

LA-QUAL for WINDOWS USER'S MANUAL

Model Version 11.00 (August 14, 2021)

Prepared for the

Louisiana Department of Environmental Quality
Water Permits Division
Water Quality Modeling/TMDL Section
Baton Rouge, Louisiana

by

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Manual Rev. A

PREFACE

LA_QUAL is a steady-state one-dimensional water quality model that has been developed by the Watershed Support Division of the Louisiana Department of Environmental Quality. Its history dates back to the QUAL-I model developed by the Texas Water Development Board with Frank D. Masch & Associates in 1970 to 1971. The original code was written by William A. White. In June, 1972, the United State Environmental Protection Agency awarded Water Resources Engineers, Inc. (now Camp Dresser & McKee) a contract to modify QUAL-I for application to the Chattahoochee-Flint River, the Upper Mississippi River, the Iowa-Cedar River, and the Santee River. The modified version of QUAL-I was known as QUAL-II. Over the next three years, several versions of the model evolved in response to specific client needs. In March, 1976, the Southeast Michigan Council of Governments (SEMCOG) contracted with Water Resources Engineers, Inc. to make further modifications and to combine the best features of the existing versions of QUAL-II into a single model. That became known as the QUAL-II/SEMCOG version. Between 1978 and 1984, Bruce L. Wiland with the Texas Department of Water Resources (now the Texas Commission on Environmental Quality) modified QUAL-II for application to the Houston Ship Channel estuarine system. Numerous modifications were made to enable modeling this very large and complex system including the addition of tidal dispersion, lower boundary conditions, nitrification inhibition, sensitivity analysis capability, branching tributaries, and various input/output changes. This model became known as QUAL-TX and was subsequently applied to streams throughout the State of Texas. In 1985, EPA's Center for Water Quality Modeling sponsored a National Council of the Paper Industry for Air and Stream Improvement (NCASI) review of other versions of QUAL-II and incorporated certain features of these versions into a program called QUAL2E. In 1987, further enhancements were added to QUAL2E in cooperative agreements between EPA, NCASI, and the Department of Civil Engineering at Tufts University.

In 1999, the Louisiana Department of Environmental Quality and Wiland Consulting, Inc. developed LA-QUAL based on QUAL-TX Version 3.4. The program was converted from a DOS-based program to a Windows-based program with a graphical interface and enhanced graphic output. Other program modifications specific to the needs of Louisiana and the Louisiana DEQ were also made. Karen LeBlanc Vidrine was the Louisiana DEQ project manager providing guidance and assisting in revisions to this User's Manual. Other enhancements have been made by Wiland Consulting, Inc. in subsequent years.

Version History of LA-QUAL

- 11.00 - a) changed warning to error when sequencing a model where last reach is highly dispersive
b) output from sequenced files now takes precedence over initial conditions when input as headwaters
- 10.06 - a) added slope to HYDR-1 data type for the velocity/depths hydraulic formula option
b) added program control options to "ignore wasteloads" and "ignore chlorophyll a in initial conditions"
c) added a notice if one of the data types is misspelled
d) changed ocean exchange ratio default for advective streams
e) corrected error in stream loading report
- 10.05 - a) changed how output from sequenced files is managed on input as headwaters
b) added option to preferences for special reports
c) rearranged preferences format
d) added DO summary report of minimum and maximum in each stream
- 10.04 - a) corrected deprecated 'MACROPHY' model option code name
b) added a final warning message that gives the number of warnings
c) corrected length of code word in LBC error messages
d) modified capsule report
e) added option to preferences for outputting a tab-delimited file
f) corrected plot issue that plotted standard criteria outside of lower range
g) added warning when sequencing a model where last reach is highly dispersive
h) changed flows to double precision so flow totals would be more accurate
i) added warning for misspelled card types
- 10.03 - a) corrected problem with warning flags not being reset
b) allow execution to proceed as a warning even if rate inhibition nonconvergence occurs
- 10.02 - a) added a second set of standards criteria to the overlay plot
b) added option to display rich-text output report immediately after execution
c) added control card enabling program preference for state default to be overridden
- 10.01 - a) corrected problem with plot not using requested scale
- 10.00 - a) add effective concentrations capability for nonconservative material
b) added comma-delimited output file options
c) enhanced stream summary report
d) added some additional error checking
e) reordered plot menu

- f) reformatted some reports
- g) added calculation of performance measures
- h) correct error in coliform calculations from non-point sources
- 9.39 - a) increase maximum number of plots from 12 to 21
- b) added "flow" to initial constituent to display in additional preferences
- c) added ability to choose initial plot to display in additional preferences
- d) added ability to display plot abbreviations rather than numbers in plotting window
- 9.38 - a) correct issue with evaporation error checking
- b) correct issue with overlay file error checking
- c) no longer requires an overlay file for every plot
- 9.37 - a) add additional error checking for invalid formats in plot cards
- b) correct issue with some plot preferences not keeping changes
- c) increase maximum observed values from 100 to 200
- d) increase maximum number of plots from 9 to 12
- e) increase number of recent files opened from 9 to 15
- f) add option to increase line width of predicted profile on plot
- 9.36 - a) Correct loading table issues with NH3 in withdrawals and BOD1 in phytoplankton and periphyton death
- b) Add error checking for dam in first reach
- c) Correct evaporation calculation when advective flow is extremely low.
- d) Increase maximum observed values from 80 to 100
- e) Add flow, width, and depth to allowable initial views for plot in additional preferences
- f) Add warning when negative flows occur in an advective element that may have insufficient depth
- g) Enable output of a tab-delimited data file
- h) Correct issue with overlay values plotting outside plot limits
- 9.35 - a) Add nonpoint source loadings for salinity, conservative material #1, and conservative material #2
- b) Implement a program switch to allow batch run without the GUI interface
- c) Implement batch mode to allow the user to supply an input file name on the command line
- d) Correct issue with PO4 nonpoint source loading
- e) Correct some loading table issues
- f) Add additional sensitivities.
- 9.34 - a) correct error in loading report when reach is not being modeled (i.e., initial temp = 0)
- b) correct issue with saving loading report preferences
- 9.33 - a) increased maximum number of dams from 20 to 30
- b) fix river distance formatting on plots
- 9.32 - a) added additional error checking information for reach id cards (Data Type 8)
- 9.31 - a) increased number of allowable stations in overlay from 50 to 80
- b) added nonpoint input for NH3, NO3, PO4, and associated sensitivities
- c) fix line wrapping in rich-text output
- 9.30 - a) corrected error in calculation of constituent CM-2 related to wasteloads (error originated in LA-QUAL v.9.10)
- b) added sensitivities for dam coefficients
- c) corrected labeling of plot legend when displaying multiple sensitivity parameters per set
- 9.29 - a) added additional informing warnings
- b) added HELP menu item to access Users Manual
- 9.28 - a) added additional error checking information
- b) corrected issue with preferences for labeling of filename on plot
- c) corrected issue with effective concentration adjustments when chlorophyll a is included in headwaters
- d) added table to show adjustment of concentrations when using effective concentrations
- 9.27 - a) added additional error checking and method for reading legacy overlay cards
- 9.26 - a) add rich-text file format option to output report
- 9.25 - a) corrected input echo in output report for dispersive hydraulic parameters (HYDR-2)
- 9.24 - a) added additional error checking for plot cards (Data Type 30)
- b) increased number of allowable reaches per RCH card to 40 (Data Type 30)
- c) added ability to show tributary locations on plots
- d) added ability to specify different programs for viewing and editing
- 9.23 - a) corrected display issue in the File dialog menu when more than 9 files had been opened
- 9.22 - a) corrected issue with reading HDWTR-2 values in sequenced files
- b) added additional error checking for overlay cards
- c) corrected dimensioning of RSENS from MXH to MXR
- 9.21 - a) made some unit conversions more precise
- 9.20 - a) added evaporation component to hydraulics
- b) corrected problem with width going negative during flow reversals
- c) corrected some sensitivity problems (incorrect array dimension; crashed when mixing 1 and 2 columns per set)

- d) default of .inp extension added to open list options
- e) added option to KTIDE to set all dispersion to 0
- f) added salinity to loading table
- g) added additional tidal information to final report
- 9.14 - a) added error message when no reaches are specified for a plot
- 9.13 - a) corrected factor when using English units
 - b) added flow in both English and metric units on some output reports
- 9.12 - a) added code to close sequential files after they are read
- 9.11 - a) increased number of stations that the model could handle in the overlay
- 9.10 - a) changed river kilometers to double precision so model could handle large river kilometers and small element lengths
 - b) corrected sensitivity runs for dispersion sensitivity when using dispersion equation 1
 - c) corrected immediate display of reports and sensitivity table when "Run Sensitivity" selected in Preferences
 - d) corrected sensitivity exclusion issue for headwaters and wasteloads
 - e) added sensitivity exclusion capability for reach hydraulics (depth, width, velocity)
 - f) added width parameter to sensitivity
 - g) added additional dam reaeration equations
 - h) added error message for Evans and Butts dam equation for depths greater than 4.6 meters
- 9.09 - a) corrected sensitivity parameter descriptions in sensitivity report
- 9.08 - a) corrected program crash when the maximum 9 overlay plots were used
- 9.07 - a) corrected how physical coefficients plotted in sensitivity runs
 - b) enhanced reaeration rate plot and legend
- 9.06 - a) changed how physical coefficients plotted
 - b) added ability to change some labels and fonts on plot
 - c) added some error checking to headwaters and wasteloads related to sensitivity
- 9.05 - a) changed some output format in capsule summary
 - b) corrected how nitrogen preference is selected when phytoplankton is not being simulated
 - c) corrected some error checking
 - d) added ability to name plot image capture file to Preferences
- 9.04 - a) added additional error checking for plot cards
- 9.03 - a) added deprecated NBOD OXY code word in Data Type 1
 - b) added ability to alter phytoplankton self-shading coefficients/exponents (now in Data Type 6)
- 9.02 - a) corrected spelling of KL MINIM code word in Data Type 3
- 9.01 - a) corrected initialization of CCONT(2) for periphyton
- 9.00 - a) added Organic Phosphorus constituent
 - b) corrected KSETT for phytoplankton
 - c) fixed problem with english/metric conversion of settling rate
 - d) changed some THETA, SENS, OPTION, PROGRAM code words to avoid confusion
 - e) added "Effective Concentration" option and corrected some conversions
 - f) added hydrolysis from BOD2 to BOD1
 - g) changed how denitrification is handled
 - h) added algae death term
 - i) combined input parameters for available settled SOD
 - j) changed how periphyton are modeled
 - k) simplified plot card input
- 8.11 - a) corrected error checking for light limitation equation in INDATA
- 8.10 - a) corrected algae/macrophyte growth rate equation
 - b) added solar information output report
 - c) added option for no light limitation in algae/macrophyte growth calculation
- 8.01 - a) added ability to change temperature equation for atmospheric attenuation
 - b) added ability to change temperature equation for atmospheric longwave radiation
 - c) added bank shading coefficient to temperature and algae simulations
- 8.00 - a) made major changes to temperature simulation
 - b) added ability to exclude specific wasteloads for WSL FLOW sensitivities
 - c) added ability to exclude specific headwaters for HDW FLOW sensitivities
- 7.04 - a) added ability to change sensitivity color preferences
- 7.03 - a) corrected number of allowable cards from 11 to 12 in DATA TYPE 5
 - b) corrected a minKL plotting problem
 - c) added k2 value before applying minKL on reaeration plot
 - d) corrected error message for missing Chl a card in LBC Data Type 27
 - e) increased allowable sensitivities to 100
 - f) added sensitivities LBC Salinity, Wind Velocity, Pressure, Dry Bulb Temp, Wet Bulb Temp
- 7.02 - a) corrected model sequencing for BOD2

- 7.01 - a) corrected DOSENS sensitivities from 67 to 90
 - b) allow comments in overlay file
 - c) corrected initialization of certain LBC concentrations
 - d) added ability to print out wasteload names on plots
 - e) added ability to open previous files in Open dialog
 - f) corrected problems in loading summary
 - g) corrected fatal error termination when there was an error junction input
 - h) added additional options for nutrient limitations
 - i) added additional options for nutrient limitations
 - j) added option to calculate dispersion as a function of mean velocity
 - k) changed default KL min from 0.6 to 0.7 to reflect Louisiana defaults
 - l) corrected wasteload locations on plot
 - m) added ability to show reaches on plot
- 6.20 - made code modifications to allow compilation under Intel IVF 8.1
- 6.11 - added check for observed values to make sure minimum & maximum are not reversed
- 6.10 - a) added dispersion through headwater to allow second boundary condition
 - b) corrected problem with reading certain sensitivities
 - c) changed address/email for LaDEQ in About box
- 6.03 - a) removed generation of debug.txt file
 - b) corrected error in reading of Data Type 6/7 input
 - c) corrected problem with detection of errors in overlay cards
 - d) added ability to turn max/min DO text on or off on plots
- 6.02 - corrected a Lower Boundary problem if no boundary conditions were present
- 6.01 - corrected a dimension problem in the plots if there were exactly 3000 elements
- 6.00 - a) added inhibition to organic nitrogen for use as NBOD
 - b) added BOD#2 constituent
 - c) corrected temperature correction for phosphorus source and some defaults
 - d) corrected some sensitivity factors
 - e) added sensitivity factors for non-point source
 - f) added ability to specify oxygen inhibition equations for each inhibited constituent
 - g) added ability to specify oxygen threshold in equations for each inhibited constituent
 - h) added short names for use in plot menu push-buttons and in certain columns of output
- 5.02 - corrected problem with echoing of input data for wasteload flows
- 5.01 - a) corrected certain problems in preferences
 - b) added option to select editor in preferences and set colors back to default
 - c) added title to sensitivity table
 - d) corrected problems with English/Metric option
 - e) modified format in some reports
- 5.00 - added dam capability and corrected sensitivity table problem
- 4.13 - added shelter coefficient for wind driven reaeration
- 4.12 - a) Corrected coliform temperature correction theta
 - b) Corrected NCM oxygen inhibition iterative technique
 - c) Corrected program crash for non-convergence
- 4.11 - a) Corrected variable and column alignment in 20 deg rate reporting in final summary
 - b) Corrected coefficient in Owen-Gibbs <5fps reaeration equation (option 4)
- 4.10 - a) Corrected input/output fields to allow more than 1000 elements
 - b) Moved report options to "Preferences"
 - c) Added optional colors to graphic display
 - d) Added crossbar option to ranges of observed values
 - e) Added option to show wasteload locations on graphic display
 - f) Added option to view graphics, reports, or sensitivity table after execution
 - g) Removed flow augmentation and line printer plots
- 4.00 - a) Modified the intermediate, final, and capsule summary reports by extending the decimal place holder on many of the fields.
 - b) Added a header to the sensitivity analysis report.
 - c) Corrected zip code to address field
- 3.03 - corrected DO in intermediate report
- 3.02 - added extra error detection in input
- 3.01 - corrected temperature correction constants
- 3.00 - added sensitivity table
- 2.00a - a) Address & phone number change,
 - b) Temperature Correction Constants for Reaeration,

- BOD Decay, NCM Decay, Benthic, and Organic Nitrogen changed to Louisiana Technical Procedures Manual Defaults
- c) Default of .in extension added to load list options and .txt moved to top choice.
- d) Moved Exit, Print, and Capture buttons to left side of screen
- e) Modified to accept 9 plots instead of 5
- 1.00b - added dlgunit() to winplot
- 1.00a - original version

Modifications that were made during the development of LA-QUAL from QUAL-TX are listed as follows:

- 1) Conformance of the core code to American National Standard Fortran 90 (ANSI X.198-1992) and International Standards Organization standard ISO/IEC 1539-1991(E).
- 2) Development of a Windows graphical interface.
- 3) Development of on-screen graphic output showing predicted profiles and observed data.
- 4) Development of on-screen graphic output for sensitivity analysis
- 5) Allowing hydraulics to be based on width/depth input in addition to velocity/depth input.
- 6) Allowing settling rates to be input on a per day basis in addition to a settling velocity basis.
- 7) Addition of new reaeration equations that more closely fit Louisiana conditions.
- 8) Addition of low dissolved oxygen concentration inhibition of NCM decay rates.
- 9) Corrections to certain errors in coding related to reaeration rate equations, settling rates, and effective BOD in lower boundary conditions.
- 10) Corrections to certain errors in coding related to the coliform temperature correction theta, the NCM oxygen inhibition technique, and non-convergence problems
- 11) Corrections to the Owens-Edwards-Gibbs reaeration equation in option 4 of Data Type 12 (<5fps, 1964).
- 12) Temperature Correction Defaults changed to values listed in the LTP.
- 13) Addition of a Special Report Sensitivity Table.
- 14) Modified the number of significant digits reported for many of the fields in the capsule summary, intermediate report, and final report.
- 15) Corrections to variable and column alignment in 20 deg rate reporting in final report.

Modifications that were made during the conversion of QUAL-II to QUAL-TX are listed as follows:

- 1) Removal of the dynamic capability because of the steady-state hydraulic assumptions and numerical dispersion inherent with the solution technique.
- 2) Addition of more diagnostics to identify errors in the input data and format.
- 3) Addition/modification of various output reports including the creation of line printer plots and overlays.
- 4) Allowing input/output of metric units.
- 5) Allowing nitrification, BOD decay, and benthic demand inhibition at low dissolved oxygen concentrations.
- 6) Addition of sensitivity analyses for modeling runs.
- 7) Addition of macrophytes as a water quality constituent.
- 8) Combining of nitrite nitrogen and nitrate nitrogen into a single nitrite-nitrate nitrogen constituent.
- 9) Ability to alter many of the constants utilized in the model.
- 10) Removal of the flag field to facilitate adding or deleting waste loads
- 11) Allowing computational element size to vary from reach to reach.
- 12) Removing the limit in the number of computational elements per reach.
- 13) Ability to handle highly dispersive systems as well as advective systems.
- 14) Changes to reaeration equations including the ability to specify the maximum allowable reaeration rates and use tidal velocities in reaeration equations and the addition of new reaeration equations.
- 15) Conversion of benthic rates and settling rates to more conventional units.
- 16) Allowing settled BOD, algae, and conservative materials to be converted to sediment oxygen demand.
- 17) Allowing settled organic nitrogen to be converted to ammonia benthos source rate.
- 18) Addition of denitrification and anaerobic BOD decay as processes.
- 19) Inclusion of photo-inhibition, self-shading, a preference factor for ammonia or nitrate nitrogen, and a new convergence technique in the algae simulation.
- 20) Allowing multiple waste loads to be input into a single computational element including headwater and junction elements.
- 21) Accommodation of flow reversals due to withdrawals in tidal areas.
- 22) Addition of lower boundary conditions for dispersive systems and systems with flow reversals at the lower boundary.

- 23) Ability to link several separate models together in sequence to simulate very large, very detailed, or bifurcated systems.
- 24) Restructuring of the program to make it compatible with DOS-based personal computers.

MODEL USE

LA-QUAL is a user-oriented model and is used by the Louisiana Department of Environmental Quality to provide the basis for evaluating total maximum daily loads in the State of Louisiana. It can also be used in the State of Texas with the approval of the Texas Department of Environmental Quality. The theoretical basis and program documentation for LA-QUAL is contained in a separate document. The source code was compiled with Intel® Visual Fortran Composer XE Version 2013 SP1 Update 3 (3.202). The current executable version of the model with the graphic interface can be downloaded free of charge from the Louisiana Department of Environmental Quality at the following URL: <http://deq.louisiana.gov/page/tmdl>

This user's manual is intended for use with the version of LA-QUAL indicated on the title page. The following are the minimum system requirements for execution of LA-QUAL:

- PC with an Intel® 486/66MHz (or 100% compatible) or higher processor.
- Microsoft® Windows® 95, Windows® 98, Windows® ME, Windows® XP, Windows® Vista, Windows® 7, Windows NT® Version 4 with Service Pack 3 (or later) operating system, or Windows® 10.
- A VGA monitor (1024x768 or greater resolution is required for complete viewing of on-screen graphics output)
- A mouse (or compatible pointing device)

The LA-QUAL model described in this manual must be used at the user's own risk. Neither the Louisiana Department of Environmental Quality, Wiland Consulting, Inc., nor the program authors can assume responsibility for model operation, output, interpretation, or usage.

The creators of this program have used their best efforts in preparing this code and to produce a program and user's manual that is free from errors. However, it is not absolutely guaranteed to be error-free. The author/programmer makes no warranties, expressed or implied, including without limitation warranties of merchantability or fitness for any particular purpose. No liability is accepted in any event for any damages, including accidental or consequential damages, loss of profits, costs of lost data or programming materials, or otherwise in connection with or arising out of the use of this program.

If errors are detected, help in identifying these would be appreciated. In addition, some computer systems have their own individual characteristics which could cause problems during execution. Help in identifying these problems would also be appreciated so that the LA-QUAL program can be executed on other computer systems with a minimal amount of effort. However, the Louisiana Department of Environmental Quality, Wiland Consulting, Inc., and the authors of this program are under no obligation to provide support, including but not limited to installation, maintenance, debugging, and improvements. Please contact:

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GETTING STARTED

INSTALLATION INSTRUCTIONS

Create a new directory and unzip everything into it using either the built-in unzipping capability of Windows, WinZip®, WinRAR, 7-Zip, or a similar utility. The zip file contains the executable file (.exe), the user's manual (.pdf), an example data input file (.in) with commented column headings, and three overlay files (.ovl). The example data input file is based on the example stream system shown in Appendix B of this manual. The contents of the example data input file is shown in Appendix C. To properly view the graphics output, Windows settings for the display area should be set to a resolution of at least 1024x768 for both screen and desktop.

Start the model by double clicking on the executable. You can also create a shortcut to the executable by right clicking on the executable and choosing "Create Shortcut". These shortcuts can then be dragged to your desktop or programs menu.

The model uses external programs to edit the input files and view the output files. The default programs that the model uses for editing input files and viewing plain-text output files are the Notepad and Wordpad utilities that should come pre-installed with Windows. The default program used for viewing rich-text files is Microsoft® Word which may or may not be installed on your computer. If you do not have Microsoft® Word, you can change the rich-text viewer in Preferences to Wordpad which will also read rich-text files. The default program used for viewing tab-delimited and comma-delimited files is Microsoft® Excel which may or may not be installed on your computer. In order for these external programs to work, the program directories must be in the system path. Normally, these directories are already in the system path. If this is not the case, either add them to the system path or provide the full path to the programs in Preferences.

GENERAL MODEL INFORMATION

All blank lines and all lines that begin with an exclamation point (!) in the input and overlay files will be ignored. Lines beginning with an exclamation point can be used for comments.

Tabs may not be used in input or overlay files.

The use of the term BOD1 refers to short-term BOD.

The use of the term BOD2 refers long-term BOD.

The transformation of nitrite to nitrate is assumed to happen so quickly as to make it unnecessary to model nitrite separately. References to nitrate nitrogen and NO₃-N include both the nitrite and nitrate forms.

The program generates messages when there are issues with the input data. These are classified into three categories:

ERRORS: These are fatal errors that must be corrected. The program will not run until these are corrected.

WARNINGS: There are issues that could cause the model to deliver unreliable or invalid results. However, the model does run and provide results even though they are potentially unreliable. It is recommended that the cause of these warnings be eliminated. By default, the model will pause to warn the user that these issues exist. The default action to pause can be suppressed in the Preferences but the warnings will still be delivered.

NOTICES: These are notifications of input data that is deprecated or no longer consistent with the current version of the model. However, the model will still run and provide reliable results in accordance with the notice.

The current version of the model is dimensioned for a maximum of 200 reaches, 100 headwaters, 300 waste loads, and 4000 elements.

The model can be run in a command line environment without invoking the GUI):

la-qual /b *(using /b as the argument will execute the model using the last file loaded in the GUI interface)*

la-qual inputfilename *(specifying the input filename as the argument will execute the model using that input file; if the filename has spaces , it needs to be enclosed in double quotes, e.g., "some file 2.inp")*

GRAPHICAL USER INTERFACE MENUS

The following give a brief explanation of choices allowed in menus and dialog boxes that appear within the application:

MAIN MENU

This is the menu that displays when the application is started (see Figure 1 in Appendix D). It contains the following menu items:

File	Open or closes the input file for the model.
Edit Input	Opens the model input file for editing using the editor program specified in Preferences
Edit Overlay	Opens an overlay file for editing using the editor program specified in Preferences.
Xqt Model	Executes the water quality simulation model using the opened input file.
View Output	Allows user to view one of nine different output files generated by execution of the model: 1) Primary Report (plain text), 2) Primary Report (rich text), 3) Sensitivity Table , 4) Solar Information, 5) Comma-Delimited Predicted Values, 6) Comma-Delimited Observed Values, 7) Performance Measures (detailed), 8) Performance Measures (summary), and 9) Tab-Delimited File
Preferences	Allows the user to select or deselect certain application options.
Help	Opens a separate window displaying this User's Manual in PDF format.
About	Gives the current model version and contact information for any questions or comments concerning the model.
Exit	Exits the application.

PREFERENCES DIALOG BOX

This is the dialog box that displays when the Preferences menu item is clicked (see Figure 2 in Appendix D). It contains the following settings:

Run Sensitivity	Checking this box causes sensitivity to be run based on the information provided in Data Type 29
Execution Mode	Chooses between steady-state and dynamic mode. Dynamic mode is a future enhancement not currently available in this version.
Additional Preferences	Click this button to make changes to additional preferences.
Dynamic Preferences	Click this button to make changes to dynamic preferences related to dynamic mode, a future enhancement not currently available in this version.
OK	Click this button to save changes and return to the main menu
Cancel	Click this button to ignore changes and return to the main menu
Output to Display After Model Execution	Checking this box causes output to be displayed following execution of the model. You can select from one of the following choices: 1) Graphical Plot, 2) Primary Report (plain text), 3) Primary Report (rich text), 4) Sensitivity Table, 5) Performance Measures (detailed), 6) Performance Measures (summary), 7) Tab-Delimited File, and 8) Nothing. Some of these choices may not be available depending on other settings.
Primary Report Options	<p>Checking any of the boxes in this group results in generation of the primary output report. There are ten types of reports available and more than one can be requested:</p> <ol style="list-style-type: none"> 1) Data Input – echoes the input data 2) Stream Configuration Summary – summarizes the stream configuration 3) Intermediate Report – legacy report for various values by stream, reach, and element 4) Capsule Report – summary for each stream showing certain key values by reach and element 5) Final Report – the most detailed report showing almost every value 6) Reach Summary Report – provides minimum, maximum, and average values for each reach 7) Stream Summary Report – provides minimum, maximum, and average values for each stream 8) Loading Report – performs a mass balance of the model showing sinks and sources 9) Min-Max Report – summarizes minimum and maximum values of certain constituents by stream 10) Special Reports – reports developed for special purposes: <ol style="list-style-type: none"> 1 = a legacy report showing water quality constituent values by stream and element 2 = reserved 3 = reserved
Create Tab-Delimited File	<p>Checking this box will allow the creation of a tab-delimited file that can be displayed as a spreadsheet. The program used to display this file is specified in Additional Preferences. Various options are available to produce different information:</p> <ol style="list-style-type: none"> 1 = provide certain hydraulic & constituent information for reaches, headwaters, wasteloads, elements 2 = provide certain information for reaches
Graphical Plot Options	Checking any of the boxes in this group determines what will be shown on the graphical plot and how it will be displayed (e.g., colors, fonts, font size, position). There is also an option to control the upper limit of the y-axis for various constituents. The minimum upper plot limit will be the concentration specified here unless a predicted or observed concentration is higher than this limit, in which case, the limit will be automatically increased to allow plotting of the predicted or observed concentration.
Generate Comma-delimited File and Performance Measures	Checking this box generates a comma-delimited file of predicted values based on three options: 1) all elements, 2) selected elements, or 3) elements with observed data. The values can be ordered by stream number or by element number. If the “selected elements” option is chosen, click on “Edit” to create or edit a file which gives the element numbers to be output (one element number per line). If the “Elements with Observed Data” option is selected, a comma-delimited file of observed values from the overlay files will also be produced and performance measures will be calculated. With this option, you can also choose which observed data groups (up to 3) to include and whether to exclude marked outliers. See the Performance Measures section in this manual for more information.

ADDITIONAL PREFERENCES DIALOG BOX

This is the dialog box that displays when the Additional Preferences button is clicked in the Preferences dialog box (see Figure 3 in Appendix D). It contains the following settings:

Model Assumptions	Selects the regulatory agency model assumption defaults for certain constants. Select either Texas (TCEQ) or Louisiana (LaDEQ). <i>NOTE: This preference is very important.</i> Simulation results can vary significantly depending on which one you choose. The constants affected by this are the program constants for hydraulic calculation method, reaeration K_L minimum, and nonconservative material oxygen uptake rate and the temperature correction constants for sediment oxygen demand, organic nitrogen hydrolysis, ammonia nitrogen source rate, phosphorus source rate, and nonconservative material decay rate.
Suppress Popup Warning Message	Checking this box suppresses the pop-up warning messages. It is recommended that you avoid suppressing the warnings.
Save Plot Files	Checking this box saves the binary plot files used to generate the plots. These files may be used in another application to generate plots if that application can read the files.
Extension Default for Input Files	Specifies the extension default for input files. The choices are .IN/.INP, .DAT, .TXT, or All Extensions.
Extension Default for Overlay Files	Specifies the extension default for overlay files. The choices are .OVL, .TXT, or All Extensions.
Input File Editor	Specifies the application to be used as the input file editor. The default is “notepad” which is typically bundled with Windows. If another application is used, the application must include the full path if not in system path.
Plain Text Viewer	Specifies the application to be used as the plain text viewer. The default is “wordpad” which is typically bundled with Windows. If another application is used, the application must include the full path if not in system path.
Rich Text Viewer	Specifies the application to be used as the rich text viewer. The default is “winword” which is the program name for Windows Word, but Word must be installed on the user’s computer for it to work. If another application is used, the application must include the full path if not in system path.
CSV Viewer	Specifies the application to be used as the viewer for comma-delimited files (i.e, comma separated values). The default is “excel” which is the program name for Windows Excel, but Excel must be installed on the user’s computer for it to work. If another application is used, the application must include the full path if not in system path.
Plot Capture Filename	Specifies the plot capture filename (default is “image.bmp”).
Initial Constituent When Plots First Display	Specifies the constituent to initially show when the graphical plot displays.
Initial Plot When Plots First Display	Specifies which plot number to initially show when the graphical plot displays.
Constituents to Include in Performance Measures	Checking the boxes specifies those constituents to be included in the performance measures.
OK	Click this button to save changes and return to the main Preferences dialog box.
Cancel	Click this button to ignore changes and return to the main Preferences dialog box.

GRAPHICAL PLOT MENU

This is the menu in the graphical plot window that displays after Xqt Model is clicked and if Graphical Plot has been selected to display in Preferences (see Figure 4 in Appendix D). It contains the following buttons:

Exit	Clicking this button exits the graphical plot window and returns to the main window.
Print	Clicking this button allows the graphical plot to be printed. It brings up the standard Print Setup window where the printer can be selected. For best results, select Landscape orientation. If a PDF printer driver is installed, you can also print to PDF.
Capture	Clicking this button captures the graphics display window as a bitmap and stores it in the file “image.bmp” (default filename) for use in other programs such as word processors. The default filename can be changed in Additional Preferences.
Constituents & Coefficients	Clicking any one of these 39 buttons displays a graph of that constituent or coefficient for whichever plot is currently active.
Plot	Clicking any one of these 21 buttons changes the active plot currently being displayed (each plot is described by Data Type 30 in the input file). The buttons will be labeled with the Plot Abbreviation if it has been specified. Otherwise, the button will be labeled with the plot number.
Sensitivity	When sensitivity has been requested in Preferences, the buttons <S (first sensitivity), -S (previous sensitivity), +S (next sensitivity), and S> (last sensitivity) will cycle up and down through the specified sensitivity parameters described by Data Type 29 in the input file. These buttons will be grayed-out if sensitivity has not been requested in Preferences.
Time Step	The grayed-out buttons >>, <T, -T, +T, and T> are reserved for a future dynamic version of the model.

DATA TYPE 1 - TITLES AND CONTROL DATA

These data set the titles and certain program control information .

The first two lines are for titles and are required. The title information is placed in Columns 14-68 (A55) and may be used to describe the model run with descriptors such as stream conditions, alternatives, etc.

The remaining lines contain certain control information. If the action is desired, a “YES” should be placed in Columns 10-12 (A3). If the action is not desired, a “NO” should be placed in Columns 11-12 (A2). Each control line is distinguished by a eight-character code (shown underlined) in columns 14-21 (A8). Inclusion of these control lines are not required, but if a control line is not present, the default action will be taken. These lines may be input in any order.

METRIC UNITS

Default = YES

This line indicates whether the stream distances, flows, velocities, depths, dispersion rates, settling rates, and source rates are to be input using metric units or English units. If set to “YES”, units are metric. If set to “NO”, units are English. In some instances (e.g., some Data Type 3 constants), only metric units are allowed regardless of this setting and are so indicated.

USE EFFECTIVE CONCENTRATIONS

Default = YES

This line indicates whether the model will make use of “Effective Concentrations” for BOD, organic nitrogen, and organic phosphorus. It can also apply to the non-conservative material (NCM). The Effective Concentrations are intended to account for the interferences that phytoplankton create in the laboratory results of stream water quality samples that are used for calibrating the model. Typically, one uses unfiltered samples in calibrating a model because some of the constituents (e.g., BOD, organic nitrogen, and organic phosphorus) may not be in dissolved form but are nevertheless subject to decay or hydrolysis and are important in the kinetics of the model. Unfortunately, if phytoplankton are present in these samples, the BOD, organic nitrogen, and organic phosphorus contained in the living phytoplankton will also be measured even though they are not actually contributing to the the BOD, organic nitrogen, and organic phosphorus predicted by the model.

When Effective Concentrations are utilized, BOD, organic nitrogen, and organic phosphorus are adjusted based on phytoplankton concentrations (as chlorophyll *a*) and the program constants provided in Data Type 3. On input, adjustments to headwater and lower boundary condition concentrations are made by subtracting a portion of the BOD, organic nitrogen, and organic phosphorus in the headwaters and lower boundary. On output, the reverse adjustment is made by adding additional BOD, organic nitrogen, and organic phosphorus to each element concentration in proportion to the concentration of chlorophyll *a*. These adjustments can also be made to the NCM if the default constant provided in Data Type 3 for NCM is changed from the default value of zero.

USE EVAPORATION

Default = YES

This line indicates whether the model will make use of evaporation in the hydraulic calculations. Evaporation rates are set in Data Type 9 (Advective Hydraulic Coefficients).

LA DEFAULTS

Default = NO

Sets the regulatory agency model assumption defaults to Louisiana (LaDEQ) and overrides the state chosen in program preferences. This is useful if you want to ensure that the state defaults used during execution of a model run will be the same if the input file is transferred to another computer where the program preferences are not the same. If set to “NO”, the program preferences will be used.

TX DEFAULTS

Default = NO

Sets the regulatory agency model assumption defaults to Texas (TCEQ) and overrides the state chosen in program preferences. This is useful if you want to ensure that the state defaults used during execution of a model run will be the same if the input file is transferred to another computer where the program preferences are not the same. If set to “NO”, the program preferences will be used.

The following lines are legacy controls from earlier versions and have been replaced by checkboxes in “Preferences” on the Windows menu. They are no longer required and will be ignored if present.

ECHO DATA INPUT
INTERMEDIATE SUMMARY
CAPSULE SUMMARY
FINAL REPORT
LOADING SUMMARY
SPECIAL REPORT
GRAPHICS CAPABILITY
SENSITIVITY ANALYSIS

The following lines are legacy controls from earlier versions and their functionality has been replaced by functionality elsewhere or completely eliminated. They are no longer valid and will be ignored if present.

FLOW AUGMENTATION (eliminated)
OVERLAY PLOT (replaced)
LINE PRINTER PLOTS (eliminated)
SEQUENCING OUTPUT (replaced)
OXYGEN DEPENDENT RATES (replaced)

IMPORTANT: The last line of this group must read “ENDATA01”, left justified.

DATA TYPE 2 – MODEL OPTIONS

These lines determine which constituents are to be simulated. They are required only if the constituents are being modeled, but it is recommended that they all be included (except the Nitrogen Series and NBOD cannot both be present at the same time). If the constituent is to be simulated, “YES” should be placed in Columns 10-12 (A3). If the constituent is not to be simulated, a “NO” should be placed in Columns 11-12 (A2). If the line is not included, NO” is the default action. Each line is distinguished by a eight-character code (shown underlined) in Columns 14-21 (A8):

TEMPERATURE

Temperature is used in calculating dissolved oxygen saturation concentrations and reaction rates. If temperature is not simulated, it must be specified in the Initial Conditions (Data Type 11). Temperature units are in °C only, even if English units are specified in Data Type 1.

SALINITY

Salinity is used in calculating dissolved oxygen saturation concentrations. If salinity is not being simulated, it must be specified in the Initial Conditions (Data Type 11). Salinity units are in ppt.

CM1 CONSERVATIVE MATERIAL **or** CONSERVATIVE MATERIAL #1 *(the latter is deprecated)*

Any conservative constituent may be simulated (chlorides, TDS, sulfates, conductivity, etc.). The constituent name should be specified in Columns 41-66 (A26) and the units should be specified in Columns 71-78 (A8). A short name, if specified in Columns 80-87 (A8), will be displayed in certain column headings in the output and in the graphical display menu push-buttons (rather than CM-1). Units are arbitrary and user-defined.

CM2 CONSERVATIVE MATERIAL **or** CONSERVATIVE MATERIAL #2 *(the latter is deprecated)*

Any conservative constituent may be simulated (chlorides, TDS, sulfates, conductivity, etc.). The constituent name should be specified in Columns 41-66 (A26) and the units should be specified in Columns 71-78 (A8). A short name, if specified in Columns 80-87 (A8), will be displayed in certain column headings in the output and in the graphical display menu push-buttons (rather than CM-2). Units are arbitrary and user-defined.

DISSOLVED OXYGEN

Dissolved oxygen units are in mg/L.

BOD1 BIOCHEMICAL OXYGEN DEMAND **or** BIOCHEMICAL OXYGEN DEMAND *(the latter is deprecated)*

BOD1 as used in this model refers to short-term BOD. Short-term biochemical oxygen demand may be simulated as either BOD5 or BODu. The BOD1 oxygen uptake rate specified in the Program Constants (Data Type 3) determines whether BOD5 or BODu is being utilized (the default is BODu). BOD1 units are in mg/L.

BOD2 BIOCHEMICAL OXYGEN DEMAND

BOD2 as used in this model refers to long-term BOD. Long-term biochemical oxygen demand may be simulated as either BOD5 or BODu. The BOD2 oxygen uptake rate specified in the Program Constants (Data Type 3) determines whether BOD5 or BODu is being utilized (the default is BODu). BOD1 units are in mg/L.

NITROGEN SERIES

Simulation of the nitrogen series will result in organic nitrogen, ammonia nitrogen, and nitrate nitrogen being simulated. If the nitrogen series option is included, the NBOD option cannot be used or included. Nitrogen series units are in mg/L as N.

NBOD_____ **or** NBOD OXY *(NBOD OXY is deprecated)*

Simulation of NBOD will result in nitrogenous BOD being simulated. If the NBOD option is included, the nitrogen series option cannot be used or included. When NBOD is used, it is entered in the same columns as organic nitrogen in subsequent Data Types, and the ammonia nitrogen and nitrate nitrogen columns are ignored. NBOD units are in mg/L as N.

PHOSPHORUS SERIES

Simulation of the phosphorus series will result in organic phosphorus and inorganic phosphorus being simulated. Phosphorus series units are in mg/L as P.

PHYTOPLANKTON or CHLOROPHYLL A (*CHLOROPHYLL A is deprecated*)

The constituent “phytoplankton” as used in this model refers only to floating algae. If phytoplankton are not simulated, they may be specified in the Initial Conditions (Data Type 11) to account for net productivity in the oxygen balance, net loss of nitrogen and phosphorus, and to adjust for effective concentrations of BOD, organic nitrogen, and organic phosphorus. Phytoplankton units are in µg/L as chlorophyll a.

PERIPHYTON or MACROPHYTES (*MACROPHYTES is deprecated*)

The constituent “periphyton” as used in this model refers to attached algae. If periphyton are not simulated, they may be specified in the Initial Conditions (Data Type 11) to account for net productivity in the oxygen balance and net loss of nitrogen and phosphorus. Periphyton units are in grams of biomass per square meter of bottom surface.

COLIFORM

Coliform units are in #/100 mL.

NONCONSERVATIVE MATERIAL

Any nonconservative constituent may be modeled. The constituent name should be specified in Columns 41-66 (A26) and the units should be specified in Columns 71-78 (A8). A short name, if specified in Columns 80-87, will be displayed in certain column headings in the output and in the graphical display menu push-buttons (rather than NCM). Units are arbitrary and user-defined.

IMPORTANT: The last line of this group must read “ENDATA02”, left justified.

DATA TYPE 3 – PROGRAM CONSTANTS

These data set certain program constants and are optional. Only those lines for which a change in the default value is desired need to be input. They are not required in any specific order. Only the specified units are allowed, regardless of whether the Metric or English units option has been selected. Columns 47-56 (F10.0) contain the new value that will override the default value. Each line is distinguished by a eight-letter character code (shown underlined) in Columns 10-17 (A8) and are described as follows:

HYDRAULIC CALCULATION METHOD

Default = 2 (Louisiana)

Default = 1 (Texas)

This line gives the method of hydraulic calculations in Data Type 9. Although Method 1 is the default, Method 2 is the preferred method. Method 1 is set as the default for backward compatibility with previous data sets .

1: Velocities and Depths

2: Widths and Depths

SETTLING RATE UNITS

Default = 1.

This line specifies the type of units to be used when settling rates are input.

1: If inputting a settling velocity (m/day or ft/day)

2: If inputting a settling rate (1/day)

KL MINIMUM

Default = 0.7 (Louisiana)

Default = 0.6 (Texas)

This line gives the K_L (meters/day only) used to calculate the minimum reaeration rate.

K2 MAXIMUM

Default = 10.0

This line gives the maximum K_2 at 20°C (1/day) allowed for any computational element. Sensitivity and temperature adjustments are applied to the maximum rate if it is used. Individual reaches with constant reaeration rates (Reaeration Option 1, Data Type 12) are not limited by the maximum K_2 value.

SENSITIVITY PARAMETERS PER SET

Default = 1

This line indicates how the sensitivity parameters are to be grouped. If only one sensitivity parameter is to be evaluated at a time, input the value "1"; if two parameter values are to be evaluated at a time, input the value "2"; etc.

Tidal Constants

DISPERSION EQUATION

Default = 1

This line controls the form of the tidal dispersion equation.

1: $E = a$

2: $E = aD^bQ^cV_T^d$

3: $E = aD^bQ^cV_M^d$

9: $E = 0$ (sets all dispersion to zero)

OCEAN EXCHANGE RATIO

Default = 1.0

This line gives the percentage of dispersive/tidal exchange between the lower boundary and the stream as a decimal amount. Values range from 0.0 to 1.0.

TIDE HEIGHT

Default = 0.0

This line gives the tidal amplitude (meters only) at the lower boundary. It is used for calculating tidal velocities.

TIDAL PERIOD

Default = 25.0

This line gives the tidal period (hours) which is used for calculating tidal velocities. This value is used only when tide height is greater than zero and must be greater than zero when it is used.

PERIOD OF TIDAL RISE

Default = 12.5

This line gives the period (hours) of the rising tide. It is used for calculating tidal velocities. This value is used only when tide height is greater than zero and must be greater than zero when it is used.

Meteorological Constants

BAROMETRIC PRESSURE

Default = 1013.25

This line gives the barometric pressure (millibars only). Barometric pressure is used in the temperature simulation and in calculating dissolved oxygen saturation concentrations.

WIND VELOCITY or WIND (*WIND is deprecated*)

Default = 0.0

This line gives the wind velocity (meters/second only). It is used in temperature simulations and some reaeration calculations.

Iteration Constants

MAXIMUM ITERATION LIMIT

Default = 3000

This line gives the maximum iteration limit used in the iterative convergence techniques for simulating temperature, oxygen dependent rates, phytoplankton, and periphyton. If the model fails to converge, the iteration limit may need to be increased.

O ERROR CLOSURE LIMITS

Default = 0.005

This line gives the relative error allowed for convergence of oxygen dependent rates in the iterative solution technique. The smaller the number, the more accurate the answer. Avoid increasing this value unless convergence is a problem.

P ERROR CLOSURE LIMITS

Default = 0.005

This line gives the relative error allowed for convergence of photosynthetic rates in the iterative solution technique. The smaller the number, the more accurate the answer. Avoid increasing this value unless convergence is a problem.

T ERROR CLOSURE LIMIT

Default = 0.05

This line gives the relative error allowed for convergence of temperature in the iterative solution technique. The smaller the number, the more accurate the answer. Avoid increasing this value unless convergence is a problem.

O RELAXATION COEFFICIENT

Default = 0.5

This line gives the relaxation coefficient used in the iterative convergence techniques for simulating oxygen dependent rates. If the model fails to converge, the relaxation coefficient may need to be decreased.

P RELAXATION COEFFICIENT

Default = 0.5

This line gives the relaxation coefficient used in the iterative convergence techniques for simulating photosynthetic rates. If the model fails to converge, the relaxation coefficient may need to be decreased.

O ITERATIONS PER CYCLE

Default = 0

This line gives the number of iterations oxygen dependent rates that take place before the relaxation coefficient is reduced incrementally. If the value is 0, the number of iterations is computed automatically.

P ITERATIONS PER CYCLE

Default = 0

This line gives the number of iterations for photosynthetic rates that take place before the relaxation coefficient is reduced incrementally. If the value is 0, the number of iterations is computed automatically.

Inhibition Constants

INHIBITION CONTROL VALUE

Default = 4

This line controls which biological rates (NH₃-N decay, NBOD decay, aerobic BOD decay, anaerobic BOD decay, denitrification, sediment oxygen demand, and non-conservative material decay) are to be dependent upon dissolved oxygen concentrations.

- 0: No rates are oxygen dependent
- 1: Nitrification rates only (NH₃-N decay or NBOD decay)
- 2: Aerobic BOD decay, anaerobic BOD decay and denitrification rates only
- 3: All rates but sediment oxygen demand
- 4: All rates

FORMS OF INHIBITION EQUATIONS (Default depends on the type of inhibition; see subsequent Program Constants)

These are the forms of equations for calculating oxygen inhibition.

- 0: No inhibition
- 1: Two-step inhibition (fraction of maximum rate)
 - = 1.0 if DO \geq 7.8
 - = $1.2 \times \text{DO} / (1.56 + \text{DO})$ if DO < 7.8
- 2: Three-step inhibition (fraction of maximum rate)
 - = 1.0 if DO \geq 7.8
 - = $1.2 \times \text{DO} / (1.56 + \text{DO})$ if DO < 7.8 and DO \geq 2.0
 - = $0.05 \times \text{DO}^{3.81}$ if DO < 2.0
- 3: Straight-line inhibition (fraction of maximum rate)
 - = 1.0 if DO \geq oxygen inhibition threshold
 - = DO / oxygen inhibition threshold if DO < oxygen inhibition threshold
- 4: Reverse straight-line inhibition (fraction of maximum rate)
 - = 1.0 if DO \geq oxygen inhibition threshold
 - = $1 - \text{DO} / \text{oxygen inhibition threshold}$ if DO < oxygen inhibition threshold

N INHIBITION EQUATION

Default = 2

This line controls the form of the NH₃-N decay or NBOD decay (nitrification) inhibition equation as shown in "Forms of Inhibition Equations." Default is three-step inhibition.

B1 INHIBITION EQUATION

Default = 3

This line controls the form of the short-term BOD decay inhibition equation as shown in "Forms of Inhibition Equations." Default is straight-line inhibition.

B2 INHIBITION EQUATION

Default = 3

This line controls the form of the long-term BOD decay inhibition equation as shown in “Forms of Inhibition Equations.” Default is straight-line inhibition.

S INHIBITION EQUATION

Default = 3

This line controls the form of the SOD inhibition equation as shown in “Forms of Inhibition Equations.” Default is straight-line inhibition.

NC INHIBITION EQUATION

Default = 3

This line controls the form of the non-conservative material inhibition equation as shown in “Forms of Inhibition Equations.” Default is straight-line inhibition.

D INHIBITION EQUATION

Default = 4

This line controls the form of the denitrification inhibition equation as shown in “Forms of Inhibition Equations.” Default is reverse straight-line inhibition.

A INHIBITION EQUATION

Default = 4

This line controls the form of the anaerobic BOD decay inhibition equation as shown in “Forms of Inhibition Equations.” Both BOD#1 and BOD#2 anaerobic decay are controlled by the same equation. Default is reverse straight-line inhibition.

N OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the nitrification (NH₃ to NO₃) or NBOD decay rate when an equation that is a function of an oxygen threshold (such as straight-line inhibition) is selected.

B1 OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the short-term BOD rates when an equation that is a function of an oxygen threshold (such as straight-line inhibition) is selected.

B2 OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the long-term BOD rates when an equation that is a function of an oxygen threshold (such as straight-line inhibition) is selected.

S OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the SOD rates when an equation that is a function of an oxygen threshold (such as straight-line inhibition) is selected.

A OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the anaerobic BOD rates when an equation that is a function of an oxygen threshold (such as reverse straight-line inhibition) is selected.

NC OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the non-conservative material rates when an equation that is a function of an oxygen threshold (such as straight-line inhibition) is selected.

D OXYGEN DEPENDENCE THRESHOLD

Default = 2.0

This line controls the threshold oxygen concentration (in mg/L) for the denitrification rates when an equation that is a function of an oxygen threshold (such as reverse straight-line inhibition) is selected.

Oxygen Uptake Constants

SOD MAXIMUM RATE or BENTHAL MAXIMUM RATE (*the latter is deprecated*) Default = 10.0

This line gives the maximum sediment oxygen demand allowable (gm/m²-day only) regardless of the quantity of oxygen demanding materials settled.

BOD1 OXYGEN UPTAKE RATE Default = 1.0

This line gives the oxygen uptake rate per unit of carbonaceous BOD#1 oxidized (mg O/mg BOD). When inputting ultimate BOD, the values should be 1.0. When inputting BOD5, a typical value is 2.3. (Note: BOD is a legacy code for this parameter and will still work.)

BOD2 OXYGEN UPTAKE RATE Default = 1.0

This line gives the oxygen uptake rate per unit of carbonaceous BOD#2 oxidized (mg O/mg BOD). When inputting ultimate BOD, the values should be 1.0. When inputting BOD5, a typical value is 2.3.

ORGN OXYGEN UPTAKE RATE Default = 0.0

This line gives the oxygen uptake rate per unit of organic nitrogen decayed (mg O/mg N). It is used in the dissolved oxygen simulation. The default assumes the reaction is by hydrolysis and consumes no oxygen.

NH3 OXYGEN UPTAKE RATE Default = 4.33

This line gives the oxygen uptake rate per unit of ammonia oxidized (mg O/mg N). It is used in the dissolved oxygen simulation.

NBOD OXYGEN UPTAKE RATE Default = 1.0

This line gives the oxygen uptake rate per unit of nitrogenous BOD oxidized (mg O/mg NBOD). It is used in the dissolved oxygen simulation.

NCM OXYGEN UPTAKE RATE Default = 1.0 (Louisiana)
Default = 0.0 (Texas)

This line gives the oxygen uptake rate per unit of nonconservative material decayed (mg O/unit nonconservative material). It is used in the dissolved oxygen simulation. The default assumes that the NCM decay does not consume oxygen.

CARBON OXYGEN UPTAKE RATE Default = 2.67

This line gives the oxygen uptake rate per unit of carbon oxidized (mg O/mg C) .

NITRATE UPTAKE RATE Default = 0.66

This line gives the nitrate uptake rate per unit of ultimate BOD oxidized (mg N/mg BOD) under anaerobic conditions.

Algae-Related Constants

EFF BOD1 DUE TO PHYTOPLANKTON or EFFECTIVE BOD (*EFFECTIV is deprecated*) Default = auto

This line gives the short-term BOD due to phytoplankton (mg/L BOD / μ g/L chlorophyll a) when the user wishes to override the automatic calculation. It is used in calculating the effective short-term BOD concentration as a result of algal interference. The default action when this line is not included is to make an automatic calculation of the appropriate value using the carbon content of phytoplankton (Data

Type 6), the carbon oxygen uptake rate (Data Type 3), and the chlorophyll a to phytoplankton ratio (Data Type 14) in accordance with the following formula:

$$\frac{\text{Carbon Oxygen Uptake Rate}}{\text{BOD1 Oxygen Uptake Rate}} \times \frac{\text{Carbon Content of Phytoplankton}}{1000 \times \text{Chl a:Phytoplankton Ratio}} \times \text{BOD1/BOD2 Split}$$

Including this line will override the automatic calculation. A value of 0.10 to 0.25 (based on ultimate BOD) is suggested when this factor is utilized.

EFF BOD2 DUE TO PHYTOPLANKTON

Default = auto

This line gives the long-term BOD due to phytoplankton (mg/L BOD / µg/L chlorophyll a) when the user wishes to override the automatic calculation. It is used in calculating the effective long-term BOD concentration as a result of algal interference. The default action when this line is not included is to make an automatic calculation of the appropriate value using the carbon content of phytoplankton (Data Type 6), the carbon oxygen uptake rate (Data Type 3), and the chlorophyll a to phytoplankton ratio (Data Type 14) in accordance with the following formula:

$$\frac{\text{Carbon Oxygen Uptake Rate}}{\text{BOD2 Oxygen Uptake Rate}} \times \frac{\text{Carbon Content of Phytoplankton}}{1000 \times \text{Chl a:Phytoplankton Ratio}} \times (1 - \text{BOD1/BOD2 Split})$$

Including this line will override the automatic calculation. A value of 0.10 to 0.25 (based on ultimate BOD) is suggested when this factor is utilized.

EFF ORGN DUE TO PHYTOPLANKTON

Default = auto

This line gives the organic nitrogen due to phytoplankton (mg/L N / µg/L chlorophyll a) when the user wishes to override the automatic calculation. It is used in calculating the effective organic nitrogen concentration as a result of algal interference. The default action when this line is not included is to make an automatic calculation of the appropriate value using the nitrogen content of phytoplankton (Data Type 6) and the chlorophyll a to phytoplankton ratio (Data Type 14)) in accordance with the following formula:

$$\frac{\text{Nitrogen Content of Phytoplankton}}{1000 \times \text{Chl a:Phytoplankton Ratio}}$$

The automatic calculation will produce a value of 0.0085 if Data Type 6 and Data Type 14 defaults are used. Including this line will override the automatic calculation.

EFF ORGP DUE TO PHYTOPLANKTON

Default = auto

This line gives the organic phosphorus due to phytoplankton (mg/L P / µg/L chlorophyll a) when the user wishes to override the automatic calculation. It is used in calculating the effective organic phosphorus concentration as a result of algal interference. The default action when this line is not included is to make an automatic calculation of the appropriate value using the phosphorus content of phytoplankton (Data Type 6) and the chlorophyll a to phytoplankton ratio (Data Type 14)) in accordance with the following formula:

$$\frac{\text{Phosphorus Content of Phytoplankton}}{1000 \times \text{Chl a:Phytoplankton Ratio}}$$

The automatic calculation will produce a value of 0.0013 if Data Type 6 and Data Type 14 defaults are used. Including this line will override the automatic calculation.

EFF NCM DUE TO PHYTOPLANKTON

Default = 0.0

This line gives the nonconservative material due to phytoplankton (conc NCM / µg/L chlorophyll a). It is used in calculating the effective nonconservative material concentration as a result of algal interference.

The default action is for phytoplankton to have no effect on the nonconservative material. Including this line will override the “no effect” default action. The value is dependent on the type of nonconservative being modeled.

PHOTO PERIOD

Default = 14

This line gives the photoperiod (hours) for algae simulations. It is used when temperature is not being simulated.

TOTAL DAILY RADIATION

Default = 500.0

This line gives the total daily radiation (langleys) for algae simulations. It is used when temperature is not being simulated.

SECCHI DISC CONSTANT

Default = 1.7

This line gives the constant used in relating secchi disk depth to the extinction coefficient (Extinction Coefficient = Constant/Secchi Disc Depth). The constant itself is unitless. The default value of 1.7 was intended for use with secchi depths measured in meters. The units of the extinction coefficient (which are calculated internally) are 1/m or 1/ft depending on whether metric or english is selected. Since field measurements generally consisted of measurement of the secchi depth rather than direct measurement of the extinction, the model was changed to accept the secchi depth directly. This meant extinction coefficients did not have to be calculated by hand before being input to the model. This change necessitated the addition of the secchi disk constant to allow calculation of the extinction coefficient internally in the model.

PHYTOPLANKTON OXYGEN PROD

Default = 0.05

This line gives the net oxygen production per unit of phytoplankton chlorophyll a (mg O/ug chlorophyll a/day). It is used in the dissolved oxygen simulation when phytoplankton are not being simulated but are specified in the Initial Conditions (Data Type 11).

N PHYTOPLANKTON UPTAKE

Default = 0.0025

This line gives the net nitrogen uptake per unit of phytoplankton chlorophyll a (mg N/ug chlorophyll a/day). It is used in the dissolved oxygen simulation when phytoplankton are not being simulated but are specified in the Initial Conditions (Data Type 11).

P PHYTOPLANKTON UPTAKE

Default = 0.0002

This line gives the net phosphorus uptake per unit of phytoplankton chlorophyll a (mg P/ug chlorophyll a/day). It is used in the dissolved oxygen simulation when phytoplankton are not being simulated but are specified in the Initial Conditions (Data Type 11).

PERIPHYTON OXYGEN PROD

Default = 0.05

This line gives the net oxygen production per unit of periphyton (mg O/mg biomass/day). It is used in the dissolved oxygen simulation when periphyton are not being simulated but are specified in the Initial Conditions (Data Type 11).

N PERIPHYTON UPTAKE

Default = 0.0025

This line gives the net nitrogen uptake per unit of periphyton (mg N/mg biomass/day). It is used in the nitrogen simulation when periphyton are not being simulated but are specified in the Initial Conditions (Data Type 11).

P PERIPHYTON UPTAKE

Default = 0.0002

This line gives the net phosphorus uptake per unit of periphyton (mg P/mg biomass/day). It is used in the phosphorus simulation when periphyton are not being simulated but are specified in the Initial Conditions (Data Type 11).

This line determines the nitrogen preference of phytoplankton and periphyton when they are not being simulated but are specified in the Initial Conditions (Data Type 11). A value of 1.00 indicates a total preference for nitrate nitrogen; a value of 0.00 indicates a total preference for ammonia nitrogen; values between 1.00 and 0.00 indicate intermediate preferences. If phytoplankton and periphyton are being simulated, the nitrogen preference is determined by the preferences set in Data Type 6 (phytoplankton) and Data Type 7 (periphyton) and this program constant is not used.

Sequencing Control

LOGICAL UNIT NUMBER FOR SEQUENCING

Default = 0

This line gives the logical unit number of the file on which the constituent values in the last element can be stored. Only file numbers greater than 31 are allowable. The stored values can be used as headwater conditions in conjunction with a subsequent model when sequenced with this model.

SECOND UNIT NUMBER FOR SEQUENCING

Default = 0

The line functions identically to the preceding line and is utilized when a bifurcation occurs and a second logical unit number is required. The flow split is specified on the following line.

FLOW SPLIT FOR PRIMARY UNIT

Default = 100.0

This line gives the percent flow split to the primary logical unit used for sequencing and is utilized only when the secondary logical unit (see preceding line) is used.

The following lines are legacy controls from Versions 4.0 and earlier and have been replaced by checkboxes in "Preferences" on the Windows menu. They are no longer required and will be ignored if present.

PLOT TYPEINTERMEDIATE REPORT TYPEFINAL REPORT TYPESPECIAL REPORT TYPE

The following lines are legacy controls from Versions 5.0 and earlier and their functionality has been replaced. They are no longer valid and will result in an error message if present.

OXYGEN DEPENDENCE THRESHOLD (*superceded by individual thresholds*)

IMPORTANT: The last line of this group must read "ENDATA03", left justified, even if no default values are changed.

DATA TYPE 4 – TEMPERATURE CORRECTION CONSTANTS

These data set the empirical constant θ used for the temperature corrections to rate coefficients [$K_T = K_{20} \theta^{(T-20)}$] and are optional. Only those lines for which a change in the default value is desired need to be input. They are not required in any specific order. Each line is distinguished by an eight-character code word in Columns 10-17 (A8). Columns 19-26 (F8.0) contain the new value that will override the default value. The affected rate coefficient, default value, and eight-character code for each temperature correction constant is shown as follows:

Affected Rate Coefficient Number	Default Value (Louisiana)	Default Value (Texas)	Code Word	Code
Ammonia Nitrogen Decay Rate (nitrification)	1.083	1.083	NH3 DECA	5
Background Sediment Ammonia Nitrogen Source Rate	1.065	1.074	NH3 SRCE	6
Background Sediment Inorganic Phosphorus Source Rate	1.065	1.074	PO4 SRCE	8
Background Sediment Oxygen Demand	1.065	1.074	SOD	3
BOD1 Aerobic Decay Rate	1.047	1.047	BOD1 DEC	1
BOD1 Anaerobic Decay Rate	1.047	1.047	BOD1 ANA	19
BOD1 Settling Rate	1.024	1.024	BOD1 SET	2
BOD2 Aerobic Decay Rate	1.047	1.047	BOD2 DEC	22
BOD2 Anaerobic Decay Rate	1.047	1.047	BOD2 ANA	24
BOD2 Hydrolysis Rate	1.020	1.020	BOD2 HYD	31
BOD2 Settling Rate	1.024	1.024	BOD2 SET	23
Coliform Die-off Rate	1.047	1.047	COLI DIE	9
Denitrification Rate	1.047	1.047	DENITRIF	20
NBOD Decay Rate	1.070	1.070	NBOD DEC	25
NBOD Settling Rate	1.024	1.024	NBOD SET	26
Non-Conservative Material Decay Rate	1.070	1.000	NCM DECA	10
Non-Conservative Material Settling Rate	1.024	1.024	NCM SETT	7
Organic Nitrogen Hydrolysis Rate	1.020	1.047	ORGN HYD	4
Organic Nitrogen Settling Rate	1.024	1.024	ORGN SET	16
Organic Phosphorus Hydrolysis Rate	1.020	1.020	ORGP HYD	29
Organic Phosphorus Settling Rate	1.024	1.024	ORGP SET	30
Periphyton Death Rate	1.047	1.047	PERIP DE	28
Periphyton Growth Rate	1.047	1.047	PERIP GR	12
Periphyton Production Rate	1.047	1.047	PERIP PR	18
Periphyton Respiration Rate	1.047	1.047	PERIP RE	15
Phytoplankton Death Rate	1.047	1.047	PHYTO DE	27
Phytoplankton Growth	1.047	1.047	PHYTO GR	11
Phytoplankton Production Rate	1.047	1.047	PHYTO PR	17
Phytoplankton Respiration Rate	1.047	1.047	PHYTO RE	14
Phytoplankton Settling Rate	1.024	1.047	PHYTO SE	13
Reaeration Rate	0.000*	0.000*	REAERATI	21

If a rate constant is not temperature dependent, 1.000 should be used as the empirical constant.

* When the reaeration temperature correction constant is set to zero, the temperature correction for the reaeration rate is temperature dependent and is calculated as the ratio of dissolved oxygen saturation concentration at the ambient temperature to dissolved oxygen saturation concentration at 20°C. This is the default action in the model. If applied in the exponential temperature correction equation, this would translate to a reaeration temperature correction "constant" ranging between 1.017 at 50°C and 1.024 at 0°C. If a non-computed non-varying reaeration temperature correction constant is desired, a non-zero number should be input.

IMPORTANT: The last line of this group must read "ENDATA04", left justified, even if no default values are changed.

DATA TYPE 5 – TEMPERATURE DATA

These data set certain temperature constants and are optional. They are utilized only if temperature is being simulated and if a change in a default value is desired. Only those lines for which a change in the default value is desired need to be input. They are not required in any specific order. Only metric units are allowed. Columns 47-56 (F10.0) contain the new value that will override the default value. Each line is distinguished by a eight-letter character code (shown underlined) in Columns 10-17 (A8) and are described as follows:

LATITUDE Default = 30.0

This line gives the latitude of the basin (degrees).

LONGITUDE Default = 98.0

This line gives the longitude of the basin (degrees).

STANDARD MERIDIAN Default = 90.0

This line gives the standard meridian (degrees).

ELEVATION Default = 300.0

This line gives the elevation of the basin (meters above MSL).

AE EVAPORATION COEF Default = 0.0147

This line gives the evaporation coefficient AE (cm/day/mbar).

BE EVAPORATION COEF Default = 0.0091

This line gives the evaporation coefficient BE (cm/day/mbar/kph).

DUST ATTENUATION COEF Default = 0.0

This line gives the dust attenuation coefficient. The dust attenuation coefficient ranges from 0.00 to 0.13.

DAY OF YEAR Default = 183

This line gives the day of the year, where January 1 = 1 and December 31 = 365.

CLOUDINESS Default = 0.0

This line gives the cloudiness (percent).

DRY BULB TEMP Default = 20.0

This line gives the dry bulb temperature of the air (degrees C).

WET BULB TEMP Default = 20.0

This line gives the wet bulb temperature of the air (degrees C).

CLEAR SKY ATTENUATION EQUATION Default = 2

This line gives the equation for atmospheric attenuation from a clear sky:

- 1: Water Resources Engineers (1967)
- 2: Bras (1990)
- 3: Ryan and Stolzenbach (1972)

This line gives the equation for atmospheric longwave radiation:

- 1: Texas Water Development Board, Report 128 (1971)
- 2: Brutsaert (1982)
- 3: Brunt (1932)

IMPORTANT: The last line of this group must read “ENDATA05”, left justified, even if no default values are changed.

DATA TYPE 6 – PHYTOPLANKTON CONSTANTS

These data set certain phytoplankton constants and are optional. They are utilized only if phytoplankton are being simulated and if a change in a default value is desired. Only those lines for which a change in the default value is desired need be input. They are not required in any specific order. Only metric units are allowed. Columns 47-56 (F10.0) contain the new value that will override the default value. Each line is distinguished by a eight-letter character code (shown underlined) in Columns 10-17 (A8) and are described as follows:

O PROD DUE TO GROWTH

Default = 1.6

This line gives the oxygen production per unit of phytoplankton growth (mg O/mg dry wt biomass). It generally ranges from 1.4 to 1.8.

O UPTAKE DUE TO RESP

Default = 2.0

This line gives the oxygen uptake per unit of phytoplankton respiration (mg O/mg dry wt biomass). It generally ranges from 1.6 to 2.3.

C CONTENT

Default = 0.400

This line gives the carbon content of phytoplankton (mg C/mg biomass).

N CONTENT

Default = 0.085

This line gives the nitrogen content of phytoplankton (mg N/mg dry wt biomass). It generally ranges from 0.08 to 0.09.

P CONTENT

Default = 0.013

This line gives the phosphorus content of phytoplankton (mg P/mg dry wt biomass). It generally ranges from 0.012 to 0.015.

N HALF SATURATION CONSTANT

Default = 0.3

This line gives the nitrogen half saturation constant (mg/L) for phytoplankton. It generally ranges from 0.2 to 0.4.

P HALF SATURATION CONSTANT

Default = 0.04

This line gives the phosphorus half saturation constant (mg/L) for phytoplankton. It generally ranges from 0.03 to 0.05.

LIGHT SATURATION CONSTANT

Default = 30

This line gives the light saturation constant and is defined differently depending on which light limitation option is selected. It generally ranges from 10 to 40 langleys/hour for the Steel Equation.

L OPTION

Default = 3

This line controls the light limitation option:

- 1: Half-saturation Equation
- 2: Smith Equation
- 3: Steel Equation
- 4: No light limitation

COEF LINEAR SELF-SHADING

Default = 0.0088

This line gives the linear coefficient of phytoplankton self-shading in the light extinction coefficient equation.

COEF NONLINEAR SELF-SHADING

Default = 0.054

This line gives the non-linear coefficient of phytoplankton self-shading in the light extinction coefficient equation.

EXP NONLINEAR SELF-SHADING

Default = 0.667

This line gives the non-linear exponent of phytoplankton self-shading in the light extinction coefficient equation.

N OPTION

Default = 1

This line controls the nutrient limitation option for nitrogen and phosphorus:

- 1: Harmonic mean
- 2: Multiplicative
- 3: Law of minimum
- 4: Average

N PREFERENCE

Default = auto

When present, this line sets the nitrogen preference of phytoplankton. A value of 1.00 indicates a total preference for nitrate nitrogen; a value of 0.00 indicates a total preference for ammonia nitrogen; values between 1.00 and 0.00 indicate intermediate preferences. If this line is not present, the nitrogen preference is determined automatically based on the ratio of concentrations of ammonia nitrogen and nitrate nitrogen.

BOD SPLIT

Default = 1.00

This line controls the form of BOD which is created upon the death phytoplankton. A value of 1.00 indicates that all of it takes the form of short-term BOD (BOD1). A value of 0.00 indicates that all of it takes the form of long-term BOD (BOD2). Values may range between 0.00 and 1.00.

IMPORTANT: The last line of this group must read "ENDATA06", left justified, even if no default values are changed.

DATA TYPE 7 – PERIPHYTON CONSTANTS

These data set certain periphyton constants and are optional. They are utilized only if periphyton are being simulated and if a change in a default value is desired. Only those lines for which a change in the default is desired need to input. They are not required in any specific order. Only metric units are allowed. Columns 47-56 (F10.0) contain the new value that will override the default value. Each word is distinguished by a eight-letter character code (shown underlined) in Columns 10-17 (A8) and are described as follows:

O PROD DUE TO GROWTH

Default = 1.6

This line gives the oxygen production per unit of periphyton growth respiration (mg O/mg biomass). It generally ranges from 1.4 to 1.8.

O UPTAKE DUE TO RESP

Default = 2.0

This line gives the oxygen uptake per unit of periphyton respiration (mg O/mg biomass). It generally ranges from 1.6 to 2.3.

C CONTENT

Default = 0.400

This line gives the carbon content of periphyton (mg C/mg biomass).

N CONTENT

Default = 0.085

This line gives the nitrogen content of periphyton (mg N/mg biomass). It generally ranges from 0.08 to 0.09.

P CONTENT

Default = 0.013

This line gives the phosphorus content of periphyton (mg P/mg biomass). It generally ranges from 0.012 to 0.015.

N HALF SATURATION CONSTANT

Default = 0.3

This line gives the nitrogen half saturation constant (mg/L) for periphyton. It generally ranges from 0.2 to 0.4.

P HALF SATURATION CONSTANT

Default = 0.04

This line gives the phosphorus half saturation constant (mg/L) for periphyton. It generally ranges from 0.03 to 0.05.

LIGHT SATURATION CONSTANT

Default = 30

This line gives the light saturation constant and is defined differently depending on which light limitation option is selected. It generally ranges from 10 to 40 langleys/hour for the Steel Equation.

L OPTION

Default = 3

This line controls the light limitation option:

- 1: Half-saturation Equation
- 2: Smith Equation
- 3: Steel Equation
- 4: No light limitation

N OPTION

Default = 1

This line controls the nutrient limitation option for nitrogen and phosphorus:

- 1: Harmonic mean
- 2: Multiplicative
- 3: Law of minimum
- 4: Average

N PREFERENCE

Default = auto

When present, this line sets the nitrogen preference of periphyton. A value of 1.00 indicates a total preference for nitrate nitrogen; a value of 0.00 indicates a total preference for ammonia nitrogen; values between 1.00 and 0.00 indicate intermediate preferences. If this line is not present, the nitrogen preference is determined automatically based on the ratio of concentrations of ammonia nitrogen and nitrate nitrogen.

BOD SPLIT

Default = 1.00

This line controls the form of BOD which is created upon the death periphyton. A value of 1.00 indicates that all of it takes the form of short-term BOD (BOD1). A value of 0.00 indicates that all of it takes the form of long-term BOD (BOD2). Values may range between 0.00 and 1.00.

MAXIMUM PERIPHYTON DENSITY

Default = 10.0

This line gives the maximum density (g/m^2) for periphyton .

IMPORTANT: The last line of this group must read "ENDATA07", left justified, even if no default values are changed.

DATA TYPE 8 – REACH IDENTIFICATION DATA

These data identify the stream reach system (stretches of constant characteristics) by number, name, and stream distance and are required. Line entries must be placed in numerical order by reach number. The reach numbers are numbered from the most upstream point in the stream system to the most downstream point. When a tributary junction is reached, the order is continued from the most upstream point of the tributary. When a junction is encountered, the upstream reach must end and a new reach must begin immediately below the junction. The program is dimensioned for a maximum of 200 reaches.

Each reach consists of computational elements. The lengths of computational elements depend on the desired accuracy and computational time and are limited by the maximum number of elements allowed in the model. Ideally, element lengths would be approximately equal to the width of the stream, but this is not usually practical. Shorter element lengths provide more accurate results but require longer computation times and produce more elements. Typical lengths of computational elements range from 1 kilometer to 0.01 kilometers with 0.1 kilometer or smaller recommended under most circumstances. The computational element length should be short enough so that the predicted concentrations are not substantially affected by further reductions in the element length. A comparison of predicted results based on different element sizes can be found in Appendix E.

Computational element lengths may vary from reach to reach but must be even multiples of the reach length. Computational elements are numbered from upstream to downstream in the same manner as the reaches. The program is dimensioned for a maximum of 4000 elements. If more elements are needed, it is possible to sequence models end-to-end using the Sequencing Controls in Program Constants (Data Type 3) and Headwaters (Data Type 20).

River distances are measured from the confluence or mouth of the stream. Distances and lengths may be entered in metric or English units, depending on the setting of the metric flag in Data Type 1. Each card represents one reach and contains the following information:

The reach identification code should be a two or three-character abbreviation of the stream name to help when looking at the output of some of the reports.

Reach number	Columns 11-13 (I3)
Reach identification code	Columns 15-17 (A3)
Reach name	Columns 19-50 (A32)
River distance at head of reach (kilometers or miles)	Columns 51-60 (F10.0)
River distance of end of reach (kilometers or miles)	Columns 61-70 (F10.0)
Computational element length (kilometers or miles)	Columns 71-80 (F10.0)

IMPORTANT: The last line of this group must read “ENDATA08”, left justified.

DATA TYPE 9 – ADVECTIVE HYDRAULIC COEFFICIENTS

These data describe the advective hydraulic characteristics of the system and are required. Lines must be placed in numerical order by reach number. The advective hydraulic characteristics may be specified in either of two methods depending on the setting of the HYDRAULIC CALCULATION METHOD program constant in Data Type 3.

Method 1 – Velocities and Depths

Advective velocity (m/s; ft/s) is calculated as $V = aQ^b$. Average depth (m; ft) is calculated as $D = dQ^e + f$. If a depth less than one centimeter is calculated, the depth will be set to one centimeter. Manning's "n" is used to compute advective dispersion and to compute reaeration coefficients when the Thackston-Krenkel or Tsivoglou-Neal option is specified in the Reaeration, Sediment Oxygen Demand, and BOD Coefficients (Data Type 12). Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Sensitivity exclusion flag (must use "*" to set)	Columns 15-15 (A1)
Velocity coefficient "a"	Columns 16-25 (F10.0)
Velocity exponent "b"	Columns 26-35 (F10.0)
Depth coefficient "d"	Columns 36-45 (F10.0)
Depth exponent "e"	Columns 46-55 (F10.0)
Depth constant "f"	Columns 56-65 (F10.0)
Manning's "n"	Columns 66-72 (F7.0)
Evaporation rate (cm/day)	Columns 73-79 (F7.0)

Method 2 – Widths and Depths

Surface width (m; ft) is calculated as $W = aQ^b + c$. Average depth (m; ft) is calculated as $D = dQ^e + f$. If a depth less than one centimeter is calculated, the depth will be set to one centimeter. Slope is used in certain reaeration equations. Manning's "n" is used to compute advective dispersion and to compute reaeration coefficients when the Thackston-Krenkel or Tsivoglou-Neal option is specified in the Reaeration, Sediment Oxygen Demand, and BOD Coefficients (Data Type 12). Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Sensitivity exclusion flag (must use "*" to set)	Columns 15-15 (A1)
Width coefficient "a"	Columns 16-22 (F7.0)
Width exponent "b"	Columns 23-29 (F7.0)
Width constant "c"	Columns 30-36 (F7.0)
Depth coefficient "d"	Columns 37-43 (F7.0)
Depth exponent "e"	Columns 44-50 (F7.0)
Depth constant "f"	Columns 51-57 (F7.0)
Slope (unitless, m/m or ft/ft)	Columns 58-65 (F8.0)
Manning's "n"	Columns 66-72 (F7.0)
Evaporation rate (cm/day)	Columns 73-79 (F7.0)

IMPORTANT: The last line of this group must read "ENDATA09", left justified.

DATA TYPE 10 – DISPERSIVE HYDRAULIC COEFFICIENTS

These data describe the dispersive characteristics of the system and are optional on a reach by reach basis. Only those reaches that are highly dispersive or for which manual entry is desired should have a line entry, and those line entries must be placed in numerical order by reach number. The tidal range as a fraction (0.0 – 1.0) of the boundary tide is used to calculate tidal velocities for the reaeration equations and tidal dispersion equations. Tidal dispersion (m²/sec; ft²/sec) may be specified in several ways depending on the setting of the DISPERSION EQUATION program constant in Data Type 3:

- 1: $E = a$
- 2: $E = aD^b Q^c V_T^d$
- 3: $E = aD^b Q^c V_M^d$

Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Tidal range, fraction of boundary tide	Columns 16-20 (F5.0)
Dispersion coefficient “a”	Columns 21-30 (F10.0)
Dispersion exponent “b”	Columns 31-40 (F10.0)
Dispersion exponent “c”	Columns 41-50 (F10.0)
Dispersion exponent “d”	Columns 51-60 (F10.0)

Typical values for dispersion are given in the following table (after Gloyna 1967):

System Classification	E (ft ² /sec)	E (m ² /sec)	E (mi ² /day)
Flumes and small streams	0.03 - 3	0.003 - 0.3	0.0001 - 0.01
Large rivers	3 - 300	0.3 - 30	0.01 - 1
Estuaries	300 - 6000	30 - 600	1 - 20

IMPORTANT: The last line of this group must read “ENDATA10”, left justified.

DATA TYPE 11 – INITIAL CONDITIONS

These data establish initial conditions for the stream system and are required. Line entries must be placed in numerical order by reach number. Initial conditions are used to initialize the constituent concentrations in each element of a reach.

If a constituent is being modeled, the initial conditions are used only as a starting point in iterative solution techniques and have no impact on the final predicted concentrations. However, they can impact how quickly the iterative technique converges. Temperature is used as a starting point in the iterative solution technique for temperature. Dissolved oxygen is used as a starting point in the iterative solution technique for oxygen dependent rates. Ammonia nitrogen, nitrate nitrogen, and phosphorus are used as a starting point in the iterative solution technique for phytoplankton and periphyton growth rates.

If a constituent is not being modeled, the initial conditions determine the constituent concentrations for those constituent that impact other modeled constituents. Temperature is used in calculating reaction rates and dissolved oxygen saturation concentrations. Salinity is used in calculating dissolved oxygen saturation concentrations. Phytoplankton and periphyton concentrations are used in calculating net oxygen production and nutrient removal due to photosynthesis. Phytoplankton also impacts effective concentrations. As a special case, if temperature is set to zero for a reach, that reach is not modeled.

Initial conditions should be specified for the head of each reach since the model interpolates initial conditions from the head of one reach to the head of the next reach. For the last reach, the model interpolates between the Initial Conditions concentrations for that last reach and the Lower Boundary Conditions (Data Type 27) if the Lower Boundary Conditions exist. Otherwise, the last reach is not interpolated.

Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Temperature, °C	Columns 16-23 (F8.0)
Salinity, ppt	Columns 24-31 (F8.0)
Dissolved oxygen, mg/L	Columns 32-39 (F8.0)
Ammonia nitrogen, mg/L	Columns 40-47 (F8.0)
Nitrate nitrogen, mg/L	Columns 48-55 (F8.0)
Inorganic phosphorus, mg/L	Columns 56-63 (F8.0)
Phytoplankton (as chlorophyll <u>a</u>), µg/L	Columns 64-71 (F8.0)
Periphyton, g/sq m or mg/sq ft	Columns 72-79 (F8.0)
BOD1, mg/L	Columns 80-87 (F8.0)
BOD2, mg/L	Columns 88-95 (F8.0)
Organic nitrogen, mg/L	Columns 96-103 (F8.0)
Organic phosphorus, mg/L	Columns 104-111 (F8.0)
Coliform, mg/L	Columns 112-119 (F8.0)
Nonconservative material, units as defined in Data Type 2	Columns 120-127 (F8.0)
Conservative material #1, units as defined in Data Type 2	Columns 128--135 (F8.0)
Conservative material #2, units as defined in Data Type 2	Columns 136-143 (F8.0)

IMPORTANT: The last line of this group must read “ENDATA11”, left justified.

DATA TYPE 12 – REAERATION, SEDIMENT OXYGEN DEMAND, AND BOD COEFFICIENTS

These data set the reaeration, sediment oxygen demand, and BOD coefficients and are required only if biochemical oxygen demand or dissolved oxygen is being simulated. Otherwise, they may be omitted. If present, line entries must be placed in numerical order by reach number. All rates should be input in base e for 20°C. Twenty options for reaeration coefficient calculation are currently available. These are listed below:

<u>Option</u>	<u>Method</u>	<u>Equation (metric units)</u>
1	K ₂ is a constant value	$K_2 = a$
2	Churchill-Elmore-Buckingham (1962)	$K_2 = \frac{5.026 V^{0.969}}{D^{1.673}}$
3	O'Connor-Dobbins (1958)	$K_2 = \frac{3.932 V^{0.500}}{D^{1.500}}$
4	Owens-Edwards-Gibbs <5.0 fps (1964)	$K_2 = \frac{6.932 V^{0.670}}{D^{1.850}}$
5	Thackston-Krenkel (1966)	$K_2 = \frac{24.9 (1 + F^{0.5}) U}{D^{0.5}}$ where $F = \frac{0.319 V}{D^{0.5}}$ and $U = \frac{4.654 V n}{D^{0.167}}$
6	Langien-Durum (1967)	$K_2 = \frac{5.135 V^{1.000}}{D^{1.330}}$
7	K ₂ is a function of flow	$K_2 = a Q^b$
8	K ₂ is a function of velocity and slope	$K_2 = a 86400 V S$
9	K ₂ is a function of velocity and depth	$K_2 = \frac{a V^b}{D^c}$
10	K ₂ is a function of wind and depth	$K_2 = \frac{a + b W^c}{D}$
11	Texas Equation (1982)	$K_2 = \frac{1.923 V^{0.273}}{D^{0.894}}$
12	Banks (1975)	$K_2 = \frac{0.362 W^{0.5}}{D}$
13	Johanson (1977)	$K_2 = \frac{0.479 + 0.081 W^2}{D}$
14	Banks-Herrera (1977)	$K_2 = \frac{0.728 W^{0.5} - 0.317 W + 0.0372 W^2}{D}$
15	Louisiana Equation (1995)	$K_2 = \frac{0.664 (1 + 21.52 V)}{D}$
16	Bennett-Rathbun (1972)	$K_2 = \frac{5.585 V^{0.607}}{D^{1.689}}$
17	Isaacs-Gaudy (1968)	$K_2 = \frac{4.759 V^{1.000}}{D^{1.500}}$
18	Tsvioglou-Neal (1972)	$K_2 = 31182.6 V S$ for $Q < 0.283 \text{ m}^3/\text{s}$ $K_2 = 15307.8 V S$ for $Q > 0.708 \text{ m}^3/\text{s}$
19	Owens-Edwards-Gibbs <1.8 fps (1964)	$K_2 = \frac{6.935 V^{0.730}}{D^{1.750}}$
20	K ₂ = K _L / D	$K_2 = a / D$
21	Yu (1977)	$K_2 = 0.319 W/D$

where:

- K₂ = reaeration rate (1/day)
- Q = flow (m³/s or ft³/s)
- V = stream mean velocity (m/s or ft/s)
- D = depth (m or ft)
- S = slope (unitless, m/m or ft/ft)
- W = wind velocity (m/s) [input in Data Type 3 as km/hr]
- n = Manning's "n" as set in Data Type 9 (unitless)
- K_L = oxygen transfer coefficient (m/day or ft/day)

For option 8, if slope = 0.0, the slope will be calculated internally using Manning's equation:

$$S = \frac{0.995 n^2 V^2}{D^{1.333}} \quad (\text{metric units})$$

For options 12,13,14, and 21, a wind sheltering coefficient between 0.01 and 1.00 can be applied to the wind value to account for sheltering effects of trees, buildings, high banks, etc. where 1.00 = no shelter and 0.01= virtually complete sheltering. If the wind sheltering coefficient is not entered or is zero, the wind sheltering coefficient will be set to 1.0.

Except for options 1 and 20, the reaeration rate will set to the larger of the calculated rate and $(K_L)_{\min} / D$ (see Data Type 3 to set the value of $(K_L)_{\min}$). The value of coefficients and exponents a, b, and c may depend on which system of units (English or metric) is set in Data Type 1. Care should be given to providing a value consistent with the system of units being utilized.

The source of options #2 through #6, #12, and #16 through #21 is Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition), EPA/600/3-85/040, June 1985. The source of option #14 is Principles of Surface Water Quality Modeling and Control, Robert V. Thomann and John A. Mueller, 1987. The source of option #15 is the Louisiana Department of Environmental Quality. The source of option #11 is the Texas Commission on Environmental Quality. Options #7 through #10 are generic.

When anaerobic BOD decay occurs, oxygen must be provided from another source other than free dissolved oxygen. When the nitrogen series is also being modeled, this source is assumed to be nitrate nitrogen. Nitrate nitrogen is consumed in accordance with a program constant set in Data Type 3. If no nitrate is consumed under anaerobic decay, this constant should be set to zero.

Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Reaeration Option (1 to 20, as above)	Columns 16-20 (F5.0)
Reaeration rate "a" (option 1), 1/day	Columns 21-26 (F6.0)
Coefficient "a" (option 7), 1/day	Columns 21-26 (F6.0)
Coefficient "a" (option 8), per m or per ft	Columns 21-26 (F6.0)
Coefficient "a" (option 9), m/day or ft/day	Columns 21-26 (F6.0)
Coefficient "a" (option 10), m/day or ft/day	Columns 21-26 (F6.0)
Oxygen transfer coefficient "a" (option 20), m/day or ft/day	Columns 21-26 (F6.0)
Wind shelter coefficient (options 12, 13, 14, 21), unitless (0.01-1.00)	Columns 21-26 (F6.0)
Exponent "b" (option 7), unitless	Columns 27-32 (F6.0)
Exponent "b" (option 9), unitless	Columns 27-32 (F6.0)
Coefficient "b" (option 10), m/day or ft/day	Columns 27-32 (F6.0)
Slope if not provided in Data Type 9 (option 8), m/m or ft/ft	Columns 27-32 (F6.0)
Exponent "c" (options 9 and 10), unitless	Columns 33-38 (F6.0)
Background sediment oxygen demand, g/m ² /day or mg/ft ² /day	Columns 39-45 (F7.0)
Aerobic BOD1 decay rate, 1/day	Columns 46-52 (F7.0)
BOD1 settling rate if Data Type 3 "SETT=1", m/day or ft/day if Data Type 3 "SETT=2", 1/day	Columns 53-59 (F7.0)
Settled organics available as sediment oxygen demand, unitless (range 0.00-1.00; 0=none available; 1=all available)	Columns 60-66 (F7.0)
Anaerobic BOD1 decay rate, 1/day	Columns 67-73 (F7.0)
BOD2 decay rate (aerobic), 1/day	Columns 74-80 (F7.0)

BOD2 settling rate if Data Type 3 “SETT=1”, m/day or ft/day if Data Type 3 “SETT=2”, 1/day	Columns 81-87 (F7.0)
Unused field	Columns 88-94
Anaerobic BOD2 decay rate, 1/day	Columns 95-101 (F7.0)
Hydrolysis rate of BOD2 to BOD1, 1/day	Columns 102-108 (F7.0)

IMPORTANT: The last line of this group must read “ENDATA12”, left justified, even if the data are deleted.

DATA TYPE 13 – NITROGEN AND PHOSPHORUS COEFFICIENTS

These data set the nitrogen and phosphorus coefficients and are required only if nitrogen or phosphorus is to be simulated. Otherwise, they may be omitted. If present, line entries must be placed in numerical order by reach number. All rates should be input in base e for 20°C.

Each card represents one reach and contains the following information:

Reach number	Columns 11-13 (I3)
Organic nitrogen or NBOD decay rate, per day	Columns 16-22 (F7.0)
Organic nitrogen or NBOD settling rate if Data Type 3 “SETT=1”, m/day or ft/day if Data Type 3 “SETT=2”, 1/day	Columns 23-29 (F7.0)
Settled organic nitrogen available as sediment ammonia nitrogen source rate, fraction (range 0.00-1.00; 0=none available; 1=all available)	Columns 30-36 (F7.0)
Ammonia nitrogen decay rate (nitrification), per day	Columns 37-43 (F7.0)
Background sediment ammonia nitrogen source rate, g/m ² /day or mg/ft ² /day	Columns 44-50 (F7.0)
Background sediment inorganic phosphorus source rate, g/m ² /day or mg/ft ² /day	Columns 51-57 (F7.0)
Denitrification rate, per day	Columns 58-64 (F7.0)
Organic phosphorus hydrolysis rate, per day	Columns 65-71 (F7.0)
Organic phosphorus settling rate, if Data Type 3 “SETT=1”, m/day or ft/day if Data Type 3 “SETT=2”, 1/day	Columns 72-78 (F7.0)
Settled organic phosphorus available as sediment inorganic phosphorus source rate, fraction (range 0.00-1.00; 0=none available; 1=all available)	Columns 79-85 (F7.0)

IMPORTANT: The last line of this group must read “ENDATA13”, left justified, even if the data are deleted.

DATA TYPE 14 – PHYTOPLANKTON AND PERIPHYTON COEFFICIENTS

These data provide the coefficients for phytoplankton and periphyton and are required if phytoplankton or periphyton are to be simulated. If effective concentrations are being Otherwise, they may be omitted. If present, line entries must be placed in numerical order by reach number. All rates should be input in base e for 20°C. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Secchi disc depth with no phytoplankton present, m or ft (must be greater than zero)	Columns 16-22 (F7.0)
Chlorophyll <i>a</i> to phytoplankton ratio, mg chl <i>a</i> /mg dry wt biomass (0.01 typical)	Columns 23-29 (F7.0)
Phytoplankton settling rate, if Data Type 3 “SETT=1”, m/day or ft/day if Data Type 3 “SETT=2”, 1/day (range of 0.05 to 0.20)	Columns 30-26 (F7.0)
Phytoplankton death rate, per day	Columns 37-43 (F7.0)
Phytoplankton maximum growth rate, per day (range of 1.3 to 2.5)	Columns 44-50 (F7.0)
Phytoplankton respiration rate, per day (range of 0.05 to 0.15)	Columns 51-57 (F7.0)
Periphyton death rate, per day	Columns 58-64 (F7.0)
Periphyton maximum growth rate, per day	Columns 65-71 (F7.0)
Periphyton respiration rate, per day	Columns 72-78 (F7.0)
Bank shading coefficient, unitless (range 0.00-1.00; 0=no shade; 1=complete shade)	Columns 79-84 (F6.0)

IMPORTANT: The last line of this group must read “ENDATA14”, left justified, even if the data are deleted.

DATA TYPE 15 – COLIFORM AND NONCONSERVATIVE COEFFICIENTS

These data set the coliform and nonconservative material coefficients and are required only if coliform or a nonconservative material is to be simulated. Otherwise, they may be omitted. If present, line entries must be placed in numerical order by reach number. All rates should be input in base e for 20°C. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Coliform decay rate, per day	Columns 16-22 (F7.0)
Nonconservative material decay rate, per day	Columns 23-29 (F7.0)
Nonconservative material settling rate settling rate if Data Type 3 “SETT=1”, m/day or ft/day settling rate if Data Type 3 “SETT=2”, 1/day	Columns 30-36 (F7.0)

IMPORTANT: The last line of this group must read “ENDATA15”, left justified, even if the data are deleted.

DATA TYPE 16 – INCREMENTAL DATA FOR FLOW, TEMPERATURE, SALINITY, AND CONSERVATIVES

These data account for the flows, temperature, salinity, and conservative constituents associated with incremental inflow/outflow and are optional on a reach by reach basis. Those line entries that are present must be placed in numerical order by reach number. Inflows require concentrations; outflows do not require concentrations. The concentration of any constituent not being simulated may be left blank. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Incremental outflow, m ³ /s or ft ³ /s (must have [-] sign)	Columns 16-24 (F9.0)
Incremental inflow, m ³ /s or ft ³ /s	Columns 25-33 (F9.0)
Temperature, °C	Columns 34-42 (F9.0)
Salinity, ppt	Columns 43-51 (F9.0)
Conservative Material #1, units as defined in Data Type 2	Columns 52-60 (F9.0)
Conservative Material #2, units as defined in Data Type 2	Columns 61-69 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA16”, left justified, even if the data are deleted.

DATA TYPE 17 – INCREMENTAL DATA FOR DO, BOD, AND NITROGEN

These data account for the DO, BOD, and nitrogen associated with the optional incremental inflow/outflow line entries (Data Type 16) and are required only if dissolved oxygen, biochemical oxygen demand, or nitrogen is being simulated. Otherwise, they may be omitted. If present, one card is required for each reach specified in the Data Type 16 line entries and must be placed in numerical order by reach number. Inflows require concentrations; outflows do not require concentrations. The concentration of any constituent not being simulated may be left blank. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Dissolved oxygen, mg/L	Columns 16-24 (F9.0)
Short-term biochemical oxygen demand (BOD1), mg/L	Columns 25-33 (F9.0)
Organic nitrogen or NBOD, mg/L	Columns 34-42 (F9.0)
Ammonia nitrogen, mg/L	Columns 43-51 (F9.0)
Nitrate nitrogen, mg/L	Columns 52-60 (F9.0)
Long-term biochemical oxygen demand (BOD2), mg/L	Columns 61-69 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA17, left justified, even if the data are deleted.

DATA TYPE 18 - INCREMENTAL DATA FOR PHOSPHORUS, PHYTOPLANKTON, COLIFORM, AND NONCONSERVATIVE MATERIAL

These data account for the phosphorus, phytoplankton (as chlorophyll a), coliform, and nonconservative material associated with the optional incremental inflow/outflow cards (Data Type 16) and are required only if phosphorus, phytoplankton, coliform, or a nonconservative material is being simulated. Otherwise, they may be omitted. If present, one card is required for each reach specified in the Data Type 16 cards and must be placed in numerical order by reach number. Inflows require concentrations; outflows do not require concentrations. The concentration of any constituent not being simulated may be left blank. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Inorganic phosphorus, mg/L	Columns 16-24 (F9.0)
Phytoplankton (as chlorophyll <u>a</u>), µg/L	Columns 25-33 (F9.0)
Coliform, #/100 mL	Columns 34-42 (F9.0)
Nonconservative material, units as defined in Data Type 2	Columns 43-51 (F9.0)
Organic phosphorus, mg/L	Columns 52-60 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA18”, left justified, even if the data are deleted.

DATA TYPE 19 – NONPOINT SOURCE DATA

These data account for nonpoint source loads not associated with flows and are optional on a reach by reach basis. Those cards that are present must be placed in numerical order by reach number. The concentration of any constituent not being simulated may be left blank. Each card represents one reach and contains the following information:

Reach Number	Columns 11-13 (I3)
Short-term biochemical oxygen demand (BOD1), kg/day or lb/day	Columns 16-24 (F9.0)
Organic nitrogen or NBOD, kg/day or lb/day	Columns 25-33 (F9.0)
Coliform, #/day	Columns 34-42 (F9.0)
Nonconservative material, used-defined units*	Columns 43-51 (F9.0)
Dissolved oxygen, kg/day or lb/day	Columns 52-60 (F9.0)
Long-term biochemical oxygen demand (BOD2), kg/day or lb/day	Columns 61-69 (F9.0)
Organic phosphorus, kg/day or lb/day	Columns 70-78 (F9.0)
Ammonia nitrogen, kg/day or lb/day	Columns 79-87 (F9.0)
Nitrate nitrogen, kg/day or lb/day	Columns 88-96 (F9.0)
Inorganic phosphorus, kg/day or lb/day	Columns 97-105 (F9.0)
Salinity, kg/day or lb/day	Columns 106-114 (F9.0)
Conservative Material 1, used-defined units*	Columns 115-123 (F9.0)
Conservative Material 2, used-defined units*	Columns 124-132 (F9.0)

* The units are typically kg/day (metric) or lb/day (English), but can be any mass/day. However, they must be consistent with the concentrations specified in Data Type 2 and used in other input data (headwaters, wasteloads, incremental inflows). For example, if concentrations are in mg/L, mass loadings must be given in kg/day, and if concentrations are in µg/L, mass loadings must be given in g/day.

IMPORTANT: The last line of this group must read “ENDATA19, left justified, even if the data are deleted.

DATA TYPE 20 – HEADWATER DATA FOR FLOW, TEMPERATURE, SALINITY, AND CONSERVATIVES

These data account for the flows, temperature, salinity, and conservative constituents associated with headwater inflow and are required. Cards must be placed in numerical order by the computational element number of the headwater. The concentration of any constituent not being simulated may be left blank. Computationally, the flow cannot be zero or the program will crash. If zero is entered as the flow, the flow will be set automatically to a very small value (0.0000001 m³/s). Depending on the hydraulics and whether there are additional flows from other sources, this can lead to unrealistic results for some calculated values where the stream flow remain extremely low.

As part of a sequence of models, the headwater data may alternately be read from a logical unit created by a previously executed model. Only file numbers 31 or higher can be used. Any unit outside this range will result in the constituent values being read from the data line entries. If a logical unit number is specified, the flow and constituent concentrations on that headwater data card should be left blank.

The Sensitivity Exclusion Flag is used to exclude a specific headwater from the sensitivity analysis (see Data Type 29 for more information).

The headwater exchange ratio gives the percentage of dispersive exchange between the headwater and the stream as a decimal amount. It is intended to be used when a water body has two highly dispersive boundaries such as a tidal lake with two openings to a gulf or ocean and requires another dispersive boundary in addition to the lower boundary. With the value set at 0.0, the headwater acts as a normal advective inflow. With the value set as a positive number, the headwater acts similar to the lower boundary condition.

Values range from 0.0 to 1.0. The program is dimensioned for a maximum of 100 headwaters. Each card represents one headwater and contains the following information:

Computational element number of headwater	Columns 10-13 (I4)
Sensitivity exclusion flag (must set the flag to “*” to exclude the headwater)	Columns 15-15 (A1)
Headwater name	Columns 16-35 (A20)
Logical unit number for sequenced model data input (leave blank if concentrations are to be read from data line entries)	Columns 37-39 (F3.0)
Headwater flow, m ³ /s or ft ³ /s	Columns 41-48 (F8.0)
Temperature, °C	Columns 49-56 (F8.0)
Salinity, ppt	Columns 57-64 (F8.0)
Conservative Material #1, units as defined in Data Type 2	Columns 65-72 (F8.0)
Conservative Material #2, units as defined in Data Type 2	Columns 73-80 (F8.0)
Headwater exchange ratio, unitless	Columns 81-88 (F8.0)

IMPORTANT: The last line of this group must read “ENDATA20”, left justified.

DATA TYPE 21 – HEADWATER DATA FOR DO, BOD, AND NITROGEN

These data account for the DO, BOD, and nitrogen associated with headwater inflows and are required only if dissolved oxygen, biochemical oxygen demand, or nitrogen is being simulated. Otherwise, they may be omitted. If present, line entries must be placed in numerical order by the computational element number of the headwater. The concentration of any constituent not being simulated may be left blank. If concentrations for a given headwater are to be read from a logical unit as specified in the Data Type 20 line entries, the constituent concentrations on that headwater data card should be left blank although that data card must still be included.

The BOD values and organic nitrogen values entered are the “effective” BOD and “effective” organic nitrogen when the Use Effective Concentration option is selected. They will be corrected for phytoplankton (i.e., reduced) based on the program constant in Data Type 3 and the phytoplankton concentration (as chlorophyll *a*) specified in the headwater data (or the Initial Conditions value in Data Type 11 if headwater data for phytoplankton are not present) regardless of whether phytoplankton are being modeled.

Each card represents one headwater and contains the following information:

Computational element number of headwater	Columns 10-13 (I4)
Dissolved oxygen, mg/L	Columns 16-24 (F9.0)
Short-term biochemical oxygen demand (BOD1), mg/L	Columns 25-33 (F9.0)
Organic nitrogen or NBOD, mg/L	Columns 34-42 (F9.0)
Ammonia nitrogen, mg/L	Columns 43-51 (F9.0)
Nitrate nitrogen, mg/L	Columns 52-60 (F9.0)
Long-term biochemical oxygen demand (BOD2), mg/L	Columns 61-69 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA21”, left justified, even if the data are deleted.

DATA TYPE 22 – HEADWATER DATA FOR PHOSPHORUS, PHYTOPLANKTON, COLIFORM, AND NONCONSERVATIVE MATERIAL

These data account for the phosphorus, phytoplankton (as chlorophyll a), coliform, and nonconservative material associated with headwater inflows and are required if phosphorus, phytoplankton, coliform, or a nonconservative material is being simulated. Additionally, if the Use Effective Concentration option is selected in Data Type 1, the phytoplankton value entered here will be used instead of the value in Initial Conditions (Data Type 11). Otherwise, they may be omitted. If present, line entries must be placed in numerical order by the computational element number of the element. The concentration of any constituent not being simulated may be left blank. If concentrations for a given headwater are to be read from a logical unit as specified in the Data Type 20 line entries, the constituent concentrations on that headwater data card should be left blank although that data card must still be included.

The organic phosphorus values entered are the “effective” organic phosphorus when the Use Effective Concentration option is selected. They will be corrected for phytoplankton (i.e., reduced) based on the program constant in Data Type 3 and the phytoplankton concentration (as chlorophyll a) specified here in the headwater data (or the Initial Conditions value in Data Type 11 if headwater data for phytoplankton are not present here) regardless of whether phytoplankton are being modeled.

Each card represents one headwater and contains the following information:

Computational element number of headwater	Columns 10-13 (I4)
Inorganic phosphorus, mg/L	Columns 16-24 (F9.0)
Phytoplankton (as chlorophyll <u>a</u>), µg/L	Columns 25-33 (F9.0)
Coliform, #/100 mL	Columns 34-42 (F9.0)
Nonconservative material, units as defined in Data Type 2	Columns 43-51 (F9.0)
Organic phosphorus, mg/L	Columns 52-60 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA22”, left justified, even if the data are deleted.

DATA TYPE 23 – JUNCTION DATA

These data describe the junction configuration and are required only if there are two or more headwaters. There is always one less junction data line entry than headwater data line entries. Line entries must be placed in numerical order by the computational element number of the element immediately downstream of the junction. The last (most downstream) computational element may not be a junction element. Each card represents one junction and contains the following information:

Computational element number of the element immediately downstream of the junction (i.e., the junction element)	Columns 10-13 (I4)
Computational element number of the element immediately upstream of the junction	Columns 15-18 (I4)
Junction name	Columns 21-80 (A60)

IMPORTANT: The last line of this group must read “ENDATA23”, left justified, even if the data are deleted.

DATA TYPE 24 – WASTE LOAD DATA FOR FLOW, TEMPERATURE, SALINITY, AND CONSERVATIVES

These data account for the flows, temperature, salinity, and conservative constituents associated with waste loads or withdrawals and are optional. Those line entries that are present must be placed in numerical order by the computational element number of the waste load/withdrawal. Waste loads require concentrations; withdrawals do not require concentrations. The concentration of any constituent not being simulated may be left blank. The Sensitivity Exclusion Flag is used to exclude specific wasteloads from the sensitivity analysis (see Data Type 29 for more information). The program is dimensioned for a maximum of 300 waste loads/withdrawals. Each card represents one waste load/withdrawal and contains the following information:

Computational element number of waste load/withdrawal	Columns 10-13 (I4)
Sensitivity exclusion flag (must set the flag to “*” to exclude the wasteload)	Columns 15-15 (A1)
Waste load/withdrawal name	Columns 16-35 (A20)
Waste load/withdrawal flow, m ³ /s or ft ³ /s (a withdrawal must have a [-] sign)	Columns 36-44 (F9.0)
Temperature, °C	Columns 45-53 (F9.0)
Salinity, ppt	Columns 54-62 (F9.0)
Conservative Material #1, units as defined in Data Type 2	Columns 63-71 (F9.0)
Conservative Material #2, units as defined in Data Type 2	Columns 72-80 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA24”, left justified, even if the data are deleted.

DATA TYPE 25 – WASTE LOAD DATA FOR DO, BOD, AND NITROGEN

These data account for the DO, BOD, and nitrogen associated with waste load/withdrawal flow line entries (Data Type 24) and are required only if dissolved oxygen, biochemical oxygen demand, or nitrogen is being simulated. Otherwise, they may be omitted. If present, one card is required for each waste load/withdrawal specified in the Data Type 24 line entries and must be placed in numerical order by the computational element number of the waste load/withdrawal. Waste loads require concentrations; withdrawals do not require concentrations although the data card is still required. The concentration of any constituent not being simulated may be left blank. Each card represents one waste load/withdrawal and contains the following information:

Computational element number of waste load/withdrawal	Columns 10-13 (I4)
Dissolved oxygen, mg/L	Columns 16-24 (F9.0)
Short-term biochemical oxygen demand (BOD1), mg/L	Columns 25-33 (F9.0)
BOD decayed, percent	Columns 34-38 (F5.0)
Organic nitrogen or NBOD, mg/L	Columns 39-47 (F9.0)
Ammonia nitrogen, mg/L	Columns 48-56 (F9.0)
Ammonia nitrogen nitrified, percent	Columns 57-61 (F5.0)
Nitrate nitrogen, mg/L	Columns 62-70 (F9.0)
Long-term biochemical oxygen demand (BOD2), mg/L	Columns 71-79 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA25”, left justified, even if the data are deleted.

**DATA TYPE 26 – WASTE LOAD DATA FOR PHOSPHORUS, PHYTOPLANKTON, COLIFORM, AND
NONCONSERVATIVE MATERIAL**

These data account for the phosphorus, phytoplankton (as chlorophyll a), coliform, and nonconservative material associated with waste load/withdrawal flow line entries (Data Type 24) and are required only if phosphorus, phytoplankton, coliform, or a nonconservative material is being simulated. Otherwise, they may be omitted. If present, one card is required for each waste load/withdrawal specified in the Data Type 24 line entries and must be placed in numerical order by the computational element number of the waste load/withdrawal. Waste loads require concentrations; withdrawals do not require concentrations although the data card is still required. The concentration of any constituent not being simulated may be left blank. Each card represents one waste load/withdrawal and contains the following information:

Computational element number of waste load/withdrawal	Columns 10-13 (I4)
Inorganic phosphorus, mg/L	Columns 16-24 (F9.0)
Phytoplankton (as chlorophyll <u>a</u>), µg/L	Columns 25-33 (F9.0)
Coliform, #/100 mL	Columns 34-42 (F9.0)
Nonconservative material, units as defined in Data Type 2	Columns 43-51 (F9.0)
Organic phosphorus, mg/L	Columns 52-60 (F9.0)

IMPORTANT: The last line of this group must read “ENDATA26”, left justified, even if the data are deleted.

DATA TYPE 27 – LOWER BOUNDARY CONDITIONS

These data specify the constituent concentrations for the lower boundary. They are required only if a constituent is being modeled and only if the system contains high dispersion or flow reversals in the last element. Otherwise, they may be omitted.

If this option is used, be sure to include the tidal information specified in Data Type 3, if appropriate. If the nitrogen series is modeled, NBOD must not be included. Conversely, if NBOD is being modeled, organic nitrogen, ammonia nitrogen, and nitrate nitrogen must not be included.

The BOD, organic nitrogen, and organic phosphorus values entered are the “effective” BOD, organic nitrogen, and organic phosphorus. They will be corrected for phytoplankton (i.e., reduced) based on the program constant in Data Type 3 and the phytoplankton concentration (as chlorophyll a) specified in these boundary conditions regardless of whether phytoplankton are being modeled.

Each card is distinguished by the eight-character code (shown underlined) in Columns 10-17 (A8). Columns 47-56 (F10.0) contain the constituent concentration:

TEMPERATURE (in °C only)

SALINITY (in ppt)

CONSERVATIVE MATERIAL #1 (units as defined in Data Type 2)

CONSERVATIVE MATERIAL #2 (units as defined in Data Type 2)

DISSOLVED OXYGEN (in mg/L)

BOD1 BIOCHEMICAL OXYGEN DEMAND (in mg/L) **or** BIOCHEMICAL OXYGEN DEMAND (*deprecated*)

BOD2 BIOCHEMICAL OXYGEN DEMAND (in mg/L)

ORGANIC NITROGEN (in mg/L; omit if NBOD is modeled)

AMMONIA NITROGEN (in mg/L; omit if NBOD is modeled)

NITRATE NITROGEN (in mg/L; omit if NBOD is modeled)

PO4 PHOSPHORUS (in mg/L) **or** PHOSPHORUS (*PHOSPHORUS is deprecated*)

ORG PHOSPHORUS (in mg/L)

PHYTOPLANKTON (as chlorophyll a in µg/L) **or** CHLOROPHYLL A (*CHLOROPHYLL A is deprecated*)

COLIFORM (in #100 mL)

NONCONSERVATIVE MATERIAL (units as defined in Data Type 2)

NBOD (in mg/L; omit if the Nitrogen Series is modeled)

IMPORTANT: The last line of this group must read “ENDATA27”, left justified, even if the data are deleted.

DATA TYPE 28 – DAM DATA

These data identify dams along the stream and are optional. Placing a dam in the model causes the dispersion to be set to zero across the dam and also causes the dissolved oxygen to increase below the dam (or decrease if supersaturated) due to reaeration. Line entries must be placed in numerical order by element number. The dam is considered to be at the upstream end of the computational element in which it is located. A dam element must begin a new reach. A dam element may not also be a headwater or junction element. The program is dimensioned for a maximum of 30 dams.

Two options for dam reaeration are currently available. These are listed below:

<u>Option</u>	<u>Method</u>	<u>Equation (metric units)</u>
0	No reaeration over or through dam	
1	Butts and Evans (1983)	$(Cs-Cu)/(Cs-Cd)=1+0.38abH(1-0.11H)(1+0.046T)$
2	Gameson (1957)	$(Cs-Cu)/(Cs-Cd)=1+0.40abH$
3	Gameson et al (1959)	$(Cs-Cu)/(Cs-Cd)=1+0.0335abH (1+0.046T)$
4	Specific increase in dissolved oxygen	a

where:

Cs = dissolved oxygen saturation concentration (mg/L)
Cu = concentration of dissolved oxygen upstream of dam (mg/L)
Cd = concentration of dissolved oxygen downstream of dam (mg/L)
a = subjective water quality factor, 0.65 for grossly polluted and 1.8 for clean (unitless)
 Gross = 0.65
 Moderate = 1.0
 Slight = 1.6
 Clean = 1.8
b = weir dam aeration coefficient based on weir type (unitless)
 Flat broad-crested regular step = 0.70
 Flat broad-crested irregular step = 0.80
 Flat broad-crested vertical face = 0.80
 Flat broad-crested straight slope face = 0.90
 Flat broad-crested curved face = 0.75
 Round broad-crested curved face = 0.60
 Sharp-crested straight slope face = 1.05
 Sharp-crested vertical slope face = 0.80
 Sluice gates with submerged discharge = 0.05
H = static head loss over dam (meters)
T = water temperature of water upstream of dam (deg C) (Temperature is calculated by the model)

The source of option #1 is Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition), EPA/600/3-85/040, June 1985.

Each line entry represents one dam and contains the following information:

Element number	Columns 10-13 (I4)
Dam name	Columns 16-35 (A20)
Dam reaeration option (0, 1, 2, 3, or 4 as described above)	Columns 37-38 (I2)
Water quality factor “a”, options 1, 2, or 3 (unitless)	Columns 40-47 (F8.0)
Dissolved oxygen increase, option 4 (mg/L)	Columns 40-47 (F8.0)
Weir dam aeration coefficient “b”, options 1, 2, or 3 (unitless)	Columns 48-55 (F8.0)
Static head loss over dam “H”, options 1, 2, or 3 (meters)	Columns 56-63 (F8.0)

IMPORTANT: The last line of this group must read “ENDATA28”, left justified, even if the data are not present.

DATA TYPE 29 – SENSITIVITY ANALYSIS DATA

These data specify the sensitivity parameters and are required only if sensitivity analysis is to be performed. Otherwise, they may be omitted. Each card specifies the sensitivity parameter by an eight-character code (word) in Columns 10-17 (A8) followed by values indicating the per change to the parameter (degree change for temperatures). Up to eight percentages per card are allowable. Negative percent change must include the (-) sign. The eight fields for the percentages are in columns 19-25, 26-32, 33-39, 40-46, 47-53, 54-60, 61-67, and 68-74 (all F7.0). During a sensitivity analysis, the model is executed once without any changes to parameters and then executed again for each sensitivity parameter set and percentages indicated, one column at a time. For headwater and wasteload sensitivity parameters, individual headwaters and wasteloads can be excluded from the sensitivity changes by setting the Sensitivity Exclusion Flag for those headwaters and wasteloads in Data Type 20 and Data Type 24, respectively. More than one parameter at a time may be changed according to the grouping specified in the Program Constants (Data Type 3). The affected parameter and eight-character code word for each sensitivity parameter is shown as follows:

Affected Parameter	Code Word
Atmospheric Pressure	PRESSURE
Background NH3-N Sediment Source Rate	NH3 SRCE
Background PO4-P Sediment Source Rate	PO4 SRCE
Background Sediment Oxygen Demand	SOD
BOD1 Aerobic Decay Rate	BOD1 DEC
BOD1 Anaerobic Decay Rate	BOD1 ANA
BOD1 Settling Rate	BOD1 SET
BOD2 Aerobic Decay Rate	BOD2 DEC
BOD2 Anaerobic Decay Rate	BOD2 ANA
BOD2 Hydrolysis Rate	BOD2 HYD
BOD2 Settling Rate	BOD2 SET
Chlorophyll <i>a</i> /Phytoplankton Ratio	ARATIO
Coliform Die-off Rate	COLI DIE
Dam Coefficient A	DAM A
Dam Coefficient B	DAM B
Dam Height H	DAM H
Denitrification Rate	DENTRIF
Evaporation Rate	EVAPORAT
Headwater BOD #1	HDW BOD1
Headwater BOD #2	HDW BOD2
Headwater Coliform	HDW COLI
Headwater Conservative Material 1	HDW CON1
Headwater Conservative Material 2	HDW CON2
Headwater Dissolved Oxygen	HDW DO
Headwater Flow	HDW FLOW
Headwater NBOD	HDW NBOD
Headwater NH3-N	HDW NH3
Headwater NO3-N	HDW NO3
Headwater Nonconservative Material	HDW NCM
Headwater Organic Nitrogen	HDW ORGN
Headwater Organic Phosphorus	HDW ORGP
Headwater Phytoplankton (as chlorophyll <i>a</i>)	HDW CHLO
Headwater PO4-P	HDW PO4
Headwater Salinity	HDW SALI
Headwater Temperature	HDW TEMP
Incremental BOD #1	INC BOD1
Incremental BOD #2	INC BOD2
Incremental Coliform	INC COLI
Incremental Conservative Material 1	INC CON1
Incremental Conservative Material 2	INC CON2
Incremental Dissolved Oxygen	INC DO
Incremental Flow (inflow)	INC INFL

Incremental Flow (outflow)	INC OUTF
Incremental NBOD	INC NBOD
Incremental NH3-N	INC NH3
Incremental NO3-N	INC NO3
Incremental Nonconservative Material	INC NCM
Incremental Organic Nitrogen	INC ORGN
Incremental Organic Phosphorus	INC ORGP
Incremental Phytoplankton (as chlorophyll <u>a</u>)	INC CHLO
Incremental PO4-P	INC PO4
Incremental Salinity	INC SALI
Incremental Temperature	INC TEMP
Initial Periphyton	PERIPHYT
Initial Phytoplankton (as chlorophyll <u>a</u>)	CHLOR A
Initial Salinity	SALINITY
Initial Temperature	TEMPERAT
Lower Boundary Condition BOD #1	LBC BOD1
Lower Boundary Condition BOD #2	LBC BOD2
Lower Boundary Condition Coliform	LBC COLI
Lower Boundary Condition Conservative Material 1	LBC CON1
Lower Boundary Condition Conservative Material 2	LBC CON2
Lower Boundary Condition Dissolved Oxygen	LBC DO
Lower Boundary Condition NBOD	LBC NBOD
Lower Boundary Condition NH3-N	LBC NH3
Lower Boundary Condition NO3-N	LBC NO3
Lower Boundary Condition Nonconservative Material	LBC NCM
Lower Boundary Condition Organic Nitrogen	LBC ORGN
Lower Boundary Condition Organic Phosphorus	LBC ORGP
Lower Boundary Condition Phytoplankton (as chlorophyll <u>a</u>)	LBC CHLO
Lower Boundary Condition PO4-P	LBC PO4
Lower Boundary Condition Salinity	LBC SALI
Lower Boundary Condition Temperature	LBC TEMP
NBOD Decay Rate	NBOD DEC
NBOD Settling Rate	NBOD SET
NH3-N Decay Rate (nitrification)	NH3 DECA
Nonconservative Material Decay Rate	NCM DECA
Nonconservative Material Settling Rate	NCM SETT
Non-Point Source BOD #1	NPS BOD1
Non-Point Source BOD #2	NPS BOD2
Non-Point Source Coliform	NPS COLI
Non-Point Source Conservative Material 1	NPS CON1
Non-Point Source Conservative Material 2	NPS CON2
Non-Point Source Dissolved Oxygen	NPS DO
Non-Point Source NBOD	NPS NBOD
Non-Point Source NH3-N	NPS NH3
Non-Point Source NO3-N	NPS NO3
Non-Point Source Nonconservative Material	NPS NCM
Non-Point Source Organic Nitrogen	NPS ORGN
Non-Point Source Organic Phosphorus	NPS ORGP
Non-Point Source PO4-P	NPS PO4
Non-Point Source Salinity	NPS SALI
Ocean Exchange Ratio	OXR
Organic Nitrogen Hydrolysis Rate	ORGN HYD
Organic Nitrogen Settling Rate	ORGN SET
Organic Phosphorus Hydrolysis Rate	ORGP HYD
Organic Phosphorus Settling Rate	ORGP SET
Periphyton Death Rate	PERIP DE
Periphyton Growth Rate	PERIP GR
Periphyton Respiration Rate	PERIP RE

Phytoplankton Death Rate	PHYTO DE
Phytoplankton Growth Rate	PHYTO GR
Phytoplankton Respiration Rate	PHYTO RE
Phytoplankton Settling Rate	PHYTO SE
Secchi Disc Depth	SECCHI
Stream Baseflow	BASEFLOW
Stream Depth	DEPTH
Stream Dispersion	DISPERSI
Stream Reaeration	REAERATI
Stream Velocity	VELOCITY
Temperature, Dry Bulb	DRY BULB
Temperature, Wet Bulb	WET BULB
Tidal Range	TRANGE
Waste Load BOD #1	WSL BOD1
Waste Load BOD #2	WSL BOD2
Waste Load Coliform	WSL COLI
Waste Load Conservative Material 1	WSL CON1
Waste Load Conservative Material 2	WSL CON2
Waste Load Dissolved Oxygen	WSL DO
Waste Load Flow	WSL FLOW
Waste Load NBOD	WSL NBOD
Waste Load NH3-N	WSL NH3
Waste Load NO3-N	WSL NO3
Waste Load Nonconservative Material	WSL NCM
Waste Load Organic Nitrogen	WSL ORGN
Waste Load Organic Phosphorus	WSL ORGP
Waste Load Phytoplankton (as chlorophyll <u>a</u>)	WSL CHLO
Waste Load PO4-P	WSL PO4
Waste Load Salinity	WSL SALI
Waste Load Temperature	WSL TEMP
Width	WIDTH
Wind Speed	WIND

Caution: Temperatures must be input as degrees, not as percentages.

If Sensitivity Analysis and Graphics Display have been checked in Preferences, upon execution of the model simulation, the user can view the sensitivity of certain constituents and coefficients to the sensitivity parameters specified in this data type. The constituent/coefficient to be viewed can be selected using the appropriate button in the plot display. The <S, -S, S+, and S> buttons located above the graphics to the far right allow the user to scroll through the different sensitivity parameters specified in the input data set. A Sensitivity Table which summarizes the sensitivity parameters specified in the input data set is generated whenever the Sensitivity Analysis is run. It may be viewed by selecting it under the View menu. The filename is the same name as the input set with the extension of .SNT.

IMPORTANT: The last line of this group must read “ENDATA29”, left justified, even if the data are deleted.

DATA TYPE 30 – PLOT CONTROL DATA

These data control the constituent plots and the special report sensitivity table and are required only if graphic capability or the sensitivity table is desired. Otherwise, they may be omitted. The main stem and/or tributaries may be plotted. **There is a maximum of 21 plots.** For each plot requested, two line types are necessary.

Line Type 1

The first line type gives the plot number, optional plot abbreviation, and optional plot title. Providing a plot abbreviation here labels the plot button in the graphical display with the abbreviation rather than the default action of simply showing the plot number. Providing a plot title here labels the plot with the plot title rather than the default action of using the name of the headwater.

Keyword Indicating Line Type: PLT	Columns 1-3 (A3)
Number Corresponding to Plot Number	Columns 4-5 (I2)
Plot Abbreviation (optional)	Columns 7-9 (A3)
Plot Title (optional)	Columns 11-40 (A30)

Line Type 2

The second line type gives the reach numbers to be plotted. The reach numbers do not need to be in specific columns but must be separated by at least one space and may not extend beyond Column 124. No more than 40 reaches may be specified on a single RCH line. A second RCH line may be used if there are more than 40 reaches in the plot.

Keyword Indicating Line Type: RCH	Columns 1-3 (A3)
Reaches to be Plotted (each reach separated by a space)	Columns 5-84 (I)

The format of the plot control data has changed from the format used in the earliest versions of this model. These previous formats are deprecated but will normally be detected by the program and will continue to be accepted without errors although they are not documented here. If any changes are required to legacy formats, it is recommended that the data be reformatted to the format described above.

IMPORTANT: The last line of this group must read “ENDATA30”, left justified, even if the data are deleted.

DATA TYPE 31 – OVERLAY FILENAMES

These data complement the Plot Control Data (Data Type 30) and identify the file name of the overlay datafiles. The overlay data files add the ability to overlay the predicted profiles with observed averages and ranges of water quality constituents and hydraulics. Overlay plots are useful visual tools for the calibration and verification procedures as well as comparison to water quality criteria. Identification of the file name of the overlay data file(s) is required only for each plot in Data Type 30 for which display of this overlay data is desired. Graphics Display in the Preferences menu must be enabled for the overlays to be displayed on screen.

Generally, all of the data for a given mainstem or tributary can be contained in a single file. It is not necessary to split it into multiple files even though there may be multiple plots along a single stream or tributary. The graphic overlay routine is capable of selecting the data it needs for the particular reaches being plotted. Therefore, the same overlay datafile can be used for multiple plots even though each plot may represent a different part of the stream. If there are multiple streams or tributaries, multiple overlay plots will be necessary.

The following is the format for identifying the name of the file which contains the overlay data. The format for the file which contains the actual overlay data is shown on the following page of this manual.

Keyword: OVERLAY	Column 1-7 (A7)
Number Corresponding to Plot Number	Column 8-9 (I2)
Flag to Skip Overlay Data in Performance Measure Calculations [set to “-” (hyphen) to skip; otherwise blank]	Column 10 (A1)
Filename of Overlay Datafile	Columns 11-40 (A30)

The format of the overlay plot data has changed from the format used in the earliest versions of this model. These previous formats are deprecated but should be detected by the program and should continue to be accepted without errors although they are not documented here. However, if any changes are required to legacy formats, it is recommended that the data be reformatted to the format described above.

IMPORTANT: The last line of this group must read “ENDATA31”, left justified, even if the data are deleted.

OVERLAY FILE FORMAT

The overlay file can contain several types of information: 1) station data which gives minimum, average, and maximum parameter values for various locations, 2) segment boundaries, 3) water quality standards criteria for specified parameters, and 4) marking lines for arbitrary use. The overlay file must be contained in the same directory as the input data set. It can have any name and extension but the length of the name must not exceed 30 characters including the extension. A file extension of .OVL is recommended but not required. All blank lines and all lines that begin with an exclamation point (!) will be ignored. Lines beginning with an exclamation point can be used for comments.

The Table of Codes has changed from the ones used in the earliest versions of this model. These changes are too extensive to allow all legacy formats and code numbers to be accepted. If the overlay file contains legacy code numbers, it is recommended that the code number in the overlay files be renumbered to match the Table of Codes shown below. In addition, if any of the code numbers (as shown in the Table of Codes below) were used in overlay files prior to Version 9.0 of this model and are higher than 19, the code number in the overlay files must be renumbered to match the Table of Codes shown below.

River distances are input as kilometer or miles, depending upon whether the Metric or English units option has been selected. The following is the format for each type of information in the overlay file:

Station Data

Station data is specified by a Station Location card followed immediately by any number of Parameter Value line entries for data related to that station. This set of line entries is repeated for each station location. The Station Location card gives information concerning the location of a station along the stream. The Parameter Value line entries give the minimum, average, and maximum values of parameters measured at that location. Any combination of the average and/or range (maximum and minimum) may be specified. **Data for up to 200 stations may be entered.** Any number or types of parameters may be specified for each station location, and they need not be the same from station to station.

Station Location Line Entry

Line Identifier (must be "STA")	Columns 1- 3 (A3)
Station Label (optional)	Columns 9-11 (A3)
Location of Station (kilometers or miles)	Columns 23-32 (F10.0)
Performance Measures Group Code (letters must be capitalized)	Column 34 (A1)

Parameter Value Line Entry

Parameter Code (see table of codes)	Columns 1- 2 (I2)
Flag to Ignore as Outlier in Performance Measures [set to "--" (hyphen) to ignore; otherwise blank]	Column 3 (A1)
Minimum Value	Columns 6-15 (F10.0)
Average Value	Columns 16-25 (F10.0)
Maximum Value	Columns 26-35 (F10.0)

Table of Codes (legacy numbers in parenthesis):

1 = Temperature (10)	21 = Total Phosphorus	41 = Reaeration Rate	61 = Flow
2 = Salinity (9)	22 = Total BOD	42 =	62 = Dispersion
3 = Conservative #1 (7)	23 = Effective Total BOD	43 =	63 = Depth
4 = Conservative #2 (8)	24 = Effective Organic N	44 = Sediment Oxygen Demand	64 = Width
5 = Dissolved Oxygen (1)	25 = Effective Total N	45 =	65 = Advective Velocity
6 = Effective BOD1 (2)	26 = Effective Organic P	46 = Sediment Nitrogen Rate	66 = Mean Velocity
7 = BOD1	27 = Effective Total P	47 =	
8 = Organic Nitrogen (4)	28 = Effective NCM	48 =	
9 = Ammonia Nitrogen (3)	29 =	49 =	
10 = Nitrate Nitrogen (5)	30 =	50 =	
11 = Total Nitrogen	31 =	51 =	
12 = Inorganic Phosphorus (6)	32 = Phytoplankton Growth	52 =	
13 = Chlorophyll a (11)	33 = Periphyton Growth	53 =	
14 = Coliform	34 = Sediment Phosphorus Rate	54 =	
15 = Nonconservative (12)	35 =	55 =	
16 = Effective BOD2	36 =	56 =	
17 = BOD 2	37 =	57 =	
18 = NBOD	38 =	58 =	
19 = Periphyton	39 =	59 =	
20 = Organic Phosphorus	40 =	60 = Secchi Depth	

The legacy numbers for parameters shown in parenthesis will continue to work, but only with the legacy format. If any changes are made to legacy datafiles, it is recommended that all parameter codes be revised. If the legacy format is changed to the format documented here, the parameter codes numbers must be revised.

Water Quality Standards

These line entries cause a horizontal dashed line representing the numerical water quality criteria to be placed on the graphic plots. Two different sets of criteria may be specified (set 1 line color default=green; set 2 line color default=magenta). If you want a two-letter identification of the criteria set to appear in the plot legend, begin with the following line entry:

Line Identifier*	Columns 1- 3 (A3)
Parameter Code (must be "00")	Columns 5- 6 (I2)
Legend Identifier	Columns 8-9 (A2)

The standards criteria are specified using the following format (up to 30 line entries per criteria set may be specified):

Line Identifier*	Columns 1- 3 (A3)
Parameter Code (see table of codes)	Columns 5- 6 (I2)
Numerical Criteria	Columns 8-17 (F10.0)
Upstream River Distance (kilometers or miles)	Columns 18-27 (F10.0)
Downstream River Distance (kilometers or miles)	Columns 28-37 (F10.0)

*must be "STD" or "ST1" for criteria set 1 or "ST2" for criteria set 2

Segment Boundaries

This line entry causes a vertical line (default=blue) to be placed on the graphic plots at the location of a segment boundary. Up to 10 line entries may be made.

Line Identifier (must be "SEG")	Columns 1- 3 (A3)
Location of Boundary (kilometers or miles)	Columns 5-14 (F10.0)

Marking Lines

This card causes a vertical line (default=magenta) with label to be placed on the graphic plots at a given location. Up to 30 line entries may be made.

Line Identifier (must be "MRK")	Columns 1- 3 (A3)
Location of Marking Line (kilometers or miles)	Columns 5-14 (F10.0)
Label for Marking Line	Columns 16-55 (A40)

IMPORTANT: The last line in the file must read "END", left justified.

Example:

	1	2	3	4	5	6
123456789012345678901234567890123456789012345678901234567890						
STATION A	KILOMETER	6.3				
05	5.8	6.2	7.5			
06	1.3	2.8	4.2			
STATION B	KILOMETER	3.4				
05	4.5	4.8	4.9			
06	1.1	1.5	3.2			
MRK	2.30	TIDAL	BOUNDARY			
STD 05	5.0	6.5	2.3			
STD 05	4.0	2.3	0.0			
END						

MODEL PERFORMANCE MEASURES

The model predictions can be compared to the observed data in the overlay files to provide a statistical measure of model performance. Performance measures will be calculated when “Generate Comma-delimited File and Performance Measures” is checked in the Preferences menu and the “Elements with Observed Data” option is selected.

Performance measures need not be calculated for all of the parameters or using all of the observed data in the overlay files. There are four methods to limit the calculations:

- 1) The parameters to be included can be limited by the parameters checked under “Constituents to Include in Performance Measures” in the Additional Preferences menu.
- 2) All of the observed data can be ignored in any single overlay file (see Data Type 31, Column 10).
- 3) Observed data from individual stations can be labeled as belonging to certain groups (see Overlay File Format, “Performance Measures Group Code” under “Stations Location Line Entry”) and then selected by group in the Preferences menu. If desired, up to three groups can be combined and selected for calculating performance measures.
- 4) Individual data values can be ignored as being an outlier (see Overlay File Format, “Flag to Ignore as Outlier in Performance Measures” under “Stations Location Line Entry”)

Several performance measure statistics are provided: 1) difference, 2) absolute difference, and 3) percent absolute error (also known as percent relative difference). The absolute percentage error (or percent relative difference) can be calculated in several different ways depending on the goal of the performance measures analysis. In general, it is calculated as the absolute difference of the predicted and observed values (the numerator) divided by the absolute value of a function of the predicted and observed values (the denominator). Two methods of calculating the function used in the denominator have been utilized in this model. Method 1 uses, in the denominator of the formula, the absolute value of the average of the simulated data point and corresponding observed data point; Method 2 uses, in the denominator of the formula, simply the absolute value of the observed data point. The performance measure statistics are calculated by the following formulas:

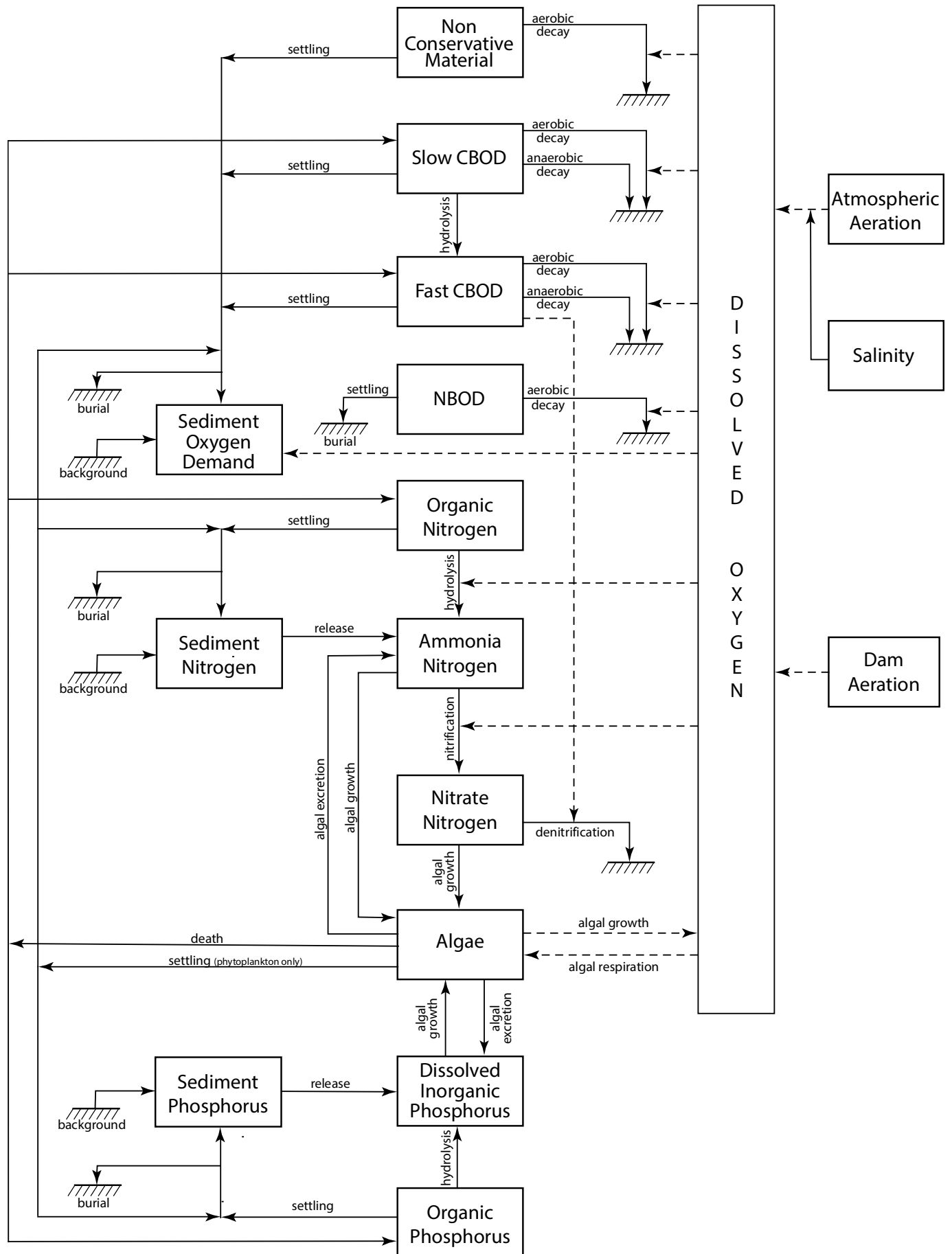
$$\text{Difference} = \text{predicted} - \text{observed}$$

$$\text{Absolute Difference} = | \text{predicted} - \text{observed} |$$

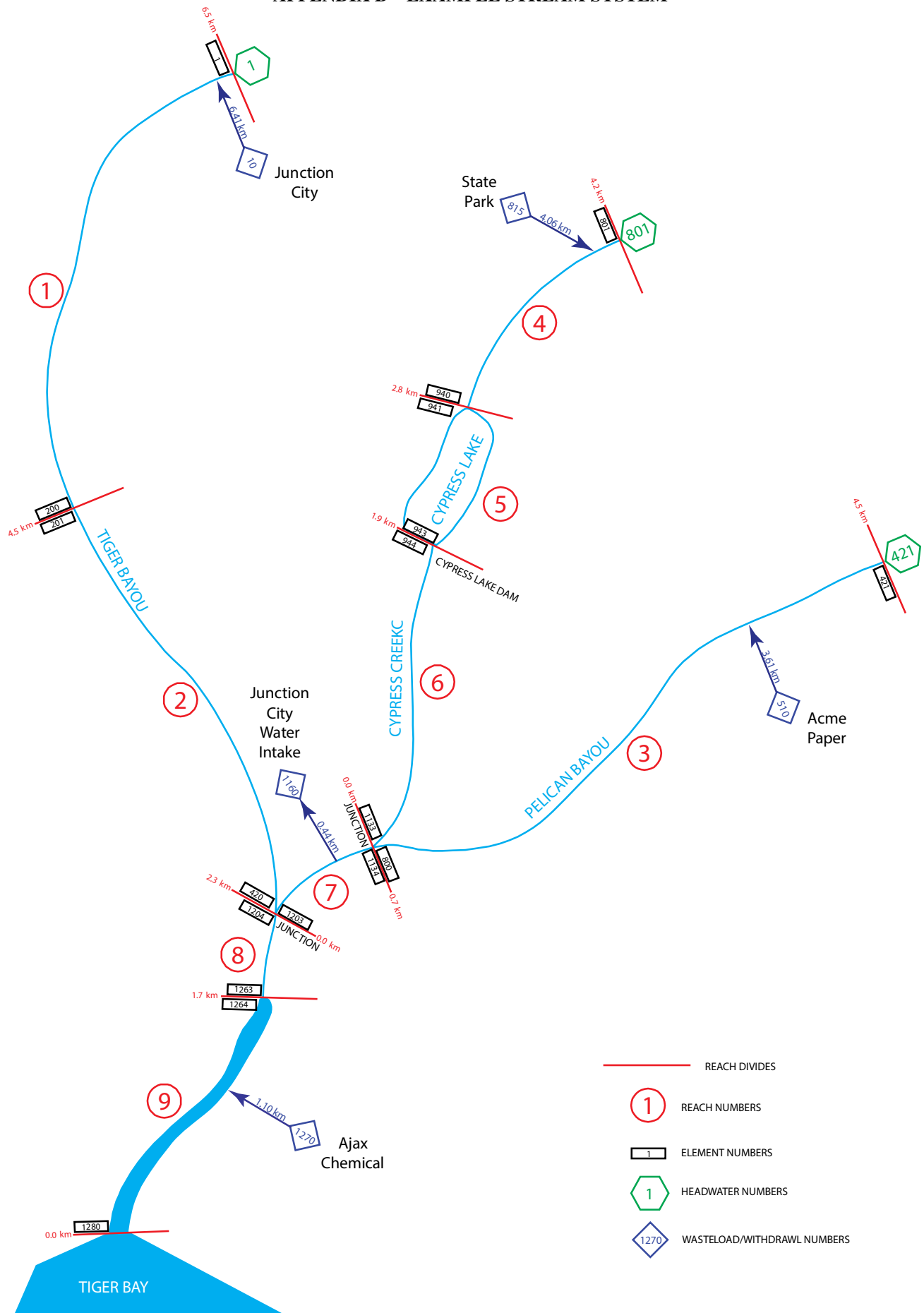
$$\text{Absolute Percentage Error (Method 1)} = \frac{| \text{predicted} - \text{observed} |}{| (\text{predicted} + \text{observed}) / 2 |} \times 100$$

$$\text{Absolute Percentage Error (Method 2)} = \frac{| \text{predicted} - \text{observed} |}{| \text{observed} |} \times 100$$

APPENDIX A – CONSTITUENT INTERACTIONS



APPENDIX B – EXAMPLE STREAM SYSTEM



APPENDIX C - SAMPLE DATA INPUT

```

!-----1-----2-----3-----4-----5-----6-----7-----8-----9-----0-----1-----2-----3-----4-----5
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
!
*****
TITLE01      EXAMPLE DATA SET
TITLE02      FOR TESTING MODEL
!
! Y/N CODE
! --- *****
CONTROL YES  METRIC UNITS
CONTROL YES  USE EFFECTIVE
ENDATA01
! Y/N CODE          CONSTITUENT LONG NAME          UNITS    SHORT NAME
! --- *****
MODOPT NO  TEMPERATURE
MODOPT YES SALINITY
MODOPT YES  CONSERVATIVE MATERIAL I = CONDUCTIVITY          IN µmohs/cm Conduct.
MODOPT YES  CONSERVATIVE MATERIAL II = ALUMINUM             IN µg/L      Aluminum
MODOPT YES  DISSOLVED OXYGEN
MODOPT YES  BOD1 BIOCHEMICAL OXYGEN DEMAND
MODOPT YES  BOD2 BIOCHEMICAL OXYGEN DEMAND
MODOPT YES  NITROGEN
MODOPT YES  PHOSPHORUS
MODOPT YES  PHYTOPLANKTON (AS CHLOROPHYLL A)
MODOPT NO  PERIPHYTON
MODOPT YES  COLIFORM
MODOPT YES  NONCONSERVATIVE MATERIAL =                      IN µg/L
ENDATA02
! CODE          VALUE
! *****
PROGRAM HYDRAULIC CALCULATION METHOD          = 2.
PROGRAM MAXIMUM ITERATION LIMIT              = 500.
PROGRAM BOD1 OXYGEN UPTAKE RATE              = 2.3
PROGRAM BOD2 OXYGEN UPTAKE RATE              = 2.3
PROGRAM NCM OXYGEN UPTAKE RATE                = 0.0
ENDATA03
! CODE          VALUE
! *****
THETA NH3 DECA      1.07
THETA BENTHAL       1.065
THETA NCM DECA      1.07
ENDATA04
! CODE          VALUE
! *****
TEMP LATITUDE       = 30.
TEMP LONGITUDE      = 92.
TEMP ELEVATION       = 100.
ENDATA05
! CODE          VALUE
! *****
PHYTO O PROD DUE TO GROWTH          = 1.6
PHYTO O UPTAKE DUE TO RESP          = 2.0
PHYTO C CONTENT                    = 0.400
PHYTO N CONTENT                    = 0.085
PHYTO P CONTENT                    = 0.013
ENDATA06
! CODE          VALUE
! *****
PERIP O PROD DUE TO GROWTH          = 1.6
PERIP O UPTAKE DUE TO RESP          = 2.0
PERIP C CONTENT                    = 0.400
PERIP N CONTENT                    = 0.085
PERIP P CONTENT                    = 0.013
ENDATA07
! R#  ID  REACH NAME          RKM      RKM      LENGTH
! ***  -- *****
REACH ID  1  TB UPPER TIGER BAYOU          6.5      4.5      0.01
REACH ID  2  TB TIGER BAYOU ABOVE TIDAL    4.5      2.3      0.01
REACH ID  3  PB UPPER PELICAN BAYOU        4.5      0.7      0.01
REACH ID  4  CC UPPER CYPRESS CREEK        4.2      2.8      0.01
REACH ID  5  CC CYPRESS LAKE               2.8      1.9      0.30
REACH ID  6  CC LOWER CYPRESS CREEK        1.9      0.0      0.01
REACH ID  7  PB LOWER PELICAN BAYOU        0.7      0.0      0.01
REACH ID  8  TB TIGER BAYOU UPPER TIDAL    2.3      1.7      0.01
REACH ID  9  TB TIGER BAYOU LOWER TIDAL    1.7      0.0      0.10
ENDATA08
!
!
! R#  a      b      c      d      e      f
! R#  COEFF  EXP  WIDTH DEPTH DEPTH DEPTH
! ***  f-----*****-----*****-----*****-----
HYDR-1  1  15.00  0.10  0.0  3.00  0.50  0.00      0.035  0.00
HYDR-1  2  15.00  0.10  0.0  3.00  0.50  0.00      0.035  0.00
HYDR-1  3  5.00   0.10  0.0  2.00  0.50  0.00      0.035  0.00
HYDR-1  4  5.00   0.10  0.0  2.00  0.50  0.00      0.035  0.00
HYDR-1  5  0.00   0.00 300.0 0.00  0.00  3.00      0.035  0.00
HYDR-1  6  5.00   0.10  0.0  2.00  0.50  0.00      0.035  0.00
HYDR-1  7  5.00   0.10  0.0  2.00  0.50  0.00      0.035  0.00
HYDR-1  8  0.00   0.00 20.0  0.00  0.00  2.00      0.035  0.00
HYDR-1  9  0.00   0.00 100.0 0.00  0.00  2.50      0.035  0.00
ENDATA09
! R#  RANGE  a      b      c      d
! ***  -----*****-----*****-----
HYDR-2  5  0.00   0.3      0.0      0.0      0.0
HYDR-2  8  0.50   10.      0.0      0.0      0.0
HYDR-2  9  1.00   30.      0.0      0.0      0.0
ENDATA10

```

APPENDIX C - SAMPLE DATA INPUT (continued)

!	R#	TEMP	SALINITY	DO	NH3-N	NO3-N	PO4-P	CHL A	PERIP	BOD1	BOD2	ORG-N	ORG-P	COLI	NCM	CM-I	CM-II
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
INITIAL	1	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	2	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	3	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	4	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	5	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	6	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	7	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	8	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
INITIAL	9	30.0	0.0	5.00	0.1	0.1	0.1	0.	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0
ENDATA11																	
!	REARC	a	b	c		BOD1	BOD1	SETT	BOD1	BOD2	BOD2		BOD2	BOD2			
!	R#	EQN	K2	K2	K2	SOD	DECAY	SETT	AVAIL	ANAER	DECAY	SETT		ANAER	HYDR		
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
COEF-1	1	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	2	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	3	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	4	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	5	20.	1.0			0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	6	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	7	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	8	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
COEF-1	9	3.				0.20	0.10	0.05	0.50	0.05	0.05	0.02		0.02	0.10		
ENDATA12																	
!	ORGN	ORGN	ORGN	NH3	NH3	PO4	DENIT	ORGP	ORGP	ORGP							
!	R#	DECAY	SETT	AVAIL	DEC	SRC	RATE	DEC	SETT	AVAIL							
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
COEF-2	1	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	2	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	3	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	4	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	5	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	6	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	7	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	8	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
COEF-2	9	0.10	0.00	0.50	0.30	0.00	0.01	0.02	0.05	0.10	0.50						
ENDATA13																	
!	CHL/ALG	PHYTO	PHYTO	PHYTO	PHYTO	PERIP	PERIP	PERIP	PERIP	BANK							
!	R#	SECCHI	RATIO	SETT	DEATH	GROW	RESP	DEATH	GROW	RESP	SHADE						
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
COEF-3	1	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	2	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	3	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	4	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	5	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	6	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	7	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	8	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
COEF-3	9	1.00	0.010	0.05	0.10	2.00	0.20	0.10	1.00	0.1	0.02						
ENDATA14																	
!	COLI	NCM	NCM														
!	R#	DECAY	DECAY	SETT													
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
COEF-4	1	0.40	0.20	0.05													
COEF-4	2	0.40	0.20	0.05													
COEF-4	3	0.40	0.20	0.05													
COEF-4	4	0.40	0.20	0.05													
COEF-4	5	0.40	0.20	0.05													
COEF-4	6	0.40	0.20	0.05													
COEF-4	7	0.40	0.20	0.05													
COEF-4	8	0.40	0.20	0.05													
COEF-4	9	0.40	0.20	0.05													
ENDATA15																	
!	R#	OUTFLOW	INFLOW	TEMP	SALIN	CM-I	CM-II										
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
INCR-1	1		0.01		0.0	0.0	0.0										
INCR-1	5	-0.1															
ENDATA16																	
!	R#	DO	BOD1	ORG-N	NH3-N	NO2-N	BOD2										
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
INCR-2	1	0.0	0.0	0.0	0.0	0.0	0.0										
INCR-2	5																
ENDATA17																	
!	R#	PO4-P	CHL-A	COLI	NCM	ORG-P											
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
INCR-3	1	0.0	0.0	15.	0.0	0.0											
INCR-3	5																
ENDATA18																	
!	R#	BOD1	ORG-N	COLI	NCM	DO	BOD2	ORG-P	NH3-N	NO3-N	PO4-P	SALIN	CM-1	CM-2			
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
NONPOINT	1	5.00	1.00	10.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00			
NONPOINT	3	5.00	1.00	0.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00			
NONPOINT	4	5.00	1.00	10.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00			
NONPOINT	5	5.00	1.00	10.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00			
ENDATA19																	
!	E#	STREAM NAME			FLOW	TEMP	SALIN	CM-I	CM-II	HDISP							
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
HDWTR-1	1	TIGER BAYOU			0.20		0.0	0.0	0.0								
HDWTR-1	421	PELICAN BAYOU			0.20		0.0	0.0	0.0								
HDWTR-1	801	CYPRESS BAYOU			0.40		0.0	0.0	0.0								
ENDATA20																	
!	E#	DO	BOD1	ORG-N	NH3-N	NO3-N	BOD2										
!	***	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
HDWTR-2	1	6.8	1.00	0.20	0.10	0.10	0.00										
HDWTR-2	421	6.8	1.00	0.20	0.10	0.10	0.00										
HDWTR-2	801	6.8	1.00	0.20	0.10	0.10	0.00										
ENDATA21																	

APPENDIX C - SAMPLE DATA INPUT (continued)

```

!      E#      PO4-P      CHL-A      COLI      NCM      ORG-P
!      ****      -----*****-----*****-----
HDWTR-3      1      0.01      1.0      1.      0.00      0.20
HDWTR-3      421      0.01      1.0      0.      0.00      0.20
HDWTR-3      801      0.01      1.0      0.      0.00      0.20
ENDATA22
!      JE#      ME#      JUNCTION NAME
!      ****      -----*****-----*****-----
JUNCTION      1134      800      PELICAN BAYOU AND CYPRESS CREEK
JUNCTION      1204      420      TIGER BAYOU AND PELICAN BAYOU
ENDATA23
!      E#      WASTELOAD NAME      FLOW      TEMP      SALIN      CM-I      CM-II
!      ****      f-----*****-----*****-----*****
WSTLD-1      10      JUNCTION CITY WWTP      0.050      0.00      0.0      0.
WSTLD-1      510      ACME PAPER      0.050      0.00      0.0      0.
WSTLD-1      815      STATE PARK WWTP      0.010      0.00      0.0      0.
WSTLD-1      1160      CITY WATER INTAKE      -0.200
WSTLD-1      1270      AJAX CHEMICAL      0.100      0.00      20000.      1000.
ENDATA24
!      E#      DO      BOD1      ORG-N      NH3-N      NO3-N      BOD2
!      ****      -----*****-----*****-----*****
WSTLD-2      10      4.0      10.0      1.0      3.0      6.0      0.0
WSTLD-2      510      4.0      5.0      1.0      2.0      0.5      20.0
WSTLD-2      815      4.0      20.0      1.0      8.0      1.0      0.0
WSTLD-2      1160
WSTLD-2      1270      4.0      20.0      1.0      5.0      0.5      2.0
ENDATA25
!      E#      PO4-P      CHL-A      COLI      NCM      ORG-P
!      ****      -----*****-----*****-----
WSTLD-3      10      4.00      0.0      0.0      0.0      1.0
WSTLD-3      510      0.50      0.0      0.0      0.0      0.1
WSTLD-3      815      4.00      0.0      1E5      0.0      1.0
WSTLD-3      1160
WSTLD-3      1270      0.00      0.0      0.0      10.0      0.5
ENDATA26
!      CODE      VALUE
!      *****-----*****
LOWER BC TEMPERATURE      =      30.00
LOWER BC SALINITY      =      20.00
LOWER BC CONSERVATIVE MATERIAL #1      =      10000.
LOWER BC CONSERVATIVE MATERIAL #2      =      0.00
LOWER BC DISSOLVED OXYGEN      =      6.00
LOWER BC BOD1 BIOCHEMICAL OXYGEN DEMAND      =      1.00
LOWER BC BOD2 BIOCHEMICAL OXYGEN DEMAND      =      0.01
LOWER BC ORGANIC NITROGEN      =      0.05
LOWER BC AMMONIA NITROGEN      =      0.10
LOWER BC NITRATE NITROGEN      =      0.10
LOWER BC PO4 PHOSPHORUS      =      0.10
LOWER BC ORG PHOSPHORUS      =      0.05
LOWER BC PHYTOPLANKTON (AS CHLOROPHYLL A)      =      0.00
LOWER BC COLIFORM      =      0.00
LOWER BC NONCONSERVATIVE MATERIAL      =      0.00
ENDATA27
!      DAM#      DAM NAME      EQN      A      B      C
!      ****      -----**-----*****-----
DAM DATA      944      CYPRESS LAKE DAM      1      1.6      0.6      3.05
ENDATA28
!      CODE      VALUE      VALUE
!      *****-----*****-----*****
SENSITIV BOD1 DEC      -20.0      20.0
SENSITIV BOD1 DEC      -40.0      40.0
ENDATA29
PLT01
RCH 1 2 8 9
PLT02
RCH 3 7
PLT03
RCH 4 5 6
ENDATA30
OVERLAY1 EXAMPLE-TIGER.OVL
OVERLAY2 EXAMPLE-PELICAN.OVL
OVERLAY3 EXAMPLE-CYPRESS.OVL
ENDATA31
!-----1-----2-----3-----4-----5-----6-----7-----8-----9-----0-----1-----2-----3-----4-----5
!234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

```


APPENDIX D – GRAPHIC SCREENS

Figure 1 - Main Menu

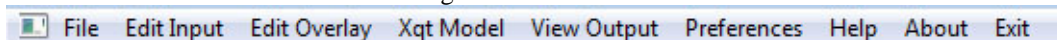


Figure 2 – Preferences

Preferences

Location of EXE file: Z:\Vortran\VFVLA-QUAL\LA-QUAL.exe
 Location of .INI File: Z:\Vortran\VFVLA-QUAL\laqual.ini
 Location of Help File: Z:\Vortran\VFVLA-QUAL\LA-QUAL User's Manual (v11.00).pdf

Model Assumptions: Texas (TCEQ) defaults

☐ Run Sensitivity Execution Mode: ☒ Steady-State ☐ Dynamic

Output to Display After Model Execution

- ☒ Graphical Plot
- ☐ Primary Report (plain-text)
- ☐ Primary Report (rich-text)
- ☐ Sensitivity Table
- ☐ Performance Measures (detailed)
- ☐ Performance Measures (summary)
- ☐ Tab-delimited File
- ☐ Nothing

Primary Report Options

- ☒ Echo Data Input
- ☒ Create Stream Configuration Summary
- ☐ Create Intermediate Reports
 - ☒ Dissolved Oxygen
 - ☐ Other Water Quality Constituents
 - ☐ Hydraulic Parameters
 - ☐ Biological/Physical Constants
- ☐ Create Capsule Report
 - ☒ Include Reach Inputs
 - ☐ Show Mainstem Only
- ☒ Create Final Report
 - ☒ Include Reach Inputs
 - ☒ Include Hydraulic Parameters
 - ☐ Include Additional Tidal Information
 - ☒ Include Biological/Physical Coefficients
 - ☒ Include Water Quality Constituents
 - ☐ Include Phytoplankton/Periphyton Data
 - ☐ Show Mainstem Only
- ☐ Create Reach Summary Report
- ☒ Create Stream Summary Report
- ☐ Create Loading Reports
 - ☒ Overall Summary for Entire System
 - ☒ Summary by Stream
 - ☒ Dissolved Oxygen by Element
- ☒ Create Min-Max Report
- ☐ Create Special Report Option:

☐ Create Tab-Delimited File Option:

Performance Measures Options

- ☐ Generate Comma-delimited File and Performance Measures
 - ☐ All Elements ☐ In Stream Order
 - ☐ Selected Elements ☐ In Element Order
 - ☐ Elements with Observed Data
 - Grouping: ☒ Ignore Marked Outliers

Graphical Plot Options

- ☐ Show Model Version ☐ Show Date of Run ☐ Show Name of Input File ☒ Show Min/Max Values
- ☒ Show Measured Values
 - ☒ With Labels above Measured Values
 - ☒ With Crossbars on Ranges
- ☒ Show Tributary Locations
 - ☒ With Tributary Names
- ☒ Show Wasteload Locations
 - ☒ With Wasteload Names
- ☒ Show Reach Locations (dashed line)
 - ☐ With No Descriptor ☐ With Number Only ☐ With Name Only ☒ With Number and Name
- ☒ Show Marker Lines
- ☐ Show Element Locations
- ☒ Show Segment Boundaries
- ☒ Show Standards Criteria 1
- ☒ Show Standards Criteria 2
- ☒ Show D.O. Saturation on D.O. Plot

Colors for Predicted Values Line Width for Predicted Values

Normal: ☐ Thin ☒ Thick

Sens 1: Sens 2:

Flow: Dissolved Oxygen:

Temperature: BOD 1:

Salinity: BOD 2:

Cons 1: N Series:

Cons 2: P Series:

NCM: Chlorophyll a:

Coliform:

Minimum Upper Plot Limit Concentration

Figure 3 – Additional Preferences

Additional Preferences

Model Assumptions: ☒ Louisiana (LaDEQ) defaults ☐ Suppress Popup Warning Message ☐ Save Plot Files

☐ Texas (TCEQ) defaults

Extension Default for Input Files: ☒ .IN, .INP ☐ .DAT ☐ .TXT ☐ All Extensions

Extension Default for Overlay Files: ☒ .OVL ☐ .TXT ☐ All Extensions

Input File Editor:

Plain Text Viewer:

Rich Text Viewer:

CSV Viewer:

Plot Capture Filename:

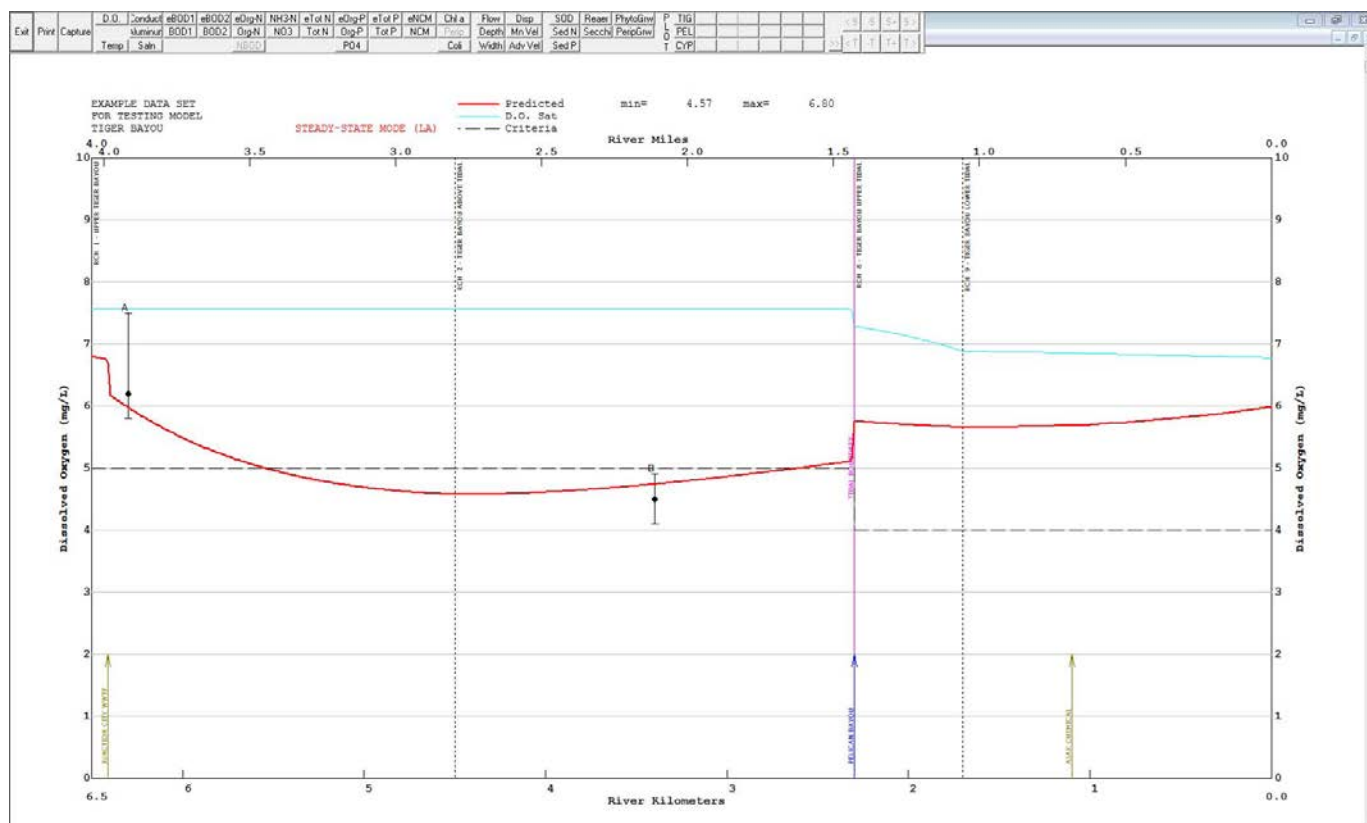
Initial Constituent When Plots First Display: Initial Plot When Plots First Display:

Constituents to Include in Performances Measures:

<input checked="" type="checkbox"/> Temperature	<input checked="" type="checkbox"/> Effective Organic N	<input checked="" type="checkbox"/> Effective Organic P	<input checked="" type="checkbox"/> Effective NCM
<input checked="" type="checkbox"/> Salinity	<input checked="" type="checkbox"/> Organic Nitrogen	<input checked="" type="checkbox"/> Organic Phosphorus	<input checked="" type="checkbox"/> NCM
<input checked="" type="checkbox"/> Conservative #1	<input checked="" type="checkbox"/> Ammonia Nitrogen	<input checked="" type="checkbox"/> Inorganic Phosphorus	<input checked="" type="checkbox"/> Coliform
<input checked="" type="checkbox"/> Conservative #2	<input checked="" type="checkbox"/> Nitrate Nitrogen	<input checked="" type="checkbox"/> Effective Total P	<input checked="" type="checkbox"/> Flow
<input checked="" type="checkbox"/> Dissolved Oxygen	<input checked="" type="checkbox"/> Effective Total N	<input checked="" type="checkbox"/> Total Phosphorus	<input checked="" type="checkbox"/> Depth
<input checked="" type="checkbox"/> Effective BOD1	<input checked="" type="checkbox"/> Total Nitrogen	<input checked="" type="checkbox"/> Chlorophyll a	<input checked="" type="checkbox"/> Width
<input checked="" type="checkbox"/> BOD1	<input checked="" type="checkbox"/> NBOD	<input checked="" type="checkbox"/> Periphyton	<input checked="" type="checkbox"/> Advective Velocity
<input checked="" type="checkbox"/> Effective BOD2			
<input checked="" type="checkbox"/> BOD2			

APPENDIX D – GRAPHIC SCREENS (continued)

Figure 4 – Plot Display Window



APPENDIX E – ELEMENT SIZE COMPARISON

The following six figures show the impact that element size has on predictions by comparing the “exact” prediction based on the Streeter-Phelps first-order equations (represented by the black dots) to the finite-difference predictions of LA-QUAL (represented by the red line) based on 6 different element sizes from 0.01 km to 5 km. The Streeter-Phelps “exact” solution predicts a minimum dissolved concentration of 0.73 mg/L. The actual magnitude of the differences depends on the hydraulics (specifically, the travel time) and the rate coefficients of a particular model.

Figure 1 (0.01 km element length; LA-QUAL predicted minimum D.O. = 0.73 mg/L)

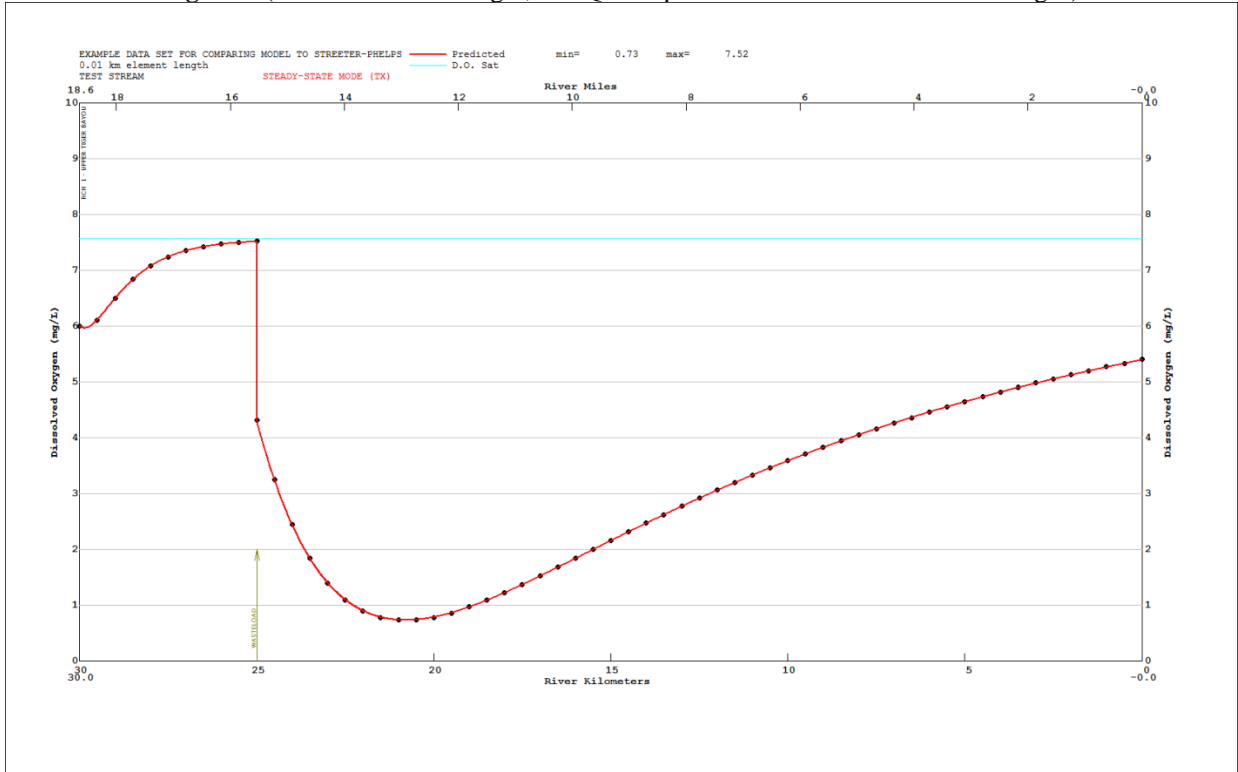
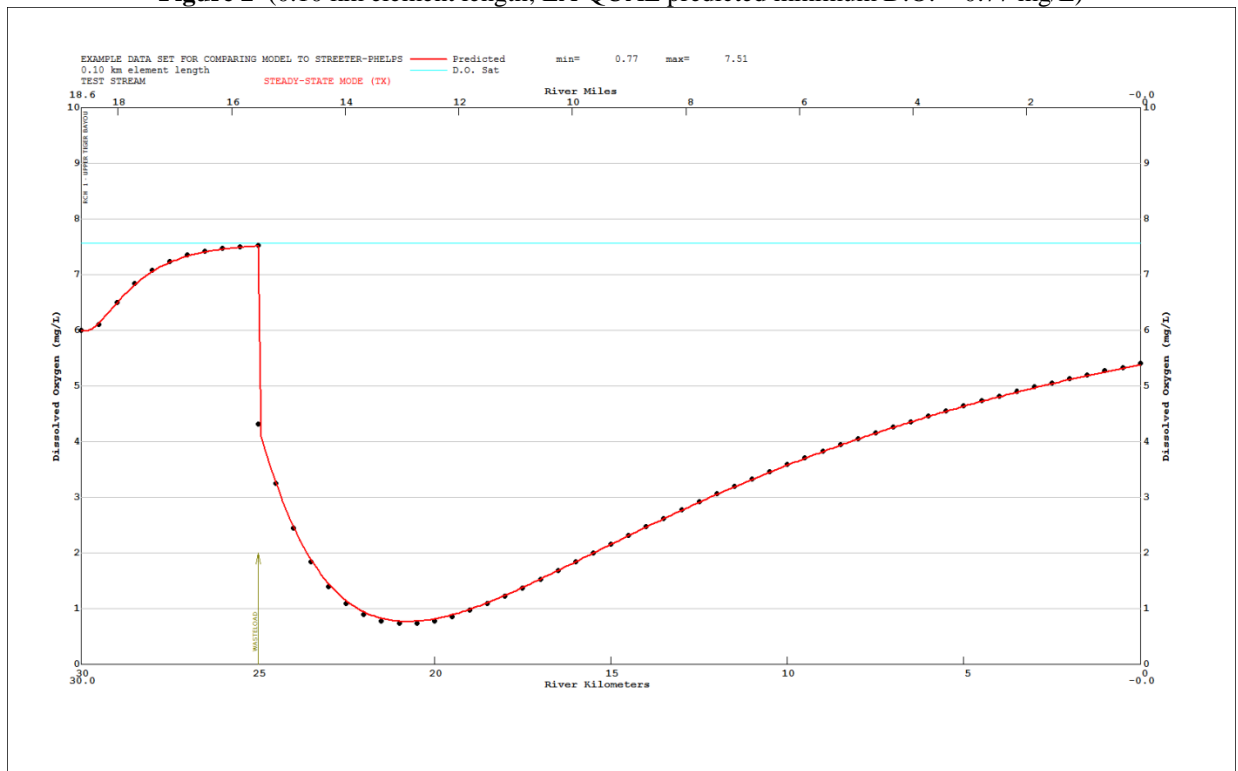


Figure 2 (0.10 km element length; LA-QUAL predicted minimum D.O. = 0.77 mg/L)



APPENDIX E – ELEMENT SIZE COMPARISON (continued)

Figure 3 (0.50 km element length; LA-QUAL predicted minimum D.O. = 0.91 mg/L)

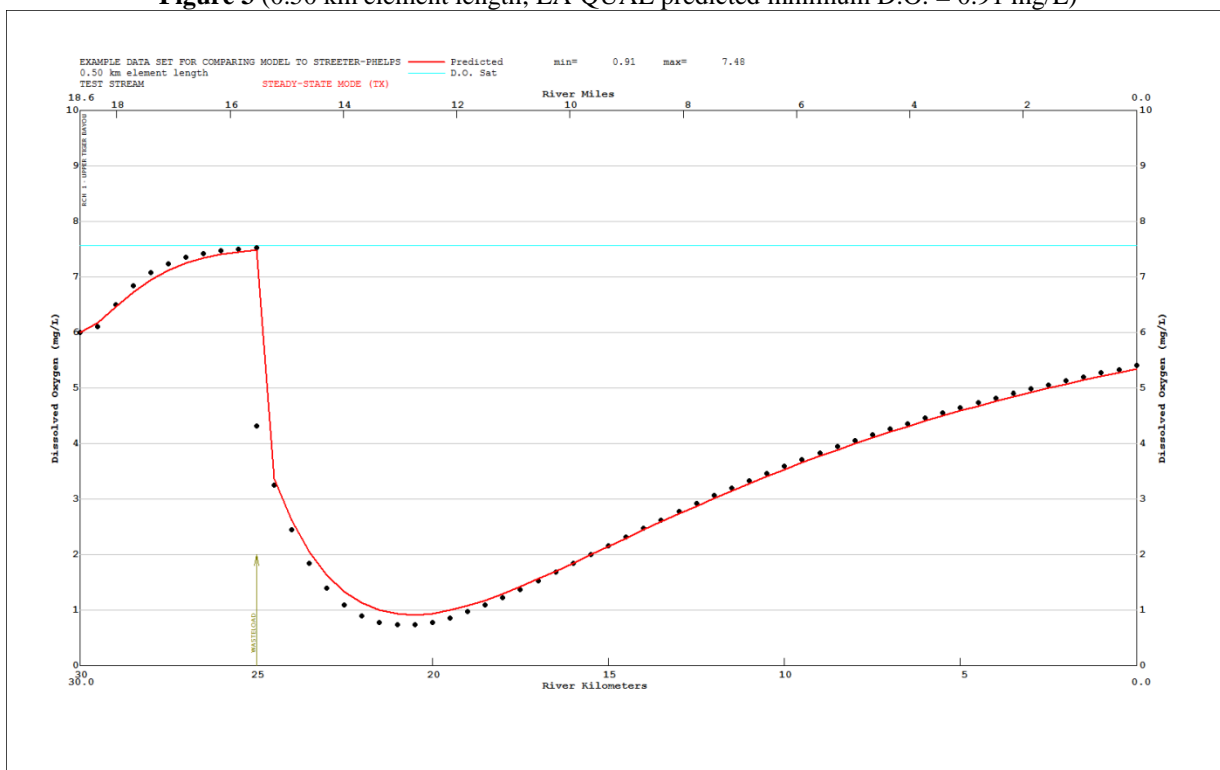
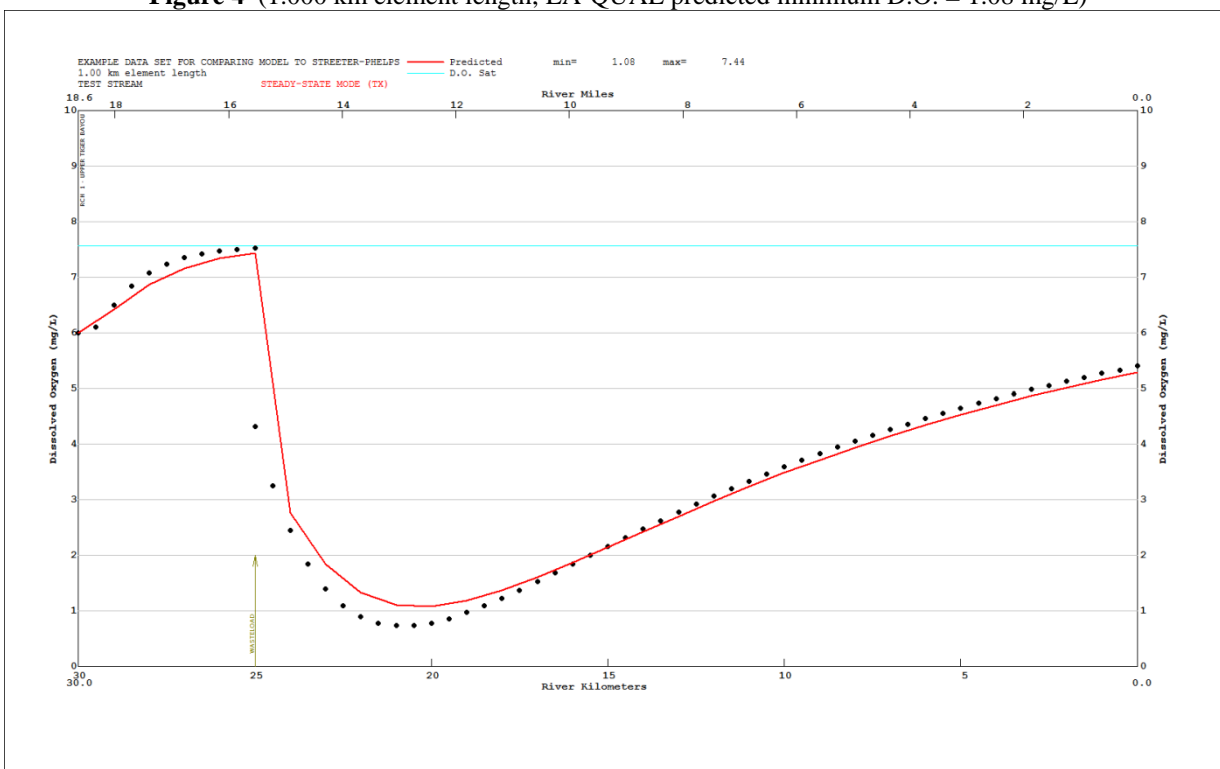


Figure 4 (1.000 km element length; LA-QUAL predicted minimum D.O. = 1.08 mg/L)



APPENDIX E – ELEMENT SIZE COMPARISON (continued)

Figure 5 (2.50 km element length; LA-QUAL predicted minimum D.O. = 1.44 mg/L)

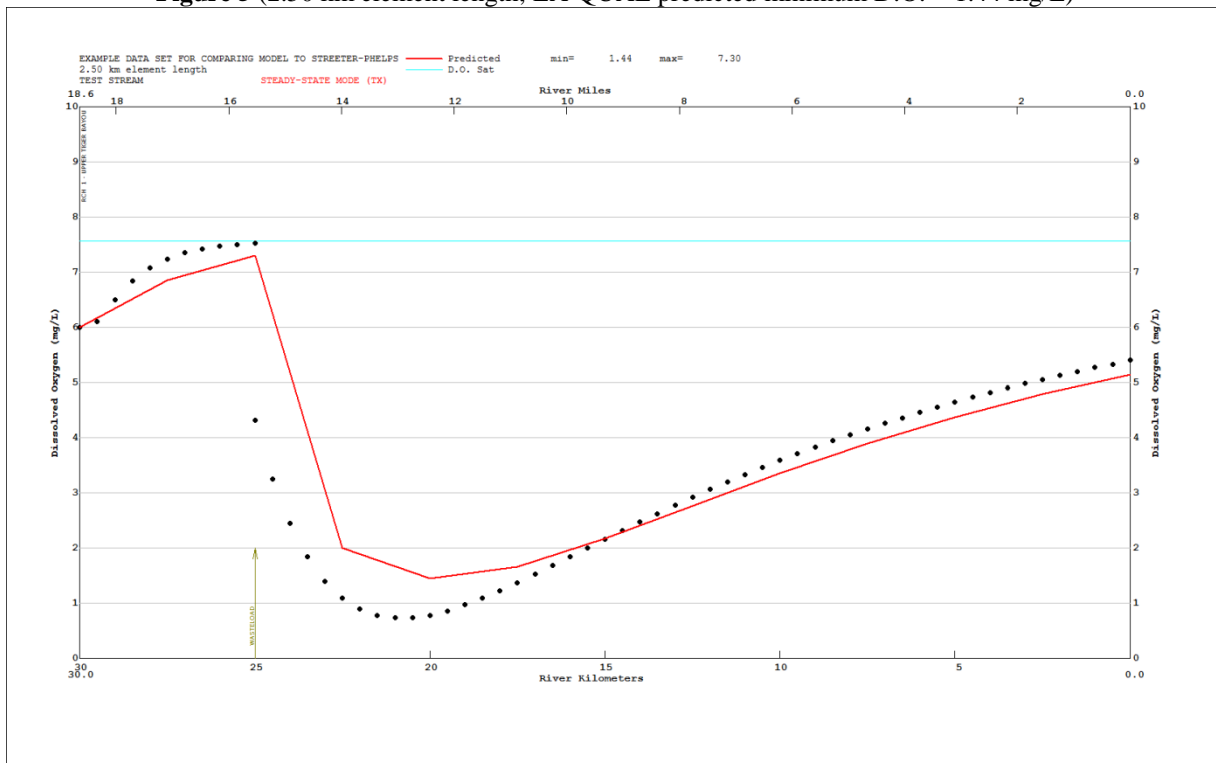


Figure 6 (5.00 km element length; LA-QUAL predicted minimum D.O. = 1.90 mg/L)

