR=1
 1605 I=I+1
      READ(NI,1601) (DATA(I,J), J=1,12)
      IF (DATA(I,1)-ENDA) 1605,1607,1605
 1607 N=I-II
      WRITE (NJ,1620) N
 1620 FORMAT (1H0,5X,16H***** TOO MANY (,I3,21H) DATA 11A CARDS READ)
      GO TO 1604
 1621 IF (I.GE.II) GO TO 1604
      IF(IDATA) 1630,1630,1640
 1630 NCRDS=0
      GO TO 1650
 1640 NERROR=1
      N=II-I
      WRITE (NJ,1622) N
 1622 FORMAT (1H0,5X,15H***** TOO FEW (,I3,21H) DATA 11A CARDS READ)
 1604 CONTINUE
      NCRDS=I
      DO 1606 I=1,NWASTE
      NWS=DATA(I,5)
      WSALG(NWS)=DATA(I,6)/ALPHAO(1)
      WSNH3(NWS)=DATA(I,7)
      WSNO2(NWS)=DATA(I,8)
      WSNO3(NWS)=DATA(I,9)
      WSPHOS(NWS)=DATA(I,10)
```

```
      WSCOLI(NWS)=DATA(I,11)
      WSRADN(NWS)=DATA(I,12)
 1606 CONTINUE
 1650 IF(ILIST .EQ. 0) GO TO 1699
      WRITE (NU,1610)
 1610 FORMAT(1H0,10X,48H$$$ DATA TYPE 11A (WASTE LOAD CHARACTERISTICS -
     *20H ALGAE,NITROGEN,PHOSPHOROUS,/30X,27HCOLIFORMS AND RADIONUCLIDES
     * 5H) $$$,/)
      WRITE(NU,1611)
 1611 FORMAT(10X,9HCARD TYPE,6X,26HWASTE LOAD ORDER AND IDENT,4X,6HCHL.
     *A,5X,4H TH3,6X,4H NO2,6X,4H NO3,6X,4H PO4,6X,4HCOLI,6X,4HRADN)
      IF(IDATA .EQ. 0) GO TO 1655
      NCRDS=NCRDS-1
      DO 1615 I=1,NCRDS
      NWS=DATA(I,5)
      FNWS=NWS
      WRITE(NU,1612)(DATA(I,J), J=1,4),FNWS,(WASTID(NWS,K), K=1,5),
     * (DATA(I,J), J=6,12)
 1612 FORMAT(10X,3A4,A2,F6.0,1X,5A4,5(4X,F6.2),2F12.2)
 1615 CONTINUE
 1655 WRITE (NU,1612) (DATA(NCRDS+1,J),J=1,3)
 1699 CONTINUE
      WRITE (NU,2055)                                                   00064300
 2055 FORMAT (1H1)                                                      00064400
C                                                                       00064500
C                                       STEP 4-0                        00064600
C                                       IF THE CORRECT NO. OF DATA CARDS00064700
C                                       NOT BEEN READ IN, THE PROGRAM WI00064800
C                                       TERMINATE.                      00064900
C                                                                       00065000
      IF (NERROR.EQ.0) GO TO 88A                                        00065100
      WRITE (NU,2066)                                                   00065200
 2066 FORMAT (1H1,15X,34H* * * * * * * * * * * * * * * * * * ,           00065300
     *                33H* * * * * * * * * * * * * * * * * *,//,        00065400
     *            16X,34H* E X E C U T I O N   W A S   T E ,            00065500
     *                33HR M I N A T E D   B E C A U S E *,//,          00065600
     *            16X, 1H*,31X,3HO F,31X,1H*,//,                        00065700
     *            16X,34H*             E R R O R S   I N   ,            00065800
     *                33HI N P U T   D A T A           *,//,           00065900
     *            16X,34H* * * * * * * * * * * * * * * * * * ,          00066000
     *                33H* * * * * * * * * * * * * * * * * *)           00066100
      STOP
  88A RETURN
      END
```

SUBROUTINE NH3S*

Subroutine NH3S completes the setup of the equations necessary to calculate ammonia nitrogen concentration levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i + (K_7)_i \; t$
7. Withdrawal	$b_i = x_i + (K_7)_i \; t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = (N_1)_i^* + q_i' \, (N_1)_i' \frac{\Delta t}{v_i} - a_i (N_1)_h + \alpha_1 \rho A_i \Delta t + \sigma_2 \, \Delta x \frac{\Delta t}{v_i}$
6. Waste Input	$S_i = (N_1)_i^* + q_i' \, (N_1)_i' \frac{\Delta t}{v_i} + q_w (N_1)_w \frac{\Delta t}{v_i} + \alpha_1 \rho A_i \Delta t + \sigma_2 \, \Delta x \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

TYPE	RIGHT HAND SIDE
All Others	$S_i = (N_1)_i^* + q_i' (N_1)_i' \frac{\Delta t}{v_i} + \alpha_1 \rho A_i \Delta t + \sigma_2 \Delta x \frac{\Delta t}{v_i}$

For steady-state simulation, the only difference is that the value from the previous time step, $(N_1)_i^*$, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-11 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

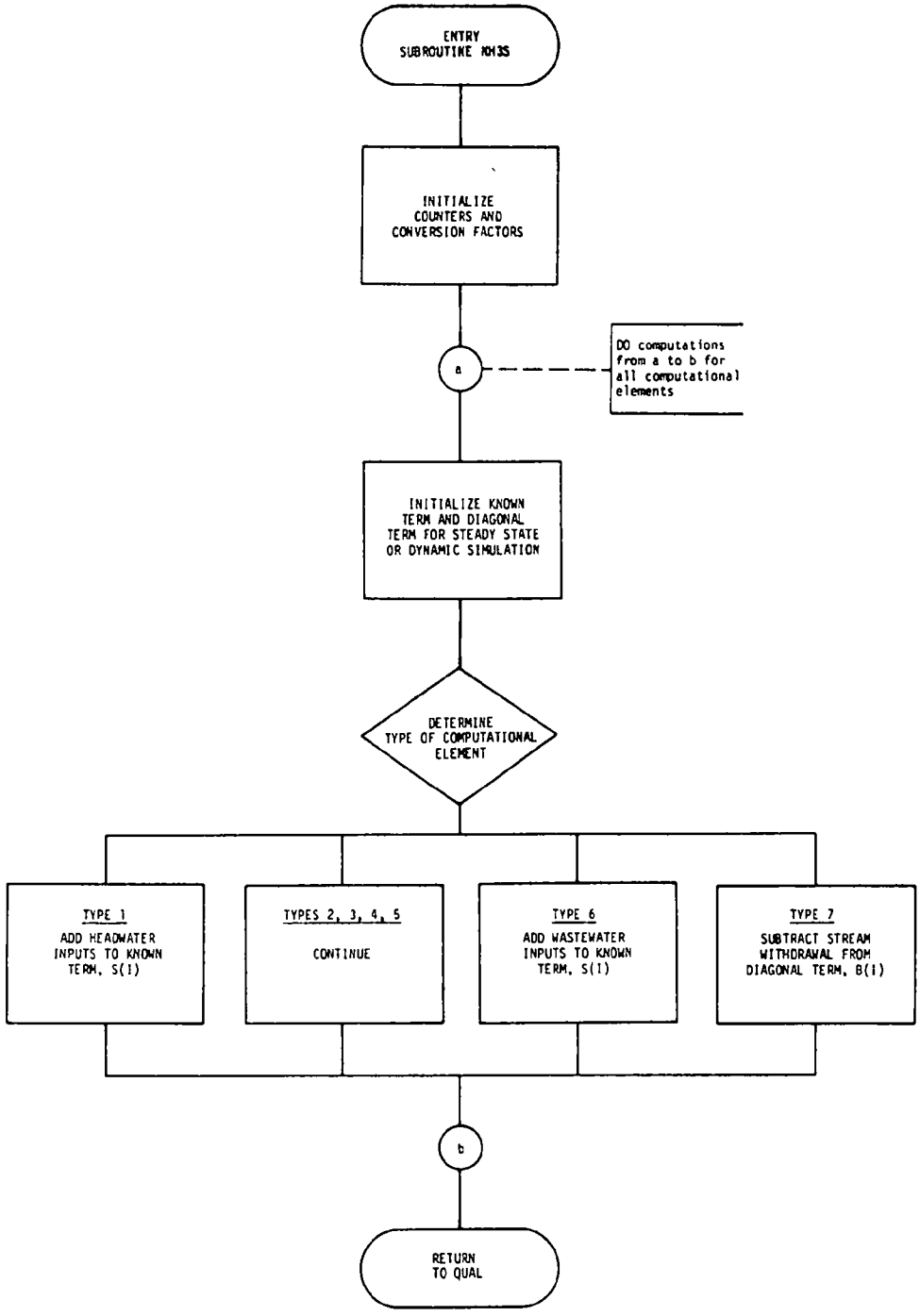

FIGURE IV-11 FLOW CHART FOR SUBROUTINE NH3S

```
      SUBROUTINE FH3S
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOK(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFOV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,RE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCO,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *NEW
C                                                                                *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),               *NEW
     *       CKN,CKP,CKL,ALPHAO(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,                 *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSFT(75),SPHOS(75),                   *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),                 *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),                 *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                   *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),               *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),              *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),                 *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),               *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                   *NEW
C                                                                                *-29
      COMMON/SSTATE/X(500),ISS
      REAL KNH3
C
C                                INITIALIZE COUNTERS
C
      NHW=0
      NWS=0
      FACT = 1.0 / (28.3 * 86400.0)
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELR=NCELRH(I)
      CNCELR=NCELR
      CNH3IJ=QI(I)/CNCELR*CNH3I(I)
      DO 100 J=1,NCELR
      IOR=ICLORD(I,J)
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      IF (MODOPT(4).EQ.0) ALGAE(IOR)=0.0
      TC=0.556*(T(IOR)-68.0)
      KNH3(IOR)=CKNH3(I)*1.047**TC
```

```
      REACT=ALPHA1*RESPKR(IOR)*ALGAF(IOR)*DILT*SNH3(I)*DELX*
     *      DTOVCL(IOR) * FACT
      B(IOR)=X(IOR)+DILT*KNH3(IOR)
      S(IOR)=CNH3(IOR)
      IF (ISS.GT.0) S(IOR)=0.0
      S(IOR)=S(IOR)+REACT+CNH3IJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR)=S(IOR)-A(IOR)*HWNH3(NHW)
      GO TO 100
C
  103 NWS=NWS+1
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSNH3 (NWS)*DTOVCL(IOR)
      GO TO 100
C
  104 NWS=NWS+1
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE NO2S*

Subroutine NO2S completes the setup of the equations necessary to calculate nitrite nitrogen levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i + (K_8)_i \, \Delta t$
7. Withdrawal	$b_i = x_i + (K_8)_i \, \Delta t - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	RIGHT HAND SIDE
1. Headwater	$S_i = (N_2^*)_i + q_i' \, (N_2')_i \frac{\Delta t}{v_i} - a_i \, (N_2)_h + (K_7 N_1)_i \, \Delta t$
6. Waste Input	$S_i = (N_2^*)_i + q_i' \, (N_2')_i \frac{\Delta t}{v_i} - q_w \, (N_2)_w \frac{\Delta t}{v_i} + (K_7 N_1)_i \, \Delta t$
All Others	$S_i = (N_2^*)_i + q_i' \, (N_2')_i \frac{\Delta t}{v_i} + (K_7 N_1)_i \, \Delta t$

*All symbols used are defined at the end of this section of the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, $(N^*)_i$, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-12 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

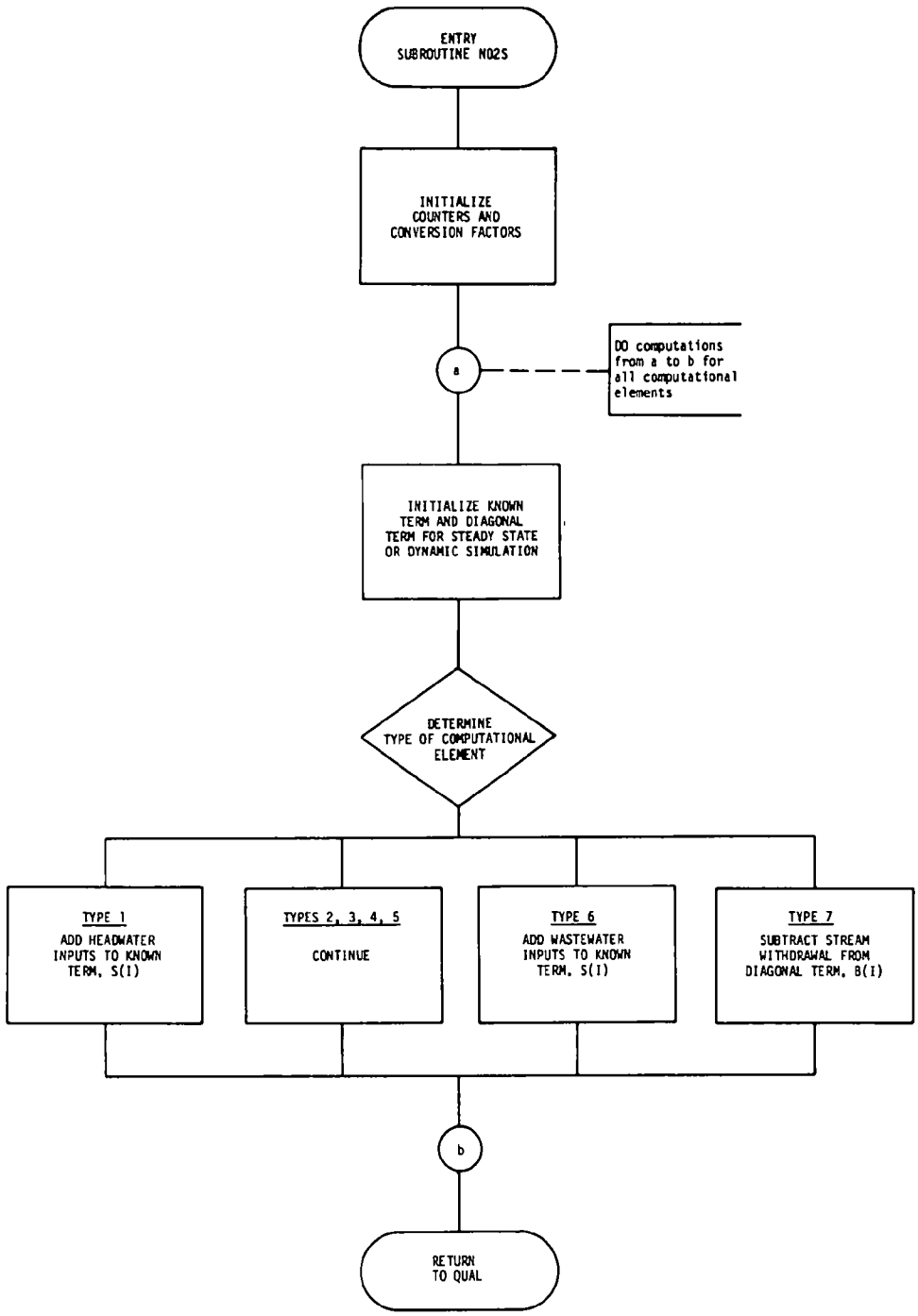

FIGURE IV-12 FLOW CHART FOR SUBROUTINE NO2S

```
      SUBROUTINE H023
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *        TABCOO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                   *NEW
     *        ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),         *NEW
     *        CKANE(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),            *NEW
     *        EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),           *NEW
     *        OI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),           *NEW
     *        JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),            *NEW
     *        HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),         *NEW
     *        WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),              *NEW
     *        A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),             *NEW
     *        FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),         *NEW
     *        HSMET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),              *NEW
     *        DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                    *NEW
     *        NHWTKS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,           *NEW
     *        LAT,LSM,LLM,ELEV,DAT,AF,PE,DAYOFY,DRYBLB,WETBLB,DEWPT,             *NEW
     *        ATMPR,WIND,CLOUD,SOLRT,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS           *NEW
C                                                                                *NEW
C                                                                                *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),               *NEW
     *        CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,                *NEW
     *        ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                  *NEW
     *        SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),                *NEW
     *        ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),                *NEW
     *        COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                  *NEW
     *        CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),              *NEW
     *        CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),             *NEW
     *        WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),                *NEW
     *        HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),              *NEW
     *        MODOPT(10),IRCHNO(750),EXCOEF(75)                                  *NEW
C                                                                                *-29
      COMMON/SSTATE/X(500),ISS
      REAL KNO2, KNH3
C
C                                INITIALIZE COUNTERS
C
      NHW=0
      NWS=0
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELP=NCELPH(I)
      CNCELR=NCELR
      CNO2IJ=OI(I)/CNCELP*CNO2I(I)
      DO 100 J=1,NCELP
      IOR=ICLORD(I,J)
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      TC=5.556*(T(IOR)-68.0)
      KNO2(IOR)=CKNO2(I)*1.047**TC
      REACT=D1LT*KNH3(IOR)*CNH3(IOR)
      B(IOR)=X(IOR)+D1LT*KNO2(IOR)
```

```
      S(IOR)=CNO2(IOR)
      IF (ISS.GT.0) S(IOR)=0.0
      S(IOR)=S(IOR)+REACT+CNO2IJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR)=S(IOR)-A(IOR)*HWNO2(NHW)
      GO TO 100
C
  103 NWS=NWS+1
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSNO2 (NWS)*DTOVCL(IOR)
      GO TO 100
C
  104 NWS=NWS+1
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE NO3S*

Subroutine NO3S completes the setup of the equations necessary to calculate nitrate nitrogen levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i$
7. Withdrawal	$b_i = x_i - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	
1. Headwater	$S_i = (N_3^*)_i + q_i'(N_3')_i \frac{\Delta t}{v_i} - a_i(N_3)_h + (K_8N_2)_i \Delta t - \alpha_1\mu_iA_i\Delta t$
6. Waste Input	$S_i = (N_3^*)_i + q_i'(N_3')_i \frac{\Delta t}{v_i} + q_w(N_3)_w \frac{\Delta t}{v_i} + (K_8N_2)_i \Delta t - \alpha_1\mu_iA_i\Delta t$
All Others	$S_i = (N_3^*)_i + q_i'(N_3')_i + (K_8N_2)_i \Delta t - \alpha_1\mu_iA_i\Delta t$

*All symbols used are defined at the end of this section in the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, $(N_3^*)_i$, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-13 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

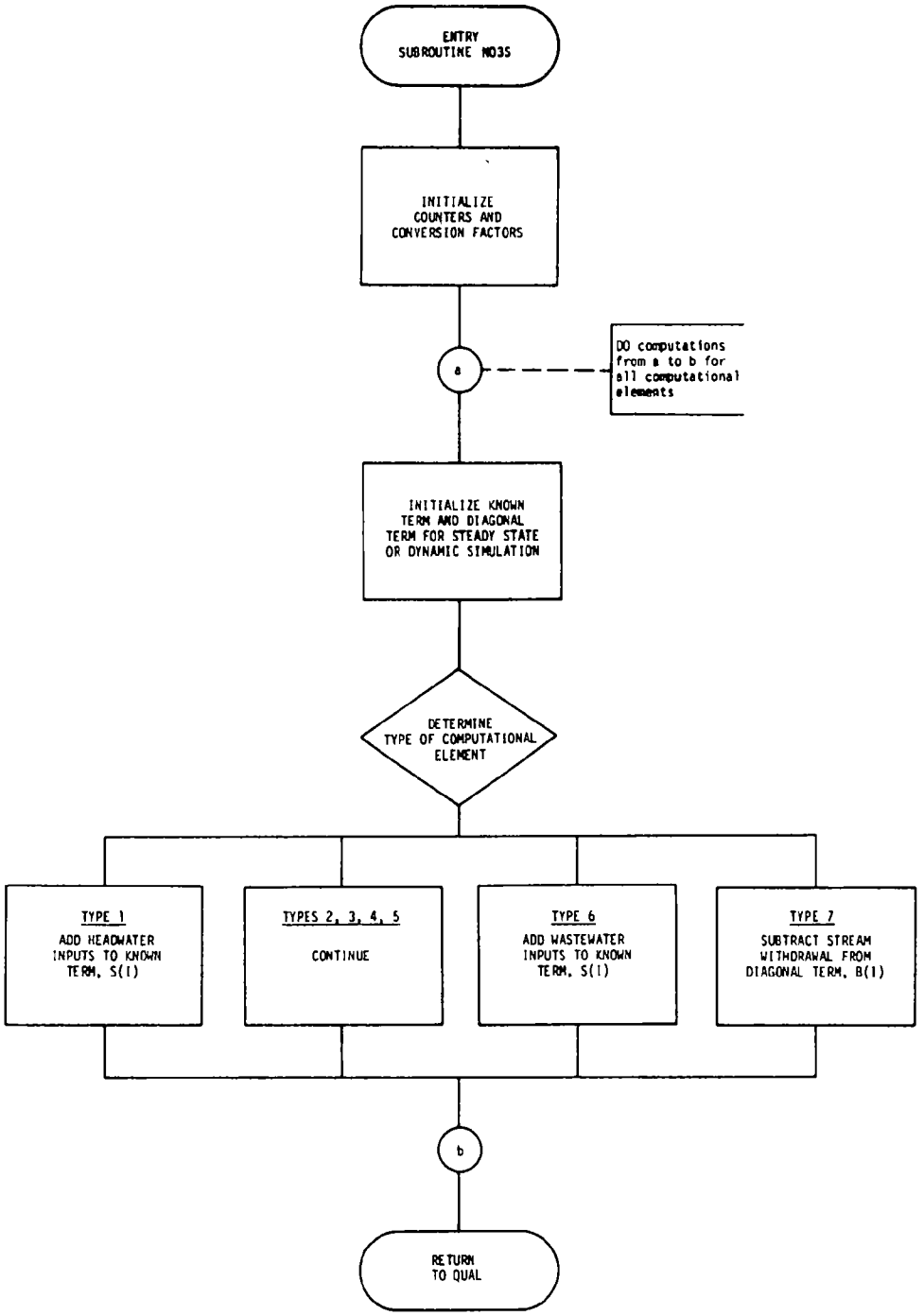

FIGURE IV-13 FLOW CHART FOR SUBROUTINE NO3S

```
      SUBROUTINE MOBS
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGBD(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFOV(75),EXPOOV(75),COEFOH(75),EXPOOH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONFT,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *NEW
C                                                                                *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),               *NEW
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,                 *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                   *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),                 *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),                 *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                   *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),               *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),              *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),                 *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),               *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                   *NEW
C                                                                                *-29
      COMMON/SSTATE/X(500),ISS
      REAL KNO2
C
C                                INITIALIZE COUNTERS
C
      NHW=0
      NWS=0
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELR=NCELRH(I)
      CNCELR=NCELR
      CNO3IJ=GI(I)/CNCELR*CNO3I(I)
      DO 100 J=1,NCELR
      IOR=ICLORD(I,J)
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      IF (MODOPT(4).EQ.0) ALGAE(IOR)=0.0
      REACT=D1LT*KNO2(IOR)*CNO2(IOR)-D1LT*ALPHA1*GROWTH(IOR)*ALGAE(IOR)
      B(IOR)=X(IOR)
      S(IOR)=CNO3(IOR)
```

```
      IF (ISS.GT.0) S(IOR)=0.0
      S(IOR)=S(IOR)+REACT+CNO3IJ*DTOVCL(IOR)
      IFL=IFLAG(I,J)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR)=S(IOR)-A(IOR)*HWNO3(NHW)
      GO TO 100
C
  103 NWS=NWS+1
      S(IOR)=S(IOR)+WSFLOW(NWS)*WSNO3 (NWS)*DTOVCL(IOR)
      GO TO 100
C
  104 NWS=NWS+1
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE PO4S*

Subroutine PO4S completes tne setup of the equations necessary to calculate phosphorous levels in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i$
7. Withdrawal	$b_i = x_i - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and, in the case of dynamic simulation, the concentration in the previous time step. The known term for eacn type of element for dynamic simulation is:

TYPE	
1. Headwater	$S_i = P_i^* + q'P' \frac{\Delta t}{v_i} - a_i P_h + \alpha_2 (\rho - \mu_i) a_i \Delta t + \sigma_3 \Delta x \frac{\Delta t}{v_i}$
6. Waste Input	$S_i = P_i^* + (q'P' + q_w P_w) \frac{\Delta t}{v_i} + \alpha_2 (\rho - \mu_i) a_i \Delta t + \sigma_3 \Delta x \frac{\Delta t}{v_1}$
All Others	$S_i = P_i^* + q'P' \frac{\Delta t}{v_i} + \alpha_2 (\rho - \mu_i) a_i \Delta t + \sigma_3 \Delta x \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

For steady-state simulation, the only difference is that the value from the previous time step, P_i^*, is set equal to zero.

The subroutine flow chart is illustrated in Figure IV-14 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

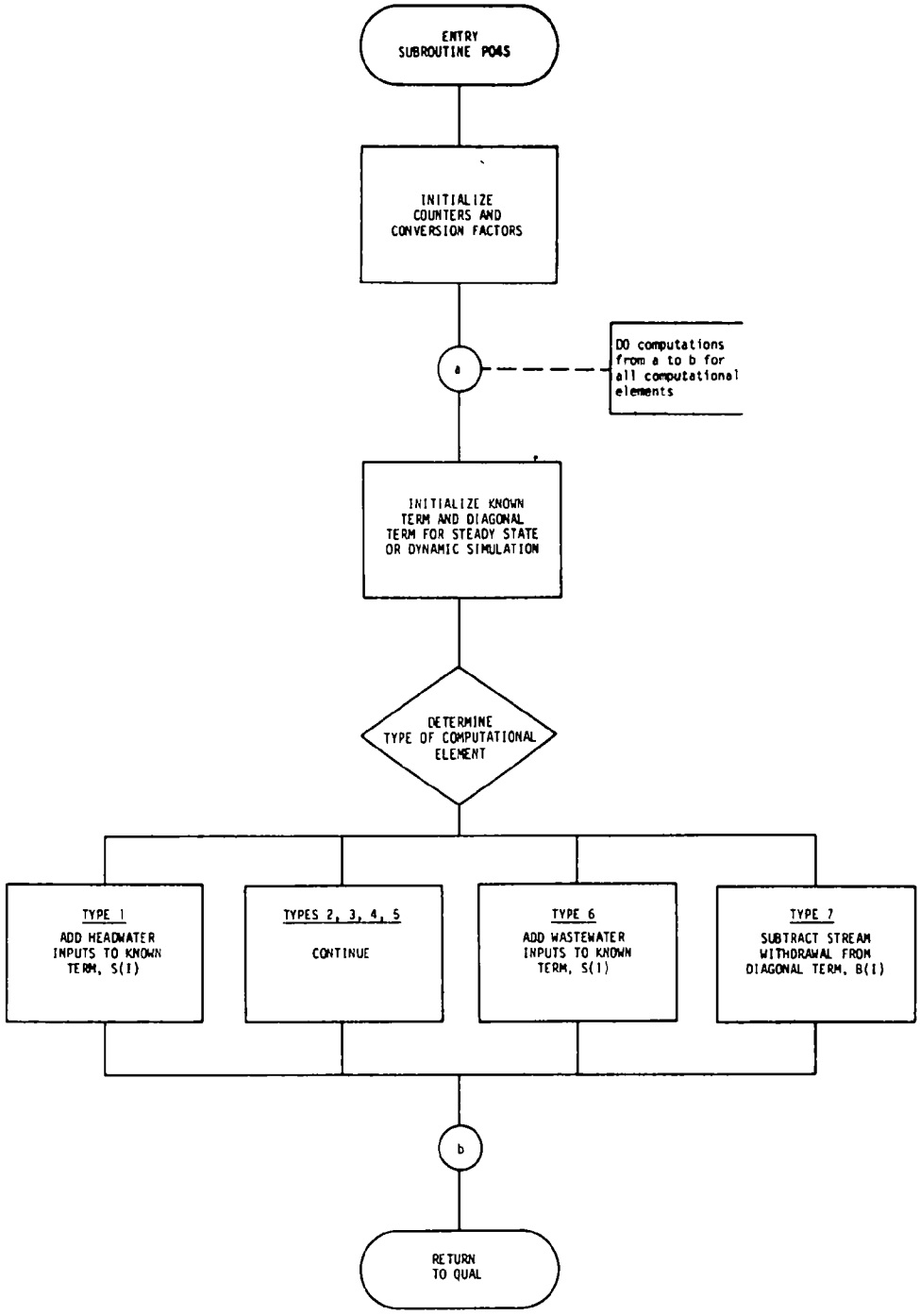

FIGURE IV-14 FLOW CHART FOR SUBROUTINE P04S

```
      SUBROUTINE P04S
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOOH(75),          *NEW
     *       CMAUN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *NEW
C                                                                                *NEW
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),               *NEW
     *       CKN,CKP,CKL,ALPHAO(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,                 *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),                   *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),                 *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),                 *NEW
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),                   *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),               *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),              *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),                 *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),               *NEW
     *       MODOPT(10),IRCHNO(750),EXCOEF(75)                                   *NEW
C                                                                                *-29
      COMMON/SSTATE/X(500),ISS
C
C
C                                INITIALIZE COUNTERS
      NHW=0
      NWS=0
      FACT = 1.0 / (28.3 * 86400.0)
C
C                                LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH
      NCELR=NCELRH(I)
      CNCELR=NCELR
      PHOSIJ = QI(I)/CNCELR*PHOSI(I)
      DO 100 J=1,NCELR
      IOR=ICLORD(I,J)
C
C                                INITIALIZE DIAGONAL AND KNOWN TERMS
C
      S(IOR)=PHOS(IOR)
      B(IOR)=X(IOR)
      IF(ISS.GT.1) S(IOR)=0.0
      PSORCE=SPHOS(I)*DELX*DTOVCL(IOR) * FACT
```

```
      REACT = ALPHA2*(RESPRR(IOR)-GROWTH(IOR))*D1LT
      S(IOR)=S(IOR)+PHOSIJ*DTOVCL(IOR)+REACT*ALGAE(IOR)+PSOPCE
      IFL=IFLAG(I,J)
C
C                                MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,100,100,100,100,103,104), IFL
C
  101 NHW=NHW+1
      S(IOR) = S(IOR) - A(IOR)*HWPHOS(NHW)
      GO TO 100
C
  103 NWS=NWS+1
      S(IOR) = S(IOR) + WSFLOW(NWS)*WSPHOS(NWS)*DTOVCL(IOR)
      GO TO 100
C
  104 NWS=NWS+1
      B(IOR) = B(IOR) - WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE
      RETURN
      END
```

SUBROUTINE RADIOS

(Not Programmed)

SUBROUTINE REAERC*

Subroutine REAERC determines the reaeration coefficient for each computational element through the use of any one of seven different procedures. However, the same procedure must be used for all computational elements within an individual reach. The choice of which procedure to use is controlled by input options for each reach. The seven options, procedures, and references are:

OPTION & PROCEDURE	REFERENCE
1. Read-in K_2 values	None
2. $K_2 = 5.026 \frac{u^{0.969}}{D^{1.673}} \times 2.31$	Churchill et al (1962)
3. $K_2 = \frac{(D_m u)^{0.5}}{D^{1.5}} \times 86{,}400$	O'Conner and Dobbins (1958)
4. $K_2 = 9.4 \frac{u^{0.67}}{D^{1.85}} \times 2.31$	Owens et al (1964)
5. $K_2 = 10.8(1 + \sqrt{F}) \frac{u^*}{D} \times 2.31$	Thackston and Krenkel (1966)
6. $K_2 = 3.3 \frac{u}{D^{1.333}} \times 2.31$	Langbien and Durum (1967)
7. $K_2 = aQ^b$	None

where

u = velocity (feet/sec)

D = depth (feet)

D_m = molecular diffusion coefficient (2.25×10^{-8} ft^2/sec)

*This subroutine is unchanged from the original version of QUAL. All symbols used are defined at the end of this section of the Documentation Report.

F = Froude Number = $u/\sqrt{Dg}$

u^* = shear velocity (ft/sec)

= $u\ n\ \sqrt{g}/1.49\ D^{1.167}$

g = acceleration of gravity (32.2 ft/sec^2)

n = Manning's roughness coefficient

The subroutine flow chart is illustrated in Figure IV-15 and is followed by the program listing. All program valuables contained in COMMON are defined in Section V.

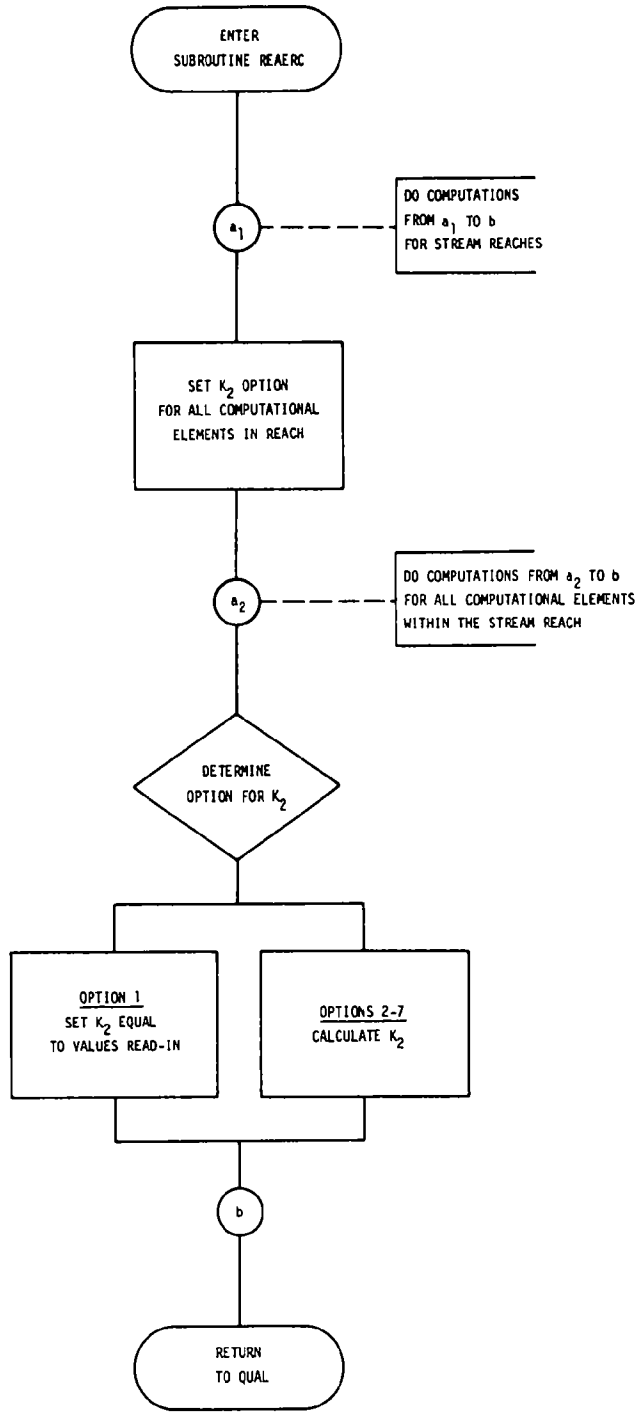

FIGURE IV-15 FLOW CHART FOR SUBROUTINE REAERC

```
      SUBROUTINE REAERC
C
C
C                                REAERC CAN EITHER READ IN REAERATION
C                                COEFFICIENTS (OPTION1), COMPUTE THEM
C                                USING A SELECTED EQUATION (OPTION 2,3,
C                                4,5, AND 6), OR COMPUTE THEM BASED ON
C                                K2=A*Q**B.  ALL K2'S  ARE TO THE BASE E.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TAPGDU(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TT(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
      REAL K2                                                          00002500
C                                                                      00002600
C                                        STEP 1-0                      00002700
C                                        LOOP THROUGH SYSTEM OF NREACH RE00002800
C                                        AND NCELR COMPUTATIONAL ELEMENTS00002900
C                                        REACH.                        00003000
C                                                                      00003100
      DO 100 I=1,NREACH                                                00003200
      NCELR=NCELRH(I)                                                  00003300
      KOPT=K2OPT(I)                                                    00003400
      DO 100 J=1,NCELR                                                 00003500
      IOR=ICLORD(I,J)                                                  00003600
      IFL=IFLAG(I,J)                                                   00003700
C                                                                      00003800
C                                        STEP 1-1                      00003900
C                                        SELECT K2'S FOR ANY OPTION AS DE00004000
C                                        BY REACH.                     00004100
C                                                                      00004200
C                                                                      00004300
C                                        KOPT = 1  K2 IS READ IN.      00004400
C                                        KOPT = 2  CHURCHILL (1962)    00004500
C                                        KOPT = 3  O'CONNER - DOBBINS (190004600
C                                        KOPT = 4  OWENS, EDWARDS, - GIBB00004700
C                                        KOPT = 5  THACKSTON - KRENKEL (100004800
C                                        KOPT = 6  LANGBIEN - DURUM (196700004900
C                                        KOPT = 7  K2 = A * Q ** B     00005000
C                                                                      00005100
      GO TO (101,102,103,104,105,106,107), KOPT                        00005200
  101 K2(IOR)=CK2(I)                                                   00005300
```

```
      GO TO 100                                                         00005400
  102 K2(IOR)=5.026*VEL(IOR)**0.969/DEPTH(IOR)**1.673*2.31              00005500
      GO TO 100                                                         00005600
  103 D4=2.25E-08                                                       00005700
      K2(IOR)=SQRT(D4*VEL(IOR))/DEPTH(IOR)**1.5*8.64E+04                00005800
      GO TO 100                                                         00005900
  104 K2(IOR)=9.4*VEL(IOR)**0.67/DEPTH(IOR)**1.85*2.31                  00006000
      GO TO 100                                                         00006100
  105 F=0.176*VEL(IOR)/SQRT(DEPTH(IOR))                                 00006200
      SHRVEL=5.675*VEL(IOR)*CMANN(I)/(1.49*DEPTH(IOR)**1.167)           00006300
      K2(IOR)=10.8*(1.0+SQRT(F))*SHRVEL*2.31                            00006400
      GO TO 100                                                         00006500
  106 K2(IOR)=3.3*VEL(IOR)/DEPTH(IOR)**1.333*2.31
      GO TO 100                                                         00006700
  107 K2(IOR)=COEQK2(I)*FLOW(IOR)**EXPQK2(I)                            00006800
  100 CONTINUE                                                          00006900
      RETURN                                                            00007000
      END                                                               00007100
```

SUBROUTINE SOVMAT

Subroutine SOVMAT remains unchanged from the original version of QUAL as documented by the Texas Water Development Board (2). According to reference (2):

> *Subroutine SOVMAT solves a system of simultaneous linear equations whose coefficient matrix is of tridiagonal form by using a modified Gaussian Elimination algorithm.*

The solution algorithm is presented, in detail, in Report 128 of the Texas Water Development Board (1). The subroutine flow chart shown in Figure IV-16 is taken from reference (2). The program listing follows the Figure.

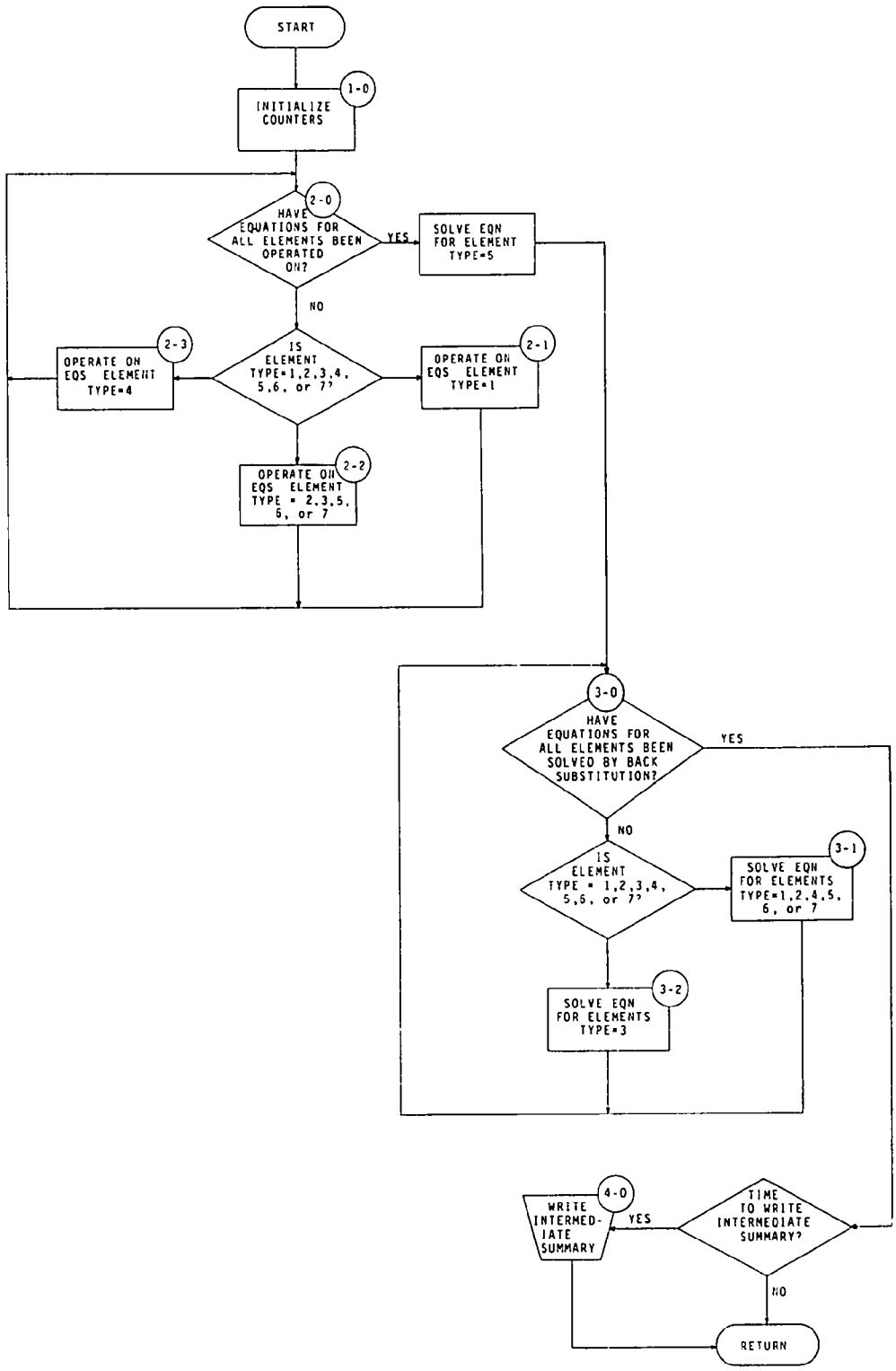

FIGURE IV-16 FLOW CHART FOR SUBROUTINE SOVMAT

```
      SUBROUTINE SOVMAT
C
C
C                                SOVMAT SOLVES A SYSTEM OF SIMULTANEOUS
C                                LINEAR EQUATIONS WHOSE COEFFICIENT
C                                MATRIX IS OF TRIDIAGONAL FORM USING
C                                A MODIFIED GAUSSIAN ELIMINATION TYPE OF
C                                ALGORITHM.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       IAPGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
      DIMENSION IFLG(500)                                                 00002500
C                                                                         00002600
C                                        STEP 1-0                         00002700
C                                        INITIALIZE COUNTER FOR STREAM JU00002800
C                                                                         00002900
      IJUNC=0                                                             00003000
C                                                                         00003100
C                                        STEP 2-0                         00003200
C                                        LOOP THROUGH SYSTEM OF NREACH RE00003300
C                                        WITH NCELR COMPUTATIONAL ELEMENT00003400
C                                        REACH.                           00003500
C                                                                         00003600
      DO 100 I=1,NREACH                                                   00003700
      NCELR=NCELRH(I)                                                     00003800
      DO 100 J=1,NCELR                                                    00003900
      IOR=ICLORD(I,J)                                                     00004000
      IFL=IFLAG(I,J)                                                      00004100
      IFLG(IOR)=IFL                                                       00004200
      GO TO (101,102,102,103,102,102,102), IFL                            00004300
C                                                                         00004400
C                                        STEP 2-1                         00004500
C                                        OPERATE ON EQUATION FOR AN ELEME00004600
C                                        TYPE 1.                          00004700
C                                                                         00004800
  101 W(IOR)=C(IOR)/B(IOR)                                                00004900
      G(IOR)=S(IOR)/B(IOR)                                                00005000
      GO TO 100                                                           00005100
C                                                                         00005200
C                                        STEP 2-2                         00005300
```

```
C                                       OPERATE ON EQUATION FOR ELEMENTS00005400
C                                       2,3,5,6, OR 7.                   00005500
C                                                                        00005600
  102 DENOM=B(IOR)-A(IOR)*W(IOR-1)                                       00005700
      W(IOR)=C(IOR)/DENOM                                                00005800
      G(IOR)=(S(IOR)-A(IOR)*G(IOR-1))/DENOM                              00005900
      GO TO 100                                                          00006000
C                                                                        00006100
C                                       STEP 2-3                         00006200
C                                       OPERATE ON EQUATION FOR AN ELEME00006300
C                                       TYPE 4.                          00006400
C                                                                        00006500
  103 IJUNC=IJUNC+1                                                      00006600
      NS=1                                                               00006700
      NN=JUNC(IJUNC,NS)                                                  00006800
      S(IOR)=S(IOR)-D(IJUNC)*G(NN)                                       00006900
      DENOM=B(IOR)-A(IOR)*W(IOR-1)-D(IJUNC)*W(NN)
      W(IOR)=C(IOR)/DENOM
      G(IOR)=(S(IOR)-A(IOR)*G(IOR-1))/DENOM                              00007200
  100 CONTINUE                                                           00007300
C                                                                        00007400
C                                       STEP 3-0                         00007500
C                                       SOLVE SYSTEM OF NREACH BY NCELR 00007600
C                                       EQUATIONS USING BACK SUBSTITUTIO00007700
C                                                                        00007800
      Z(IOR)=G(IOR)                                                      00007900
      IF (Z(IOR).LT.0.0) Z(IOR) = 0.0
  109 IOR=IOR-1                                                          00008000
      IFL=IFLG(IOR)                                                      00008100
      GO TO (106,106,107,106,106,106,106), IFL                           00008200
C                                                                        00008300
C                                       STEP 3-1                         00008400
C                                       SOLVE THE EQUATION FOR ELEMENTS 00008500
C                                       1,2,4,5,6, OR 7.                 00008600
C                                                                        00008700
  106 Z(IOR)=G(IOR)-W(IOR)*Z(IOR+1)                                      00008800
      IF (Z(IOR).LT.0.0) Z(IOR)=0.0                                      00008900
      GO TO 108                                                          00009000
C                                                                        00009100
C                                       STEP 3-2                         00009200
C                                       SOLVE THE EQUATION FOR AN ELEMEN00009300
C                                       TYPE 3.                          00009400
C                                                                        00009500
  107 NS=1
      DO 98 IJ=1,NJUNC
      IF (IOR.EQ.JUNC(IJ,NS)) IJUNC=IJ
   98 CONTINUE
      NS=2
      NN=JUNC(IJUNC,NS)                                                  00009700
      Z(IOR)=G(IOR)-W(IOR)*Z(NN)                                         00009800
      IF (Z(IOR).LT.0.0) Z(IOR)=0.0                                      00009900
  108 CONTINUE                                                           00010100
      IF (IOR.NE.1) GO TO 109                                            00010200
C                                                                        00010300
C                                       STEP 4-0                         00010400
C                                       IF DESIRED, WRITE REPORT2 WHICH 00010500
C                                       AN INTERMEDIATE SUMMARY OF CONDI00010600
C                                       WITHIN THE SYSTEM AT ANY GIVEN T00010700
C                                                                        00010800
      IF (TPRINT.LT.PTIME) GO TO 99                                      00010900
```

```
      CALL WRPT2 (Z)
99    CONTINUE                                                  00011100
      RETURN                                                    00011200
      END                                                       00011300
```

SUBROUTINE TEMPS*

Subroutine TEMPS completes the setup of the equations necessary to calculate temperatures in each computational element. Specifically, the subroutine completes the definition of the diagonal term of the coefficient matrix and defines the vector of known terms on the right hand side of the equations.

The additions to the diagonal term represent the individual constituent changes caused by constituent reactions and interactions, and mass changes caused by stream withdrawals. The resulting diagonal term for each type of computational element is:

TYPE	DIAGONAL TERM
All except type 7	$b_i = x_i$
7. Withdrawal	$b_i = x_i - q_0 \frac{\Delta t}{v_i}$

where x_i is defined in Subroutine TRIMAT.

The right hand side term contains all known inputs, which include headwater inflows, wastewater discharges, tributary flows and incremental runoff, and the concentration in the previous time step. The known term for each type of element for dynamic simulation is:

TYPE	
1. Headwater	$S_i = T_i^* + \frac{h_i}{\zeta \bar{D}_i} + q_i' T_i' \frac{\Delta t}{v_i} - q_i T_h$
6. Waste Input	$S_i = T_i^* + \frac{h_i}{\zeta \bar{D}_i} + q_i' T_i' \frac{\Delta t}{v_i} + q_w T_w \frac{\Delta t}{v_i}$
All Others	$S_i = T_i^* + \frac{h_i}{\zeta \bar{D}_i} + q_i' T_i' \frac{\Delta t}{v_i}$

*All symbols used are defined at the end of this section of the Documentation Report.

Steady-state temperature distributions cannot be simulated with the model.

The subroutine flow chart is illustrated in Figure IV-17 and is followed by the program listing. All program variables contained in COMMON are defined in Section V.

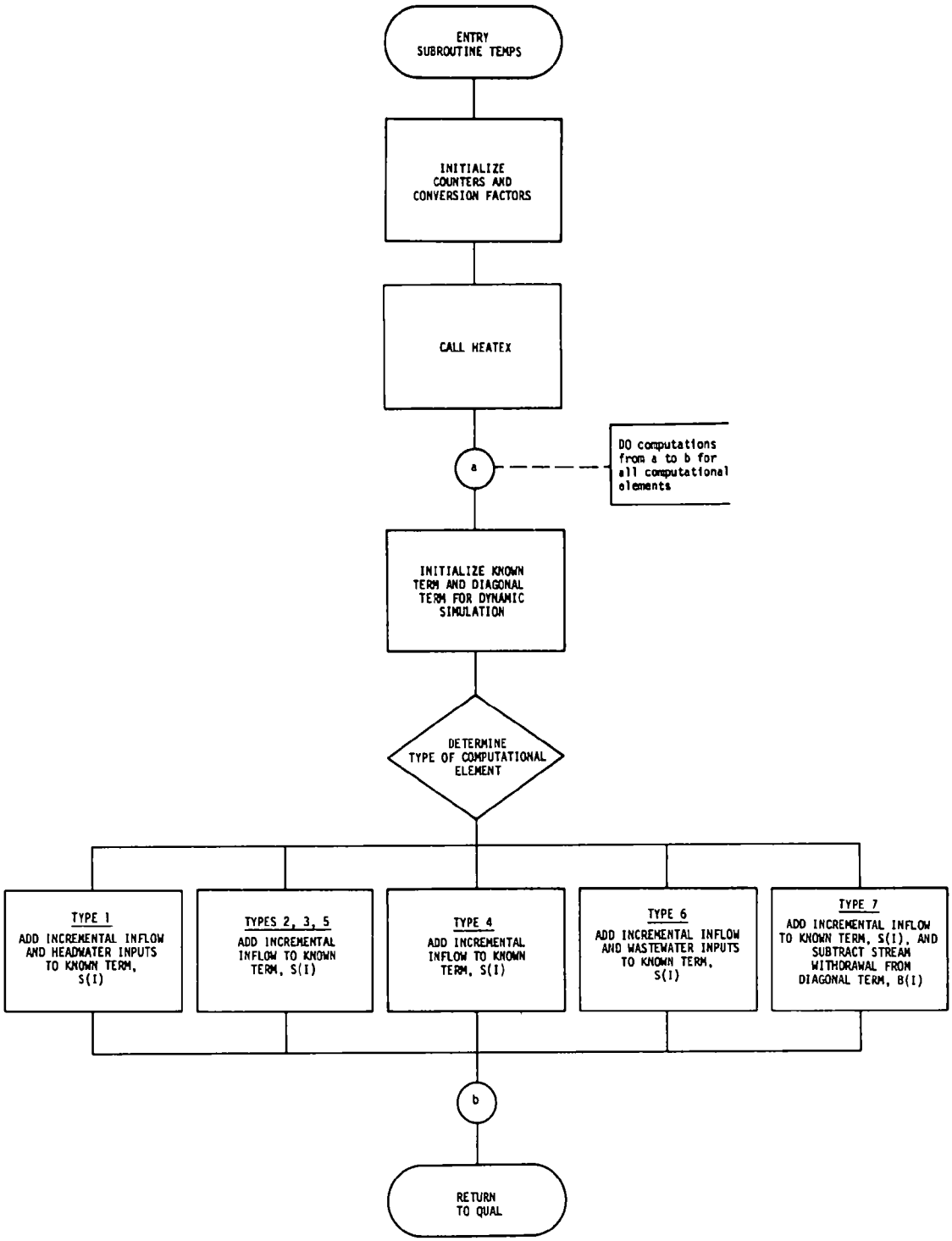

FIGURE IV-17 FLOW CHART FOR ENTRY SUBROUTINE TEMPS

```
      SUBROUTINE TEMPS
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMAND(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,RE,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
C
      COMMON /SSTATE/ X(500),ISS
C                                                                       00002200
C                              INITIALIZE COUNTERS
C                                                                       00002700
      NHW=0                                                             00002800
      NWS=0                                                             00002900
      IJUNC=0                                                           00003000
      RHOCP=62.4                                                        00003100
      CALL HEATEX                                                       00003200
C
C                              LOOP THROUGH REACHES AND COMP. ELEMENTS
C
      DO 100 I=1,NREACH                                                 00003300
      NCELR=NCELRH(I)                                                   00003400
      CNCELR=NCELR                                                      00003500
      TPIJ=QI(I)/CNCELR*TI(I)                                           00003600
C                                                                       00004200
      DO 100 J=1,NCELR                                                  00004300
      IOR=ICLORD(I,J)                                                   00004400
C
C                              INITIALIZE KNOWN TERMS
C
      B(IOR)=X(IOR)
      IFL=IFLAG(I,J)                                                    00004500
C
C                              MODIFY DIAGONAL AND/OR KNOWN TERMS
C
      GO TO (101,102,102,104,102,103,105), IFL                          00004600
C                                                                       00004700
  101 NHW=NHW+1                                                         00005200
      ADEPTH=0.5*(DEPHW(NHW)+DEPTH(IOR))                                00005300
      REACT=HSNET(IOR)/(RHOCP*ADEPTH)                                   00005400
      S(IOR)=T(IOR)+REACT+TPIJ+DTOVCL(IOR)-A(IOR)*HWTEMP(NHW)           00005500
      GO TO 100                                                         00005600
C                                                                       00005700
```

```
  102 ADEPTH=0.5*(DEPTH(IOR-1)+DEPTH(IOR))                          00006200
      REACT=HSNET(IOR)/(RHOCP*ADEPTH)                               00006300
      S(IOR)=T(IOR)+REACT+TPIJ*DTOVCL(IOR)                          00006400
      GO TO 100                                                     00006500
C                                                                   00006600
  103 NWS=NWS+1                                                     00007100
      ADEPTH=0.5*(DEPTH(IOR-1)+DEPTH(IOR))                          00007200
      REACT=HSNET(IOR)/(RHOCP*ADEPTH)                               00007300
      S(IOR)=T(IOR)+REACT+(TPIJ+WSFLOW(NWS)*WSTEMP(NWS))*DTOVCL(IOR)  00007400
      GO TO 100                                                     00007500
C                                                                   00007600
  104 IJUNC=IJUNC+1                                                 00008100
      NS=1                                                          00008200
      NN=JUNC(IJUNC,NS)                                             00008300
      ADEPTH=0.25*(DEPTH(IOR-1)+DEPTH(NN)+2.0*DEPTH(IOR))           00008400
      REACT=HSNET(IOR)/(RHOCP*ADEPTH)                               00008500
      S(IOR)=T(IOR)+REACT+TPIJ*DTOVCL(IOR)                          00008600
      GO TO 100                                                     00008700
C                                                                   00008800
  105 NWS=NWS+1                                                     00009300
      ADEPTH=0.5*(DEPTH(IOR-1)+DEPTH(IOR))                          00009400
      REACT=HSNET(IOR)/(RHOCP*ADEPTH)                               00009500
      S(IOR)=T(IOR)+REACT+(TPIJ)*DTOVCL(IOR)
      B(IOR)=B(IOR)-WSFLOW(NWS)*DTOVCL(IOR)
  100 CONTINUE                                                      00009700
      RETURN                                                        00009800
      END                                                           00009900
```

SUBROUTINE TRIMAT

Subroutine TRIMAT computes all coefficients for the implicit, finite difference advection-dispersion equation for each computational element except for the diagonal term. In the case of the diagonal term, b_i, TRIMAT computes that portion of term that is fixed and independent of the constituent to be simulated. This fixed portion of the diagonal term is designated as x_i.

In general, the basic equation that TRIMAT sets up for a computational element, i, is:

$$a_i z_{i-1} + b_i z_i + c_i z_{i+1} = S_i$$

where

b_i = x_i + (constituent dependent terms)
a_i, c_i = off-diagonal terms
S_i = known term
z = variable

In the case of a computational element that contains a junction and the upstream element in the tributary stream is n, the basic equation becomes:

$$a_i z_{i-1} + b_i z_i + c_i z_{i+1} + d_i z_n = S_i$$

Table IV-1 contains the equations for each term in each type of computational element.

The subroutine flow chart is illustrated in Figure IV-18 followed by the program listing. All program variables in COMMON are defined in Section V.

TABLE IV-1

SUBROUTINE TRIMAT EQUATIONS

FOR VARIOUS TYPES OF COMPUTATIONAL ELEMENTS

Reach Type	a	x	c	d
1. Headwater	$-D_n \frac{\Delta T}{\Delta x^2} - Q_h \frac{\Delta T}{v_i}$	$(1.0 + (D_o + D_j) \frac{\Delta T}{\Delta x^2} + Q_j \frac{\Delta T}{v_j})$	$-D_j \frac{\Delta T}{\Delta x^2}$	none
2. Regular	$-D_{j-1} \frac{\Delta T}{\Delta x^2} - Q_{j-1} \frac{\Delta T}{v_i}$	$(1.0 + (D_{j-1} + D_j) \frac{\Delta T}{\Delta x^2} + Q_j \frac{\Delta T}{v_j})$	same as 1	none
3. Upstream from junction	same as 2	same as 2	same as 2	none
4. Junction (with n)	same as 2	$(1.0 + D_{j-1} + 2D_j + D_n) \frac{\Delta T}{\Delta x^2} + Q_j \frac{\Delta T}{v_j}$	same as 2	$-D_n \frac{\Delta T}{\Delta x^2} - Q_n \frac{\Delta T}{v_j}$
5. End of Reach	$-(D_{j-1}+D_j) \frac{\Delta T}{\Delta x^2} - Q_{j-1} \frac{\Delta T}{v_j}$	same as 2	-0-	none
6. Input	same as 2	same as 2	same as 2	none
7. Withdrawal	same as 2	same as 2	same as 2	none

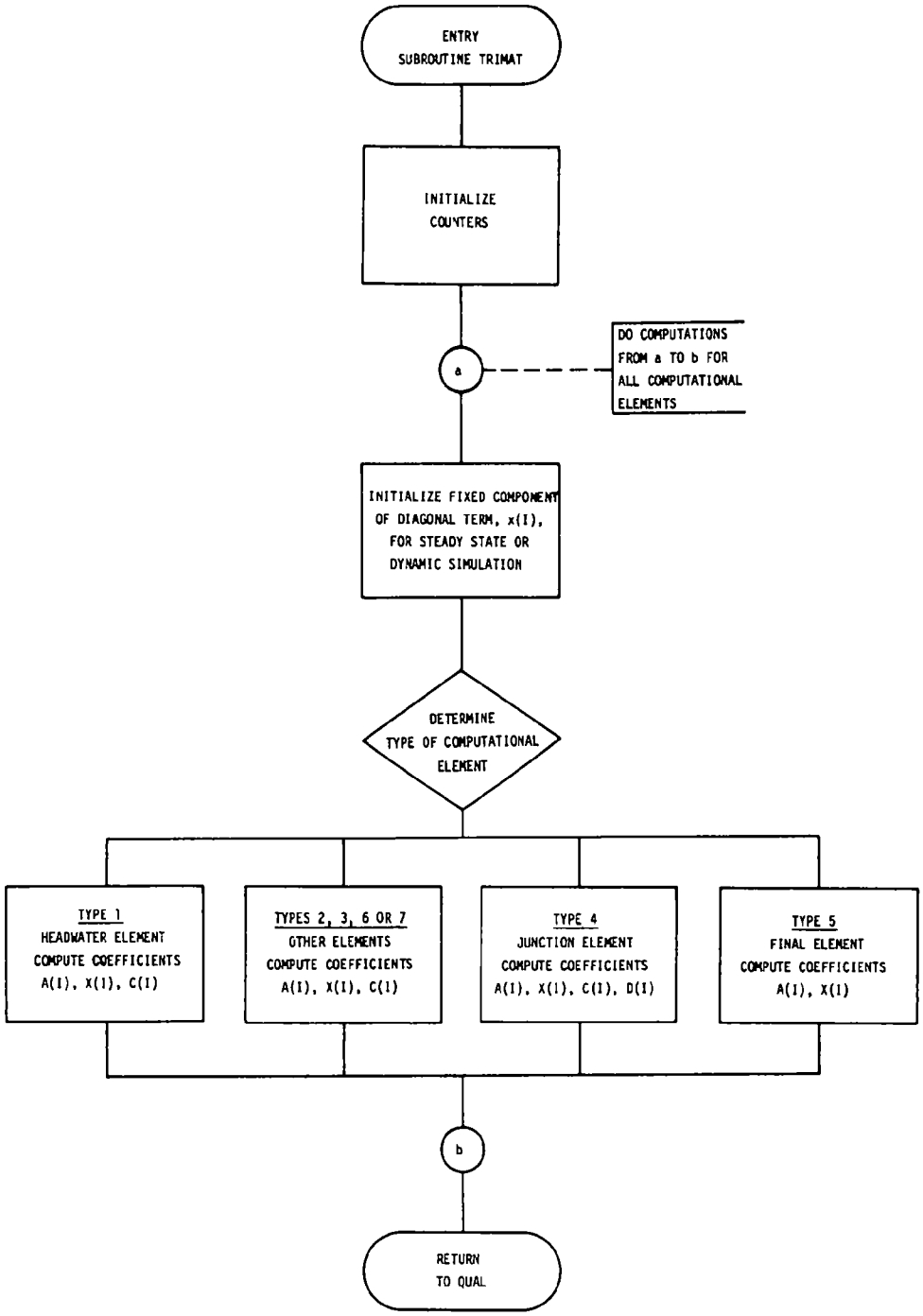

FIGURE IV-18 FLOW CHART FOR SUBROUTINE TRIMAT

```
      SUBROUTINE TRIMAT
C
C
C                                TRIMAT COMPUTES THE COEFFICIENT MATRIX
C                                FOR THE IMPLICIT-FINITE-DIFFERENCE FORM
C                                OF THE ONE-DIMENSIONAL (ADVECTION +
C                                DISPERSION) TRANSPORT EQUATION.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),          *NEW
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),                    *NEW
     *       ICLORD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),          *NEW
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),             *NEW
     *       EXPOK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),            *NEW
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),            *NEW
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),             *NEW
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),          *NEW
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),               *NEW
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),              *NEW
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),          *NEW
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),               *NEW
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,                     *NEW
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,            *NEW
     *       LAT,LSM,LLM,ELEV,DAT,AE,PF,DAYOFY,DRYBLB,WETBLB,DEWPT,              *NEW
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS            *NEW
C                                                                                *-16
      COMMON/SSTATE/X(500),ISS
C                                                                 00002400
C                                     STEP 1-0                    00002500
C                                     INITIALIZE COUNTERS FOR HEADWATE00002600
C                                     WASTE LOADS OR WITHDRAWLS, AND S00002700
C                                     JUNCTIONS.                  00002800
C                                                                 00002900
      NHW=0                                                       00003000
      NWS=0                                                       00003100
      IJUNC=0                                                     00003200
C                                                                 00003300
C                                     STEP 2-0                    00003400
C                                     LOOP THROUGH SYSTEM OF NREACH RE00003500
C                                     WITH NCELR COMPUTATIONAL ELEMENT00003600
C                                     REACH.                      00003700
C                                                                 00003800
      DO 100 I=1,NREACH                                           00003900
      NCELR=NCELRH(I)                                             00004000
      DO 100 J=1,NCELR                                            00004100
      IOR=ICLORD(I,J)                                             00004200
      X(IOR) = 1.0
      IF (ISS.GT.0) X(IOR) = 0.0
      IFL=IFLAG(I,J)                                              00004300
      GO TO (101,102,102,103,104,102,102), IFL                    00004400
C                                                                 00004500
C                                     STEP 2-1                    00004600
C                                     COMPUTE COEFFICIENTS B AND C FOR00004700
C                                     ELEMENT OF TYPE 1.          00004800
C                                                                 00004900
  101 NHW=NHW+1                                                   00005000
```

```
      A(IOR)=-DTODX2*DLHW(NHW)-HWFLOW(NHW)*DTOVCL(IOR)                  00005100
      X(IOR)=X(IOR)+DTODX2*(DLHW(NHW)+DL(IOR))+FLOW(IOR)*DTOVCL(IOR)
      C(IOR)=-DTODX2*DL(IOR)                                            00005300
      GO TO 100                                                         00005400
C                                                                       00005500
C                                       STEP 2-2                        00005600
C                                       COMPUTE COEFFICIENTS A,B, AND C 00005700
C                                       ELEMENTS OF TYPE 2,3,6, OR 7.   00005800
C                                                                       00005900
  102 A(IOR)=-DTODX2*DL(IOR-1)-FLOW(IOR-1)*DTOVCL(IOR)                  00006000
      X(IOR)=X(IOR)+DTODX2*(DL(IOR-1)+DL(IOR))+FLOW(IOR)*DTOVCL(IOR)
      C(IOR)=-DTODX2*DL(IOR)                                            00006200
      GO TO 100                                                         00006300
C                                                                       00006400
C                                       STEP 2-3                        00006500
C                                       COMPUTE COEFFICIENTS A,B,C, AND 00006600
C                                       ELEMENT OF TYPE 4.              00006700
C                                                                       00006800
  103 IJUPC=IJUPC+1                                                     00006900
      NS=1                                                              00007000
      NN=JUNC(IJUPC,NS)                                                 00007100
      B(IJUPC)=-DTODX2*DL(NN)-FLOW(NN)*DTOVCL(IOR)                      00007200
      A(IOR)=-DTODX2*DL(IOR-1)-FLOW(IOR-1)*DTOVCL(IOR)                  00007300
      X(IOR)=X(IOR)+DTODX2*(DL(IOR-1)+DL(NN)+2.0*DL(IOR))+FLOW(IOR)*
     *        DTOVCL(IOR)                                               00007500
      C(IOR)=-DTODX2*DL(IOR)                                            00007600
      GO TO 100                                                         00007700
C                                                                       00007800
C                                       STEP 2-4                        00007900
C                                       COMPUTE COEFFICIENTS A AND B FOR00008000
C                                       ELEMENT OF TYPE 5.              00008100
C                                                                       00008200
C                                                                       00008300
  104 A(IOR)=-DTODX2*(DL(IOR-1)+DL(IOR))-FLOW(IOR-1)*DTOVCL(IOR)        00008400
      X(IOR)=X(IOR)+DTODX2*(DL(IOR-1)+DL(IOR))+FLOW(IOR)*DTOVCL(IOR)
  100 CONTINUE                                                          00008600
      RETURN                                                            00008700
      END                                                               00008800
```

SUBROUTINE WRPT2

Subroutine WRPT2 is basically the same program as documented by the Texas Water Development Board (2). Minor changes to report headings and formats are the only differences from the original version of the program. QUAL-II uses WRPT2 to print intermediate summaries of simulation results. For dynamic simulations, the intermediate reports occur at preselected time intervals; while for steady-state simulations, the reports are printed at a preselected iteration interval. WRPT2 writes the concentration of the quality constituents simulated for each reach and all computational elements within the reach. For steady-state simulations the WRPT2 also reports the number of computational elements that do not satisfy the convergent criteria. The following page illustrates an example output report from WRPT2 for a steady-state simulation.

Figure IV-19 illustrates the subroutine flow chart, and the following pages contain the program listing. Variables in COMMON are defined in Section V.

ITERATION 1
GROWTH RATE NON CONVERGENT IN 97 ELEMENTS
ITERATION 2
GROWTH RATE NON CONVERGENT IN 52 ELEMENTS
ITERATION 3
GROWTH RATE NON CONVERGENT IN 0 ELEMENTS

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	8.30	8.21	8.14	8.07	8.01	7.96	7.92	7.88	7.85	7.83	7.81	7.80	7.79	7.78	7.78	7.78	7.78	7.79	7.80	7.81
2	7.83	7.64	7.86	7.88	7.89	7.36	7.11	6.89	6.69	6.51	6.36	6.22	6.10	6.00						
3	10.35	10.21	10.08	9.97	9.87	9.78	9.69	9.62	9.56	9.50	9.44	9.40								
4	9.36	9.32	9.28	9.26	9.23	9.21	9.19	9.17	9.15	9.14	9.13	9.11	9.11	9.10	9.09					
5	7.02	7.04	7.06	7.09	7.11	7.13	7.16	7.18	7.20	7.23	7.25	7.27	7.29	7.31	7.33	7.35				
6	7.38	7.40	7.42	7.45	7.47	7.49	7.51	7.53	7.55	7.57	7.59	7.61	7.63	7.65	7.68	7.74	7.81	7.86	7.92	7.97

BIOCHEMICAL OXYGEN DEMAND 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	2.87	2.75	2.63	2.52	2.41	2.31	2.21	2.11	2.02	1.93	1.85	1.77	1.70	1.62	1.55	1.49	1.42	1.36	1.30	1.25
2	1.19	1.14	1.09	1.05	1.01	7.42	7.11	6.82	6.53	6.26	6.00	5.76	5.52	5.29						
3	1.96	1.92	1.89	1.85	1.81	1.78	1.74	1.71	1.68	1.65	1.61	1.58								
4	1.55	1.52	1.49	1.46	1.43	1.41	1.38	1.35	1.33	1.30	1.28	1.25	1.23	1.20	1.18					
5	3.91	3.86	3.81	3.76	3.72	3.67	3.63	3.58	3.54	3.50	3.45	3.41	3.37	3.33	3.29	3.25				
6	3.21	3.18	3.15	3.12	3.10	3.07	3.04	3.01	2.98	2.96	2.93	2.90	2.88	2.85	2.83	2.79	2.76	2.73	2.69	2.66

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	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.81	.80
2	.79	.79	.78	.77	.76	2.03	2.01	1.99	1.97	1.95	1.93	1.91	1.89	1.87						
3	.50	.50	.49	.49	.49	.49	.48	.48	.48	.48	.47	.47								
4	.47	.47	.46	.46	.46	.46	.46	.45	.45	.45	.45	.44	.44	.44	.44					
5	1.41	1.41	1.40	1.40	1.39	1.39	1.39	1.38	1.38	1.37	1.37	1.36	1.36	1.36	1.35	1.35				
6	1.34	1.34	1.34	1.33	1.33	1.33	1.33	1.32	1.32	1.32	1.31	1.31	1.31	1.30	1.30	1.30	1.29	1.29	1.29	1.28

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	.06	.06	.07	.07	.08	.08	.09	.09	.09	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11
2	.11	.11	.11	.11	.11	.16	.17	.18	.18	.19	.20	.20	.21	.21						
3	.01	.01	.02	.02	.02	.02	.02	.02	.03	.03	.03	.03								
4	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04					
5	.16	.16	.17	.47	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.47	.17				
6	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18

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	.30	.31	.31	.32	.32	.33	.34	.34	.35	.36	.36	.37	.38	.38	.39	.40	.41	.41	.42	.43
2	.44	.45	.45	.46	.47	1.35	1.36	1.07	1.08	1.40	1.41	1.42	1.44	1.45						
3	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11								
4	.11	.11	.11	.11	.11	.11	.12	.12	.12	.12	.12	.12	.12	.13	.13					
5	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.09	1.09				
6	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.14	1.14	1.14	1.15

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

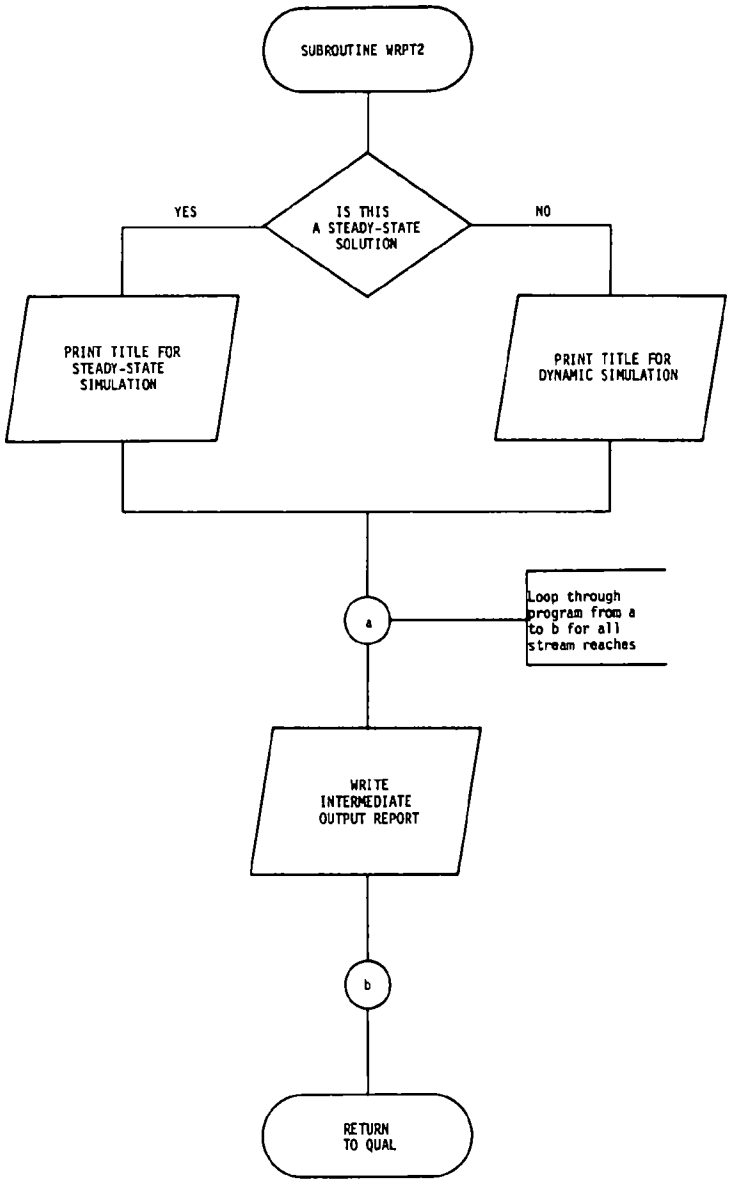

FIGURE IV-19 FLOW CHART FOR SUBROUTINE WRPT2

```
      SUBROUTINE WRPT2(CONC)
C
C
C                                WRPT2 WRITES AN INTERMEDIATE SUMMARY
C                                OF THE SELECTED QUALITY CONSTITUENTS.
C                                THESE CONSTITUENTS ARE WRITTEN BY REACH
C                                AND BY ELEMENT.  THIS SUMMARY CAN BE
C                                GIVEN AT A TIME INTERVAL OF DELT OR
C                                SOME MULTIPLE OF DELT.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),
     *       TAPGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),
     *       ICLORU(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),
     *       CMANN(75),CK1(75),CK3(75),K2OPT(75),CK2(75),COEQK2(75),
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTOOX2,DT2OOX,
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS
C
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),          *NEW
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,            *NEW
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),              *NEW
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),            *NEW
     *       ALGAE(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),            *NEW
     *       COLIP(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),              *NEW
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),          *NEW
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),         *NEW
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),            *NEW
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),          *NEW
     *       MODOPT(10),IPCHNO(750),EXCOEF(75)                              *NEW
C                                                                            *NEW
C                                                                            *NEW
      COMMON/RADION/ CK6(75),RADNIT(75),RADPI(75),HWRADN(15),WSRADN(90)     *NEW
C                                                                            *NEW
      COMMON/SSTATE/X(500),ISS
      DIMENSION P(20),CONC(500)
C
      IF (ISS) 20,20,10
   10 ITIME=TIME
      WRITE (NJ,15) (TITLE(NT,J),J=6,20),ITIME
   15 FORMAT (1H0,19X,15A4,4X,9HITERATION,I3)
      GO TO 55
   20 CONTINUE
      TIMDAY=TIME/24.0                                                  00002700
      WRITE (NJ,50) (TITLE(NT,J),J=6,20),TIMDAY                         00002800
   50 FORMAT (1H0,19X,15A4,1X,F5.2,5H DAYS,/)                           00002900
C                                        STEP 1-0                      00003000
```

```
   55 WRITE (NJ,60)
   60 FORMAT (2X,123HPCH/CL  1     2     3     4     5     6     7     8
     *     9    10    11    12    13    14    15    16    17    18    19
     *    20,/)
C                                                                       00003400
C                                       LOOP THROUGH SYSTEM OF NREACH RE00003500
C                                       BY NCELR COMPUTATIONAL ELEMENTS 00003600
C                                       REACH.                          00003700
C                                                                       00003800
      DO 100 I=1,NREACH                                                 00003900
      NCELR=NCELRH(I)                                                   00004000
      DO 200 J=1,NCELR                                                  00004100
      IOR=ICLORD(I,J)                                                   00004200
      P(J)=CONC(IOR)
      IF(NT .EQ. 8) P(J)=P(J)*ALPHAO(I)                                          *NEW
  200 CONTINUE                                                          00004500
C                                                                       00004600
C                                       STEP 1-1                        00004700
C                                       WRITE INTERMEDIATE SUMMARY.     00004800
C                                                                       00004900
      WRITE (NJ,300) I,(P(J),J=1,NCELR)                                 00005000
  300 FORMAT (2X,I3,20F6.2)
  100 CONTINUE                                                          00005200
      RETURN                                                            00005300
      END                                                               00005400
```

SUBROUTINE WRPT3

Subroutine WRPT3 prints for each reach the final results of the simulation. The output report contains three basic parts; these are:

1. Values of hydraulic parameters
2. Water quality results
3. Average values of reach coefficients

The following page contains an example of the output report produced by Subroutine WRPT3. Figure IV-20 illustrates the subroutine flow chart and the following pages contain the program listing. Variables in COMMON are defined in Section V.

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 1.0 RCH= REACH 1
RIVER MILES 90.0 TO 70.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	100.000	100.000	100.000	100.000	100.000
VELOCITY (FPS)	=	.757	.757	.757	.757	.757
DEPTH (FT)	=	5.547	5.547	5.547	5.547	5.547

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	8.30	8.21	8.14	8.07	8.01	7.96	7.92	7.88	7.85	7.83	7.81	7.80	7.79	7.78	7.78	7.78	7.78	7.79	7.80	7.81
BOD	2.87	2.75	2.63	2.52	2.41	2.31	2.21	2.11	2.02	1.93	1.85	1.77	1.70	1.62	1.55	1.49	1.42	1.36	1.30	1.25
NH3	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.81	.80
NO2	.06	.06	.07	.07	.08	.08	.09	.09	.09	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11
NO3	.30	.31	.31	.32	.32	.33	.34	.34	.35	.36	.36	.37	.38	.38	.39	.40	.41	.41	.42	.43
PO4	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
ALGY	10.12	10.25	10.38	10.51	10.65	10.79	10.93	11.08	11.23	11.38	11.54	11.70	11.86	12.03	12.21	12.38	12.57	12.75	12.95	13.14
COLI	.45	.40	.36	.33	.29	.26	.24	.21	.19	.17	.16	.14	.13	.11	.10	.09	.08	.07	.07	.06
CON1	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)			SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD	=	.50	BOD	= .00	BOD	= .00	K2	= .863	RATIO	= 50.00
KNH3	=	.15	ALGAE	= .50	NH3	= .00				
KNO2	=	1.00			PO4	= .00				
KCOLI	=	1.50								
KRON	=	.00								

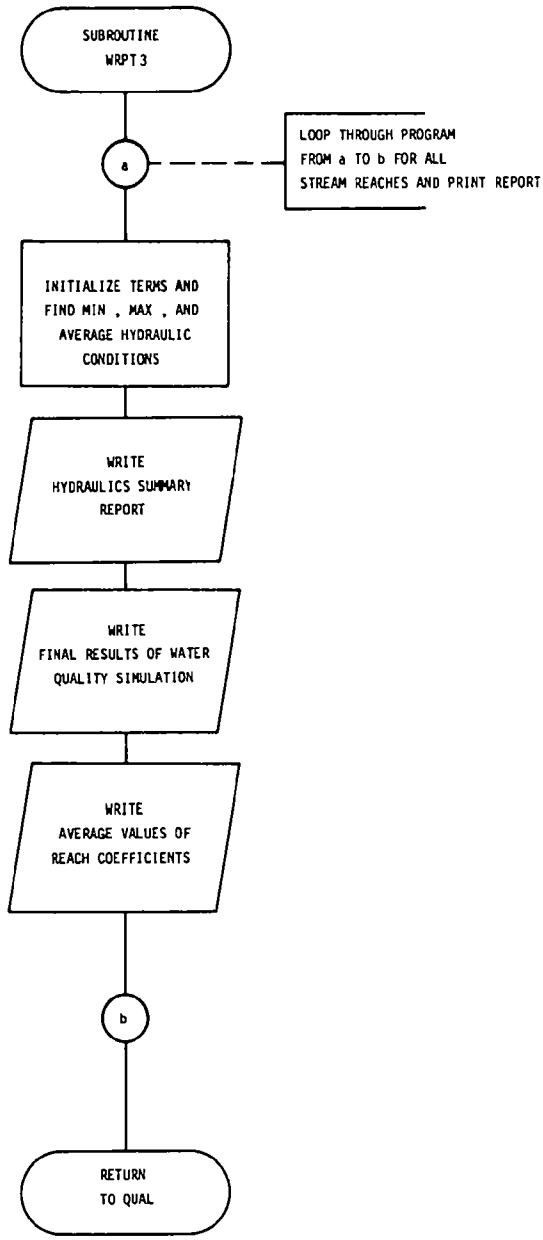

FIGURE IV-20 FLOW CHART FOR SUBROUTINE WRPT3

```
      SUBROUTINE WRPT3
C
C
C                                 WRPT3 GIVES A FINAL SUMMARY (REACH BY
C                                 REACH) AFTER STEADY-STATE CONDITIONS
C                                 HAVE BEEN REACHED. IT SUMMARIZES THE
C                                 CONDITIONS AT THE BEGINNING AND END OF
C                                 EACH REACH AS WELL AS THE MAXIMUM,
C                                  MINIMUM, AND AVERAGE CONDITIONS WITHIN
C                                 THE REACH.
C
C
      COMMON TITLE(20,20),RCHID(75,5),RMTHOR(75),RMTEOR(75),NHWWAR(15),
     *       TARGDO(75),IAUGOR(75,6),NCELRH(75),IFLAG(75,20),
     *       ICLOPD(75,20),COEFQV(75),EXPOQV(75),COEFQH(75),EXPOQH(75),
     *       CMANN(75),CK1(75),CK3(75),K20PT(75),CK2(75),COEQK2(75),
     *       EXPQK2(75),TINIT(75),DOINIT(75),BOINIT(75),COINIT(75,3),
     *       QI(75),TI(75),DOI(75),BODI(75),CONSI(75,3),JUNCID(15,5),
     *       JUNC(15,3),HWTRID(15,5),HWFLOW(15),HWTEMP(15),HWDO(15),
     *       HWBOD(15),HWCONS(15,3),WASTID(90,5),TRFACT(90),WSFLOW(90),
     *       WSTEMP(90),WSDO(90),WSBOD(90),WSCONS(90,3),QATOT(15),
     *       A(500),B(500),C(500),D(5),S(500),Z(500),W(500),G(500),
     *       FLOW(500),DEPTH(500),VEL(500),DTOVCL(500),K2(500),K1(500),
     *       HSNET(500),DL(500),VHW(15),DEPHW(15),DLHW(15),T(500),
     *       DO(500),BOD(500),CONS(500,3),PTIME,TPRINT,DELX,
     *       NHWTRS,NREACH,NWASTE,NJUNC,DELT,D1LT,D2LT,DTODX2,DT2ODX,
     *       LAT,LSM,LLM,ELEV,DAT,AE,BE,DAYOFY,DRYBLB,WETBLB,DEWPT,
     *       ATMPR,WIND,CLOUD,SONET,NI,NJ,TRLCD,TOFDAY,NT,NC,TIME,NCS
C
C
      COMMON/MODIF/ CK4(75),CK5(75),CKNH3(75),CKNO2(75),CKNO3(75),
     *       CKN,CKP,CKL,ALPHA0(75),ALPHA1,ALPHA2,ALPHA3,ALPHA4,
     *       ALPHA5,ALPHA6,GROMAX,RESPRT,ALGSET(75),SPHOS(75),
     *       SNH3(75),KNH3(500),KNO2(500),RESPRR(500),COLI(500),
     *       ALGAF(500),PHOS(500),CNH3(500),CNO2(500),CNO3(500),
     *       COLIR(75),ALGI(75),PHOSI(75),CNH3I(75),CNO2I(75),
     *       CNO3I(75),COLIIT(75),ALGIT(75),PHOSIT(75),CNH3IT(75),
     *       CNO2IT(75),CNO3IT(75),WSCOLI(90),WSALG(90),WSPHOS(90),
     *       WSNH3(90),WSNO2(90),WSNO3(90),HWCOLI(15),HWALG(15),
     *       HWPHOS(15),HWNH3(15),HWNO2(15),HWNO3(15),GROWTH(500),
     *       MODOPT(10),IPCHNO(750),EXCOEF(75)
C
C
      COMMON/RADION/ CK6(75),RADNIT(75),RADNI(75),HWRADN(15),WSRADN(90)
C
      COMMON/SSTATE/ X(500),ISS
      REAL K2
CCCCCCCCC
      DIMENSION PNAME(5,3),P(20),DATA(13)
      DATA PNAME   /4HFLOW,4H (CF,4HS)  ,4H    ,4H  = ,
     *              4HVFLO,4HCITY,4H (FP,4HS)  ,4H  = ,                  00003100
     *              4HDEPT,4HH (F,4HT)  ,4H    ,4H  = /
      DATA DATA/4H NO3,4HTEMP,4H BOD,4HALGY,4H PO4,4H NH3,4H  DO,
     1 4HCOLI,4H RAD,4H NO2,4HCON1,4HCON2,4HCON3/
C                                                                       00004200
C                                       STEP 1-0                        00003000
```

```
C                                                                       00003400
C                                       LOOP THROUGH SYSTEM ONE REACH
C                                       AT A TIME
C
      DO 30 KK=1,750
   30 IRCHNO(KK) = IABS( IRCHNO(KK) )
C
C                                                                       00004700
      DO 100 I=1,NREACH                                                 00004600
      DO 50 KK=1,750
      IF (IRCHNO(KK)) 50,50,40
   40 RCHNO=FLOAT(KK)/10.
      IRCHNO(KK)=-IRCHNO(KK)
      GO TO 60
   50 CONTINUE
   60 CONTINUE
C
      WRITE (NU,101) RCHNO,(RCHID(I,J),J=1,5),RMTHOR(I),RMTEOR(I)
  101 FORMAT (1H1,/  ,22X, 84H *     *     *     *     *     *     F I N A L
     * R E P O R T     *     *     *     *     *     *,//,
     *       50X,9HREACH NO.,F5.1,3X,  5A4,  /,50X,11HRIVER MILES,
     *       F 7.1,2X,2HTO,F 7.1,/)
C
C                                       STEP 1-1
C                                       INITIALIZE TERMS,               00004900
C                                                                       00005000
      FLOAVE=0.0                                                        00005100
      FLOMAX=0.0                                                        00005200
      FLOMIN=1.0E+06                                                    00005300
      AVEK2=0.0
      NCELR=NCELRH(I)
      IS=ICLORD(I,1)
      IE=IS-1+NCELR
      AVE=NCELR                                                         00007200
      DO 250 J=1,NCELR
      IOR=ICLORD(I,J)                                                   00008100
C                                                                       00008200
C                                      STEP 1-2
C                                       FIND MAXIMUM, MINIMUM, AND AVERA00008400
C                                       CONDITIONS WITHIN EACH REACH.   00008500
C                                                                       00008600
      IF (FLOW(IOR).LT.FLOMAX) GO TO 1                                  00008700
      FLOMAX=FLOW(IOR)                                                  00008800
    1 IF (FLOW(IOR).GT.FLOMIN) GO TO 2                                  00008900
      FLOMIN=FLOW(IOR)                                                  00009000
    2 FLOAVE=FLOAVE+FLOW(IOR)/AVE                                       00009100
      AVEK2=AVEK2+K2(IOR)/AVE
  250 CONTINUE
      CK2(I)=AVEK2
      VELMAX=COEFQV(I)*FLOMAX**EXPOQV(I)                                00012000
      VELMIN=COEFQV(I)*FLOMIN**EXPOQV(I)                                00012100
      VELAVE=COEFQV(I)*FLOAVE**EXPOQV(I)                                00012200
      DEPMAX=COEFQH(I)*FLOMAX**EXPOQH(I)                                00012300
      DEPMIN=COEFQH(I)*FLOMIN**EXPOQH(I)                                00012400
      DEPAVE=COEFQH(I)*FLOAVE**EXPOQH(I)                                00012500
C                                                                       00012600
C                                       STEP 1-3                        00008300
C                                       WRITE HYDRAULICS SUMMARY
C                                                                       00012900
      WRITE (NU,301)
```

```
  301 FORMAT ( //,95H 1.  H Y D R A U L I C   P A R A M E T E R   V A L U
     *E S      *      *      *      *      *      *     */)
      WRITE (NJ,302)
  302 FORMAT (1H0,11X,9HPARAMETER,9X,13HHEAD OF REACH,7X,
     *          12HEND OF REACH,5X,7HMAXIMUM,5X,7HMINIMUM,5X,7HAVERAGE,/)
  303 FORMAT (  9X,5A4,F10.3,10X,F10.3,4X,F10.3,2(2X,F10.3))
      WRITE (NJ,303) (PNAME(J,1),J=1,5),FLOW(IS),FLOW(IE),FLOMAX,
     *               FLOMIN,FLOAVE                                      00014000
      WRITE (NJ,303) (PNAME(J,2),J=1,5),VEL(IS),VEL(IE),VELMAX,
     *               VELMIN,VELAVE                                      00014200
      WRITE (NJ,303) (PNAME(J,3),J=1,5),DEPTH(IS),DEPTH(IE),
     *               DEPMAX,DEPMIN,DEPAVE                               00014400
      WRITE (NJ,105)
  105 FORMAT ( //,95H 2.  W A T E R   Q U A L I T Y   P A R A M E T E R   V
     * A L U E S    *      *      *      *      *     *//)
      WRITE (NJ,106)
  106 FORMAT (2X,123H  ELEM  1      2      3      4      5      6      7      8
     *      9     10     11     12     13     14     15     16     17     18     19
     *     20,/)
C
C                                        STEP 2-0                       00012700
C                                                                       00004600
C                                        WRITE REACH SUMMARY ON WATER
C                                        QUALITY PARAMETERS
C                                                                       00004900
      MPRIN=0
  150 MPRIN=MPRIN+1
      GO TO (155,160,165,170,175,180,185,190,195),MPRIN
  155 CONTINUE
      IF (MODOPT( 7).LE.0) GO TO 200
      NT=13
      DO 156 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=DO(IOR)
  156 CONTINUE
      WRITE (NJ,158) DATA( 7),(P(K),K=1,NCELR)
  158 FORMAT (1X,A4,20F6.2)
      GO TO 200
  160 CONTINUE
      IF (MODOPT( 3).LE.0) GO TO 200
      NT=7
      DO 161 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=BOD(IOR)
  161 CONTINUE
      WRITE (NJ,158) DATA( 3),(P(K),K=1,NCELR)
      GO TO 200
  165 CONTINUE
      IF (MODOPT( 6).LE.0) GO TO 200
      NT=10
      DO 166 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=CNH3(IOR)
  166 CONTINUE
      WRITE (NJ,158) DATA( 6),(P(K),K=1,NCELR)
      NT=11
      DO 167 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=CNO2(IOR)
  167 CONTINUE
```

```
      WRITE (NJ,158) DATA(10),(P(K),K=1,NCELR)
      NT=12
      DO 168 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=CRO3(IOR)
  168 CONTINUE
      WRITE (NJ,158) DATA( 1),(P(K),K=1,NCELR)
      GO TO 200
  170 CONTINUE
      IF (MODOPT( 5).LE.0) GO TO 200
      NT=9
      DO 171 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=PHOS(IOR)
  171 CONTINUE
      WRITE (NJ,158) DATA( 5),(P(K),K=1,NCELR)
      GO TO 200
  175 CONTINUE
      IF (MODOPT( 4).LE.0) GO TO 200
      NT=8
      DO 176 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=ALGAE(IOR)*ALPHAO(I)                                          *NEW
  176 CONTINUE                                                           **-1
      WRITE (NJ,158) DATA( 4),(P(K),K=1,NCELR)
      GO TO 200
  180 CONTINUE
      IF (MODOPT( 8).LE.0) GO TO 200
      NT=14
      DO 181 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=COLI(IOR)
  181 CONTINUE
      WRITE (NJ,158) DATA( 8),(P(K),K=1,NCELR)
      GO TO 200
  185 CONTINUE
      IF (MODOPT( 2).LE.0) GO TO 200
      NT=6
      DO 186 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=T (IOR)
  186 CONTINUE
      WRITE (NJ,158) DATA( 2),(P(K),K=1,NCELR)
      GO TO 200
  190 CONTINUE
      IF (MODOPT( 1).LE.0) GO TO 200
      NT=2
      DO 192 NNC=1,NCS
      NT=NT+1
      DO 191 J=1,NCELR
      IOR=ICLORD(I,J)
      P(J)=CONS(IOR,NNC)
  191 CONTINUE
      KK=10+NNC
      WRITE (NJ,158) DATA(KK),(P(K),K=1,NCELR)
  192 CONTINUE
      GO TO 200
  195 CONTINUE
      IF (MODOPT( 9).LE.0) GO TO 200
      NT=15
```

```
      DO 196 J=1,NCELR
      IOR=ICLORD(I,J)
C               RADIONUCLIDE  NOT PROGRAMMED THIS DATE  15 FEB 73
      P(J)=Z (IOR)
  196 CONTINUE
      WRITE (NJ,158) DATA( 9),(P(K),K=1,NCELR)
  200 CONTINUE
      IF (MPRIN.LT.9) GO TO 150
      WRITE(NJ,210) (TITLE(8,J),J=6,20)                                  *NEW
  210 FORMAT (37H0* NOTE:  UNITS ARE MG/L, EXCEPT FOR ,15A4)             **-1
      WRITE(NJ,215) (TITLE(14,J),J=6,20)                                 *NEW
      IF (MODOPT(1).LE.0) GO TO 220
      DO 216 KK=1,NCS
      KKK=KK+2
      WRITE (NJ,215) (TITLE(KKK,J),J=6,20)
  215 FORMAT (33X,4HAND ,15A4,/)
  216 CONTINUE
  220 CONTINUE
C                                                                        00003800
C
C                                        STEP 3-0
C
C                                        WRITE AVERAGE VALUES OF REACH
C                                        COEFFICIENTS
C                                                                        00007500
C                                        STEP 3-1
C
C                                        LOOP THROUGH ALL COMPUTATIONAL
C                                        ELEMENTS IN THE REACH
C                                                                        00007900
      WRITE (NJ,107)
  107 FORMAT (///,95H 3.  A V E R A G E  V A L U E S  O F  R E A C H  C
     *O E F F I C I E N T S     *     *     *    *///)
      WRITE (NJ,102)
  102 FORMAT (32H        DECAY RATES (1/DAY)            ,3X,
     * 22HSETTLING RATES (1/DAY),3X,32HBENTHOS SOURCE RATES (MG/FT/DAY),
     *3X,15HREAERATION RATE,3X,13HCHLOR A/ALGAE)
      WRITE (NJ,103)
  103 FORMAT (94X,10H   (1/DAY),9X,13HRATIO (UG/MG)/)
      WRITE (NJ,104) CK1(I),CK3(I),CK4(I),CK2(I),ALPHAO(I),CKNH3(I),
     1 ALGSET(I),SNH3(I),CKNO2(I),SPHOS(I),CK5(I),CK6(I)
  104 FORMAT (9X,8H K1BOD =,F7.2,16X,7HBOD   =,F7.2,16X,5HBOD =,F5.2,
     *17X,4HK2 =,F8.3,4X,7HRATIO =,F7.2,/,
     *        9X,8H KNH3  =,F7.2,16X,7HALGAE =,F7.2,16X,5HNH3 =,F5.2,/,
     *        9X,8H KNO2  =,F7.2,46X,5HPO4 =,F5.2,/,
     *        9X,8H KCOLI =,F7.2,/,9X,8H KRDN  =,F7.2)
  100 CONTINUE                                                           00016200
      RETURN                                                             00005300
      END
```

DEFINITION OF SYMBOLS

The following tabulation defines the symbols used in the right hand side of the equations shown in each subroutine description, except TRIMAT, which is self-explanatory.

SYMBOL	DEFINITION
a	Coefficient in convection-diffusion equation due to upstream stream segment
A	Algal biomass
α_1	Fraction of respired algal biomass resolubilized as ammonia nitrogen by bacterial action
α_2	Fraction of algal biomass that is phosphorus
α_3	Rate of oxygen production per unit of algae (photosynthesis)
α_4	Rate of oxygen uptake per unit of algae respired
α_5	Rate of oxygen uptake per unit of ammonia oxidation
α_6	Rate of oxygen uptake per unit of nitrite nitrogen oxidation
C	Concentration of a conservative material
C_5	Difference between oxygen concentration and oxygen saturation concentration
D	Average stream depth
$\bar{D}$	Average stream depth
D_m	Molecular diffusion coefficient
ϕ	Concentration of oxygen
E	Concentration of coliform
F	Froude number
g	Acceleration of gravity

SYMBOL	DEFINITION
λ	Light extinction coefficient
h	Net heat flux
K_L	Emperical half-saturation constant, light
K_N	Emperical half-saturation constant, nitrogen
K_P	Emperical half-saturation constant, phosphorus
K_1	Rate of decay of carbonaceous BOD
K_2	Aeration rate in accordance with the Fickian diffusion analogy
K_3	Rate of loss of carbonaceous BOD due to settling
K_4	Constant benthic uptake of oxygen
K_5	Rate of coliform die-off
K_7	Rate constant for the biological oxidation of ammonia nitrogen
K_8	Rate constant for the oxidation of nitrite nitrogen
L	Intensity of light (ALGAES)
L	Concentration of carbonaceous BOD (BODS)
μ	Algal specific growth rate
$\hat{\mu}$	Maximum specific algal growth rate
n	Manning's roughness coefficient
N_1	Concentration of ammonia nitrogen
N_2	Concentration of nitrite nitrogen
N_3	Concentration of nitrate nitrogen
P	Concentration of orthophosphate
ρ	Algal respiration rate
q	Stream flow
σ_1	Algal settling rate
σ_2	Benthos source rate for ammonia
σ_3	Benthos source rate for phosphorus
t	Time
T	Temperature

SYMBOL	DEFINITION
u	Velocity
u^*	Shear velocity
v	Volume
x	Length
ζ	Specific heat times density
h (subscript)	Headwater
i (subscript)	Element
o (subscript)	Taken out of system
w (subscript)	Waste load
* (superscript)	Previous time step value
^{1} (superscript)	Upstream element

SECTION V

QUAL-II

DESCRIPTION OF VARIABLES IN COMMON

SECTION V

QUAL-II

DESCRIPTION OF VARIABLES IN COMMON

SECTION V

QUAL-II

DESCRIPTION OF VARIABLES IN COMMON

Variable Name	Definition	Units
A(IOR)	= Vector below diagonal in tridiagonal coefficient matrix for computational element IOR	---
AE	= Evaporation coefficient	ft/hour-in. Hg
ALGAE(IOR)	= Concentration of algae in computational element IOR	mg/l
ALGI(I)	= Incremental inflow concentration of chlorophyll a into reach J	μg/l
ALGIT(I)	= Initial concentration of chlorophyll a in reach I	μg/l
ALGSET(I)	= Local settling rate for algae in reach I	ft/day
ALPHAO(I)	= Ratio of chlorophyll a to algae biomass in reach I	$\frac{\mu g\ Chl\text{-}a}{mg\ A}$
ALPHA1	= Fraction of algae biomass which is N	$\frac{mg\ N}{mg\ A}$
ALPHA2	= Fraction of algae biomass which is P	$\frac{mg\ P}{mg\ A}$
ALPHA3	= O_2 production per unit of algae growth	$\frac{mg\ O}{mg\ A}$
ALPHA4	= O_2 uptake per unit of algae respired	$\frac{mg\ O}{mg\ A}$
ALPHA5	= O_2 uptake per unit of NH_3 oxidation	$\frac{mg\ O}{mg\ A}$
ALPHA6	= O_2 uptake per unit of NO_2 oxidation	$\frac{mg\ O}{mg\ A}$
ATMPR	= Local barometric pressure	in. Hg

Variable Name	Definition	Units
B(IOR)	= Diagonal vector in tridiagonal coefficient matrix for computational element IOR	---
BE	= Evaporation coefficient	ft/hour-in. Hg-MPH
BOD(IOR)	= Ultimate BOD in computational element IOR	mg/l
BODI(I)	= Ultimate BOD of incremental inflow in reach I	mg/l
BOINIT(I)	= Initial ultimate BOD in reach I	mg/l
C(IOR)	= Vector above diagonal in tridiagonal coefficient matrix for computational element IOR	---
CK1(I)	= BOD decay rate coefficient (base e) for reach I	1/day
CK2(I)	= Reaeration coefficient (base e) for reach I	1/day
CK3(I)	= Rate of settling or scouring of BOD (base e) in reach I	1/day
CK4(I)	= Benthos source rate for BOD in reach I	$\frac{mg}{day\text{-}foot}$
CK5(I)	= Coliform die-off rate in reach I	1/day
CK6(I)	= Radionuclide decay rate in reach I	1/day
CKN	= Nitrogen half-saturation constant for algae growth	mg/l
CKNH3(I)	= Rate constant for biological oxidation of $NH_3 \rightarrow NO_2$ in reach I	1/day
CKNO2(I)	= Rate constant for biological oxidation of $NO_2 \rightarrow NO_3$ in reach I	1/day
CKL	= Light half-saturation constant for algae growth	Langleys/day

Variable Name	Definition	Units
CKP	= Phosphorus half-saturation constant for algae growth	mg/l
CLOUD	= Fraction of sky covered (cloudiness express as decimal)	---
CMANN(I)	= Manning's channel roughness coefficient for reach I	---
CNH3(IOR)	= Concentration of NH_3 in computational element IOR	mg/l
CNH3I(I)	= Incremental inflow concentration of NH_3 in reach I	mg/l
CNH3IT(I)	= Initial concentration of NH_3 in reach I	mg/l
CNO2(IOR)	= Concentration of NO_2 in computational element IOR	mg/l
CNO2I(I)	= Incremental inflow concentration of NO_2 in reach I	mg/l
CNO2IT(I)	= Initial concentration of NO_2 in reach I	mg/l
CNO3(IOR)	= Concentration of NO_3 in computational element IOR	mg/l
CNO3I(I)	= Incremental inflow concentration of NO_3 in reach I	mg/l
CNO3IT(I)	= Initial concentration of NO_3 in reach I	mg/l
COEFQH(I)	= Coefficient of flow for depth-discharge relationship in reach I	---
COEFQV(I)	= Coefficient of flow for velocity-discharge relationship in reach I	---
COEQK2(I)	= Coefficient of flow for reaeration-discharge relationship in reach I	---

Variable Name	Definition	Units
COINIT(I,NC)	= Initial conservative mineral concentration in reach I	mg/l
COLI(IOR)	= Concentration of coliform in computational element IOR	$\frac{1000}{100\ ml}$
COLIR(I)	= Incremental inflow concentration of coliform in reach I	$\frac{1000}{100\ ml}$
COLIIT(I)	= Initial concentration of coliform in reach I	$\frac{1000}{100\ ml}$
CONS(IOR,NC)	= Concentration of conservative minerals in computational element IOR	mg/l
CONSI(I,NC)	= Concentration of conservative minerals in incremental inflow in reach I	mg/l
D(IJUNC)	= Vector of coefficients not in the tridiagonal portion of the coefficient matrix for junction IJUNC	---
DAT	= Dust attenuation coefficient	---
DAYOFY	= Day of the year on which temperature routing begins (from January 1)	days
DELT	= Time interval of integration (time step over which the solution to the routing equation is advanced)	seconds
DELX	= Space interval of integration (length of computational element)	miles
DEPHW(NHW)	= Depth of headwater source NHW	feet
DEPTH(IOR)	= Depth in computational element IOR	feet
DEWPT	= Dew point temperature	degrees Fahr.
DL(IOR)	= Dispersion coefficient in computational element IOR	ft^2/sec

Variable Name	Definition	Units
DLHW(NHW)	= Dispersion coefficient at headwater source NHW	ft^2/sec
DO(IOR)	= Dissolved oxygen concentration in computational element IOR	mg/l
DOI(I)	= Dissolved oxygen concentration in incremental inflow in reach I	mg/l
DOINIT(I)	= Initial dissolved oxygen concentration in reach I	mg/l
DRYBLB	= Dry bulb temperature	degrees Fahr.
DTODX2	= $DELT/DELX^2$	sec/ft^2
DT2ODX	= (2.0 x DELT)/DELX	sec/ft
DTOVCL(IOR)	= DT2ODX/(FLOW(IOR)/VEL(IOR) + FLOW(IOR-1)/VEL(IOR-1))	sec/ft^3
D1LT	= Time interval of integration	days
D2LT	= Time interval of integration	hours
ELEV	= Mean elevation of river basin	ft
EXCOEF	= Light extinction coefficient	1/ft
EXPOQH(I)	= Exponent of flow for depth-discharge relationship in reach I	---
EXPOQV(I)	= Exponent of flow for velocity-discharge relationship in reach I	---
EXPQK2(I)	= Exponent of flow for reaeration discharge relationship in reach I	---
FLOW(IOR)	= Discharge in computational element IOR	CFS
GROMAX	= Maximum specific growth rate of algae	1/day
GROWTH(IOR)	= Algae growth rate in computational element IOR	1/day

Variable Name	Definition	Units
HSNET(IOR)	= Net heat exchanged through air-water interface in computational element IOR	BTU/ft^2
HWALG(NHW)	= Concentration of chlorophyll A in headwater source NHW	µg/l
HWBOD(NHW)	= Ultimate BOD of headwater source NHW	mg/l
HWCOLI(NHW)	= Concentration of coliform in headwater source NHW	$\frac{1000}{100\ ml}$
HWCONS(NHW,NC)	= Concentration of conservative minerals at headwater source NHW	mg/l
HWDO(NHW)	= Dissolved oxygen concentration at headwater source NHW	mg/l
HWFLOW(NHW)	= Discharge at headwater source NHW	CFS
HWNH3(NHW)	= Concentration of NH_3 in headwater source NHW	mg/l
HWNO2(NHW)	= Concentration of NO_2 in headwater source NHW	mg/l
HWNO3(NHW)	= Concentration of NO_3 in headwater source NHW	mg/l
HWPHOS(NHW)	= Concentration of PO_4 in headwater source NHW	mg/l
HWRADN(NHW)	= Concentration of radionuclide in headwater source NHW	---
HWTEMP(NHW)	= Temperature in headwater source NHW	degrees Fahr.
HWTRID(NHW,15)	= Alphanumeric name of headwater source NHW	---
IAUGOR(I,NHW)	= Order of headwater sources available for flow augmentation	---
ICLORD(I,J)	= Order of computation	---

Variable Name	Definition	Units
IFLAG(I,J)	= Computational flag field	---
IRCHNO(250)	= Number of inserted reach	---
ISS	= Program internal variable	---
JUNC(IJUNC,3)	= Order of computational elements clockwise around junction IJUNC	---
JUNCID(IJUNC,15)	= Alphanumeric name of stream junction IJUNC	---
K1(IOR)	= BOD decay rate (base e) coefficient in computational element IOR	1/day
K2(IOR)	= Reaeration coefficient (base e) in computational element IOR	1/day
K2OPT(I)	= Option for determining reaeration coefficient in reach I	---
KNH3(IOR)	= Internal variable, temperature corrected $CKNH_3$ in computational element IOR	---
KNO2(IOR)	= Internal variable, temperature corrected $CKNO_2$ in computational element IOR	---
LAT	= Mean latitude of river basin	degrees
LLM	= Local meridian of river basin	degrees
LSM	= Standard meridian of time zone in which river basin is located	degrees
MODOPT(10)	= Model option, program internal variable	---
NC	= Counter for the conservative mineral being routed	---
NCELRH(I)	= Number of computational elements in reach I (maximum = 20)	---
NCS	= Number of conservative minerals being routed (maximum = 3)	---

Variable Name	Definition	Units
NHWTRS	= Number of headwaters in stream system (maximum = 15)	---
NHWWAR(I)	= Number of headwater sources available for flow augmentation	---
NI	= Input tape	---
NJ	= Output tape	---
NJUNC	= Number of stream junctions in system (maximum = 15)	---
NREACH	= Number of reaches in system (maximum = 75)	---
NT	= Counter for printing titles	---
NWASTE	= Number of waste discharges or withdrawals (maximum = 90)	---
PHOS(IOR)	= Concentration of PO_4 in computational element IOR	mg/l
PHOSI(I)	= Incremental inflow concentration of PO_4 in reach I	mg/l
PHOSIT(I)	= Initial concentration of PO_4 in reach I	mg/l
PTIME	= Time interval for writing intermediate summary	hours
QATOT(NHW)	= Total flow augmentation from each headwater source used	CFS
QI(I)	= Incremental inflow in reach I	CFS
RADNI(I)	= Incremental inflow concentration of radionuclides in reach I	---
RADNIT(I)	= Initial concentration of radionuclides in reach I	---
RCHID(I,15)	= Alphanumeric name of reach I	---
RESPRR(IOR)	= Algae respiration rate in computation element IOR	1/day

Variable Name	Definition	Units
RESPRT	= Algae respiration rate	1/day
RMTEOR(I)	= River mile at end of reach I	miles
RMTHOR(I)	= River mile at head of reach I	miles
S(IOR)	= Vector of the known heat or material balance obtained in computational element IOR	degrees Fahr. or mg/l
SNH3(I)	= Benthos source rate for NH_3 in reach I	$\frac{\text{mg N}}{\text{day-foot}}$
SONET	= Average light intensity in basin	Langleys/day (for dynamic run use Langleys/hour)
SPHOS(I)	= Benthos source rate for PO_4 in reach I	$\frac{\text{mg P}}{\text{day-foot}}$
TARGDO(I)	= Minimum allowable target level for dissolved oxygen concentration in reach I	mg/l
T(IOR)	= Temperature in computational element IOR	degrees Fahr.
TI(I)	= Temperature of incremental inflow in reach I	degrees Fahr.
TIME	= Length of time over which a quality constituent has been routed	hours
TINIT(I)	= Temperature of incremental inflow in reach I	degrees Fahr.
TITLE(I,J)	= Alphanumeric program titles	---
TOFDAY	= Hour of day	hours
TPRINT	= Time counter to determine when to write intermediate summary	hours
TRFACT(NWS)	= Treatment plant efficiency (decimal fraction) for waste discharge NWS	---

Variable Name	Definition	Units
TRLCD	= Time counter to determine when to reach Local Climatological Data	hours
VEL(IOR)	= Velocity in computational element IOR	FPS
VHW(NHW)	= Velocity at headwater source NHW	FPS
WASTID(NWS,90)	= Alphanumeric name of treatment plant, withdrawal, or point source NWS	---
WETBLB	= Wet bulb temperature	degrees Fahr.
WIND	= Wind velocity	KNOTS
WSALG(NWS)	= Input concentration of chlorophyll a for waste load or point source NWS	μg/l
WSBOD(NWS)	= Ultimate BOD of waste loading or point source NWS	mg/l
WSCOLI(NWS)	= Input concentration of fecal coliform for waste load or point source NWS	1000
WSCONS(NWS,NC)	= Concentration of conservative mineral in waste load or point source NWS	mg/l
WSDO(NWS)	= Concentration of dissolved oxygen in waste load or point source NWD	mg/l
WSFLOW(NWS)	= Discharge of waste load, withdrawal or point source NWS	CFS
WSNH3(NWS)	= Input concentration of NH_3 for waste load or point source NWS	mg/l
WSNO2(NWS)	= Input concentration of NO_2 for waste load or point source NWS	mg/l
WSNO3(NWS)	= Input concentration of NO_3 for waste load or point source NWS	mg/l

Variable Name	Definition	Units
WSPHOS(NWS)	= Input concentration of PO_4 for waste load or point source NWS	mg/l
WSRADN(NWS)	= Input concentration of radionuclide for waste load or point source NWS	---
WSTEMP(NWS)	= Temperature of waste load or point source NWS	degrees Fahr.
X(IOR)	= Program internal variable for computational element IOR	---
Z(IOR)	= Temporary storage vector for computational element IOR	---

SECTION VI

QUAL-II INPUT DATA DESCRIPTION

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SECTION VI
QUAL-II INPUT DATA DESCRIPTION

All the input data required by the program are in card form. The card data and input formats are itemized on the input forms (1 through 19). 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 sixteen 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. NH_3, NO_2, and NO_3 must be simulated as a group. 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-DAYbBIØCHEMICALbØXYGENbDEMANDbINbMG/L" on the TITLE07 card beginning in column 22.

PROGRAM ANALYSIS CONTROL DATA (Form 2 of 19)

The first four cards control input-output printing. *If any characters other than those shown are inserted in the first four columns of these cards, requested action will <u>not</u> occur.*

LIST - Card 1, list the input data

WRIT - Card 2, write the final summary

FLOW - Card 3, use flow augmentation, on Form 2 shown in the documentation there will be no flow augmentation.

STEA - Card 4, on Form 2 shown this is a steady-state simulation. If it is <u>not</u> to be a steady-state, write dynamic simulation and it is automatically a dynamic simulation.

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

The first card (card five), contains the number of reaches into which the stream is broken down and the number of stream junctions (confluences) within the stream system.

Card 6 has the number of headwater sources and the number of inputs or withdrawals within the stream system. These inputs can be small streams, wasteloads, etc. Withdrawals can be municipal water supplies, canals, etc. (NOTE: Withdrawals must have a minus sign in type 11 data and must have IFLAG=7 in type 4 data).

Card 7 contains the time step interval in hours and the length of the computational element in miles. For steady state computations leave the time step interval blank.

The maximum route time for dynamic simulations is on card 8, and it 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. 30 iterations should be sufficient

in most cases. Also on card 8 is the time increment in hours for summary reports. For the steady-state solutions, leave this blank.

The next four cards (cards 9-12) 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 on card 9 and represent mean values in degrees for the basin. On card 10 enter the standard meridian in degrees, and the day of the year the simulation is to begin. The evaporation coefficients are entered on card 11. On data card 12, enter the mean basin elevation in feet above MSL, and the dust attenuation coefficient for solar radiation.

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, NH_3, NO_2, NO_3, PO_4, coliforms or radionuclides are to be simulated. Otherwise they may be deleted. The data fields are columns 33-39 and 74-80. Card 1 inputs data on oxygen uptake per unit of ammonia oxidation, 4.0 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, and the respiration rate of algae, which has a range of 0.05 to 0.5 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

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

This card group must end with ENDATA4.

HYDROLOGIC DATA (FORM 6 OF 19)

The cards in this group contain variables for determining the hydraulic conditions in the system. Flow characteristics are determined for each reach by the program. Velocity is calculated as $V = aQ^b$ and depth is found by $D = \alpha Q^\beta$. Each card represents one reach, containing 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	Columns 71-80

The last card for this group 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. Seven 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 $K2 = aQ^b$

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 7, as above)	Columns 41-50
K2 (option 1 only) reaeration coefficient	Columns 51-60

a, coefficient for K2 (option 7 only)	Columns 61-70
b, exponent for K2 (option 7 only)	Columns 71-80

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, NH_3, NO_2, NO_3, PO_4, coliforms or radionuclides are to be simulated. Otherwise, they may be deleted. 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 to 100)	Columns 33-40
Algae settling rate, feet/day (range of 0.5 to 6.0)	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)	Columns 65-72

Benthos source rate for phosphorus (mg/foot/day)	Columns 73-80

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 algae, NH_3, NO_2, NO_3, PO_4, coliform or radionuclides are 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)	Columns 33-40
Coliform decay rate, per day	Columns 41-48
Light extinction coefficient, per foot	Columns 49-56
Radionuclide 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. Only temperature is required for steady-state simulations. The information is contained as follows.

Reach order or number	Columns 26-30
Temperature in degrees F	Columns 31-40
Dissolved Oxygen, mg/l	Columns 41-45
BOD, mg/l	Columns 46-50
Conservative mineral I, mg/l	Columns 51-60
Conservative mineral II, mg/l	Columns 61-70
Conservative mineral III, mg/l	Columns 71-80

This group of cards must end with ENDATA7.

INITIAL CONDITIONS FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES (FORM 11 OF 19)

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

Reach order or number	Columns 20-24
Chlorophyl 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 N, mg/l	Columns 57-64
Coliforms (MPN)	Columns 65-72
Radionuclides	Columns 73-80

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

INCREMENTAL RUNOFF DATA (FORM 12 OF 19)

This group of cards, one per reach, accounts for the additional flows into the system not represented by inflows or headwaters. 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 flow, cfs	Columns 31-35
Temperature of flow, degrees F	Columns 36-40
Dissolved oxygen concentration, mg/l	Columns 41-45
BOD concentration, mg/l	Columns 46-50
Conservative Mineral I, mg/l	Columns 51-60
Conservative Mineral II, mg/l	Columns 61-70
Conservative Mineral III, mg/l	Columns 71-80

This group of cards must end with ENDATA8.

INCREMENTAL RUNOFF DATA FOR ALGAE, N, P, COLIFORMS, RADIONUCLIDES (FORM 13 OF 19)

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

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 MNP	Columns 65-72
Radionuclides	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. 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 mainstream reach immediately upstream of the junction (See example below. In the example, for Junction 1, the order number of the last mainstream element immediately upstream of the junction is number 17. For Junction 2 it is number 43. The Junction 1 mainstream element order number immediately downstream of the junction is 29. For Junction 2 it is number 52. The Junction 1 element order number of the last element of the tributary is number 28. For Junction 2 it is number 51.)	Columns 56-60

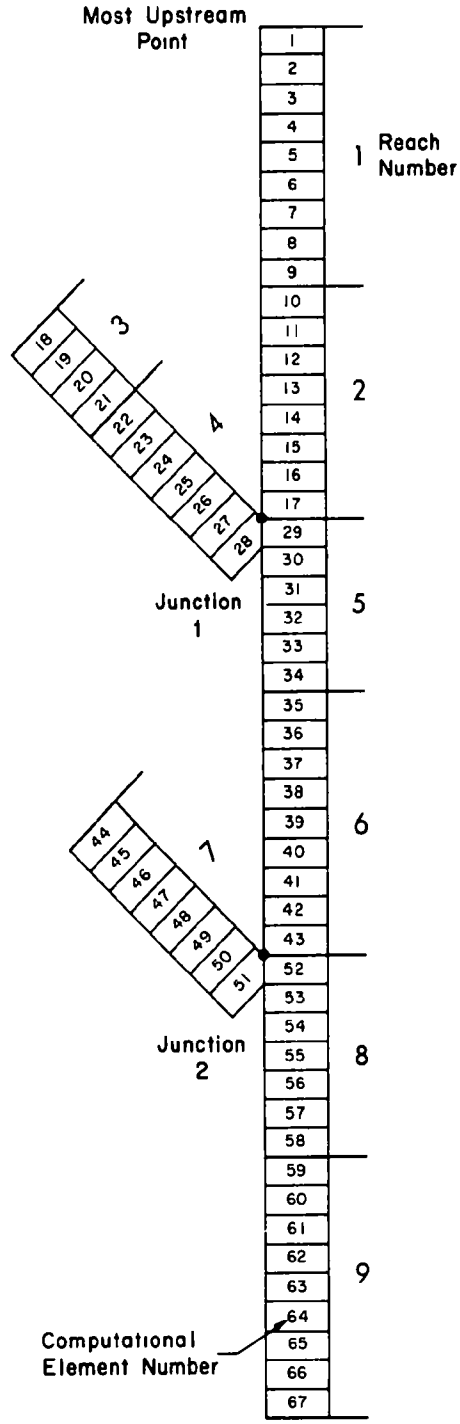


FIGURE VI-1 STREAM NETWORK FOR EXAMPLE PROBLEM

Order number of the first element in the mainstream reach immediately downstream from the junction	Columns 66-70
Order number of the last element in the last reach of the tributary entering the junction	Columns 76-80

This group of cards must end with ENDATA9, even if no data are entered.

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	Columns 41-50
Temperature in degrees, F.	Columns 51-55
Dissolved oxygen concentration, mg/l	Columns 56-60
BOD concentration, mg/l	Columns 61-65
Conservative Mineral I, mg/l	Columns 66-70
Conservative Mineral II, mg/l	Columns 71-75
Conservative Mineral III, mg/l	Columns 76-80

This group of cards must end with ENDATA10.

HEADWATER SOURCES DATA FOR ALGAE, N, P, COLIFORMS AND RADIONUCLIDES (FORM 16 OF 19)

This group of cards, one per headwater is required only if algae, NH_3, NO_2, NO_3, PO_4, coliforms, and radionuclides are to be simulated. Otherwise they may be deleted. 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, MPN	Columns 65-72
Radionuclides	Columns 73-80

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

WASTELOADINGS AND WITHDRAWALS DATA (FORM 17 OF 19)

This group of cards, one per inflow or withdrawal, 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.

Wasteload order number	Columns 11-15
Wasteload identification or name	Columns 20-35
Percent treatment (use only if influent BOD values are used)	Columns 36-40
Wasteload inflow or withdrawal in cfs (a withdrawal must have a (-) sign).	Columns 41-50
Temperature, degrees F	Columns 51-55
Dissolved oxygen concentration, mg/l	Columns 56-60
BOD concentration, mg/l	Columns 61-65
Conservative Mineral I, mg/l	Columns 66-70
Conservative Mineral II, mg/l	Columns 71-75
Conservative Mineral III, mg/l	Columns 76-80

This group of cards must end with ENDATA11.

WASTELOAD DATA FOR ALGAE, N, P, COLIFORMS, AND RADIONUCLIDES (FORM 18 OF 19)

This group of cards, one per wasteload, is required only if algae, NH_3, NO_2, NO_3, PO_4, coliforms, and radionuclides are to be simulated. Otherwise they may be deleted. The following information is on each card.

Wasteload 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, MPN	Columns 65-72
Radionuclides	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)

The following cards are required only if dynamic temperature and/or dynamic algae is being simulated. Otherwise they may be deleted. 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
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	Columns 49-56
Wet Bulb Temperature[2], degrees F	Columns 57-64
Barometric pressure[2], inches Hg	Columns 65-72
Wind speed[2], knots	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 dynamically simulated.

SECTION VII
EXAMPLE PROBLEM

	Page
EXAMPLE	VII-1
TEST PROBLEM DATA AND RESULTS	VII-2

SECTION VII
EXAMPLE PROBLEM

	Page
EXAMPLE	VII-1
TEST PROBLEM DATA AND RESULTS	VII-2

SECTION VII
EXAMPLE PROBLEM

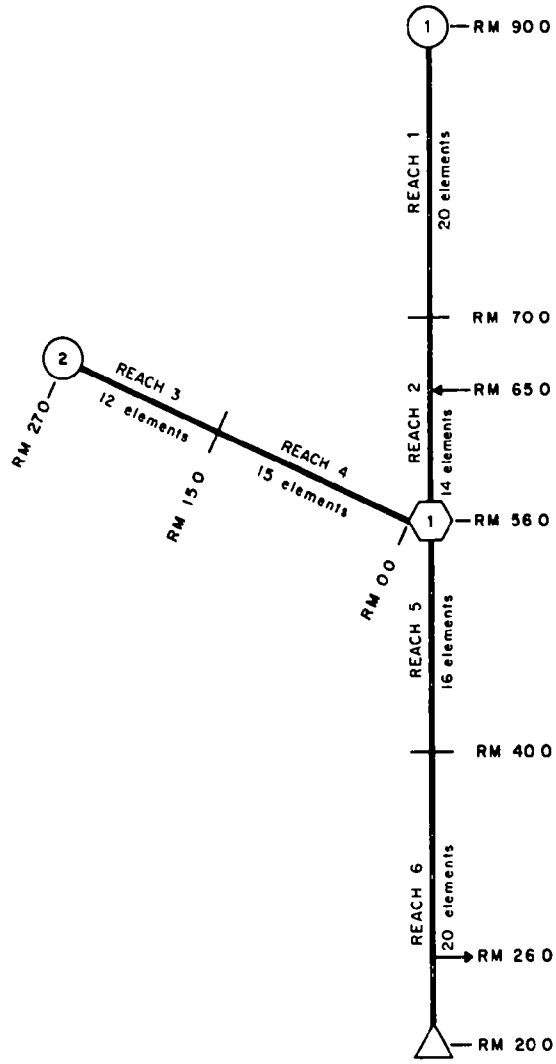
The example problem was for a branched system of 6 reaches, 97 elements, 2 headwaters, 1 junction, 1 point source waste load, and 1 withdrawal. The water temperature was 65.0°F., and the total daily radiation was 400 Langleys. The input information is shown on the following pages.

The problem was set to compute the steady state concentrations of TDS, BOD, chlorophyll A, phosphorus, ammonia, nitrite, nitrate, dissolved oxygen and fecal coliform. There was no incremental runoff or flow augmentation. Reaeration was computed by the #3 option, the equation by O'Conner and Dobbins. The computed values can be seen in the final report on each reach, shown on the following pages.

The DO saturation at 65°F. is 9.48 mg/l.

The interim report shown on the following pages indicates that almost all of reach 3 is supersaturated. The point source waste load effects can be seen in reach 2, element 6, the input point for all water quality constituents. DO levels and chlorophyll a levels go down, other constituent concentrations increase.

COMPUTER DATA SHEETS
AND REPORT



The above basin contains the following features

2 Headwaters (maximum allowable = 15)

1 Junction (maximum allowable = 15)

6 Reaches (maximum allowable = 75)

1 Waste discharge (maximum allowable = 90)

1 Withdrawal

97 computational elements (max allowable = 500)

FIGURE VII-1

SCHEMATIC DIAGRAM OF A HYPOTHETICAL STREAM SYSTEM

ITERATION 1
GROWTH RATE NON CONVERGENT IN 97 ELEMENTS
ITERATION 2
GROWTH RATE NON CONVERGENT IN 52 ELEMENTS
ITERATION 3
GROWTH RATE NON CONVERGENT IN 0 ELEMENTS

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	8.30	8.21	8.14	8.07	8.01	7.96	7.92	7.88	7.85	7.83	7.81	7.80	7.79	7.78	7.78	7.78	7.78	7.79	7.80	7.81
2	7.83	7.84	7.86	7.88	7.89	7.36	7.11	6.89	6.69	6.51	6.36	6.22	6.10	6.00						
3	10.35	10.21	10.08	9.97	9.87	9.78	9.69	9.62	9.56	9.50	9.44	9.40								
4	9.36	9.32	9.28	9.26	9.23	9.21	9.19	9.17	9.15	9.14	9.13	9.11	9.11	9.10	9.09					
5	7.02	7.04	7.06	7.09	7.11	7.13	7.16	7.18	7.20	7.23	7.25	7.27	7.29	7.31	7.33	7.35				
6	7.38	7.40	7.42	7.45	7.47	7.49	7.51	7.53	7.55	7.57	7.59	7.61	7.63	7.65	7.68	7.74	7.81	7.86	7.92	7.97

BIOCHEMICAL OXYGEN DEMAND 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	2.87	2.75	2.63	2.52	2.41	2.31	2.21	2.11	2.02	1.93	1.85	1.77	1.70	1.62	1.55	1.49	1.42	1.36	1.30	1.25
2	1.19	1.14	1.09	1.05	1.01	7.42	7.11	6.82	6.53	6.26	6.00	5.76	5.52	5.29						
3	1.96	1.92	1.89	1.85	1.81	1.78	1.74	1.71	1.68	1.65	1.61	1.58								
4	1.55	1.52	1.49	1.46	1.43	1.41	1.38	1.35	1.33	1.30	1.28	1.25	1.23	1.20	1.18					
5	3.91	3.86	3.81	3.76	3.72	3.67	3.63	3.58	3.54	3.50	3.45	3.41	3.37	3.33	3.29	3.25				
6	3.21	3.18	3.15	3.12	3.10	3.07	3.04	3.01	2.98	2.96	2.93	2.90	2.88	2.85	2.83	2.79	2.76	2.73	2.69	2.66

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	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.81	.80
2	.79	.79	.78	.77	.76	2.03	2.01	1.99	1.97	1.95	1.93	1.91	1.89	1.87						
3	.50	.50	.49	.49	.49	.49	.48	.48	.48	.48	.47	.47								
4	.47	.47	.46	.46	.46	.46	.46	.45	.45	.45	.45	.44	.44	.44	.44					
5	1.41	1.41	1.40	1.40	1.39	1.39	1.39	1.38	1.38	1.37	1.37	1.36	1.36	1.36	1.35	1.35				
6	1.34	1.34	1.34	1.33	1.33	1.33	1.33	1.32	1.32	1.32	1.31	1.31	1.31	1.30	1.30	1.30	1.29	1.29	1.29	1.28

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	.06	.06	.07	.07	.08	.08	.09	.09	.09	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11
2	.11	.11	.11	.11	.11	.16	.17	.18	.18	.19	.20	.20	.21	.21						
3	.01	.01	.02	.02	.02	.02	.02	.02	.03	.03	.03	.03								
4	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04					
5	.16	.16	.17	.47	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.47	.17				
6	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18

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	.30	.31	.31	.32	.32	.33	.34	.34	.35	.36	.36	.37	.38	.38	.39	.40	.41	.41	.42	.43
2	.44	.45	.45	.46	.47	1.35	1.36	1.07	1.08	1.40	1.41	1.42	1.44	1.45						
3	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11								
4	.11	.11	.11	.11	.11	.11	.12	.12	.12	.12	.12	.12	.12	.13	.13					
5	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.09	1.09				
6	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.14	1.14	1.14	1.15

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	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
2	.20	.20	.20	.20	.20	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00						
3	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05								
4	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05					
5	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39				
6	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39

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	10.12	10.25	10.38	10.51	10.65	10.79	10.93	11.08	11.23	11.38	11.54	11.70	11.86	12.03	12.21	12.38	12.57	12.75	12.95	13.14
2	13.34	13.54	13.75	13.97	14.19	13.22	13.57	13.93	14.29	14.67	15.05	15.45	15.86	16.28						
3	5.00	5.01	5.01	5.02	5.02	5.02	5.03	5.03	5.04	5.04	5.04	5.05								
4	5.05	5.06	5.06	5.07	5.08	5.08	5.09	5.09	5.10	5.10	5.11	5.12	5.12	5.13	5.14					
5	12.96	13.05	13.15	13.24	13.33	13.43	13.53	13.62	13.72	13.82	13.92	14.02	14.12	14.22	14.32	14.42				
6	14.51	14.59	14.67	14.75	14.83	14.91	14.99	15.07	15.16	15.24	15.32	15.40	15.49	15.57	15.65	15.77	15.90	16.02	16.15	16.28

FECAL COLIFORM AS 1000/100 ML — 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	.45	.40	.36	.33	.29	.26	.24	.21	.19	.17	.16	.14	.13	.11	.10	.09	.08	.07	.07	.06
2	.05	.05	.04	.04	.06	49.39	44.58	40.23	36.31	32.78	29.58	26.70	24.10	21.75						
3	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01								
4	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00					
5	14.09	13.67	13.26	12.86	12.47	12.10	11.73	11.38	11.04	10.71	10.39	10.07	9.77	9.48	9.19	8.92				
6	8.68	8.48	8.29	8.10	7.92	7.74	7.56	7.39	7.22	7.06	6.90	6.74	6.59	6.44	6.32	6.13	5.95	5.77	5.60	5.43

CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1) — 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	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
2	27.00	27.00	27.00	27.00	27.00	33.64	33.64	33.64	33.64	33.64	33.64	33.64	33.64	33.63						
3	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00								
4	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00					
5	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78				
6	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78

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	.23	.23	.23	.23	.24	.24	.24	.24	.24	.25	.25	.25	.25	.25	.26	.26	.26	.26	.26	.27
2	.27	.27	.27	.27	.28	.42	.42	.42	.42	.42	.42	.42	.42	.43						
3	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10								
4	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.11					
5	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41				
6	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.45	.45	.45	.45	.45	.45

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	1.98	2.00	2.01	2.03	2.04	2.06	2.08	2.09	2.11	2.13	2.14	2.16	2.18	2.20	2.21	2.23	2.25	2.27	2.28	2.30
2	2.31	2.33	2.34	2.36	2.38	3.63	3.63	3.64	3.64	3.65	3.66	3.66	3.67	3.67						
3	.82	.83	.83	.83	.83	.84	.84	.84	.85	.85	.86	.86								
4	.87	.87	.88	.88	.89	.89	.90	.90	.91	.92	.92	.93	.93	.94	.95					
5	3.52	3.52	3.52	3.52	3.53	3.53	3.53	3.53	3.54	3.54	3.54	3.54	3.54	3.55	3.55	3.55				
6	3.55	3.56	3.56	3.56	3.56	3.56	3.56	3.57	3.57	3.57	3.57	3.57	3.57	3.58	3.87	3.87	3.87	3.87	3.88	3.88

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 1.0 RCH= REACH 1
RIVER MILES 90.0 TO 70.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	100.000	100.000	100.000	100.000	100.000
VELOCITY (FPS)	=	.757	.757	.757	.757	.757
DEPTH (FT)	=	5.547	5.547	5.547	5.547	5.547

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	8.30	8.21	8.14	8.07	8.01	7.96	7.92	7.88	7.85	7.83	7.81	7.80	7.79	7.78	7.78	7.78	7.78	7.79	7.80	7.81
BOD	2.87	2.75	2.63	2.52	2.41	2.31	2.21	2.11	2.02	1.93	1.85	1.77	1.70	1.62	1.55	1.49	1.42	1.36	1.30	1.25
NH3	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.81	.80
NO2	.06	.06	.07	.07	.08	.08	.09	.09	.09	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11
NO3	.30	.31	.31	.32	.32	.33	.34	.34	.35	.36	.36	.37	.38	.38	.39	.40	.41	.41	.42	.43
PO4	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
ALGY	10.12	10.25	10.38	10.51	10.65	10.79	10.93	11.08	11.23	11.38	11.54	11.70	11.86	12.03	12.21	12.38	12.57	12.75	12.95	13.14
COLI	.45	.40	.36	.33	.29	.26	.24	.21	.19	.17	.16	.14	.13	.11	.10	.09	.08	.07	.07	.06
CON1	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)			SETTLING RATES (1/DAY)			BENTHOS SOURCE RATES (MG/FT/DAY)			REAERATION RATE (1/DAY)			CHLOR A/ALGAE RATIO (UG/MG)		
K1BOD	=	.60	BOD	=	.00	BOD	=	.00	K2	=	.863	RATIO	=	50.00
KNH3	=	.15	ALGAE	=	.50	NH3	=	.00						
KNO2	=	1.00				PO4	=	.00						
KCOLI	=	1.50												
KBON	=	.00												

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 2.0 RCH= REACH 2
RIVER MILES 70.0 TO 56.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	100.000	110.000	110.000	100.000	106.429
VELOCITY (FPS)	=	.757	.787	.787	.757	.776
DEPTH (FT)	=	5.547	5.874	5.874	5.547	5.758

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.83	7.84	7.86	7.88	7.89	7.36	7.11	6.89	6.69	6.51	6.36	6.22	6.10	6.00						
BOD	1.19	1.14	1.09	1.05	1.01	7.42	7.11	6.82	6.53	6.26	6.00	5.76	5.52	5.29						
NH3	.79	.79	.78	.77	.76	2.03	2.01	1.99	1.97	1.95	1.93	1.91	1.89	1.87						
NO2	.11	.11	.11	.11	.11	.16	.17	.18	.18	.19	.20	.20	.21	.21						
NO3	.44	.45	.45	.46	.47	1.35	1.36	1.37	1.38	1.40	1.41	1.42	1.44	1.45						
PO4	.20	.20	.20	.20	.20	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00						
ALGY	13.34	13.54	13.75	13.97	14.19	13.22	13.57	13.93	14.29	14.67	15.05	15.45	15.86	16.28						
COLI	.05	.05	.04	.04	.06	49.39	44.58	40.23	36.31	32.78	29.58	26.70	24.10	21.75						
CON1	27.00	27.00	27.00	27.00	27.00	33.64	33.64	33.64	33.64	33.64	33.64	33.64	33.64	33.63						

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)		CHLOR A/ALGAE RATIO (UG/MG)	
K1BOD =	.60	BOD =	.00	BOD =	.00	K2 =	.827	RATIO =	50.00
KNH3 =	.15	ALGAE =	.50	NH3 =	.00				
KNO2 =	1.00			PO4 =	.00				
KCOLI =	1.50								
KRON =	.00								

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 3.0 RCH= REACH 3 TRIB
RIVER MILES 27.0 TO 15.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	50.000	50.000	50.000	50.000	50.000
VELOCITY (FPS)	=	1.721	1.721	1.721	1.721	1.721
DEPTH (FT)	=	3.137	3.137	3.137	3.137	3.137

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	10.35	10.21	10.08	9.97	9.87	9.78	9.69	9.62	9.56	9.50	9.44	9.40								
BOD	1.96	1.92	1.89	1.85	1.81	1.78	1.74	1.71	1.68	1.65	1.61	1.58								
NH3	.50	.50	.49	.49	.49	.49	.48	.48	.48	.48	.47	.47								
NO2	.01	.01	.02	.02	.02	.02	.02	.02	.03	.03	.03	.03								
NO3	.10	.10	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11								
PO4	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05								
ALGY	5.00	5.01	5.01	5.02	5.02	5.02	5.03	5.03	5.04	5.04	5.04	5.05								
COLI	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01								
CON1	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00								

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)			SETTLING RATES (1/DAY)			BENTHOS SOURCE RATES (MG/FT/DAY)			REAERATION RATE (1/DAY)			CHLOR A/ALGAE RATIO (UG/MG)		
K1BOD	=	.60	BOD	=	.00	BOD	=	.00	K2	=	3.061	RATIO	=	50.00
KNH3	=	.15	ALGAE	=	.50	NH3	=	.00						
KNO2	=	1.00				PO4	=	.00						
KCOLI	=	1.50												
KBON	=	.00												

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 4.0 RCH= REACH 4 TRIB
RIVER MILES 15.0 TO .0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	50.000	50.000	50.000	50.000	50.000
VELOCITY (FPS)	=	1.721	1.721	1.721	1.721	1.721
DEPTH (FT)	=	3.137	3.137	3.137	3.137	3.137

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	9.36	9.32	9.28	9.26	9.23	9.21	9.19	9.17	9.15	9.14	9.13	9.11	9.11	9.10	9.09					
BOD	1.55	1.52	1.49	1.46	1.43	1.41	1.38	1.35	1.33	1.30	1.28	1.25	1.23	1.20	1.18					
NH3	.47	.47	.46	.46	.46	.46	.46	.45	.45	.45	.45	.44	.44	.44	.44					
NO2	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04					
NO3	.11	.11	.11	.11	.11	.11	.12	.12	.12	.12	.12	.12	.12	.13	.13					
PO4	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05					
ALGY	5.05	5.06	5.06	5.07	5.08	5.08	5.09	5.09	5.10	5.10	5.11	5.12	5.12	5.13	5.14					
COLI	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00					
CON1	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00					

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD =	.60	BOD =	.00	BOD =	.00	K2 = 3.061	RATIO = 50.00
KNH3 =	.15	ALGAE =	.50	NH3 =	.00		
KNO2 =	1.00			PO4 =	.00		
KCOLI =	1.50						
KBON =	.00						

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 5.0 RCH= REACH 5
RIVER MILES 56.0 TO 40.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	160.000	160.000	160.000	160.000	160.000
VELOCITY (FPS)	=	2.741	2.741	2.741	2.741	2.741
DEPTH (FT)	=	5.253	5.253	5.253	5.253	5.253

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.02	7.04	7.06	7.09	7.11	7.13	7.16	7.18	7.20	7.23	7.25	7.27	7.29	7.31	7.33	7.35				
BOD	3.91	3.86	3.81	3.76	3.72	3.67	3.63	3.58	3.54	3.50	3.45	3.41	3.37	3.33	3.29	3.25				
NH3	1.41	1.41	1.40	1.40	1.39	1.39	1.39	1.38	1.38	1.37	1.37	1.36	1.36	1.36	1.35	1.35				
NO2	.16	.16	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17				
NO3	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.09	1.09				
PO4	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39				
ALGY	12.96	13.05	13.15	13.24	13.33	13.43	13.53	13.62	13.72	13.82	13.92	14.02	14.12	14.22	14.32	14.42				
COLI	14.09	13.67	13.26	12.86	12.47	12.10	11.73	11.38	11.04	10.71	10.39	10.07	9.77	9.48	9.19	8.92				
CON1	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78				

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)		SETTLING RATES (1/DAY)		BENTHOS SOURCE RATES (MG/FT/DAY)		REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD =	.60	BOD =	.00	BOD =	.00	K2 = 1.782	RATIO = 50.00
KNH3 =	.15	ALGAE =	.50	NH3 =	.00		
KNO2 =	1.00			PO4 =	.00		
KCOLI =	1.50						
KBON =	.00						

* * * * * * F I N A L R E P O R T * * * * * *

REACH NO. 6.0 RCH= REACH 6
RIVER MILES 40.0 TO 20.0

1. H Y D R A U L I C P A R A M E T E R V A L U E S * * * * * * *

PARAMETER		HEAD OF REACH	END OF REACH	MAXIMUM	MINIMUM	AVERAGE
FLOW (CFS)	=	160.000	80.000	160.000	80.000	136.000
VELOCITY (FPS)	=	3.655	2.770	3.655	2.770	3.425
DEPTH (FT)	=	5.253	3.466	5.253	3.466	4.765

2. W A T E R Q U A L I T Y P A R A M E T E R V A L U E S * * * * * *

ELEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DO	7.38	7.40	7.42	7.45	7.47	7.49	7.51	7.53	7.55	7.57	7.59	7.61	7.63	7.65	7.68	7.74	7.81	7.86	7.92	7.97
BOD	3.21	3.18	3.15	3.12	3.10	3.07	3.04	3.01	2.98	2.96	2.93	2.90	2.88	2.85	2.83	2.79	2.76	2.73	2.69	2.66
NH3	1.34	1.34	1.34	1.33	1.33	1.33	1.33	1.32	1.32	1.32	1.31	1.31	1.31	1.30	1.30	1.30	1.29	1.29	1.29	1.28
NO2	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18
NO3	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.14	1.14	1.14	1.15
PO4	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
ALGY	14.51	14.59	14.67	14.75	14.83	14.91	14.99	15.07	15.16	15.24	15.32	15.40	15.49	15.57	15.65	15.77	15.90	16.02	16.15	16.28
COLI	8.68	8.48	8.29	8.10	7.92	7.74	7.56	7.39	7.22	7.06	6.90	6.74	6.59	6.44	6.32	6.13	5.95	5.77	5.60	5.43
CON1	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78	27.78

* NOTE: UNITS ARE MG/L, EXCEPT FOR ALGAE AS CHL A IN UG/L
AND FECAL COLIFORM AS 1000/100 ML

AND CONSERVATIVE MINERAL I = TDS IN (MG/L X 0.1)

3. A V E R A G E V A L U E S O F R E A C H C O E F F I C I E N T S * * * *

DECAY RATES (1/DAY)	SETTLING RATES (1/DAY)	BENTHOS SOURCE RATES (MG/FT/DAY)	REAERATION RATE (1/DAY)	CHLOR A/ALGAE RATIO (UG/MG)
K1BOD = .60	BOD = .00	BOD = .00	K2 = 2.443	RATIO = 50.00
KNH3 = .15	ALGAE = .50	NH3 = .00		
KNO2 = 1.00		PO4 = .00		
KCOLI = 1.50				
KRON = .00				

TABLE II-2

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_3	$\frac{mg\ N}{day\text{-}ft}$	*	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	$\frac{1}{day}$	*	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	Radionuclide sink rate	$\frac{1}{day}$	*	No	No	Poor
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	$\frac{Langleys}{day}$	260	No	No	Good

*Highly variable