The Environmental Fluid Dynamics Code
User Manual
US EPA Version 1.01

Tetra Tech, Inc.
10306 Eaton Place
Suite 340
Fairfax, VA 22030

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Preface

This document comprises the user manual for the 2007 US EPA release version of the Environmental Fluid Dynamics Code (EFDC). This release version is officially referred to as U.S. EPA EFDC Version 1.01 but will simply be referred to as EFDC in this manual. The original EFDC user manual was issued as a Virginia Institute of Marine Sciences report (Hamrick, 1996). That report was subsequently revised by Tetra Tech (2002) and reissued with the U.S. EPA EFDC-Hydro version of EFDC. The EFDC-Hydro version did not include water quality-eutrophication simulation capabilities. The present document builds on the two earlier user manuals and describes the full function version of EFDC as of June 2007. In addition to inclusion of the water quality eutrophication sub-model, this release of EFDC includes enhancements for sediment and contaminant transport, a two-time level integration option, a generalized vertical coordinate (GVC) system option, observational data assimilation capabilities, and additional code optimizations. Access to most of the new features are in the master input file, with the majority of other input and output files remaining unchanged with respect to previous model documentation. The EFDC model's input file system has from the beginning been self-documented in that input text format file templates include explicit definitions of input variables which has facilitated rapid dissemination of model enhancements between user manual version. The present code distribution and accompanying user manual serve to freeze the code distribution over next year in anticipation of a number of ongoing algorithm and computational enhancements.

Acknowledgements

The Environmental Fluid Dynamics Code (EFDC) is a public domain, open source, surface water modeling system, which includes hydrodynamic, sediment and contaminant, and water quality modules fully integrated in a single source code implementation. EFDC has been applied to over 100 water bodies including rivers, lakes, reservoirs, wetlands, estuaries, and coastal ocean regions in support of environmental assessment and management and regulatory requirements.

EFDC was originally developed at the Virginia Institute of Marine Science (VIMS) and School of Marine Science of The College of William and Mary, by Dr. John M. Hamrick beginning in 1988. This activity was supported by the Commonwealth of Virginia through a special legislative research initiative. Dr. Robert Byrne, the late Dr. Bruce Neilson, and Dr. Albert Kuo, of VIMS are acknowledged for their efforts in supporting the original development activity. Subsequent support for EFDC development at VIMS was provided by the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration's Sea Grant Program. The contributions of VIMS staff and former students including Mr. Gamble Sisson, Dr. Zaohqing Yang, Dr. Keyong Park, Dr. Jian Shen, and Dr. Sarah Rennie are gratefully acknowledged.

Tetra Tech, Inc. (Tt) became the first commercial user of EFDC in the early 1990's and upon Dr. Hamrick's joining Tetra Tech in 1996, the primary location for the continued development of EFDC. Tetra Tech has provided considerable internal research and development support for EFDC over the past 10 years and Mr. James Pagenkopf, Dr. Mohamed Lahlou, and Dr. Leslie Shoemaker are gratefully acknowledged for this. Mr. Michael Morton of Tetra Tech is particularly recognized for his many contributions EFDC development and applications. The efforts Tetra Tech colleagues including Dr. Jeff Ji, Dr. Hugo Rodriguez, Mr. Steven Davie, Mr. Brain Watson, Dr. Ruiz Zou, Dr. Sen Bai, Dr. Yuri Pils, Mr. Peter von Lowe, Mr. Will Anderson, and Dr. Silong Lu are also recognized. Their wide-ranging applications of EFDC have contributed to the robustness of the model and lead to many enhancements.

Primary external support of both EFDC development and maintenance and applications at Tetra Tech over the past 10 years has been generously provided by the U.S. Environmental Protection Agency including the Office of Science and Technology, the Office of Research and Development and Regions 1 and 4. In particular, Dr. Earl Hayter (ORD), Mr. James Greenfield (R4), Mr. Tim Wool (R4) and Ms. Susan Svirsky (R1) are recognized for their contributions in managing both EFDC developmental and application work assignments.

The ongoing evolution of the EFDC model has to a great extent been application driven and it is appropriate to thank Tetra Tech's many clients who have funded EFDC applications over the past 10 years. Of these many clients, the South Florida Water Management District and Dr. Mohamed Moustafa of SFWMD, are recognized for SFWMD's support of numerous EFDC applications. The benefits of ongoing interaction with a diverse group of EFDC users in the academic, governmental, and private sectors are also acknowledged.

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1. Introduction

The EFDC (Environmental Fluid Dynamics Code) model was developed at the Virginia Institute of Marine Science (Hamrick, 1992a). The model has been applied to Virginia's James and York River estuaries (Hamrick, 1992b, 1995a) and the entire Chesapeake Bay estuarine system (Hamrick, 1994a). It is currently being used for a wide range of environmental studies in the Chesapeake Bay system including: simulations of pollutant and pathogenic organism transport and fate from point and nonpoint sources (Hamrick, 1991, 1992c), simulation of power plant cooling water discharges (Kuo and Hamrick, 1995), simulation of oyster and crab larvae transport, and evaluation of dredging and dredge spoil disposal alternatives (Hamrick, 1992b, 1994b, 1995b). The EFDC model has been used for a study of high fresh water inflow events in the northern portion of the Indian River Lagoon, Florida, (Moustafa and Hamrick, 1994, Moustafa *et al.*, 1995) and a flow through high vegetation density-controlled wetland systems in the Florida Everglades (Hamrick and Moustafa, 1995a,b; Moustafa and Hamrick, 1995).

The physics of the EFDC model and many aspects of the computational scheme are equivalent to the widely used Blumberg-Mellor model (Blumberg and Mellor, 1987) and U. S. Army Corps of Engineers' Chesapeake Bay model (Johnson *et al.*, 1993). The EFDC model solves the three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motions for a variable density fluid. The model uses a stretched or sigma vertical coordinate and Cartesian or curvilinear, orthogonal horizontal coordinates. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme (Mellor and Yamada, 1982) as modified by Galperin *et al.* (1988). An optional bottom boundary layer submodel allows for wave-current boundary layer interaction using an externally specified high frequency surface gravity wave field. The EFDC model also simultaneously solves an arbitrary number of Eulerian transport-transformation equations for dissolved and suspended materials. A complimentary Lagrangian particle transport-transformation scheme is also implemented in the model. The EFDC model also allows for drying and wetting in shallow areas by a mass conservative scheme. A number of alternatives are in place in the model to simulate general discharge control structures such as weirs, spillways and culverts. For nearshore surf zone simulation, the EFDC model can incorporate externally specified radiation stresses due to high frequency surface gravity waves. Externally specified wave dissipation due to wave breaking and bottom friction can also be incorporated in the turbulence closure model as source terms. For the simulation of flow in vegetated environments,

the EFDC model incorporates both two and three-dimensional vegetation resistance formulations (Hamrick and Moustafa, 1995a). The model provides output formatted to yield transport fields for water quality models, including WASP5 (Ambrose *et al*., 1993) and CE-QUAL-IC (Cerco and Cole, 1993).

The numerical scheme employed in EFDC to solve the equations of motion uses second order accurate spatial finite difference on a staggered or C grid. The model's time integration employs a second order accurate three time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear or baroclinic mode from the external free surface gravity wave or barotropic mode. The external mode solution is semi-implicit, and simultaneously computes the two-dimensional surface elevation field by a preconditioned conjugate gradient procedure. The external solution is completed by the calculation of the depth averaged barotropic velocities using the new surface elevation field. The model's semi-implicit external solution allows large time steps which are constrained only by the stability criteria of the explicit central difference or upwind advection scheme used for the nonlinear accelerations. Horizontal boundary conditions for the external mode solution include options for simultaneously specifying the surface elevation only, the characteristic of an incoming wave (Bennett and McIntosh, 1982), free radiation of an outgoing wave (Bennett, 1976; Blumberg and Kantha, 1985) or the normal volumetric flux on arbitrary portions of the boundary. The EFDC model's internal momentum equation solution, at the same time step as the external, is implicit with respect to vertical diffusion. The internal solution of the momentum equations is in terms of the vertical profile of shear stress and velocity shear, which results in the simplest and most accurate form of the baroclinic pressure gradients and eliminates the over determined character of alternate internal mode formulations. Time splitting inherent in the three time level scheme is controlled by periodic insertion of a second order accurate two time level trapezoidal step. The EFDC model is also readily configured as a two-dimensional model in either the horizontal or vertical planes.

The EFDC model implements a second order accurate in space and time, mass conservation fractional step solution scheme for the Eulerian transport equations at the same time step or twice the time step of the momentum equation solution (Smolarkiewicz and Margolin, 1993). The advective step of the transport solution uses either the central difference scheme used in the Blumberg-Mellor model or a hierarchy of positive definite upwind difference schemes. The highest accuracy upwind scheme, second order accurate in space and time, is based on a flux corrected transport version of Smolarkiewicz's multidimensional positive definite advection

transport algorithm (Smolarkiewicz, 1984; Smolarkiewicz and Clark, 1986; Smolarkiewicz and Grabowski, 1990) which is monotone and minimizes numerical diffusion. The horizontal diffusion step, if required, is explicit in time, while the vertical diffusion step is implicit. Horizontal boundary conditions include time variable material inflow concentrations, upwinded outflow, and a damping relaxation specification of climatological boundary concentration. For the heat transport equation, the NOAA Geophysical Fluid Dynamics Laboratory's atmospheric heat exchange model (Rosati and Miyakoda, 1988) is implemented. The Lagrangian particle transport-transformation scheme implemented in the model utilizes an implicit trilinear interpolation scheme (Bennett and Clites, 1987). To interface the Eulerian and Lagrangian transport-transformation equation solutions with near field plume dilution models, internal time varying volumetric and mass sources may be arbitrarily distributed over the depth in a specified horizontal grid cell. The EFDC model can be used to drive a number of external water quality models using internal linkage processing procedures described in Hamrick (1994a).

The EFDC model is implemented in a generic form requiring no internal source code modifications for application to specific study sites. The model includes a preprocessor system which generates a Cartesian or curvilinear-orthogonal grid (Mobley and Stewart, 1980; Ryskin and Leal, 1983), and interpolates bathymetry and initial salinity and temperature input fields from observed data. The model's input system features an interactive user's manual with extensive on-line documentation of input variables, files and formats. A menu driven, windows based, implementation of the input system is under development. The model produces a variety of real time messages and outputs for diagnostic and monitoring purposes as well as a restart file. For postprocessing, the model has the capability for inplace harmonic and time series analysis at user specified locations. A number of options exist for saving time series and creating time sequenced files for horizontal and vertical sliced contour, color shaded and vector plots. The model also outputs a variety of array file formats for three-dimensional vector and scalar field visualization and animation using a number of public and inexpensive private domain data visualization packages (Rennie and Hamrick, 1992). The EFDC model is coded in standard FORTRAN 77, and is designed to economize mass storage by storing only active water cell variables in memory. Particular attention has also been given to minimizing logical operations with the code being 99.8 per cent vectorizable for floating point operations and benchmarked at a sustained performance of 380 MFLOPS on a single Cray Y-MP C90 processor. The EFDC model is currently operational on VAX-VMS systems, Sun, HP-Apollo, Silicon Graphics, Convex, and Cray UNIX systems, IBM PC compatible DOS systems (Lahey EM32 FORTRAN) and Macintosh 68K and Power PC systems (LSI and Absoft FORTRAN).

The theoretical and computational basis for the model is documented in Hamrick (1992a). Extensions to the model formulation for the simulation of vegetated wetlands are documented in Hamrick and Moustafa (1995a,b) and Hamrick and Moustafa and Hamrick (1995a). Model formulations for computation of Lagrangian particle trajectories and Lagrangian mean transport fields are described in Hamrick (1994a) and Hamrick and Yang (1995).

The general organization of this manual is as follows. Chapter 2 presents the general structure of the EFDC modeling system focusing on the structure of the EFDC code and the sequence of steps in setting up and executing the model and processing and interpreting the computational results. Chapters 3 through 10 essentially follow the sequence of steps in the application of the model to a specific environmental flow system. Chapter 3 describes the specification of the horizontal spatial configuration of the system being modeled using the GEFDC grid generating preprocessor code. Chapter 4 describes the configuration of the master input file efdc.inp which controls the overall execution of a model simulation. Chapter 5 documents additional input files necessary to specify the simulation. Guidelines for compiling and executing the model on UNIX workstations and super computers, IBM compatible PC systems and Macintosh systems are presented in Chapter 6. Chapter 7 describes options for diagnosing execution failures using EFDC's internal diagnostic options and a number of compiler option diagnostic tools. Chapter 8 describes time series output options and formats as well a number of generic and custom, application specific, time series analysis techniques. Two-dimensional horizontal and vertical plane graphics output and visualization options are presented in Chapter 9, while Chapter 10 presents similar material for three-dimensional graphics and visualization. Appendix A contains a list of the source code subroutines and their functions. Appendix B contains a number of example grids and input files for the *gefdc.f* grid generating preprocessor.

2. General Structure of the EFDC Modeling System

The primary component of the EFDC modeling system is the FORTRAN 77 source code *efdc.for* and two include files: *efdc.com*, which contains common block declarations and arrayed variable dimensions, and *efdc.par*, which contains a parameter statement specifying the dimensions of arrayed variables. The source code *efdc.for* and the common file, *efdc.com*, are universal for all model applications or configurations. The parameter file, *efdc.par*, is configured for a particular model application to minimize memory requirements during model execution. Details of configuring the parameter file, *efdc.par*, and compiling the source code *efdc.for* are presented in Chapter 6. The source code, *efdc.for*, is comprised of a main program and 110 subroutines. A list of the subroutines and a brief description of their functions is found in Appendix A.

Model configuration and environmental data for a particular application are provided in the following sequence of input files (in alphabetical order).

Table 1. Input files for the efdc.for code

File Name	Type of Input Data
aser.inp	Atmospheric forcing time series file.
cell.inp	Horizontal cell type identifier file.
celllt.inp	Horizontal cell type identifier file for saving mean mass transport.
depth.inp	File specifying depth, bottom elevation, and bottom roughness for Cartesian grids only.
dser.inp	Dye concentration time series file.
dxdy.inp	File specifying horizontal grid spacing or metrics, depth, bottom elevation, bottom roughness and vegetation classes for either Cartesian or curvilinear-orthogonal horizontal grids.
dye.inp	File with initial dye distribution for cold start simulations.
efdc.inp	Master input file.
fldang.inp	File specifying the CCW angle to the flood axis of the local M2 tidal ellipses.

gcellmap.inp	File specifying a Cartesian grid overlay for a curvilinear-orthogonal grid.
gwater.inp	File specifying the characteristic of a simple soil moisture model.
lxly.inp	File specifying horizontal cell center coordinates and cell orientations for either Cartesian or curvilinear-orthogonal grids.
mappgns.inp	Specifies configuration of the model grid to represent a periodic region in the north-south or computational y direction.
mask.inp	File specifying thin barriers to block flow across specified cell faces.
modchan.inp	Subgrid scale channel model specification file.
moddxdy.inp	File specifying modification to cell sizes (used primarily for calibration adjustment of subgrid scale channel widths)
pser.inp	Open boundary water surface elevation time series file.
qctl.inp	Hydraulic control structure characterization file.
qser.inp	Volumetric source-sink time series file.
restart.inp	File for restarting a simulation.
restran.inp	File with arbitrary time interval averaged transport fields used to drive mass transport only simulations.
salt.inp	File with initial salinity distribution for cold start, salinity stratified flow simulations.
sdser.inp	Suspended sediment concentration time series file.
show.inp	File controlling screen print of conditions in a specified cell during simulation runs.
sser.inp	Salinity time series file.
sfser.inp	Shellfish release time series file.
sfbser.inp	Shellfish behavior time series file.
tser.inp	Temperature time series file.
vege.inp	Vegetation resistance characterization file.

wave.inp	Specifies a high frequency surface gravity wave field require to activate the wave-current boundary layer model and/or wave induced current model.

The above listed input files can be classified in five groups as follows.

Table 2. Input files grouped by function

1. Horizontal grid specification files:

cell.inp	celllt.inp
depth.inp	dxdy.inp
gcellmap.inp	lxly.inp
mappgns.inp	mask.inp

2. General data and run control files:

efdc.inp	show.inp

3. Initialization and restart files:

salt.inp	dye.inp
restart.inp	restran.inp

4. Physical process specification files:

gwater.inp	modchan.inp
moddxdy.inp	qctl.inp
vege.inp	wave.inp

5. Time series forcing and boundary condition files:

aser.inp	dser.inp
pser.inp	qser.inp
sdser.inp	sfser.inp
sfbser.inp	sser.inp
sser.inp	

The recommended sequence for the construction of the input files for configuration of the model and set up for a simulation generally corresponds to the above file group classes. The files, *dxdy.inp* and *lxly.inp*, which specify the model grid geometry and topography or bathymetry, and

the file, *gcellmap.inp*, which specifies an optional graphics overlay grid, can be automatically generated by an auxiliary grid generating preprocessor code GEFDC (FORTRAN 77 source file *gefdc.f*). The use of GEFDC is discussed in Chapter 3. The master input file, *efdc.inp*, is discussed in detail in Chapter 4, while the structure of the remaining input files are described in Chapter 5.

The EFDC modeling system produces five classes of output: 1) diagnostic output files; 2) restart and transport field files; 3) time series, point samples and least squares harmonic analysis output files; 4) two-dimensional graphics and visualization files; and 5) three-dimensional graphics and visualization files. The activation and control of these output classes is specified in the master input file *efdc.inp*, as will be discussed in Chapter 4. Guidance for activating and analyzing diagnostic output options is discussed in Chapter 7, while Chapters 8, 9, and 10 describe the formats and processing procedures for time series, two-dimensional and three-dimensional model outputs.

3. Grid Generation and Preprocessing

The first step in the setup or configuration of the EFDC modeling system is defining the horizontal plane domain of the region being modeled. The horizontal plane domain is approximated by a set of discrete quadrilateral and optional triangular cells. The terminology grid or grid lines refers to the lines defining the faces of the quadrilateral cells. (Triangular cells are defined by one of four possible regions resulting from diagonal division of a quadrilateral cell.) Since the EFDC model solves the hydrodynamic equations in a horizontal coordinate system that is curvilinear and orthogonal, the grid lines also correspond to lines having a constant value of one of the horizontal coordinates. In the following discussions, x and y, as well as I and J will be used to identify the two horizontal coordinate directions in the so-called computation domain. The terminology east and north, when associated with the curvilinear x and y coordinates respectively, will also be used to specify relative locations. The terminology true east and true north will be associated with a set of horizontal map coordinates, x* and y*, respectively, which may represent longitude-latitude, east and north state plane (SP) or universal transverse Mercator (UTM) coordinates, or any local set of map coordinates defined by the user. Since the *efdc.for* code uses the MKS (meters, kilograms and seconds unit system internally), the writer tends to favor the use of localized UTM coordinates (true zonal UTM coordinates localized to an origin southwest of the region to be modeled).

The horizontal grid of cells is defined by a cell type array which is specified by the file *cell.inp*. To illustrate the definition of the horizontal model domain and the form of the *cell.inp* file, consider a simple circular basin with an entrance channel to the East, as shown in Figure 1. The region is coarsely approximated by 18 square cells and 4 right triangular cells as shown in Figure 1. The *cell.inp* file corresponding to the 22 water cell grid is shown in Figure 2. The *cell.inp* file has four header lines, followed by an image of the cell type array, IJCT(I,J), where I and J are the cell indexes in the computational or curvilinear x and y directions respectively. In the lines following the header lines, the first three columns (I3 format) specify the value of J decreasing from a maximum of 6 to 1, followed by two blank spaces (2X format). The remaining columns across the row specify the cell type identification number entered in the array, IJCT(I,J) for I increasing from 1 to 9. Seven identification numbers are used to define the cell type. They are as follows:

Table 3. Definition of cell types in the *cell.inp* file

0	dry land cell not bordering a water cell on a side or corner.
1	triangular water cell with land to the northeast
2	triangular water cell with land to the southeast
3	triangular water cell with land to the southwest
4	triangular water cell with land to the northwest
5	quadrilateral water cell
9	dry land cell bordering a water cell on a side or corner or a fictitious dry land cell bordering an open boundary water cell on a side or a corner.

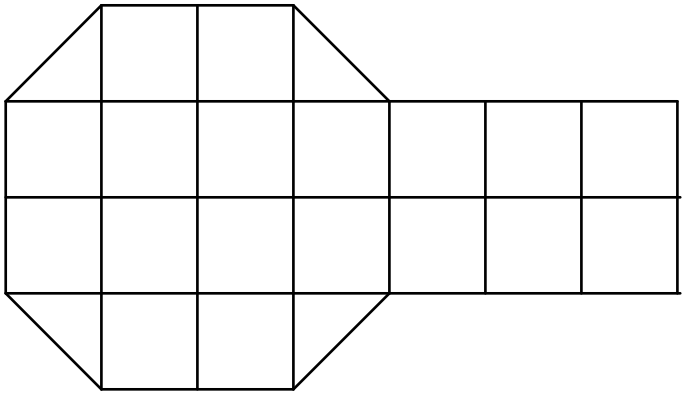

Figure 1. Representation of a circular basin and entrance channel by a 22 water cell grid.

```
C cell.inp file, i columns and j rows, for Figure 1
C    0        1
C    1234567890
C
  6  999999000
  5  945519999
  4  955555559
  3  955555559
  2  935529999
  1  999999000
C
C    1234567890
C    0        1
```

Figure 2. File *cell.inp* corresponding to the grid shown in Figure 1.

```
C celllt.inp file, i columns and j rows, for Figure 1
C    0        1
C    1234567890
C
  6  999999000
  5  945519900
  4  955555900
  3  955555900
  2  935529900
  1  999999000
C
C    1234567890
C    0        1
```

Figure 3. File *celllt.inp* corresponding to the *cell.inp* file shown in Figure 1, with four entry channel cells removed.

The type 9 dry land or fictitious dry land cell type is used in the specification of no flow boundary conditions and in graphics masking operations. For purposes of assigning adjacent

type 9 cells, triangular water cells are treated identically to quadrilateral water cells. The file *celllt.inp* may be identical to the file *cell.inp* or specify a subset of the water cells in the *cell.inp* file. In specifying the subset, the following rules apply. Type 0 cells remain unchanged, type 9 cells may be changed only to type 0, and type 1-5 cells may be changed only to types 0 or 9. Figure 3 illustrates a *celllt.inp* file corresponding to the *cell.inp* file in Figure 2 with four of the entry channel cells removed.

To specify the horizontal geometric and topographic properties and other related characteristics of the region, the files *dxdy.inp* and *lxly.inp* are preferably used. (An older model option used the *depth.inp* file for this purpose. However this is not recommended). For this simple grid, these files, shown in Figure 4 and 5, can be readily constructed by hand. Both files, which are read into the model execution in free format, begin with four header lines defining the columns. The file *dxdy.inp* provides the physical *x* and *y* dimensions of a cell, *dx* and *dy*, the initial water depth, the bottom elevation, and the roughness height (log law z_o). These quantities should generally be specified in meters, although units conversion options can be specified in the master input file, *efdc.inp*. The last column contains an integer vegetation type class identifier. This column is read only when the vegetation resistance option is activated in the master input file *efdc.inp*. The file *lxly.inp* provides cell center coordinates and the components of a rotation matrix. The cell center coordinates are used only in graphics output and can be specified in the most convenient units for graphical display such as decimal degrees, feet, miles, meters or kilometers. The rotation matrix is used to convert pseudo east and north (curvilinear x and y) horizontal velocities to true east and north for graphics vector plotting, according to:

$$\begin{Bmatrix} u_{te} \\ v_{tn} \end{Bmatrix} = \begin{bmatrix} C_{cue} & C_{cve} \\ C_{cun} & C_{cvn} \end{bmatrix} \begin{Bmatrix} u_{co} \\ v_{co} \end{Bmatrix} \tag{1}$$

where the subscripts *te* and *tn* denote true east and true north, while the subscripts *co* denote the curvilinear-orthogonal horizontal velocity components. The inverse of the rotation matrix is used to compute horizontal curvilinear components of the surface wind stress from true east and north components, according to:

$$\begin{Bmatrix} \tau_{sx,co} \\ \tau_{sy,co} \end{Bmatrix} = \begin{bmatrix} C_{cue} & C_{cve} \\ C_{cun} & C_{cvn} \end{bmatrix}^{-1} \begin{Bmatrix} \tau_{sx,te} \\ \tau_{sy,tn} \end{Bmatrix} \tag{2}$$

For the example shown in Figure 4, the horizontal grid is Cartesian and aligns with true east and north.

```
C dxdy.inp file, in free format across columns
C
C   I   J   DX      DY      DEPTH   BOTTOM ELEV  ZROUGH   VEG TYPE
C
    2   2   100.0   100.0   5.0     -5.0         0.02     0
    3   2   100.0   100.0   5.0     -5.0         0.02     0
    4   2   100.0   100.0   5.0     -5.0         0.02     0
    5   2   100.0   100.0   5.0     -5.0         0.02     0
    6   2   100.0   100.0   5.0     -5.0         0.02     0
    7   2   100.0   100.0   5.0     -5.0         0.02     0
    8   2   100.0   100.0   5.0     -5.0         0.02     0
    2   3   100.0   100.0   5.0     -5.0         0.02     0
    3   3   100.0   100.0   5.0     -5.0         0.02     0
    4   3   100.0   100.0   5.0     -5.0         0.02     0
    5   3   100.0   100.0   5.0     -5.0         0.02     0
    6   3   100.0   100.0   5.0     -5.0         0.02     0
    7   3   100.0   100.0   5.0     -5.0         0.02     0
    8   3   100.0   100.0   5.0     -5.0         0.02     0
    2   4   100.0   100.0   5.0     -5.0         0.02     0
    3   4   100.0   100.0   5.0     -5.0         0.02     0
    4   4   100.0   100.0   5.0     -5.0         0.02     0
    5   4   100.0   100.0   5.0     -5.0         0.02     0
    6   4   100.0   100.0   5.0     -5.0         0.02     0
    7   4   100.0   100.0   5.0     -5.0         0.02     0
    8   4   100.0   100.0   5.0     -5.0         0.02     0
    2   5   100.0   100.0   5.0     -5.0         0.02     0
    3   5   100.0   100.0   5.0     -5.0         0.02     0
    4   5   100.0   100.0   5.0     -5.0         0.02     0
    5   5   100.0   100.0   5.0     -5.0         0.02     0
    6   5   100.0   100.0   5.0     -5.0         0.02     0
    7   5   100.0   100.0   5.0     -5.0         0.02     0
    8   5   100.0   100.0   5.0     -5.0         0.02     0
C
C   I             ARRAY INDEX IN X DIRECTION
C   J             ARRAY INDEX IN Y DIRECTION
C   DX            CELL DIMENSION IN X DIRECTION, METERS
C   DY            CELL DIMENSION IN Y DIRECTION, METERS
C   DEPTH         INITIAL WATER DEPTH, METERS
C   BOTTOM ELEV   BOTTOM BED ELEVATION, METERS
C   ZROUGH        LOG LAW ROUGHNESS HEIGHT, ZO, METERS
C   VEG TYPE      VEGETATION TYPE CLASS, INTEGER VALUE
```

Figure 4. File *dxdy.inp* for grid shown in Figure 1.

```
C lxly.inp file, in free format across columns
C
C   I   J   XLNUTME   YLTUTMN   CCUE   CCVE   CCUN   CCVN
C
    2   2   250.0     250.0     1.0    0.0    0.0    1.0
    3   2   350.0     250.0     1.0    0.0    0.0    1.0
    4   2   450.0     250.0     1.0    0.0    0.0    1.0
    5   2   550.0     250.0     1.0    0.0    0.0    1.0
    6   2   650.0     250.0     1.0    0.0    0.0    1.0
    7   2   750.0     250.0     1.0    0.0    0.0    1.0
    8   2   850.0     250.0     1.0    0.0    0.0    1.0
    2   3   250.0     350.0     1.0    0.0    0.0    1.0
    3   3   350.0     350.0     1.0    0.0    0.0    1.0
    4   3   450.0     350.0     1.0    0.0    0.0    1.0
    5   3   550.0     350.0     1.0    0.0    0.0    1.0
    6   3   650.0     350.0     1.0    0.0    0.0    1.0
    7   3   750.0     350.0     1.0    0.0    0.0    1.0
    8   3   850.0     350.0     1.0    0.0    0.0    1.0
    2   4   250.0     450.0     1.0    0.0    0.0    1.0
    3   4   350.0     450.0     1.0    0.0    0.0    1.0
    4   4   450.0     450.0     1.0    0.0    0.0    1.0
    5   4   550.0     450.0     1.0    0.0    0.0    1.0
    6   4   650.0     450.0     1.0    0.0    0.0    1.0
    7   4   750.0     450.0     1.0    0.0    0.0    1.0
    8   4   850.0     450.0     1.0    0.0    0.0    1.0
    2   5   250.0     550.0     1.0    0.0    0.0    1.0
    3   5   350.0     550.0     1.0    0.0    0.0    1.0
    4   5   450.0     550.0     1.0    0.0    0.0    1.0
    5   5   550.0     550.0     1.0    0.0    0.0    1.0
    6   5   650.0     550.0     1.0    0.0    0.0    1.0
    7   5   750.0     550.0     1.0    0.0    0.0    1.0
    8   5   850.0     550.0     1.0    0.0    0.0    1.0
C
C   I            ARRAY INDEX IN X DIRECTION
C   J            ARRAY INDEX IN Y DIRECTION
C   XLNUTME      X CELL CENTER COORDINATE, LONGITUDE, METERS,
C                OR KM
C   YLTUTMN      Y CELL CENTER COORDINATE, LONGITUDE, METERS,
C                OR KM
C   CCUE         ROTATION MATRIX COMPONENT
C   CCVE         ROTATION MATRIX COMPONENT
C   CCUN         ROTATION MATRIX COMPONENT
C   CCVN         ROTATION MATRIX COMPONENT
C
```

Figure 5. File *lxly.inp* for grid shown in Figure 1.

For realistic model applications, the grid generating preprocessor code, *gefdc.f*, is used to generate the horizontal grid and form the *dxdy.inp* and *lxly.inp* files. The *gefdc.f* code requires the following input files:

Table 4. Input files for the *gefdc.f* grid generating preprocessor

cell.inp	Cell type file as in Figure 2.
depdat.inp	File specifying depth or bottom topography (optional if depth interpolation is not specified).
gcell.inp	Optional auxiliary file with *cell.inp* format which specifies an auxiliary square Cartesian grid for rectangular array graphics when the actual computational grid is curvilinear.
gridext.inp	File of water cell corner coordinates for used with NTYPE = 0 grid generation option.
gefdc.inp	Master input file for *gefdc.f*.
vege.inp	File specifying vegetation type classes.
zrough.inp	File specifying bottom roughness (log law *zo*).

The format of the *cell.inp* file has already been discussed. The *depdat.inp* file is a three column ASCII text file with no header, as shown in Figure 6. The first two columns are true east and true north coordinates, in meters or kilometers, with the depth or bottom elevation given in the third column. The origin of the true east and north coordinates is arbitrary, but should generally be related to an accepted geographic coordinate system such as longitude-latitude, state plane, or universal transverse Mercator. The optional file *gcell.inp* has the same format as the cell.inp file, but specifies an auxiliary, square cell, Cartesian grid corresponding to the curvilinear grid specified by the *cell.inp* file. When the option to process the *gcell.inp* file is activated in the *gefdc.inp* file, a correspondence table between the curvilinear grid and the auxiliary, square cell, Cartesian grid is generated. The correspondence table, output as file *gcellmap.inp*, is used by the *efdc.for* code to generated two and three-dimensional rectangular arrays of graphics visualization, as will be subsequently discussed. The file *gridext.inp* is used for generation of a grid constructed external to the *gefdc.f* code. This file is a four column free format ASCII text file with no header. The four columns correspond to the I indices, J indices, true east

coordinates, and true north coordinates of the water cell corners. The lower left (pseudo southwest relative to the cell center) cell corners carry the same I and J indices as the cell. The *gridext.inp* file corresponding to the simple grid in Figure 1 is shown in Figure 7. Triangular cells must be specified as equivalent quadrilaterals in the *gridext.inp* file. The files *vege.inp* and *zrough.inp* have the same format as the *depdat.inp* file, with the exception that the third column of the *vege.inp* file has an integer value corresponding to a vegetation class. The third column of the *zrough.inp* file has values of the log law bottom roughness height, *zo*, (preferably in meters, however unit conversion may be specified in the master input file *efdc.for*).

```
4.2798    6.9175    3.2309
4.2785    6.9175    3.2309
4.4509    6.7880    3.1090
4.4409    6.7927    3.1090
4.4222    6.7995    3.1090
4.4133    6.8028    3.1090
```

Figure 6. Format of the file *depdat.inp*.

```
2     2       200.      200.
3     2       300.      200.
4     2       400.      200.
5     2       500.      200.
6     2       600.      200.
2     3       200.      300.
3     3       300.      300.
4     3       400.      300.
5     3       500.      300.
6     3       600.      300.
7     3       700.      300.
8     3       800.      300.
9     3       900.      300.
2     4       200.      400.
3     4       300.      400.
4     4       400.      400.
5     4       500.      400.
6     4       600.      400.
7     4       700.      400.
8     4       800.      400.
9     4       900.      400.
2     5       200.      500.
3     5       300.      500.
4     5       400.      500.
5     5       500.      500.
6     5       600.      500.
7     5       700.      500.
8     5       800.      500.
9     5       900.      500.
2     6       200.      600.
3     6       300.      600.
4     6       400.      600.
5     6       500.      600.
6     6       600.      600.
```

Figure 7. File *gridext.inp* for grid shown in Figure 1.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
    'gefdc.inp corresponding to example in figure 1'
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    0      0      1     9     1     6     9    6
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
    0     0    0    0.    0.    1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
      0.      0.      0.      0.      0.      0.
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM  DEPMIN
     100    100    100    100    4000   1.0
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1.     1.      15.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFID INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFID INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      0       2.  .5    2        4.0     0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
    1   1   0.          0.
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure 8. Example of the *gefdc.inp*, master input file for the *gefdc.f* code.

The execution of the *gefdc.f* code is controlled by its master input file, *gefdc.inp*. An example of the *gefdc.inp* file for the grid in Figure 1 is shown in Figure 8. The file is essentially a sequence of 'card images' or input lines. Each input line is preceded by card number lines beginning with 'C' followed by a number corresponding the Card image or data input line and text defining the data type and the actual data parameters. To fully discuss the options in the execution of the *gefdc.f* code, it is useful to consider each 'card image' or input line sequence. The following discussion will sequentially present the header and data lines in Monaco text with definitions of

data parameters following in Monaco text. Additional discussion then follows in plain text. In the discussions, reference will be made to six grid generation examples in Appendix B, which illustrate specific options as well as showing the resulting grid.

Card Image 1

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
    'ENR GRID'
```

The 80 character title simply serves to identify the particular application.

Card Image 2

```
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    0      0      1     50    1     55    50   55
```

Card Image 2 Parameter Definitions

```
     NTYPE = PROBLEM TYPE
             0, READ IN FILE 'cell.inp' AND WATER GRID CELL CORNER
                COORDINATES FROM FILE 'gridext.inp' TO GENERATE
                INPUT FILES FOR AN EXTERNALLY GENERATED
                ORTHOGONAL GRID
           1-5  GENERATE AN ORTHOGONAL GRID AND INPUT FILES
                USING THE METHOD OF RYSKIN AND LEAL,
                J. OF COMP. PHYS. V50, 71-100 (1983)
                WITH SYMMETRIC REFLECTIONS AS SUGGESTED BY
                CHIKHLIWALA AND YORTSOS,
                J. OF COMP. PHYS. V57, 391-402 (1985).
             1, RL-CY EAST REFLECTION
             2, RL-CY NORTH REFLECTION
             3, RL-CY WEST REFLECTION
             4, RL-CY SOUTH REFLECTION
             5, RL NO REFLECTION
             6, GENERATE GRID AND INPUT FILES USING
                THE AREA-ORTHOGONALITY METHOD OF KNUPP,
                J. OF COMP PHYS. V100, 409-418 (1993)
                ORTHOGONALITY IS NOT GUARANTEED
             7, GENERATE GRID ORTHOGONAL GRID
                AND INPUT FILES USING THE QUASI-CONFORMAL
                METHOD OF MOBLEY AND STEWART,
                J. OF COMP PHYS. V24, 124-135 (1980)
                REQUIRES USER SUPPLIED FUNCTION SUBROUTINES
```

```
            FIB,FIE,GJB,GJE
         8, DEPTH INTERPOLATION TO CARTESIAN GRID SPECIFIED
            BY cell.inp AND GENERATE dxdy.inp AND lxly.inp
            FILES
         9, DEPTH INTERPOLATION TO CARTESIAN GRID AS FOR 8
            CONVERTING INPUT COORDINATE SYSTEM FROM
            LONG,LAT TO UTMBAY (VIMS PHYS OCEAN CHES BAY REF)
NBPP = NUMBER OF INPUT BOUNDARY POINTS (NTYPE = 1-6)
IMIN,IMAX = RANGE OF I GRID INDICES
JMIN,JMAX = RANGE OF J GRID INDICES
IC = NUMBER OF CELLS IN I DIRECTION
JC = NUMBER OF CELLS IN J DIRECTION
```

The NTYPE parameter controls the type of grid generated by the *gefdc.f* code. NTYPE = 0 corresponds to an external specification of the grid by the *gridext.inp* file, see Figure 7, with *gefdc.f* only generating input files for the *efdc.for* code. Example of NTYPE = 0 grids are given in Appendices B.1, B.2, and B.4. The NTYPE options 1-5 generate curvilinear-orthogonal grids using the method or Ryskin and Leal (1983). NTYPE options 1-4 require that one of the boundaries of the grid to be a straight line and use reflection extensions of Ryskin and Leal's method proposed by Chikhliwala and Yortsos (1985). The NTYPE = 5 option is generally recommended. A simple NTYPE = 2 grid generation example is given in Appendix B.3. A more complicated composite grid composed of NTYPE 0 and 5 subgrids is discussed in Appendix B.4. The NTYPE = 7 option generates a quasi-conformal grid using the method of Mobley and Stewart (1980). When the NTYPE = 7 option is used, the computational domain must be rectangular (i.e., the physical domain is mapped into a rectangular region). An example of a NTYPE = 7 grid is presented in Appendix B.5. The NTYPE = 8 option generates a square cell Cartesian grid using only the *cell.inp* file and information on Card Image 4. The NTYPE = 9 option generates an approximately square cell Cartesian grid using the *cell.inp* file and information on Card Image 4. However, the coordinate information on Card Image 4 must correspond to longitude and latitude, which is internally converted to a universal transverse mercator (UTM) coordinate system localized to the Chesapeake Bay region. An example NTYPE = 9 grid is presented in Appendix B.6. The NTYPE = 6 option implements the area-orthogonal method of Knupp (1992). Since this method does not guarantee an orthogonal grid, it should be used with extreme care. For NTYPE = 1-6, NBPP coordinate pairs specifying the grid points (water cell corner points) around the boundary of the domain must be specified (see Card Images 12 and 13).

Card Image 3

```
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
    0     0    0    1.    1.    1
```

Card Image 3 Parameter Definitions

```
ISGG = 1, READ IN gcell.inp WHICH DEFINES THE CARTESIAN OR
          GRAPHICS GRID OVERLAY
IGM    MAXIMUM X OR I CELLS IN CARTESIAN OR GRAPHICS GRID
JGM    MAXIMUM Y OF J CELLS IN CARTESIAN OR GRAPHICS GRID
DXCG   X GRID SIZE OF CARTESIAN OR GRAPHICS GRID
DYCG   Y GRID SIZE OF CARTESIAN OF GRAPHICS GRID
NWTGG  NUMBER OF WEIGHTED COMP CELLS USED TO INTERPOLATE
       TO THE GRAPHICS GRID (MUST EQUAL 1)
```

Activation of ISGG = 1, allows for a square cell Cartesian grid to be simultaneously generated when NTYPE = 1-7. This Cartesian grid is used by *efdc.for* to output the results of a 3D curvilinear coordinate computation in a 3D rectangular array for visualization and graphics. The relation between the I and J indices of the Cartesian grid, specified by *gcell.inp*, and the global coordinates (true east and true north) defining the curvilinear grid in physical space are defined by input on Card Image 4. The *gcell.inp* file has the same format as the *cell.inp* file. The *gefdc.inp* files shown in Figure B14 and B27 are examples where the ISGG = 1 option is activated.

Card Image 4

```
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     -77.5   1.25    -0.625  36.7    1.0     -0.5
```

```
Card Image 4 Parameter Definitions
```

```
CDLON1:    6 CONSTANTS TO GIVE CELL CENTER LAT AND LONG OR OTHER
CDLON2:    COORDINATES FOR CARTESIAN GRIDS USING THE FORMULAE
CDLON3:    DLON(L)=CDLON1+(CDLON2*FLOAT(I)+CDLON3)/60.
CDLAT1:    DLAT(L)=CDLAT1+(CDLAT2*FLOAT(J)+CDLAT3)/60.
CDLAT2:
CDLAT3:
```

The information on this card image defines the global coordinates (true east and true north) of Cartesian cell centers corresponding to the I and J indices in the *gcell.inp* file for the Cartesian graphics grid overlay when NTYPE = 1-7 is specified (see *gefdc.inp* files in Figure B14 and

B27). When NTYPE = 8 or 9 is specified, the information defines the cell center coordinates corresponding to I and J indices in the *cell.inp* file (see the *gefdc.inp* file in Figure B34). When NTYPE = 9, DLON and DLAT must correspond to longitude and latitude, otherwise DLON and DLAT can also correspond to a true east and true north coordinate system in meters or kilometers.

Card Image 5

```
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM  DEPMIN
    500    500    500    500    4000    1.0
```

Card Image 5 Parameter Definitions

```
ITRXM = MAXIMUM NUMBER OF X,Y SOLUTION ITERATIONS
ITRHM = MAXIMUM NUMBER OF HI,HJ SOLUTION ITERATIONS
ITRKM = MAXIMUM NUMBER OF KJ/KI SOLUTION ITERATIONS
ITRGM = MAXIMUM NUMBER OF GRID SOLUTION ITERATIONS
NDEPSM = NUMBER SMOOTHING PASSES TO FILL MISSING DEP DAT
DEPMIN = MINIMUM DEPTH PASSING DEPDAT.INP DATA
```

The first four parameters on Card Image 5 control the number of iterations for the various curvilinear grid generation schemes, based on successive over relaxation (SOR) solutions of elliptic equations, in *gefdc.f*. The value of 500 is recommended as a maximum for each of the these parameters based on the writer's experience that if the successive over relaxation (SOR) solution schemes do not converge after 500 iterations they are not converging at all. The value of 4000 for NDEPSM is the recommended number of smoothing passes used to fill in missing depth or bottom elevation data when the ISIDEP = 1 option on Card Image 11 is activated.

Card Image 6

```
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
```

Card Image 6 Parameter Definitions

```
RPX,RPK,RPH = RELAXATION PARAMETERS FOR X,Y; KI/KJ; AND HI,HJ
              SOR SOLUTIONS
RSQXM,RSQKM,RSQHM = MAXIMUM RESIDUAL SQUARED ERROR IN SOR
                    SOLUTION FOR X,Y; KJ/KI; AND HI,HJ
RSQKIM = CONVERGENCE CRITERIA BASED ON KI/KJ (NOT ACTIVE)
```

```
RSQHIM = CONVERGENCE CRITERIA BASED ON HI (NOT ACTIVE)
RSQHJM = CONVERGENCE CRITERIA BASED ON HJ (NOT ACTIVE)
```

The values of the first three parameters should not be changed, since they have been determined to the near optimum for the SOR solution schemes in gefdc.f. The remaining parameters are residual squared error criteria for stopping the SOR solutions. The values shown are rough estimates. For very large grids they can be decreased in magnitude to approximately 1.E-6.

Card Image 7

```
C7  COORDINATE SHIFT PARAMETERS AND ANGULAR ERROR
C7  XSHIFT   YSHIFT   HSCALE   RKJDKI   ANGORO
    0.       0.       1000.    1.       5.0
```

Card Image 7 Parameter Definitions

```
XSHIFT,YSHIFT = X,Y COORDINATE SHIFT X,Y=X,Y+XSHIFT,YSHIFT
HSCALE = SCALE FACTOR FOR HII AND HJJ WHEN PRINTED TO dxdy.out
RKJDKI = ANISOTROPIC STRETCHING OF J COORDINATE (USE 1.)
ANGORO = ANGULAR DEVIATION FROM ORTHOGONALITY IN DEGREE USED
         AS CONVERGENCE CRITERIA
```

The first two parameters allow for a coordinate translation of input coordinate data, which is generally not recommended. The scale factor is used to convert the input coordinate units to meters. For example, if the input coordinates are in kilometers, 1000 is necessary for DX and DY in the *dxdy.inp* file to be properly specified in meters. Note the cell center coordinates in the *lxly.inp* file will remain in the same units as the input coordinates. The final parameter, ANGORO, specifies the maximum deviation from orthogonal in the final grid. If the specified maximum deviation is not achieved, the generation procedure will execute the maximum number of iterations.

Card Image 8

```
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
    1       0       0        0
```

Card Image 8 Parameter Definitions

```
ISIRKI = 1, SOLUTION BASED ON INTERPOLATION OF KJ/KI TO
         INTERIOR
JSIRKI = 1, INTERPOLATE KJ/KI TO INTERIOR WITH CONSTANT
```

```
          COEFFICIENT DIFFUSION EQUATION
     ISIHIHJ =1, SOLUTION BASED ON INTERPOLATION OF HI AND HJ TO
          INTERIOR, AND THEN DETERMINING KJ/KI=HI/HJ
     JSIHIHJ = 1, INTERPOLATE HI AND HJ TO INTERIOR WITH CONSTANT
          COEFFICIENT DIFFUSION EQUATION
```

The shown configuration for this Card Image is recommended.

Card Image 9

```
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7 SERRMAX
```

Card Image 9 Parameter Definitions

```
     IB     = BEGINNING I INDEX MS METHOD
     IE     = ENDING I INDEX MS METHOD
     JB     = BEGINNING J INDEX MS METHOD
     JE     = ENDING J INDEX MS METHOD
     N7RELAX= MAXIMUM RELAXATION PER INIT LOOP, NTYPE = 7
     NXYIT  = NUMBER OF ITERS ON EACH X,Y SWEEP, NTYPE = 7
     ITN7MAX= MAXIMUM GENERATION ITERS, NTYPE = 7
     IJSMD  = 1, CALCULATE GLOBAL CONFORMAL MODULE
     ISMD   = A VALUE IB.LE.ISMD.LE.IE, CALCULATE CONFORMAL
              MODULE ALONG LINE I=ISMD
     JSMD   = A VALUE JB.LE.JSMD.LE.JE, CALCULATE CONFORMAL
              MODULE ALONG LINE J=JSMD
     RP7    = SOR RELAXATION PARAMETER, NTYPE = 7
     SERRMAX= MAXIMUM CONFORMAL MODULE ERROR, NTYPE = 7
```

Data are necessary on this line only if NTYPE = 7. The indices IB and IE define the beginning and ending I grid lines of the rectangular (in the computational domain) grid generated by the quasi-conformal mapping technique implemented for NTYPE = 7. The indices JB and JE likewise define the beginning and ending J indices. Recommended values for the remaining parameter in this card image are shown in Figure B27 in Appendix B.

Card Image 10

```
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
```

Card Image 10 Parameter Definitions

```
     XIBJB,YIBJB = IB,JB COORDINATES
     XIEJB,YIEJB = IE,JB COORDINATES
```

```
XIBJE,YIBJE = IB,JE COORDINATES
XIEJE,YIEJE = IE,JE COORDINATES
```

Data are necessary on this line only if NTYPE = 7, with the x and y coordinates specified corresponding to the true east and north physical domain coordinates of the four corners of the rectangular region in the computational domain.

Card Image 11

```
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      11564   2.   .5   2        4.0     0     0       0
```

Card Image 11 Parameter Definitions

```
ISIDEP   = 1, READ depdat.inp FILE AND INTERPOLATE DEPTH, BOTTOM
           ELEVATION AND BOTTOM ROUGHNESS DATA IN THE dxdy.inp
           FILE
NDEPDAT  = NUMBER OF X, Y, DEPTH FIELDS IN DEPDAT.INP FILE
CDEP     = WEIGHTING COEFFICIENT IN DEPTH INTERPOLATION SCHEME
RADM     = CONSTANT MULTIPLIER FOR DEPTH INTERPOLATION RADIUS
ISIDPTYP = 1, ASSUMES DEPDAT.INP CONTAINS POSITIVE DEPTHS
           TO A BOTTOM BELOW A SEA LEVEL DATUM AND THE BOTTOM
           ELEVATION IS THE NEGATIVE OF THE DEPTH
           2, ASSUMES DEPDAT.INP CONTAINS POSITIVE BOTTOM
           ELEVATIONS, LOCAL INITIAL DEPTH IS THEN DETERMINED
           BY DEPTH=SURFELV-BELB
           3, ASSUMES DEPDAT.INP CONTAINS POSITIVE BOTTOM
           ELEVATIONS WHICH ARE CONVERTED TO NEGATIVE VALUES,
           LOCAL INITIAL DEPTH IS THEN DETERMINED
           BY DEPTH=SURFELV-BELB
SURFELV  = INITIALLY FLAT SURFACE ELEVATION FOR USE WHEN
           ISIDPTYP = 2 OR 3.
ISVEG    = 1, READ AND INTERPOLATE VEGETATION DATA
NVEGDAT  = NUMBER OF X,Y,VEGETATION CLASS DATA POINTS
NVEGTYP  = NUMBER OF VEGETATION TYPES OR CLASSES
```

Setting ISIDEP = 1 activates depth or bottom elevation interpolation to the grid using NDEPDAT depth or bottom elevation data points. The depth or bottom elevation data within a radius of RDM*Min(dx,dy) of a cell center to determine a weighted average cell center or cell mean depth using an inverse distance weighting if CDEP = 1 or an inverse square weighting is CDEP = 2. If no data are within RDM*Min(dx,dy) of the cell center, the cell is flagged as having missing depth or bottom elevation data. Missing depth or bottom elevation data are determined using a Laplace equation filling technique which preserves values of the depth and

bottom elevation in the unflagged cells. Vegetation class interpolation is activated by ISVEG = 1. For vegetation class interpolation, the predominant class is selected if more than on vegetation class data point falls within a cell. Since there is no fill option for the vegetation class interpolation, cells not having vegetation data points within their boundaries are assigned the null class 0. The null class is then replaced by hand in the *dxdy.inp* file, using class information from surrounding cells.

Card Image 12

```
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
    1   1   0.          0.
```

Card Image 12 Parameter Definitions

```
LAST PAIR OF GRID COORDINATES ON BOUNDARY
USED FOR NTYPE = 1 through 6
```

The last I,J index and true east and north coordinates X,Y for the last point in the clockwise sequence of grid points around the domain is specified. See the example in Appendix B.

Card Image 13

```
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Card Image 13 Parameter Definitions

```
SEQUENCE OF GRID COORDINATES CLOCKWISE
AROUND THE BOUNDARY
USED FOR NTYPE = 1 THROUGH 6
```

The sequence of I,J index and true east and north coordinates X,Y clockwise around the domain is specified with one set of I,J,X,Y points per line, see the example in Appendix B. In the NTYPE = 1-4 options are specified, grid reflection occurs about the line joining the first and last points.

The *gefdc.f* code generates a number of output files, including the *dxdy.inp* and lxly.inp files for input into the *efdc.for* code. (These files are actually output as *dxdy.out* and *lxly.out* and must be renamed for use by *efdc.f*. The other output files and their purposes and content are as follows:

Table 5. Output files from the *gefdc.f* code

File	Description
depint.log	A file containing the I,J indices and true x,y coordinates of cells having no depth or bottom elevation data in their immediate vicinity (depths and bottom elevations are determined by a smoothing interpolation).
dxdy.diag	A file containing diagnostics for curvilinear-orthogonal grids. See following text and Figure 9.
gefdc.log	A file containing a log of the execution of the gefdc.f code. The contents of this file are also written to the screen during execution. See following text and Figure 10.
gefdc.out	This contain a listing of the *cell.inp* file, the KSGI array specifying interior grid points, the initial x,y grid coordinates, and the final x,y grid coordinates.
grid.cord	A file containing sequence of grid line coordinates with character variables separating sequences of constant I or J lines. Contents can be used for plotting grid.
grid.dpt	A pen lift plotting format (x,y,ipen). Ipen=-1 defines the start of new line sequence.
grid.dxf	A dxf (CADD drawing exchange file) of the final grid which can be plotted with any CADD or graphics software capable of importing the dxf format.
grid.init	A dxf (CADD drawing exchange file) of the initial grid which can be plotted with any CADD or graphics software capable of importing the dxf format.
grid.ixy	Similar to grid.cord, but contains only constant I lines

grid.jxy Similar to grid.cord, but contains only constant J lines

grid.mask A file containing a clockwise sequence of the true x,y coordinates of grid points along the land-water boundary. This file can be used in masking or defining the region for horizontal plane contour plotting by contouring software such as NCAR Graphic or Surfer.

gridext.out A file containing the I,J indices and true x,y coordinates of all water cell grid points. This file can be renamed gridext.inp and used for NTYPE = 0 grid generation. A number of gridext.out files form subgrids that can be combined into a single gridext.inp to generate a composite grid. See example in Section B.4 of Appendix B.

salt.inp This file is a template of the salt.inp input file for the *efdc.f* code. Salinity values are set to zero and may be filled with data. See Chapter 5.

```
  I    J     HII          HJJ          HIIHJJ       JACOBIAN     ANG ERROR

 39    6  0.1968E+02  0.2962E+02  0.5827E+03   0.5827E+03   0.3120E+00
  .    .     .           .           .            .            .
  .    .     .           .           .            .            .
  .    .     .           .           .            .            .
  .    .     .           .           .            .            .

ASQRTG=    0.3305E+06  ASHIHJ=    0.3311E+06  AERR=    0.1973E-02
NWCELLS=         325
```

Figure 9. Sample output in the *dxdy.diag* file.

```
DIFF INITIAL X&Y, ITER = 100 RSX,RSY =   0.4439E-10   0.4383E-11

DIFFUSE RKI, ITERATION =  69 RSK =   0.9475E-12

DIFF X & Y, ITER =  81 RSX,RSY =   0.9747E-12   0.8887E-12

GRID GENERATION LOOP ITERATION =         1

GLOBAL RES SQ DIFF IN RKI=  0.3978E+00

MIN AND MAX DEVIATION FROM ORTHO =    0.3837E-02    0.1008E+02

  .     .        .      .                .
  .     .        .      .                .

NWCELLS=       325
N999 =         0
DEPMAX =  0.30678E+01
```

Figure 10. Sample output in the *gefdc.log* file.

The file *dxdy.diag*, Figure 9, contains the primary diagnostics of the curvilinear-orthogonal grid generation process. For each water cell, the file lists the computed orthogonal metric factors HI and HG (which are also dx and dy, the curvilinear cell dimensions). For true orthogonality, the product HII*HJJ is the horizontal area of the cell. The actual area of the cell, which is also the Jacobian of the general curvilinear coordinate transformation, is also shown, and should agree with HII*HJJ to within a few percent. The angular error for each cell is a measure of deviation from numerical orthogonality, and should be small. The orthogonality of the grid can be improved by identifying cells along the land water boundary with the largest angular errors and adjusting their land bounding grid corner coordinate points on Card Image 13 in the *gefdc.inp* file. At the end of the *dxdy.diag* file, the exact area of the grid, ASQRTG, is printed for comparison with the sum of the HII*HJJ product for all water cells. The relative error between these two quantities, AERR, is also printed, as well as the total number of water cells in the grid. The *gefdc.log* file, shown in Figure 10, summarizes the computational steps in the grid generation. The initialization of the grid, referred to as diffuse x and y, since the generation scheme is similar to the solution of a steady state diffusion or elliptic equation, is followed by a summary of each grid generation iteration. The iteration involves diffusing the boundary metric

ratios, RKI, to the interior and then the diffusion of the x and y coordinates to the interior. The residuals for these diffusion or elliptic equation solutions by successive over relaxation are the small quantities beginning with R. The minimum and maximum deviations from orthogonality, in degree, at the end of the iteration is then printed. After the grid generation has converged or executed the specified number of maximum iterations, the equivalent contents of the *dxdy.out* (inp) file is also written in *gefdc.log*. The file ends with a summary of the number of water cells, the number of cells where depth or bottom topography failed to be determined, and the maximum initial water depth in the grid.

4. The Master Input File: EFDC.INP

This chapter describes the master input, *efdc.inp*, for EFDC. The information in efdc.inp provides run control parameters, output control and physical information describing the model domain and external forcing functions. The file is internally documented, in essence providing a template or menu for setting up a simulation. The file consists of card image sections, with each section having header lines which define the relevant input parameter in that section. The function of the various card image sections is best illustrated by a sequential discussion of each section. Card Image sections and input parameters which are judged to be clearly explained in the *efdc.inp* files internal documentation will not be discussed specifically. Before proceeding, a number of conventions should be discussed. Many options in the code are activated by integer switches (most beginning with either IS or JS). Unless otherwise noted, setting theses switches to zero deactivates the option. Options are normally activated by specifying nonzero integer values. A number of options described in the file are classified as for research purposes. This classification indicates that the option may involve an experimental and not fully tested numerical scheme or that it involves rather complex internal analysis or flow field data extraction. Detail information on the function and current status of these options may be obtained from the writer. A complete listing of the *efdc.inp* file for an actual application can be found in Appendix C, and may be used as the template for setting up a new model application.

Card Image 1

```
------------------------------------------------------------------------------
C1 TITLE FOR RUN

   TITLE OR IDENTIFIER FOR THIS INPUT FILE AND RUN

C1 (LIMIT TO 80 CHARACTERS LENGTH)
   'Housatonic River Validation Runs'
------------------------------------------------------------------------------
```

Card image 1 defines an 80 character title for the specific application

Card Image 1A

```
------------------------------------------------------------------------------
C1A  GRID CONFIGURATION AND TIME INTEGRATION MODE SELECTION
C
        IGRIDH:  0 SINGLE HORIZONTAL GRID WITHOUT HORIZONTAL PARALLELIZATION
                 1 SINGLE HORIZONTAL GRID WITH HORIZONTAL PARALLELIZATION
                   GE.2, NUMBER OF HORIZONTAL GRIDS WITH HORIZONTAL DOMAIN
                   DECOMPOSITION PARALLELIZATION
                -1 ONE-DIMENSIONAL CHANNEL NETWORK WITH HEC TYPE CROSS SECTIONS
        INESTH:  1  NO NESTING FOR IGRIDH.GE.2
                 2  2 TO 1 NESTING (FINE TO COARSE) FOR IGRIDH.GE.2
                 3  3 TO 1 NESTING (FINE TO COARSE) FOR IGRIDH.GE.2
        IGRIDV:  0 STANDARD SIGMA VERTICAL GRID OR SINGLE LAYER DEPTH AVERAGE
                 1 GENERAL VERTICAL GRID WITH SIGMA AND RESCALED HEIGHT REGIONS
       ITIMSOL:  0 THREE-TIME LEVEL INTEGRATION
                 1 TWO-TIME LEVEL INTEGRATION
  ISHOUSATONIC:  1 ACTIVATE HOUSATONIC RIVER SUPERFUND SEDIMENT-TOXICS OPTIONS
C
C1A  IGRIDH  INESTH  IGRIDV  ITIMSOL  ISHOUSATONIC
     0       0       0       1        1
------------------------------------------------------------------------------
```

This card image controls aspects of the spatial and temporal formulation. Options for IGRIDH greater than 1 are not currently available and the INESTH options are also not currently available. The ISHOUSATONIC option activates a number of sediment and toxic transport subroutines specific to the U.S. EPA Housatonic River application of EFDC. This option should be selected only by user who are extremely familiar with that application in this release.

Card Image 2

```
------------------------------------------------------------------------------
C2  RESTART, GENERAL CONTROL AND DIAGNOSTIC SWITCHES
c
     ISRESTI:  1 FOR READING INITIAL CONDITIONS FROM FILE restart.inp
              -1 AS ABOVE BUT ADJUST FOR CHANGING BOTTOM ELEVATION
               2 INITIALIZES A KC LAYER RUN FROM A KC/2 LAYER RUN FOR KC.GE.4
              10 FOR READING IC'S FROM restart.inp WRITTEN BEFORE 8 SEPT 1992
     ISRESTO: -1 FOR WRITING RESTART FILE restart.out AT END OF RUN
               N INTEGER.GE.0 FOR WRITING restart.out EVERY N REF TIME PERIODS
     ISRESTR:  1 FOR WRITING RESIDUAL TRANSPORT FILE restran.out
     ISLOG:    1 FOR WRITING LOG FILE efdc.log
     ISPAR:    0 FOR EXECUTION OF CODE ON A SINGLE PROCESSOR MACHINE
               1 FOR PARALLEL EXECUTION, PARALLELIZING PRIMARILY OVER LAYERS
               2 FOR PARALLEL EXECUTION, PARALLELIZING PRIMARILY OVER NDM
                 HORIZONTAL GRID SUBDOMAINS, SEE CARD C9
     ISDIVEX:  1 FOR WRITING EXTERNAL MODE DIVERGENCE TO SCREEN
     ISNEGH:   1 FOR SEARCHING FOR NEGATIVE DEPTHS AND WRITING TO SCREEN
     ISMMC:    1 FOR WRITING MINIMUM AND MAXIMUM VALUES OF SALT AND DYE
                 CONCENTRATION TO SCREEN
     ISBAL:    1 FOR ACTIVATING MASS, MOMENTUM AND ENERGY BALANCES AND
                 WRITING RESULTS TO FILE bal.out
     ISHP:     1 FOR CALLING HP 9000 S700 VERSIONS OF CERTAIN SUBROUTINES
     ISH0W:    1 TO SHOW PUV&S ON SCREEN, SEE INSTRUCTIONS FOR FILE show.inp
C
C2  ISRESTI ISRESTO ISRESTR ISPAR ISLOG ISDIVEX ISNEGH ISMMC ISBAL ISHP ISHOW
    1       -1      0       0     0     0       2      0     1     1    1
```

Card Image 2, specifies the mode of model startup, either a cold start, with the flow field initialized to zero, or a restart.inp using initial conditions corresponding to the conditions at the end of a previous simulation. The ISRESTO switch controls the frequency of outputting restart information to the file restart.out (which is renamed restart.inp to launch a run). The file restran.out contains the time averaged transport file, which may be used to execute the efdc.for code in a transport only mode. The switch ISPAR allows implementation of internal code options for execution on multiple processor or parallel machines. These options are currently supported on multiple vector processor Cray supercomputers, and on Silicon Graphic and Sparc (Sun and clones) based symmetric multiprocessor UNIX workstations. The choice of ISPAR equal to 1 or 2, depends on both the grid structure and the number of processors on which the code will execute. Portions of the code capable of being parallelized over vertical layers or horizontal grid subdomains are parallelized over vertical layers when ISPAR is set to 1. For layer parallelization, the number of layers must be an integer multiple of the number of processors on which the code will execute. For grids consistent with layer parallelization, portions of the code allowing either mode of parallelization are generally more efficient in the layer parallelization mode. Certain portions of the code may be parallelized only overly horizontal subdomains, with this mode being active for ISPAR equal 1 or 2. For ISPAR = 2, all parallelization is over horizontal subdomains. See Card C9 and Chapter 6 for additional details regarding parallel execution of EFDC. The switch ISLOG activates the creation of a log file (ISLOG = 2, recommended) which is deleted and reopened after each reference time period. The contents and interpretation of the material in file efdc.log will be discussed in the diagnostics chapter. The switches, ISDIVEX, ISNEGH, and ISMMC, activate diagnostic checks on volume conservation, identify negative solution depths, and check mass conservation of transport materials, activation of these switches (IS=1) produces identical output to the screen and efdc.log file. The use of these options for diagnostic purposes is discussed in the diagnostics chapter. The switch ISHP allows use of Hewlett-Packard 9000 series 700 vector libraries. The vector library calls are currently commented out with CDHP in the source code. The procedure for activating this option and accessing the HP vector library may be obtained from the writer. The switch ISBAL activates an internal volume, mass, momentum and energy balance procedure. The switch ISHOW activates a screen print of flow field conditions in a specified horizontal location during the run, with more details given with the description of the file show.inp in the next chapter.

Card Image 3

```
------------------------------------------------------------------------------
C3 EXTERNAL MODE SOLUTION OPTION PARAMETERS AND SWITCHES
C
   RP:         OVER RELAXATION PARAMETER
   RSQM:       TARGET SQUARE RESIDUAL OF ITERATIVE SOLUTION SCHEME
   ITERM:      MAXIMUM NUMBER OF ITERATIONS
   IRVEC:    0 STANDARD RED-BLACK SOR SOLUTION
             1 MORE VECTORIZABLE RED-BLACK SOR (FOR RESEARCH PURPOSES)
             2 RED-BLACK ORDERED CONJUGATE GRADIENT SOLUTION
             3 REDUCED SYSTEM R-B CONJUGATE GRADIENT SOLUTION
             9 WETTING/DRYING - CONJUGATE GRADIENT SOLUTION WITH MAXIMUM DIAGNOSTICS
   RPADJ:      RELAXATION PARAMETER FOR AUXILIARY POTENTIAL ADJUSTMENT
               OF THE MEAN MASS TRANSPORT ADVECTION FIELD
               (FOR RESEARCH PURPOSES)
   RSQMADJ:    TARGET SQUARED RESIDUAL ERROR FOR ADJUSTMENT
               (FOR RESEARCH PURPOSES)
   ITRMADJ:    MAXIMUM ITERATIONS FOR ADJUSTMENT (FOR RESEARCH PURPOSES)
   ITERHPM:    MAXIMUM ITERATIONS FOR STRONGLY NONLINEAR DRYING AND WETTING
               SCHEME (ISDRY=3 OR 4)  ITERHPM.LE.4
   IDRYCK:     ITERATIONS PER DRYING CHECK (ISDRY.GE.1)  2.LE.IDRYCK.LE.20
   ISDSOLV: 1 TO WRITE DIAGNOSTICS FILES FOR EXTERNAL MODE SOLVER
      FILT:    FILTER COEFFICIENT FOR 3 TIME LEVEL EXPLICIT ( 0.0625 )

C3 RP  RSQM    ITERM IRVEC RPADJ RSQMADJ ITRMADJ ITERHPM IDRYCK ISDSOLV FILT
   1.8 1.E-10 9999  9     1.8   1.E-16  1000    4       20     0       .0625
------------------------------------------------------------------------------
```

The information input on Card Image 3 primarily controls the external or barotropic mode solution in *efdc.for*. The relaxation parameter of 1.8 should not be changed. The RSQM parameter is the residual squared error in the external mode solution. It is generally set between 1E-6 and 1E-15, with the small values corresponding several hundred cells and a small time step (10-100 seconds) and the larger value corresponding a large number of cells (1000-10,000) and a large time step (100-1000 seconds). It RSQM is set to a small value, a simulation may crash due to accumulated roundoff error. RSQM should be adjusted such that the number of iterations shown in the efdc.log file is between approximately 10 and 40. The maximum iteration count in the external solution ITERM is set such that execution stops if the external solution does not converge in the maximum number of iterations. The parameter IRVEC controls the type of linear equation solver used in the external mode solution. The original successive over relaxation solver has been supplemented with two conjugate gradient solvers, a diagonally preconditioned solver, IRVEC = 2, and a red-black ordered, reduced system, conjugate gradient solver, IRVEC = 3. The options IRVEC = 0 or IRVEC = 3 is recommended if drying and wetting is not active, while the option, IRVEC = 2, is required when drying and wetting is activated. The remaining parameters are for research purposes, and generally not used in standard applications, or are self-explanatory.

Card Image 4

```
------------------------------------------------------------------------------
C4 LONG-TERM MASS TRANSPORT INTEGRATION ONLY SWITCHES
C
   ISLTMT:  1 FOR LONG-TERM MASS TRANSPORT ONLY (FOR RESEARCH PURPOSES)
   ISSSMMT: 0 WRITES MEAN MASS TRANSPORT TO RESTRAN.OUT AFTER EACH
              AVERAGING PERIOD  (FOR RESEARCH PURPOSES)
            1 WRITES MEAN MASS TRANSPORT TO RESTRAN.OUT AFTER LAST
              AVERAGING PERIOD  (FOR RESEARCH PURPOSES)
   ISLTMTS: 0 ASSUMES LONG-TERM TRANSPORT SOLUTION IS TRANSIENT
              (FOR RESEARCH PURPOSES)
            1 ASSUMES LONG-TERM TRANSPORT SOLUTION IS ITERATED TOWARD
              STEADY STATE (FOR RESEARCH PURPOSES)
   ISIA:    1 FOR IMPLICIT LONG-TERM ADVECTION INTEGRATION FOR ZEBRA
              VERTICAL LINE R-B SOR (FOR RESEARCH PURPOSES)
   RPIA:      RELAXATION PARAMETER FOR ZEBRA SOR(FOR RESEARCH PURPOSES)
   RSQMIA:    TARGET RESIDUAL ERROR FOR ZEBRA SOR (FOR RESEARCH PURPOSES)
   ITRMIA:    MAXIMUM ITERATIONS FOR ZEBRA SOR (FOR RESEARCH PURPOSES)
   ISAVEC:  1 USE ALTIVEC ENABLED SUBROUTINES (MAC G4 ONLY)
C
C4 ISLTMT ISSSMMT ISLTMTS ISIA RPIA RSQMIA ITRMIA ISAVEC
   0      2       0       0    1.8  1E-10  100    0
------------------------------------------------------------------------------
```

The EFDC model has the capability to function in a transport only mode using advective and diffusive transport specified in the file restran.inp. The first parameter, ISLTMT, actives this mode. The second parameter ISSSMMT controls the creation of the restran.inp file, output as restran.out, during normal execution. The frequency of graphical output of residual fields is also controlled by this parameter. The third parameter determines whether the transport only mode with be integrated to steady state or integrated for a transient residual transport field. The remaining four parameters are for research purposes, however, ISIA should be set to zero.

Card Image 5

```
------------------------------------------------------------------------------
C5 MOMENTUM ADVEC AND HORIZONTAL DIFFUSION SWITCHES AND MISC SWITCHES
C
   ISCDMA:  1 FOR CENTRAL DIFFERENCE MOMENTUM ADVECTION
            0 FOR UPWIND DIFFERENCE MOMENTUM ADVECTION
            2 FOR EXPERIMENTAL UPWIND DIFFUSION MOM ADV (FOR RESEARCH PURPOSES)
   ISAHMF:  1 TO ACTIVE HORIZONTAL MOMENTUM DIFFUSION
   ISDISP:  1 CALCULATE MEAN HORIZONTAL SHEAR DISPERSION TENSOR
              OVER LAST MEAN MASS TRANSPORT AVERAGING PERIOD
   ISWASP: 4 OR 5 TO WRITE FILES FOR WASP4 OR WASP5 MODEL LINKAGE, 99 - CE-QUAL-ICM
   ISDRY:   0 NO WETTING & DRYING OF SHALLOW AREAS
            1 CONSTANT WETTING DEPTH SPECIFIED BY HWET ON CARD 11
              WITH NONLINEAR ITERATIONS SPECIFIED BY ITERHPM ON CARD C3
            2 VARIABLE WETTING DEPTH CALCULATED INTERNALLY IN CODE
              WITH NONLINEAR ITERATIONS SPECIFIED BY ITERHPM ON CARD C3
           11 SAME AS 1, WITHOUT NONLINEAR ITERATION
          -11 SAME AS 11 BUT WITH CELL MASKING
           99 VARIABLE WETTING & DRYING USING CELL FACES
```

```
          -99 SAME AS 11 BUT WITH CELL MASKING
   ISQQ:    1 TO USE STANDARD TURBULENT INTENSITY ADVECTION SCHEME
   ISRLID:  1 TO RUN IN RIGID LID MODE (NO FREE SURFACE)
   ISVEG:   1 TO IMPLEMENT VEGETATION RESISTANCE
            2 IMPLEMENT WITH DIAGNOSTICS TO FILE CBOT.LOG
   ISVEGL:  1 TO INCLUDE LAMINAR FLOW OPTION IN VEGETATION RESISTANCE
   ISITB:   1 FOR IMPLICIT BOTTOM & VEGETATION RESISTANCE IN EXTERNAL MODE
              FOR SINGLE LAYER APPLICATIONS (KC=1) ONLY
   ISEVER:  1 TO DEFAULT TO EVERGLADES HYDRODYNAMIC SOLUTION OPTIONS
   IINTPG:  0 ORIGINAL INTERNAL PRESSURE GRADIENT FORMULATION
            1 JACOBIAN FORMULATION
            2 FINITE VOLUME FORMULATION
C
C5 ISCDMA ISAHMF ISDISP ISWASP ISDRY ISQQ ISRLID ISVEG ISVEGL ISITB ISEVER IINTPG
   0      0      0      0      -99   1    0      1     0      2     0      0
-------------------------------------------------------------------------------
```

This card image controls various options for integration of the advective and diffusive portions of the momentum equations as well as the activation of additional physical process representations and optional output processing. The parameter ISCDMA controls the finite difference representation of momentum advection, with the zero default value corresponding to upwind difference, and the values of 1 and 2 corresponding respectively to central differencing and an experimental upwind difference scheme. The central difference option is generally recommended only for smooth or idealized bottom topography and lateral boundaries. The second parameter ISAHMF activates horizontal moment diffusion. It should be activated when using central difference advection or when simulating wave induced currents. For wave induced currents, the horizontal diffusion is specified in terms of the wave energy dissipation due to wave breaking in the surf zone. The options ISDISP and ISWASP respectively control the creation of shear dispersion coefficient file disp.out and a WASP water quality model transport files waspX.out. The parameter ISDRY activates drying and wetting and the value 11 is recommended. The parameter ISQQ should remain set to unity. The parameter ISRLID implements a rigid free surface simulation and is generally used only for research purposes. The next three parameters activate the vegetation resistance model. The last parameter ISITB should be activated only in single layer or depth integrated simulations. The remaining parameter ISWAVE activates the wave-current boundary layer model and the wave induced current model, using an external specification of high frequency surface wave conditions in the input file wave.inp.

Card Image 6

```
-------------------------------------------------------------------------------
C6 DISSOLVED AND SUSPENDED CONSTITUENT TRANSPORT SWITCHES
   TURB=0,SAL=1,TEM=2,DYE=3,SFL=4,TOX=5,SED=6,SND=7,CWQ=8

   ISTRAN:  1 OR GREATER TO ACTIVATE TRANSPORT
   ISTOPT:    NONZERO FOR TRANSPORT OPTIONS, SEE USERS MANUAL
```

```
   ISCDCA:  0 FOR STANDARD DONOR CELL UPWIND DIFFERENCE ADVECTION
            1 FOR CENTRAL DIFFERENCE ADVECTION FOR THREE TIME LEVEL STEPS
            2 FOR EXPERIMENTAL UPWIND DIFFERENCE ADVECTION (FOR RESEARCH)
   ISADAC:  1 TO ACTIVATE ANTI-NUMERICAL DIFFUSION CORRECTION TO
              STANDARD DONOR CELL SCHEME
   ISFCT:   1 TO ADD FLUX LIMITING TO ANTI-NUMERICAL DIFFUSION CORRECTION
   ISPLIT:  1 TO OPERATOR SPLIT HORIZONTAL AND VERTICAL ADVECTION
              (FOR RESEARCH PURPOSES)
   ISADAH:  1 TO ACTIVATE ANTI-NUMERICAL DIFFUSION CORRECTION TO HORIZONTAL
              SPLIT ADVECTION STANDARD DONOR CELL SCHEME (FOR RESEARCH)
   ISADAV:  1 TO ACTIVATE ANTI-NUMERICAL DIFFUSION CORRECTION TO VERTICAL
              SPLIT ADVECTION STANDARD DONOR CELL SCHEME (FOR RESEARCH)
   ISCI:    1 TO READ CONCENTRATION FROM FILE RESTART.INP
   ISCO:    1 TO WRITE CONCENTRATION TO FILE RESTART.OUT
C
C6 ISTRAN ISTOPT ISCDCA ISADAC ISFCT ISPLIT ISADAH ISADAV ISCI  ISCO
   1      0      0      0      0     0      0      0      1     1     !TURB 0
   0      0      0      0      0     0      0      0      0     0     !SAL  1
   0      0      0      0      0     0      0      0      0     0     !TEM  2
   0      0      0      0      0     0      0      0      0     0     !DYE  3
   0      0      0      0      0     0      0      0      0     0     !SFL  4
   1      0      0      0      0     0      0      0      0     1     !TOX  5
   1      0      0      0      0     0      0      0      0     1     !SED  6
   1      0      0      0      0     0      0      0      0     1     !SND  7
   0      0      0      0      0     0      0      0      0     0     !CWQ  8
-------------------------------------------------------------------------------
```

Card Image 6 controls the advective transport and source sink options for transported scalar fields. The seven lines of active input represent in order, turbulent intensity, salinity, temperature, a dye tracer, suspended sediment, shellfish larvae, and water quality variables. The first switch, ISTRAN activates advective transport and sources and sinks. On the first line, corresponding to the turbulence model, only ISTRAN should be set to unity with the remaining parameters set to zero. If IGRIDV = 1, only use for simulating turbulent intensity (i.e., hydrodynamics), salinity and temperature. For water quality, ISTRAN=1, activates the embedded water quality model WQ3D (Park, 1995) which has additional input files not documented in this manual. The second parameter ISTOPT sets options for a number of the transport scalar fields. Current active options are:

Salinity

ISTOPT=1: Read initial salinity distribution from file salt.inp (ISRESTI=0, only)

Temperature

ISTOPT=1: Full surface and internal heat transfer calculation using data from file aser.inp.

ISTOPT=2: Transient equililibrium surface heat transfer calculation using external equilibrium temperature and heat transfer coefficient data from file aser.inp.

ISTOPT=3: Equilibrium surface heat transfer calculation using constant equilibrium temperature and heat transfer coefficients from Card Image 30.

Initial isothermal temperature for cold starts (ISRESTI=0) is read on Card Image 30. See Cerco and Cole (1993) for a discussion of the equilibrium temperature surface head transfer approach.

Dye Tracer

ISTOPT=1: Read initial dye tracer distribution from file dye.inp (ISRESTI=0, only). Linear or first order dye decay specified on Card Image 30.

Shellfish Larvae

No options available

Toxic Contaminant

No options specified here

Suspended Sediment

No options specified here

Water Quality Constituents

No options specified here

The third parameter, ISCDCA, specifies the advection scheme with the zero default values corresponding to donor cell upwind difference. Values of 1 and 2 specify central difference (not recommended) and an experimental first order upwind difference scheme, respectively. The parameter ISADAC=1 activates an antidiffusion advective flux correction (Smolarkiewicz and Clark, 1986) for ISCDCA equals 0 or 1. The parameter ISFCT=1, implements the antidiffusion correction in the flux corrected transport form (Smolarkiewicz and Grabowski, 1990). The three parameters ISPLIT, ISADAH, and ISADAV activate an experimentally operated split antidiffusive upwind difference scheme and should remain set to 0. The parameters ISCI and ISCO when set to 1 read and write, respectively, the specified field from and to the files

restart.inp and restart.out. Turbulence quantities are by default read from and written to the restart files.

Card Image 7

```
------------------------------------------------------------------------------
C7 TIME-RELATED INTEGER PARAMETERS
C
   NTC:     NUMBER OF REFERENCE TIME PERIODS IN RUN
   NTSPTC:  NUMBER OF TIME STEPS PER REFERENCE TIME PERIOD
   NLTC:    NUMBER OF LINEARIZED REFERENCE TIME PERIODS
   NLTC:    NUMBER OF TRANSITION REF TIME PERIODS TO FULLY NONLINEAR
   NTCPP:   NUMBER OF REFERENCE TIME PERIODS BETWEEN FULL PRINTED OUTPUT
            TO FILE EFDC.OUT
   NTSTBC:  NUMBER OF REFERENCE TIME PERIODS BETWEEN TWO TIME LEVEL
            TRAPEZOIDAL CORRECTION TIME STEP,
   NTCNB:   NUMBER OF REFERENCE TIME PERIODS WITH NO BUOYANCY FORCING
   NTCVB:   NUMBER OF REFERENCE TIME PERIODS WITH VARIABLE BUOYANCY FORCING
   NTSMMT:  NUMBER OF REFERENCE TIME TO AVERAGE OVER TO OBTAIN
            RESIDUAL OR MEAN MASS TRANSPORT VARIABLES AND MASS BALANCE INTERVAL
   NFLTMT:  USE 1 (FOR RESEARCH PURPOSES)
   NDRYSTP: MIN NO. OF TIME STEPS A CELL REMAINS DRY AFTER INITIAL DRYING
C           -NDRYSTP FOR ISDRY=-99 TO ACTIVATE WASTING WATER IN DRY CELLS
C7 NTC NTSPTC  NLTC NTTC NTCPP NTSTBC NTCNB NTCVB NTSMMT NFLTMT NDRYSTP
   365 1728000 0    0    10    4      0     0     72000  1      100
------------------------------------------------------------------------------
```

Card Images 7 and 8 provide time controls for the simulation with Card Image 7 providing integer parameters. The EFDC code executes of a specified number of time cycles, NTC. The actual length of the time cycle in seconds is specified by TREF on Card Image 8. For example, a 30 day simulation would correspond to NTC = 30 and TREF = 86400 seconds. The example shown specifies 72 time cycles and TREF = 44714.16 seconds, the period of the M2 time. The time step is specified as the number of time steps per reference time period, NTSPTC. For the values shown, the actual time step is 103.505 seconds (44714.16 sec/432). The parameter NLTC allows for NLTC time periods with no nonlinear terms in the momentum equations, while NTTC allows for a gradual introduction of the nonlinear terms over NTTC reference time periods. These two options may be useful for cold starts (ISRESTI=0) or diagnostic purposes. The NTCPP controls the frequency of printed output to efdc.out. The printed output is primarily in the form of line printer contour plots which may be useful in situations where graphics postprocessing capabilities are not readily available. Given the extensive options currently available in the code to generate graphical output, NTCPP is usually specified large enough such that the printed output is not generated. The parameter, NTSTBC is extremely important in that it specifies the frequency of insertion of a two time level trapezoidal correction step into the three-time level integration (see Hamrick, 1992a). Generally NTSTBC should be between 4 and 12, increasing if NTSPTC increases. The parameters NTCNB and NTCVB control the

introduction of buoyancy forcing into the momentum equations in a similar manner as described for NLTC and NTTC, respectively. The parameter NTSMMT specifies the number of time steps for the calculation of time averaged or residual output variables and also the output frequency to the "r" class output files. If NTSMMT is greater than or equal to NTSPTC, the averaging includes calculation of the Lagrangian mean transport fields (Hamrick, 1994a). The parameter NFLTMT should remain set to 1. The parameter NDRYSTP specifies the number of timesteps a cell must remain dry before wetting is allowed when the drying and wetting option is activated.

Card Image 8

```
------------------------------------------------------------------------------
C8 TIME-RELATED REAL PARAMETERS
C
   TCON:     CONVERSION MULTIPLIER TO CHANGE TBEGIN TO SECONDS
   TBEGIN:   TIME ORIGIN OF RUN
   TREF:     REFERENCE TIME PERIOD IN SEC (i.e., 44714.16S or 86400s)
   CORIOLIS: CONSTANT CORIOLIS PARAMETER IN 1/s = 2*7.29E-5*SIN(LAT)
   ISCORV:   1 TO READ VARIABLE CORIOLIS COEFFICIENT FROM LXLY.INP FILE
   ISCCA:    WRITE DIAGNOSTICS FOR MAX CORIOLIS-CURV ACCEL TO FILE EFDC.LOG
   ISCFL:    1 WRITE DIAGNOSTICS OF MAX THEORETICAL TIME STEP TO CFL.OUT
             GT 1 TIME STEP ONLY AT INTERVAL ISCFL FOR ENTIRE RUN
   ISCFLM:   1 TO MAP LOCATIONS OF MAX TIME STEPS OVER ENTIRE RUN
   DTSSFAC:  DYNAMIC TIME STEPPING IF 0.0.LT.DTSSFAC.LT.1.0
   DTSSDHDT: DYNAMIC TIME STEPPING RATE OF DEPTH CHANGE FACTOR
C
C8 TCON  TBEGIN TREF  CORIOLIS ISCORV ISCCA ISCFL ISCFLM DTSSFAC DTSSDHDT
   86400 4018   86400 0.000064 0      0     0     0      0.8     1.0
------------------------------------------------------------------------------
```

This card image specifies a number of real time related parameters as well as activating timestep related diagnostics. TBEGIN specifies the start time of the runs in units of seconds, minutes, hours, or days, with TCON being the multiplier factor which would convert TBEGIN to seconds. The reference time period must always be specified in seconds. The EFDC model currently is based on an f plane formulation for the Coriolis accelerations, with the variable CORIOLIS being the value of f in 1/seconds units. The maximum stable time step is constrained by the 0.5/f and the CFL criteria for advection (Hamrick, 1992a). Activation of ISDCCA causes the maximum effective Coriolis parameter to be printed to the log file efdc.log at each time step. Activation of ISCFL=1 writes the limiting time step, and the cell in which it occurs, based on the CFL condition to the file cfl out at each time step. Since the CFL condition is based on linear stability analysis of a constant coefficient, three-dimensional advection equation, a good rule for real world applications with spatial and temporal varying advective fields is to use a time step on the order of 1/4 to 1/2 the limiting CFL time step written to cfl.out. Since both of the time step diagnostics involve logic searches, they should only be activated during the start up of a new model application.

Card Image 9

```
------------------------------------------------------------------------------
C9  SPACE-RELATED AND SMOOTHING PARAMETERS
C
       IC:      NUMBER OF CELLS IN I DIRECTION
       JC:      NUMBER OF CELLS IN J DIRECTION
       LC:      NUMBER OF ACTIVE CELLS IN HORIZONTAL + 2
       LVC:     NUMBER OF VARIABLE SIZE HORIZONTAL CELLS
       ISCLO:   1 FOR CURVILINEAR-ORTHOGONAL GRID (LVC=LC-2)
       NDM:     NUMBER OF DOMAINS FOR HORIZONTAL DOMAIN DECOMPOSITION
                ( NDM=1, FOR MODEL EXECUTION ON A SINGLE PROCESSOR SYSTEM OR
                  NDM=MM*NCPUS, WHERE MM IS AN INTEGER AND NCPUS IS THE NUMBER
                  OF AVAILABLE CPU's FOR MODEL EXECUTION ON A PARALLEL
                  MULTIPLE PROCESSOR SYSTEM )
       LDW:     NUMBER OF WATER CELLS PER DOMAIN
                ( LDW=(LC-2)/NDM, FOR MULTIPE VECTOR PROCESSORS, LWD MUST BE
                  AN INTEGER MULTIPLE OF THE VECTOR LENGTH OR STRIDE NVEC
                  THUS CONSTRAINING LC-2 TO BE AN INTEGER MULTIPLE OF NVEC )
       ISMASK:  1 FOR MASKING WATER CELL TO LAND OR ADDING THIN BARRIERS
                  USING INFORMATION IN FILE mask.inp
       ISPGNS:  1 FOR IMPLEMENTING A PERIODIC GRID IN COMP N-S DIRECTION OR
                  CONNECTING ARBITRARY CELLS USING INFORMATION IN FILE mappgns.inp
       NSHMAX:  NUMBER OF DEPTH SMOOTHING PASSES
       NSBMAX:  NUMBER OF INITIAL SALINITY FIELD SMOOTHING PASSES
       WSMH:    DEPTH SMOOTHING WEIGHT
       WSMB:    SALINITY SMOOTHING WEIGHT
C
C9  IC  JC LC   LVC  ISCLO NDM LDW  ISMASK ISPGNS NSHMX NSBMX WSMH   WSMB
    45 307 4394 4392 1     1   4392 1      0      0     0     .03125 .0625
------------------------------------------------------------------------------
```

Card image 9 specifies the spatial structure of the model grid, with KC denoting the number of layers and IC and JC denoting the number of cells in the computational x and y directions as discussed in the previous chapter on grid generation. Internally, the EFDC code uses a single horizontal index, L, rather than the two indices I and J. The use of the single index L allows only for computation on and storage of only active water cells. The parameter LC is the number of active or water cells in the grid plus 2. The two additions to the L sequence at L=1 and L=LC are used for boundary condition implementation with computational loops ranging from L=2, LC-1. The parameter LVC is equal to LC-2 if the ISCLO switch is set to 1. The ISCLO switch is set to 1 for curvilinear grids, variable spaced Cartesian grids and Cartesian grids which are specified entirely by the cell.inp, dxdy.inp and lxly.inp files. The parameters NDM and LDM specify a domain decomposition of the horizontal grid for execution of EFDC on parallel or multiple processor systems. For parallel execution, NDM should equal the number of processors the code will execute on. For multiple processor systems, such as symmetric multiprocessor UNIX work stations, with no vector capability, LDM should be equal to the number of water cells in the grid, LC - 2, divided by NDM, ensuring load balancing across the processors. The same rule should also be followed for parallel vector processors, however for optimum performance, LDM should also the an integer multiple of the vector stride (usually 64 or 128).

This may require that additional cells be added to the grid. The additional cells may be in the form of one-dimensional, in the horizontal, closed channels, which do not influence the solution of the actual problem. The input shown above could be modified for execution on a 4 processor system by setting NDM equal to 4 and LDM equal to 256, which is also an integer multiple of 64 and 128. The ISMASK switch activates the 'certain of no flow' barriers on cell faces specified in the file mask.inp. The switch ISPGNS configures all or portions of north and south open boundaries to represent periodic domains in the computational y direction, using information in the file mappgns.inp. This option is useful in shelf and nearshore applications. The parameter NSHMAX specifies the number of smoothing passes applied to the input depth and bottom elevation fields with WSMH being the smoothing parameter, which must be less than 0.25. The smoother has the form:

$$H_{new}(L) = H_{old}(L) + WSMH * \begin{pmatrix} H_{old}(LS) + H_{old}(LW) + H_{old}(LE) \\ + H_{old}(LN) - 4. * H_{old}(L) \end{pmatrix} \quad (3)$$

Likewise the parameter NSBMAX specifies the number of smoothing passes to be applied to a salinity field initialized by the salt.inp file. The salinity smoother can also be used to interpolate sparse salinity data to create a smooth initial salinity field. In this case, the vertical salinity profiles in the salt.inp file must be set with zero values, except at locations where nonzero values are supplied. Setting NSBMAX to a large number, which must be greater than 10, and should usually be on the order of 2000, interpolates the salinity over the entire grid with the nonzero input data unmodified. In an estuary application, specifying small values at the limit of salinity intrusion will prevent the diffusive interpolation scheme from progressing upstream.

Card Image 9a

```
--------------------------------------------------------------------------------
C9A  VERTICAL SPACE-RELATED PARAMETERS
C
      KC:      NUMBER OF VERTICAL LAYERS
    KSIG:      NUMBER OF VERTICAL LAYERS IN SIGMA REGION FOR IGRIDV = 1
 ISETGVC;    0 READ BOTTOM LAYER ID FROM GVCLAYER.INP
             1 AUTOMATICALLY SET BOTTOM LAYER ID USING SELVREF, SELVREF
               AND BELV (IN DXDY.INP) AND WRITE RESULTS TO GVCLAYER.OUT
 SELVREF:      REFERENCE SURFACE ELEVATION IN RESCALED HEIGHT REGION (METERS)
 BELVREF:      REFERENCE (MINIMUM) BOTTOM ELEVATION IN RESCALED HEIGHT REGION
 ISGVCCK:    0 NORMAL SETTING (OPTION 1 USED FOR DEBUGGING SIGMA/GVC COMPARE)
             1 USE MULTI-LAYER BOTTOM FRICTION FOR SINGLE LAYER SIGMA
C
C9A  KC  KSIG  ISETGVC  SELVREF  BELVREF  ISGVCCK
     1   1     1        -69.5    -84.75   0
--------------------------------------------------------------------------------
```

Card Image 10

```
------------------------------------------------------------------------------
C10  LAYER THICKNESS IN VERTICAL
C
          K:  LAYER NUMBER, K=1,KC
        DZC:  DIMENSIONLESS LAYER THICKNESS (THICKNESSES MUST SUM TO 1.0)
                FOR IGRIDV=1, THE TOP KSIG LAYERS ARE PRESENT IN BOTH THE
                SIGMA AND RESCALED HEIGHT REGIONS
C
C10     K   DZC
        1   1.0
------------------------------------------------------------------------------
```

This card specifies the dimensional thickness of the vertical layers, which do not have to be equal.

Card Image 11

```
------------------------------------------------------------------------------
C11 GRID, ROUGHNESS AND DEPTH PARAMETERS
C
   DX:       CARTESIAN CELL LENGTH IN X OR I DIRECTION
   DY:       CARTESIAN CELL LENGTH IN Y OR J DIRECTION
   DXYCVT:   MULTIPLY DX AND DY BY TO OBTAIN METERS
   IMD:      GREATER THAN 0 TO READ MODDXDY.INP FILE
   ZBRADJ:   LOG BOUNDRY LAYER CONSTANT OR VARIABLE ROUGH HEIGHT ADJ IN METERS
   ZBRCVRT:  LOG BOUNDRY LAYER VARIABLE ROUGHNESS HEIGHT CONVERT TO METERS
   HMIN:     MINIMUM DEPTH OF INPUTS DEPTHS IN METERS
   HADJ:     ADJUSTMENT TO DEPTH FIELD IN METERS
   HCVRT:    CONVERTS INPUT DEPTH FIELD TO METERS
   HDRY:     DEPTH AT WHICH CELL OR FLOW FACE BECOMES DRY
   HWET:     DEPTH AT WHICH CELL OR FLOW FACE BECOMES WET
   BELADJ:   ADJUSTMENT TO BOTTOM BED ELEVATION FIELD IN METERS
   BELCVRT:  CONVERTS INPUT BOTTOM BED ELEVATION FIELD TO METERS
C
C11 DX  DY  DXYCVT IMD ZBRADJ ZBRCVRT HMIN HADJ HCVRT HDRY HWET BELADJ BELCVRT
    1   1   1      1   0.0    1.      .001 0    1     .1   .15  -280.0 1
------------------------------------------------------------------------------
```

Card image 11 specifies horizontal grid, bottom roughness and bathymetric parameters. The parameters DX and DY are used to specify constantly spaced Cartesian cell sizes for grids specified by the cell.inp and depth.inp files when ISCLO equals 0. The conversion factor DXYCVT can be used to convert the units of DX and DY in the dxdy.inp to the required internal unit of meters. The parameters ZBRADJ and ZBRCVRT are used to adjust and convert the log law, *zo*, bottom roughness specified in either the dxdy.inp or depth.inp files. The conversion equation is of the form:

$$ZBR=ZBRADJ + ZBRCVRT*ZBR$$

The parameter HMIN is used to specify a minimum depth, over-riding input values. The parameters HADJ and HCVRT and BEADJ and BECVRT provide for adjustments and conversions to the initial depth and bottom elevation inputs in the same format as that for bottom roughness. The parameter HDRY specifies the water depth at which a cell becomes dry, while HWET specifies the depth at which the cell become wet.

Card Image 11A

```
------------------------------------------------------------------------------
C11A TWO-LAYER MOMENTUM FLUX AND CURVATURE ACCELERATION CORRECTION FACTORS
C
      ICK2COR: 0 NO CORRECTION
      ICK2COR: 1 CORRECTION USING CK2UUC,CK2VVC,CK2UVC FOR CURVATURE
      ICK2COR: 2 CORRECTION USING CK2FCX,CK2FCY FOR CURVATURE
      CK2UUM:  CORRECTION FOR UU MOMENTUM FLUX
      CK2VVM:  CORRECTION FOR UU MOMENTUM FLUX
      CK2UVM:  CORRECTION FOR UU MOMENTUM FLUX
      CK2UUC:  CORRECTION FOR UU CURVATURE ACCELERATION   (NOT ACTIVE)
      CK2VVC:  CORRECTION FOR VV CURVATURE ACCELERATION   (NOT ACTIVE)
      CK2UVC:  CORRECTION FOR UV CURVATURE ACCELERATION   (NOT ACTIVE)
      CK2FCX:  CORRECTION FOR X EQUATION CURVATURE ACCELERATION
      CK2FCY:  CORRECTION FOR Y EQUATION CURVATURE ACCELERATION
C
C11A ICK2COR  CK2UUM  CK2VVM  CK2UVM  CK2UUC  CK2VVC  CK2UVC  CK2FCX  CK2FCY
     0        0       0       0       0       0       0       0       0
------------------------------------------------------------------------------
```

Card Image 11B

```
------------------------------------------------------------------------------
C11B CORNER CELL BED STRESS CORRECTION
C
     ISCORTBC:  1 TO CORRECT BED STRESS AVERAGING TO CELL CENTERS IN CORNERS
                2 TO USE SPATIALLY VARYING CORRECTION FOR CELLS IN CORNERC.INP
     ISCORTBCD: 1 WRITE DIAGNOSTICS EVERY NSPTC TIME STEPS
     FSCORTBC:  CORRECTION FACTOR, 0.0 LE FSCORTBC LE 1.0
                1.0 = NO CORRECTION, 0.0 = MAXIMUM CORRECTION, 0.5 SUGGESTED
C
C11B ISCORTBC ISCORTBCD FSCORTBC
     1        0         0.414
------------------------------------------------------------------------------
```

Card Image 12

```
------------------------------------------------------------------------------
C12 TURBULENT DIFFUSION PARAMETERS
C
       AHO:     CONSTANT HORIZONTAL MOMENTUM AND MASS DIFFUSIVITY (m*m/s)
       AHD:     DIMESIONLESS HORIZONTAL MOMENTUM DIFFUSIVITY
       AVO:     BACKGROUND, CONSTANT OR MOLECULAR KINEMATIC VISCOSITY (m*m/s)
       ABO:     BACKGROUND, CONSTANT OR MOLECULAR DIFFUSIVITY (m*m/s)
       AVMN:    MINIMUM KINEMATIC EDDY VISCOSITY (m*m/s)
       ABMN:    MINIMUM EDDY DIFFUSIVITY (m*m/s)
       VISMUD:  CONSTANT FLUID MUD VISCOSITY (m*m/s)
       AVBCON:  EQUALS ZERO FOR CONSTANT VERTICAL VISCOSITY AND DIFFUSIVITY
                WHICH ARE SET EQUAL TO AVO AND ABO; OTHERWISE SET TO 1.0
       ZBRWALL: SIDE WALL LOG LAW ROUGHNESS HEIGHT. USED WHEN HORIZONTAL
                MOMENTUM DIFFUSION IS ACTIVE AND AHO OR AHD ARE NONZERO
```

```
C              1.E-6  1.E-9  1.E-6  1.E-9
C12 AHO  AHD  AVO    ABO     AVMN  ABMN    VISMUD  AVBCON  ZBRWALL
    0.0  0.0  1.E-6  1.4E-7  1E-6  1.4E-7  1.e-6   1.0     0.0
-------------------------------------------------------------------------
```

Card image 12 provides information for horizontal and vertical momentum and mass diffusion. A spatially constant horizontal diffusion is specified by a constant value AHO. A variable horizontal diffusion may be added to the constant value by specifying a non- zero value of AHD, which is the dimensionless constant in the Smagorinsky subgrid scale horizontal diffusion formulation (Smagorinsky, 1963). The background molecular kinematic viscosity and diffusivity are specified by AVO and ABO respectively. When AVBCON is set to 0, the turbulence model is deactivated and the vertical viscosity and diffusivity are set to AVO and ABO respectively. Using this option and setting AVO and ABO to larger values representing turbulent flow readily allows model results to be compared with constant viscosity and diffusivity analytical solutions for vertical current structure. Setting the parameter ISFAVB to 1 activates a square root smoother for both the vertical turbulent viscosity and diffusivity of the form:

$$AVO(n+1)=SQRT(AVO(n+1)*AVO(n))$$

where n indicates the timestep. The smoother is particularly useful for flows having strong surface wind stress forcings.

Card Image 12A

```
-------------------------------------------------------------------------------
C12A TURBULENCE CLOSURE OPTIONS
C
       ISSTAB:  0 FOR GALPERIN ET AL STABILITY FUNCTIONS IN CALAVBOLD
                1 FOR GALPERIN ET AL STABILITY FUNCTIONS
                2 FOR KANTHA AND CLAYSON (1994) STABILITY FUNCTIONS
                3 FOR KANTAH (2003) STABILITY FUNCTIONS
                  NOTE OPTIONS SELECTED HERE OVER RIDE ISTOPT(0) ON C6
       ISSQL:   0 SETS QQ AND QQL STABILITY FUNCTIONS PROPORTIONAL TO
                   MOMENTUM STABILITY FUNCTIONS (EXCEPT FOR ISSTAB=3)
                1 SETS QQ AND QQL STABILITY FUNCTIONS TO CONSTANTS
                    (FOR ISSTAB = 0,1,2) THIS OPTION NOT ACTIVE
       ISAVBMN: SET TO 1 TO ACTIVATE MIN VIS AND DIFF OF AVMN AND ABMN
       ISFAVB:  SET TO 1 OR 2 TO AVG OR SQRT FILTER AVV AND AVB
       ISINWV:  SET TO 1 TO ACTIVATE INTERNAL WAVE PARAMETERIZATION
       ISLLIM:  0 FOR NO LENGTH SCALE AND RIQMAX LIMITATIONS
                1 LIMIT RIQMAX IN STABILITY FUNCTION ONLY
                2 DIRECTLY LIMIT LENGTH SCALE AND LIMIT RIQMAX IN STABILITY FUNCTION
       IFPROX:  0 FOR NO WALL PROXIMITY FUNCTION
                1 FOR PARABOLIC OVER DEPTH WALL PROXIMITY FUNCTION
                2 FOR OPEN CHANNEL WALL PROXIMITY FUNCTION
       ISVTURB: SET TO 1 TO INCLUDE VEGETATION GENERATED TURBULENCE PRODUCTION
```

```
      VTURBEFF: EFFICIENCY FACTOR FOR VEGETATION TURBULENCE PRODUCTION (0,1)
C
C12A ISSTAB ISSQL ISAVBMN ISFAVB ISINWV ISLLIM IFPROX ISVTURB VTURBEFF
     1      0     0       2      0      1      2      0       0.0
-------------------------------------------------------------------------------
```

Card Image 13

```
-------------------------------------------------------------------------------
C13 TURBULENCE CLOSURE PARAMETERS
C
       VKC:    VON KARMAN CONSTANT
       CTURB1: TURBULENCE CONSTANT, B1 USE 16.6 FOR ALL CLOSURES
       CTURB2: TURBULENCE CONSTANT, B2 USE 10.1 FOR ALL CLOSURES
       CTE1:   TURBULENCE CONSTANT E1 FOR SHEAR PRODUCTION IN Q*Q*L EQUATION
       CTE2:   TURBULENCE CONSTANT E2 DISSIPATION IN Q*Q*L EQ. USE 1.0
       CTE3:   TURBULENCE CONSTANT E3 (SOMETIMES CALL E2) BOUYANCY TERM IN Q*Q*L
                    EQUATION
       CTE4:   TURBULENCE CONSTANT E4 (SOMETIMES CALL E3) WALL FUNCTION IN Q*Q*L
                    EQUATION
       CTE5:   TURBULENCE CONSTANT E5 - 2ND OPEN CHANNEL WALL FUNCTION IN Q*Q*L
                    EQUATION
       RIQMAX: MAXIMUM TURBULENT INTENSITY RICHARDSON NUMBER FOR STABLE CONDITIONS
       QQMIN:  MINIMUM TURBULENT INTENSITY SQUARED
       QQLMIN: MINIMUM TURBULENT INTENSITY SQUARED TIMES MACRO-SCALE
       DMLMIN: MINIMUM DIMENSIONLESS MACRO-SCALE
C                     1.8  1.0  1.8/5. 1.33 0.25        1.E-8 1.E-12 1.E-4
C13 VKC CTURB1 CTURB2 CTE1 CTE2 CTE3 CTE4 CTE5 RIQMAX QQMIN QQLMIN DMLMIN
    0.4 16.6   10.1   1.8  1.0  1.8  1.33 0.25 0.28   1.E-8 1.E-12 1.E-4
-------------------------------------------------------------------------------
```

The turbulence closure parameters should not be modified without consulting the model developer!

Card Image 14

```
-------------------------------------------------------------------------------
C14 TIDAL & ATMOSPHERIC FORCING, GROUNDWATER AND SUBGRID CHANNEL PARAMETERS
C
    MTIDE:  NUMBER OF PERIOD (TIDAL) FORCING CONSTITUENTS
    NWSER:  NUMBER OF WIND TIME SERIES (0 SETS WIND TO ZERO)
    NASER:  NUMBER OF ATMOSPHERIC CONDITION TIME SERIES (0 SETS ALL ZERO)
    ISGWI:  1 TO ACTIVATE SOIL MOISTURE BALANCE WITH DRYING AND WETTING
            2 TO ACTIVATE GROUNDWATER INTERACTION WITH BED AND WATER COLUMN
   ISCHAN:  >0 ACTIVATE SUBGRID CHANNEL MODEL AND READ MODCHAN.INP
   ISWAVE:  1 FOR WAVE CURRENT BOUNDARY LAYER REQUIRES FILE WAVE.INP
            2 FOR WCBL AND WAVE INDUCED CURRENTS REQUIRES FILE WAVE.INP
  ITIDASM:  1 FOR TIDAL ELEVATION ASSIMILATION (NOT ACTIVE)
   ISPERC:  1 TO PERCOLATE OR ELIMINATE EXCESS WATER IN DRY CELLS
  ISBODYF:  TO INCLUDE EXTERNAL MODE BODY FORCES FROM FBODY.INP
            1 FOR UNIFORM OVER DEPTH, 2 FOR SURFACE LAYER ONLY
  ISPNHYDS: 1 FOR QUASI-NON-HYDROSTATIC OPTION
C
C14 MTIDE NWSER NASER ISGWI ISCHAN ISWAVE ITIDASM ISPERC ISBODYF ISPNHYDS
    0     0     0     0     0      0      0       0      0       0
-------------------------------------------------------------------------------
```

Card image 14 provides basic data for specifying periodic water surface elevation forcings on open boundaries as well as controlling inplace least squares harmonic analysis of modeling predictions. MTIDE specifies the number of periodic constituents. ISLSHA activates the least squares harmonic analysis at MLLSHA user specified horizontal locations over NTCLSHA reference time periods. The analysis assumes a steady component or a linear trend component if ISLSRT is set to 1. The switch ISHTA should only be activated if MTIDE is equal to 1, with a single period constituent least squares harmonic analysis activated for the entire free surface displacement and horizontal velocity field.

Card Image 15

```
------------------------------------------------------------------------------
C15 PERIODIC FORCING (TIDAL) CONSTITUENT SYMBOLS AND PERIODS
C
   SYMBOL:  FORCING SYMBOL (CHARACTER VARIABLE) FOR TIDES, THE NOS SYMBOL
   PERIOD:  FORCING PERIOD IN SECONDS
C
C15 SYMBOL   PERIOD
        'M2'     44714.16
        'S2'     43200.00
        'N2'     45570.05
        'K1'     86164.09
        'M4'     22357.08
        'O1'     92949.63
        'M6'     14904.72
        'MSf'  1275721.39
        'Mm'   2380713.14
------------------------------------------------------------------------------
```

Card image 15 specifies user defined symbols or standard NOAA tidal constituent symbols and forcing periods for the MTIDE constituents.

Card Image 16

```
------------------------------------------------------------------------------
C16 SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITION PARAMETERS
C
       NPBS:    NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
                CELLS ON SOUTH OPEN BOUNDARIES
       NPBW:    NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
                CELLS ON WEST OPEN BOUNDARIES
       NPBE:    NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
                CELLS ON EAST OPEN BOUNDARIES
       NPBN:    NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
                CELLS ON NORTH OPEN BOUNDARIES
       NPFOR:   NUMBER OF HARMONIC FORCINGS
       NPFORT:  FORCING TYPE, 0 = CONSTANT, 1 = LINEAR, 2 = QUADRATIC VARIATION
       NPSER:   NUMBER OF TIME SERIES FORCINGS
       PDGINIT: ADD THIS CONSTANT ADJUSTMENT GLOBALLY TO THE SURFACE ELEVATION
C
```

```
C16  NPBS NPBW NPBE NPBN NPFOR NPFORT NPSER PDGINIT
     0    0    0    0    0     0      0     0.0
------------------------------------------------------------------------------
```

Card image 16 specifies the I and J cell indices at which multiple constituent least squares harmonic analysis is to be performed. The following four switches activate the analysis for surface elevation, salinity, the barotropic or depth integrated horizontal velocity and the horizontal velocity in each layers. The character string identifies the analysis location in the output file lsha.out.

Card Image 17

```
------------------------------------------------------------------------------
C17 PERIODIC FORCING (TIDAL) SURFACE ELEV OR PRESSURE BOUNDARY COND. FORCINGS
C
       NPFOR:      FORCING NUMBER
       SYMBOL:     FORCING SYMBOL (FOR REFERENCE HERE ONLY)
       AMPLITUDE:  AMPLITUDE IN M (PRESSURE DIVIDED BY RHO*G), NPFORT=0
                   COSINE AMPLITUDE IN M, NPFORT.GE.1
       PHASE:      FORCING PHASE RELATIVE TO TBEGIN IN SECONDS, NPFORT=0
                   SINE AMPLITUDE IN M, NPFORT.GE.1
       NOTE:       FOR NPFORT=0 SINGLE AMPLITUDE AND PHASE ARE READ, FOR NPFORT=1
                   CONST AND LINEAR COS AND SIN AMPS ARE READ FOR EACH FORCING, FOR
                   NPFORT=2, CONST, LINEAR, QUAD COS AND SIN AMPS ARE READ FOR EACH
                   FOR EACH FORCING
C
C17 NPFOR    SYMBOL     AMPLITUDE      PHASE
      1       'M2'      0.34200E+00    0.10855E+05
      1       'S2'      0.63000E-01   -0.13959E+05
      1       'N2'      0.76000E-01   -0.11331E+05
      1       'K1'      0.44000E-01    0.21641E+05
      1       'M4'      0.0            0.0
      1       'O1'      0.35798E-01   -0.23892E+04
      1       'M6'      0.0            0.0
      2       'M2'      0.0            0.0
      2       'S2'      0.0            0.0
      2       'N2'      0.0            0.0
      2       'K1'      0.0            0.0
      2       'M4'      0.0            0.0
      2       'O1'      0.0            0.0
      2       'M6'      0.0            0.0
------------------------------------------------------------------------------
```

Card image 16 specifies the number of open boundary cells on south, west, east and north open boundaries in the computational grid, as well as the number of periodic forcing functions, the number of surface elevation time series to be used for open boundary forcings and an initial adjustment to the water surface elevation. If NPSER is greater than zero, NPSER surface elevation time series are read from the pser.inp file. The adjustment factor should in general not be used without consultation with the writer. Note that south and north boundary cells paired to

implement the periodic domain configuration in the computation y direction should not be included in the NPBS and NPBN counts.

Card Image 18

```
------------------------------------------------------------------------------
C18 PERIODIC FORCING (TIDAL) SURFACE ELEV OR PRESSURE ON SOUTH OPEN BOUNDARIES
C
       IPBS:      I CELL INDEX OF BOUNDARY CELL
       JPBS:      J CELL INDEX OF BOUNDARY CELL
       ISPBS:   0 FOR ELEVATION SPECIFIED
                1 FOR RADIATION-SEPARATION CONDITION, ZERO TANGENTIAL VELOCITY
                2 FOR RADIATION-SEPARATION CONDITION, FREE TANGENTIAL VELOCITY
       NPFORS:    APPLY HARMONIC FORCING NUMBER NPFORS
       NPSERS:    APPLY TIME SERIES FORCING NUMBER NPSERS
     TPCOORDS:    TANGENTIAL COORDINATE ALONG BOUNDARY (NPFORT.GE.1)
C
C18 IPBS  JPBS  ISPBS NPFORS  NPSERS  TPCOORDS
------------------------------------------------------------------------------
```

Card image 18 specifies NPFOR forcing functions, each having MTIDE constituents, with the first column set to the forcing number for user reference. Constituents for each forcing should be in the order sequence defined on Card image 16. The phase is specified in seconds consistent with the representation:

$$\zeta_{tot}(t) = \sum_{n=1}^{N} \zeta_n \cos\left(\frac{2\pi}{T_n}(t-\tau_n)\right) + \zeta_{ser}(t) \qquad (4)$$

where ζ and τ are the amplitude and phase of the n constituent and ζser is an additive time series specification of the surface elevation. The time origin for the phase should be consistent with the time origin for the simulation. For example TBEGIN on Card image 8 is in Julian hours relative to midnight, January 1 of a given year. For this case, then the phase should also be relative to midnight January 1 of the same year. For the analysis of field records, to accomplish this synchronization, a stand alone least square harmonic analysis program lsqhs.f is available from the writer. The null forcing function 2 might be used on an open boundary with only outgoing wave propagation, to be discussed below.

Card Image 19

```
------------------------------------------------------------------------------
C19 PERIODIC FORCING (TIDAL) SURFACE ELEV OR PRESSURE ON WEST OPEN BOUNDARIES
C
       IPBW:      SEE CARD 19
       JPBW:
       ISPBW:
```

```
       NPFORW:
       NPSERW:
       TPCOORDW:
C
C19 IPBW JPBW   ISPBW NPFORW  NPSERW  TPCOORDW
-------------------------------------------------------------------------------
```

Card Image 20

```
-------------------------------------------------------------------------------
C20 PERIODIC FORCING (TIDAL) SURFACE ELEV OR PRESSURE ON EAST OPEN BOUNDARIES
C
       IPBE:      SEE CARD 19
       JPBE:
       ISPBE:
       NPFORE:
       NPSERE:
       TPCOORDE:
C
C20 IPBE     JPBE   ISPBE    NPFORE  NPSERE  TPCOORDE
-------------------------------------------------------------------------------
```

Card Image 21

```
-------------------------------------------------------------------------------
C21 PERIODIC FORCING (TIDAL) SURFACE ELEV OR PRESSURE ON NORTH OPEN BOUNDARIES
C
       IPBN:      SEE CARD 19
       JPBN:
       ISPBN:
       NPFORN:
       NPSERN:
       TPCOORDN:
C
C21 IPBN     JPBN   ISPBN    NPFORN  NPSERN  TPCOORDN
-------------------------------------------------------------------------
```

Card Image 21A

```
-------------------------------------------------------------------------
C21A WATER SURFACE ELEVATION AND VELOCITY DATA ASSIMILATION
C
       ISWSEDA:  1 FOR WATER SURFACE ELEVATION DATA ASSIMILATION
       NLWSEDA:    NUMBER OF LOCATIONS FOR WATER SURFACE ELEVATION ASSIMILATION
       ISUVDA:   1 FOR BAROTROPIC VELOCITY DATA ASSIMILATION
                 2 FOR LAYERED VELOCITY DATA ASSIMILATION
       NLUVDA:     NUMBER OF LOCATIONS FOR VELOCITY DATA ASSIMILATION
       NUVSER:     NUMBER OF HORIZONTAL VELOCITY VECTOR TIME SERIES
C
C21A   ISWSEDA  NLWSEDA  ISUVDA  NLUVDA  NUVSER
       0        0        0       0       0
-------------------------------------------------------------------------
```

Card Image 21B

```
------------------------------------------------------------------------------
C21B WATER SURFACE ELEVATION DATA ASSIMILATION  (NO DATA WHEN ISWESDA=0)
C
       IWSEDA:     I CELL INDEX FOR WATER SURFACE ELEVATION DATA ASSIMILATION
       JWSEDA:     J CELL INDEX FOR WATER SURFACE ELEVATION DATA ASSIMILATION
       NWSESERA:     TIME SERIES ID FOR WATER SURFACE ELEVATION ASSIMILATION
       TSWSEA:       WEIGHTING FACTOR, 0. -1., 1. = FULL ASSIMILATION
C
C21B ICWSEDA   JCWSEDA  NWSESERA  TSWSEDA
------------------------------------------------------------------------------
```

Card Image 21C

```
------------------------------------------------------------------------------
C21C VELOCITY DATA ASSIMILATION  (NO DATA WHEN ISUVDA=0)
C
       IUVDA:    I CELL INDEX FOR VELOCITY DATA ASSIMILATION
       JUVDA:    J CELL INDEX FOR VELOCITY DATA ASSIMILATION
       NUVSERA:    TIME SERIES ID FOR VELOCITY DATA ASSIMILATION
       TSUVDA:     WEIGHTING FACTOR, 0.- 1., 1. = FULL ASSIMILATION
       FSUVDA:     IMPLICITNESS FACTOR, 0 EXPLICIT, 1 IMPLICIT
       IWUVDA:     0 NO ZONAL, 1 INVERSE ZONE, 2 INVERSE SQUARE ZONE
       IRUVDA:     I,J ZONE RADIUS OF INFLUENCE
       RRUVDA:     DX,DY ZONE RADIUS OF INFLUENCE (NONE ZERO TO USE)
C
C21C ICUVDA  JCUVDA  NUVSERA  TSUVDA  FSUVDA  IWUVDA  IRUVDA  RRUVDA
------------------------------------------------------------------------------
```

Card Image 22

```
------------------------------------------------------------------------------
C22 SPECIFY NUMBER OF SEDIMENT AND TOXICS AND NUMBER OF CONCENTRATION TIME SERIES
C
   NTOX:   NUMBER OF TOXIC CONTAMINANTS (DEFAULT = 1)
   NSED:   NUMBER OF COHESIVE SEDIMENT SIZE CLASSES (DEFAULT = 1)
   NSND:   NUMBER OF NON-COHESIVE SEDIMENT SIZE CLASSES (DEFAULT = 1)
   NSSER:  NUMBER OF SALINITY TIME SERIES
   NTSER:  NUMBER OF TEMPERATURE TIME SERIES
   NDSER:  NUMBER OF DYE CONCENTRATION TIME SERIES
   NSFSER: NUMBER OF SHELLFISH LARVAE CONCENTRATION TIME SERIES
   NTXSER: NUMBER OF TOXIC CONTAMINANT CONCENTRATION TIME SERIES
           EACH TIME SERIES MUST HAVE DATA FOR NTOX TOXICICANTS
   NSDSER: NUMBER OF COHESIVE SEDIMENT CONCENTRATION TIME SERIES
           EACH TIME SERIES MUST HAVE DATA FOR NSED COHESIVE SEDIMENTS
   NSNSER: NUMBER OF NON-COHESIVE SEDIMENT CONCENTRATION TIME SERIES
           EACH TIME SERIES MUST HAVE DATA FOR NSND NON-COHESIVE SEDIMENTS
   ISSBAL: SET TO 1 FOR SEDIMENT MASS BALANCE
C
C22 NTOX NSED NSND NSSER NTSER NDSER NSFSER NTXSER NSDSER NSNSER ISSBAL
    1    1    3    0     0     0     0      7      16     16     1
------------------------------------------------------------------------------
```

Card images 19 through 22 specify the open boundary conditions for the four directional faces of the horizontal computational domain. Because of the similarity of the four data sets, they will be discussed in a generic fashion. To provide background on the discussion of the model's

operation at open boundaries, it is useful to summarize the treatment of open boundary conditions in the EFDC model. The EFDC model provides for two types of hydrodynamic open boundary conditions. The first type is the standard specification of water surface elevation using combinations of harmonic constituents and time series. The second type of open boundary conditions is referred to as a radiation-separation boundary condition in that the incoming wave at an open boundary is separated from the outgoing wave (Bennett and McIntosh, 1982). For outgoing waves the condition functions as a radiation condition with a phase speed equal to the square root of gh, where h is the mean or undisturbed depth along the open boundary. For incoming waves, 1/2 of the characteristic of the incoming wave is specified. As an example, consider an east open boundary, with the model domain to the west in the negative x direction and the unmodeled region to the east in the positive x direction. The incoming characteristic for the linearized one-dimensional shallow water equation (Bennett, 1976), is:

$$\zeta - \frac{h\bar{u}}{\sqrt{gh}} \tag{5}$$

where ζ is the free surface displacement, h is the water depth and $\bar{u}$ is the x-component of velocity, with the overbar denoting depth averaged or external mode velocity. For a purely progressive wave propagating in the negative x direction, incoming toward the east open boundary:

$$\zeta = \zeta_0 \cos\left(\omega\left(\frac{x}{\sqrt{gh}} + t\right)\right) \tag{6}$$

$$\frac{h\bar{u}}{\sqrt{gh}} = -\zeta_0 \cos\left(\omega\left(\frac{x}{\sqrt{gh}} + t\right)\right) \tag{7}$$

Inserting (6) and (7) into (5) gives

$$\zeta - \frac{h\bar{u}}{\sqrt{gh}} = 2\zeta_0 \cos\left(\omega\left(\frac{x}{\sqrt{gh}} + t\right)\right) = 2\zeta \tag{8}$$

Thus 1/2 of the characteristic of the purely progressive incoming wave is the wave surface displacement.

Open boundary cells are defined by the type 5 cell type in the cell.inp file but are presumed to be external to the computation in that the continuity equation is not solved in the open boundary cell. Tangential velocities (i.e., the u or x velocity component in a south or north open boundary cell and the v or y velocity component in an east or west open boundary cell) are also not currently computed in open boundary cells. Due to the placement definition of u on west cell faces and v on south cell faces, the u is computed for east open boundary cells and v is computed for north open boundary cells. The first two parameters on each card image specify the I and J indices of the open boundary cells. The I and J indices sequence does not need to be continuous since a model domain may have multiple opening on either of the four directional face normals. The ISBPS (ISPBW,E,N) switch is set to zero for direct specification of the open boundary cell surface elevation or to 1 for the implementation of a radiation-separation boundary condition. For ISPBS set to zero, the open boundary cell water surface elevation is directly specified by the sum of the periodic forcing function (NPFORS,W,E,N) and the surface elevation time series (NPSERS,W,E,N) where NPSER_ identifies one of the NPSER surface elevation time series in the pser.inp file. The radiation-separation boundary condition specifies the linear characteristic of an assumed normal incident incoming wave as twice the surface elevation specified by the sum of the periodic and time series forcing. By default, the outgoing characteristic is left undefined allowing waves generated interior to the model domain to pass outward across the boundary with no reflection. Since the normal incident criteria is somewhat idealized, care should be used in the use of the radiation separation boundary condition. A more sophisticated radiation-separation open boundary condition (relaxing the normal incident criteria the imposition of zero tangential velocity) is under development.

Card Image 23

```
------------------------------------------------------------------------------
C23 VELOCITY, VOLUME SOURCE/SINK, FLOW CONTROL, AND WITHDRAWAL/RETURN DATA
C
   NQSIJ:  NUMBER OF CONSTANT AND/OR TIME SERIES SPECIFIED SOURCE/SINK
           LOCATIONS (RIVER INFLOWS, ETC)
   NQJPIJ: NUMBER OF CONSTANT AND/OR TIME SERIES SPECIFIED SOURCE
           LOCATIONS TREATED AS JETS/PLUMES
   NQSER:  NUMBER OF VOLUME SOURCE/SINK TIME SERIES
   NQCTL:  NUMBER OF PRESSURE CONTROLLED WITHDRAWAL/RETURN PAIRS
   NQCTLT: NUMBER OF PRESSURE CONTROLLED WITHDRAWAL/RETURN TABLES
   NQWR:   NUMBER OF CONSTANT OR TIME SERIES SPECIFIED WITHDRAWAL/RETURN
           PAIRS
   NQWRSR: NUMBER OF TIME SERIES SPECIFYING WITHDRAWAL, RETURN AND
           CONCENTRATION RISE SERIES
   ISDIQ:  SET TO 1 TO WRITE DIAGNOSTIC FILE, DIAQ.OUT
C
C23  NQSIJ  NQJPIJ  NQSER  NQCTL  NQCTLT  NQWR  NQWRSR  ISDIQ
     680    0       16     2      1       0     0       0
------------------------------------------------------------------------------
```

Card image 23 specifies basic information on volumetric sources and sinks. The first four parameters on this card are currently inactive. Volumetric source and sink representation in the EFDC model falls within three classes. The first class is constant or time varying volumetric sources and sinks at NQSIJ horizontal grid locations. The second class is pressure or surface elevation controlled hydraulic structures occurring as NQCTL source and sink pairs. The third class is constant or time variable flow withdrawal and return sources and sinks occurring as NQWR pairs. The sources and sinks associated with NQSIJ and NQWR may have constant flow rates, specified in this file or time variable flow rates as specified by one of NQSER flow time series read from the qser.inp file. For positive NQSIJ sources, inflow concentrations of the various transported scalar constituents may be associated with the flow. For negative NQSIJ sinks, mass loss of transport scalar constituents is accounted for. The withdrawal-return source sink class provides for a constant or time variable concentration rise between the withdrawal and return cells. The NQWR options is designed to power plant and industrial cooling systems. The final switch ISDIQ activates diagnostics of allowable classes of volumetric source and sink flows to be written to the file diaq.out. Since this file can become quite large, this option is recommended to be used only for debugging. Generally when activated, the model should be allowed to run only a few timesteps and then killed.

Card Image 24

```
------------------------------------------------------------------------------
C24 VOLUMETRIC SOURCE/SINK LOCATIONS, MAGNITUDES, AND CONCENTRATION SERIES
C
   IQS:     I CELL INDEX OF VOLUME SOURCE/SINK
   JQS:     J CELL INDEX OF VOLUME SOURCE/SINK
   QSSE:    CONSTANT INFLOW/OUTFLOW RATE IN M*M*M/S
   NQSMUL:  MULTIPLIER SWITCH FOR CONSTANT AND TIME SERIES VOL S/S
            = 0  MULT BY 1. FOR NORMAL IN/OUTFLOW (L*L*L/T)
            = 1  MULT BY DY FOR LATERAL IN/OUTFLOW (L*L/T) ON U FACE
            = 2  MULT BY DX FOR LATERAL IN/OUTFLOW (L*L/T) ON V FACE
            = 3  MULT BY DX+DY FOR LATERAL IN/OUTFLOW (L*L/T) ON U&V FACES
   NQSMFF:  IF NON ZERO ACCOUNT FOR VOL S/S MOMENTUM FLUX
            = 1  MOMENTUM FLUX ON NEG U FACE
            = 2  MOMENTUM FLUX ON NEG V FACE
            = 3  MOMENTUM FLUX ON POS U FACE
            = 4  MOMENTUM FLUX ON POS V FACE
   NQSERQ:  ID NUMBER OF ASSOCIATED VOLUME FLOW TIME SERIES
   NSSERQ:  ID NUMBER OF ASSOCIATED SALINITY TIME SERIES
   NTSERQ:  ID NUMBER OF ASSOCIATED TEMPERATURE TIME SERIES
   NDSERQ:  ID NUMBER OF ASSOCIATED DYE CONC TIME SERIES
   NSFSERQ: ID NUMBER OF ASSOCIATED SHELL FISH LARVAE RELEASE TIME SERIES
   NTXSERQ: ID NUMBER OF ASSOCIATED TOXIC CONTAMINANT CONC TIME SERIES
   NSDSERQ: ID NUMBER OF ASSOCIATED COHESIVE SEDIMENT CONC TIME SERIES
   NSNSERQ: ID NUMBER OF ASSOCIATED NON-COHESIVE SED CONC TIME SERIES
   QSFACTOR: FACTOR FOR FLOW SERIES
C
C24 IQS JQS QSSE NQSMUL NQSMFF NQSERQ NS- NT- ND- NSF- NTX- NSD- NSN- QSFACTOR
    10  305 0    0      0      1      0   0   0   0    1    1    1    1
```

```
------------------------------------------------------------------------------
```

Card image 24 provides information for the NQSIJ class of volumetric source sink flows, with the first two parameters specifying the location by I and J indices. The third parameter, QSSE is used to specify a time invariant inflow rate (outflows or sinks simply have negative signs) in either cubic meters per second or cubic meters per second per meter. The adjustment factor NQMUL specifies how volumetric flows per unit length are converted to true volumetric flows. The control parameter NQMF indicates if the volumetric source or sink is to have an associated momentum flux and which face of the source cell the momentum flux is assigned. Time variable flows are defined by entering a flow time series identifier number (less than or equal to NQSER) under NQSERQ. The remaining five columns allow the specification of a scalar constituent concentration time series associated with the flow time series only. Constant concentrations associated with the constant QSEE flows are defined on Card image 25, below. The constant flowrate source and sinks are distributed uniformly over the vertical layers, while the time series specification of source and sink flows allows arbitrary distribution over the vertical layers.

Card Image 25

```
------------------------------------------------------------------------------
C25 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT VOLUMETRIC SOURCES
C
   SAL: SALT CONCENTRATION CORRESPONDING TO INFLOW ABOVE
   TEM: TEMPERATURE CORRESPONDING TO INFLOW ABOVE
   DYE: DYE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
   SFL: SHELL FISH LARVAE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
   TOX: NTOX TOXIC CONTAMINANT CONCENTRATIONS CORRESPONDING TO
        INFLOW ABOVE. WRITTEN AS TOXC(N), N=1,NTOX A SINGLE DEFAULT
        VALUE IS REQUIRED EVEN IF TOXIC TRANSPO96 IS NOT ACTIVE
C
C25 SAL TEM DYE SFL TOX1 !IQS JQS
     0  0   0   0   0
------------------------------------------------------------------------------
```

Card Image 26

```
------------------------------------------------------------------------------
C26 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT VOLUMETRIC SOURCES
C
   SED: NSED COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
        INFLOW ABOVE. WRITTEN AS SEDC(N), N=1,NSED. I.E., THE FIRST
        NSED VALUES ARE COHESIVE A SINGLE DEFAULT VALUE IS REQUIRED
        EVEN IF COHESIVE SEDIMENT TRANSPO96 IS INACTIVE
   SND: NSND NON-COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
        INFLOW ABOVE. WRITTEN AS SND(N), N=1,NSND. I.E., THE LAST
        NSND VALUES ARE NON-COHESIVE. A SINGLE DEFAULT VALUE IS
        REQUIRED EVEN IF NON-COHESIVE SEDIMENT TRANSPO96 IS INACTIVE
C
C26 SED1 SND1
  0  0  0  0
```

```
------------------------------------------------------------------------------
```

Card Image 27

```
------------------------------------------------------------------------------
C27 JET/PLUME SOURCE LOCATIONS, GEOMETRY AND ENTRAINMENT PARAMETERS
C
        ID:  ID COUNTER FOR JET/PLUME
      ICAL:  0 BYPASS, 1 SOURCE DISCHARGE, 2 WITHDRAWAL-RETURN DISCHARGE
      IQJP:  I CELL INDEX OF JET/PLUME
      JQJP:  J CELL INDEX OF JET/PLUME
      KQJP:  K CELL INDEX OF JET/PLUME (DEFAULT, QJET=0 OR JET COMP DIVERGES)
     NPORT:  NUMBER OF IDENTICAL PORTS IN THIS CELL
      XJET:  LOCAL EAST JET LOCATION RELATIVE TO DISCHARGE CELL CENTER (M)
      YJET:  LOCAL NORTH JET LOCATION RELATIVE TO DISCHARGE CELL CENTER (M)
      ZJET:  ELEVATION OF DISCHARGE (M)
     PHJET:  VERTICAL JET ANGLE POSITIVE FROM HORIZONTAL (DEGREES)
     THJET:  HORIZONTAL JET ANGLE POSITIVE COUNTER-CLOCKWISE FROM EAST (DEGREES)
      DJET:  DIAMETER OF DISCHARGE PORT (M)
      CFRD:  ADJUSTMENT FACTOR FOR FROUDE NUMBER
     DJPER:  ENTRAINMENT ERROR CRITERIA
C
C27 ID ICAL IQJP JQJP KQJP NPORT XJET  YJET  ZJET  PHJET THJET DJET  CFRD  DJPER
------------------------------------------------------------------------------
```

Card Image 28

```
------------------------------------------------------------------------------
C28 JET/PLUME SOLUTION CONTROL AND OUTPUT CONTROL PARAMETERS
C
         ID:  ID COUNTER FOR JET/PLUME
       NJEL:  MAXIMUM NUMBER OF ELEMENTS ALONG JET/PLUME LENGTH
      NJPMX:  MAXIMUM NUMBER OF ITERATIONS
      ISENT:  0 USE MAXIMUM OF SHEAR AND FORCED ENTRAINMENT
              1 USE SUM OF SHEAR AND FORCED ENTRAINMENT
      ISTJP:  0 STOP AT SPECIFIED NUMBER OF ELEMENTS
              1 STOP WHEN CENTERLINE PENETRATES BOTTOM OR SURFACE
              2 STOP WITH BOUNDARY PENETRATES BOTTOM OR SURFACE
      NUDJP:  FREQUENCY FOR UPDATING JET/PLUME (NUMBER OF TIME STEPS)
       IOJP:  1 FOR FULL ASCII, 2 FOR COMPACT ASCII OUTPUT AT EACH UPDATE
              3 FOR FULL AND COMPACT ASCII OUTPUT, 4 FOR BINARY OUTPUT
       IPJP:  NUMBER OF SPATIAL PRINT/SAVE POINT IN VERTICAL
      ISDJP:  1 WRITE DIAGNOSTIS TO jplog__.out
      IUPJP:  I INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
      JUPJP:  J INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
      KUPJP:  K INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
C
C28 ID  NJEL    NJPMX ISENT ISTJP NUDJP IOJP IPJP  ISDJP IUPJP JUPJP KUPJP
------------------------------------------------------------------------------
```

Card Image 29

```
------------------------------------------------------------------------------
C29 JET/PLUME SOURCE PARAMETERS AND DISCHARGE/CONCENTRATION SERIES IDS
C
           ID:  ID COUNTER FOR JET/PLUME
         QQJP:  CONSTANT JET/PLUME FLOW RATE IN M*M*M/S
                  FOR ICAL = 1 OR 2  (FOR SINGLE PORT)
      NQSERJP:  ID NUMBER OF ASSOCIATED VOLUME FLOW TIME SERIES (ICAL=1)
```

```
     NQWRSERJP:  ID NUMBER OF ASSOCIATED WITHDRAWAL-RETURN TIME SERIES (ICAL=2)
       NSSERJP:  ID NUMBER OF ASSOCIATED SALINITY TIME SERIES (ICAL=1)
       NTSERJP:  ID NUMBER OF ASSOCIATED TEMPERATURE TIME SERIES
       NDSERJP:  ID NUMBER OF ASSOCIATED DYE CONCENTRATION TIME SERIES
       NSFSERJP: ID NUMBER OF ASSOCIATED SHELL FISH LARVAE RELEASE TIME SERIES
       NTXSERJP: ID NUMBER OF ASSOCIATED TOXIC CONTAMINANT CONCENTRATION TIME SERIES
       NSDSERJP: ID NUMBER OF ASSOCIATED COHESIVE SEDIMENT CONCENTRATION TIME SERIES
       NSNSERJP: ID NUMBER OF ASSOCIATED NON-COHESIVE SEDIMENT CONCENTRATION TIME
SERIES
C
C29  ID   QQJP   NQSERJP NQWRSERJP  NS-  NT-  ND-  NSF-  NTX-  NSD-  NSN-
-------------------------------------------------------------------------------
```

Card Image 30

```
-------------------------------------------------------------------------------
C30 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT JET/PLUME SOURCES
C
       SAL:  SALT CONCENTRATION OR RISE CORRESPONDING TO CONSTANT FLOW
       TEM:  TEMPERATURE OR RISE CORRESPONDING TO CONSTANT FLOW
       DYE:  DYE CONCENTRATION OR RISE CORRESPONDING TO CONSTANT FLOW
       SFL:  SHELL FISH LARVAE CONCENTRATION OR RISE CORRESPONDING TO CONSTANT FLOW
       TOX:  NTOX TOXIC CONTAMINANT CONCENTRATION OR RISE CORRESPONDING TO CONSTANT
             FLOW ABOVE. WRITTEN AS TOXC(N), N=1,NTOX A SINGLE DEFAULT
             VALUE IS REQUIRED EVEN IF TOXIC TRANSPORT IS NOT ACTIVE
C
C30 SAL  TEM   DYE   SFL  TOX1-20
-------------------------------------------------------------------------------
```

Card Image 31

```
-------------------------------------------------------------------------------
C31 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT JET/PLUME SOURCES
C
       SED:  NSED COHESIVE SEDIMENT CONCENTRATION OR RISE CORRESPONDING TO CONSTANT
             INFLOW ABOVE. WRITTEN AS SEDC(N), N=1,NSED. I.E., THE FIRST
             NSED VALUES ARE COHESIVE A SINGLE DEFAULT VALUE IS REQUIRED
             EVEN IF COHESIVE SEDIMENT TRANSPORT IS INACTIVE.
       SND:  NSND NON-COHESIVE SEDIMENT CONCENTRATION OR RISE CORRESPONDING TO
             INFLOW ABOVE. WRITTEN AS SND(N), N=1,NSND. I.E., THE LAST
             NSND VALUES ARE NON-COHESIVE. A SINGLE DEFAULT VALUE IS
             REQUIRED EVEN IF NON-COHESIVE SEDIMENT TRANSPORT IS INACTIVE.
C
C31 SED1  SND1  SND2   SND3
-------------------------------------------------------------------------------
```

Card Image 32

```
-------------------------------------------------------------------------------
C32 SURFACE ELEV OR PRESSURE DEPENDENT FLOW INFORMATION
C
   IQCTLU: I INDEX OF UPSTREAM OR WITHDRAWAL CELL
   JQCTLU: J INDEX OF UPSTREAM OR WITHDRAWAL CELL
   IQCTLD: I INDEX OF DOWNSTREAM OR RETURN CELL
   JQCTLD: J INDEX OF DOWNSTREAM OR RETURN CELL
   NQCTYP: FLOW CONTROL TYPE
           = -1  RATING CURVED FLOW AS FUNCTION UPSTREAM DEPTH
           =  0  HYDRAULIC STRUCTURE: INSTANT FLOW DRIVEN BY ELEVATION
                 OR PRESSURE DIFFERENCE TABLE
```

```
            =  1  ACCELERATING FLOW THROUGH TIDAL INLET
   NQCTLQ: ID NUMBER OF CONTROL CHARACTERIZATION TABLE
   NQCMUL: MULTIPLIER SWITCH FOR FLOWS FROM UPSTREAM CELL
            = 0  MULTIPLY BY 1. FOR CONTROL TABLE IN (L*L*L/T)
            = 1  MULTIPLY BY DY FOR CONTROL TABLE IN (L*L/T) ON U FACE
            = 2  MULTIPLY BY DX FOR CONTROL TABLE IN (L*L/T) ON V FACE
            = 3  MULTIPLY BY DX+DY FOR CONTROL TABLE IN (L*L/T) ON U&V FACES
   NQCMFU: IF NON ZERO ACCOUNT FOR FLOW MOMENTUM FLUX IN UPSTREAM CELL
            = 1  MOMENTUM FLUX ON NEGATIVE U FACE
            = 2  MOMENTUM FLUX ON NEGATIVE V FACE
            = 3  MOMENTUM FLUX ON POSITIVE U FACE
            = 4  MOMENTUM FLUX ON POSITIVE V FACE
   NQCMFD: IF NON-ZERO ACCOUNT FOR FLOW MOMENTUM FLUX IN DOWNSTREAM CELL
            = 1  MOMENTUM FLUX ON NEGATIVE U FACE
            = 2  MOMENTUM FLUX ON NEGATIVE V FACE
            = 3  MOMENTUM FLUX ON POSITIVE U FACE
            = 4  MOMENTUM FLUX ON POSITIVE V FACE
   BQCMFU: UPSTREAM MOMENTUM FLUX WIDTH (m)
   BQCMFD: DOWNSTREAM MOMENTUM FLUX WIDTH (m)
C
C32 IQCTLU JQCTLU IQCTLD JQCTLD NQCTYP NQCTLQ NQCMUL NQC_U NQC_D BQC_U BQC_D
    20     4      0      0      0      1      0      0     0     0     0
    21     4      0      0      0      1      0      0     0     0     0
-------------------------------------------------------------------------------
```

Card image 32 specifies the location and properties of source-sink pairs representing hydraulic control structures. The notation of upstream (sink) and downstream (source) is used for the hydraulic control structure pairs, which allow flow in only one direction. For structures such as culverts, which allow bi-directional flow, two control structure pairs are necessary to account for both flow directions. The first four parameters on this card image define the horizontal locations by the I and J indices of the upstream and downstream cells. Structures whose flowrates depend only on the surface elevation in the upstream cell (i.e., spillways and weirs) can discharge out of the computational domain by specifying the null indices 0,0 for the downstream cell. The parameter NQCTYP specifies the form of the flow dependence on the surface elevation difference between the upstream and downstream cell, (with only the 0 option currently active). The parameter NQCTLQ identifies control table number characterizing the structure. The control tables are input in the file qctl.inp. The options identifies NQCMUL and NQCMFU are similar to those discussed for the NQSIJ class sources and sinks. The remaining two indices, IQCAX and JQCAX are currently not used.

Card Image 33

```
-------------------------------------------------------------------------------
C33 FLOW WITHDRAWAL, HEAT OR MATERIAL ADDITION, AND RETURN DATA
C
   IWRU:     I INDEX OF UPSTREAM OR WITHDRAWAL CELL
   JWRU:     J INDEX OF UPSTREAM OR WITHDRAWAL CELL
   KWRU:     K INDEX OF UPSTREAM OR WITHDRAWAL LAYER
   IWRD:     I INDEX OF DOWNSTREAM OR RETURN CELL
   JWRD:     J INDEX OF DOWNSTREAM OR RETURN CELL
   KWRD:     J INDEX OF DOWNSTREAM OR RETURN LAYER
```

```
   QWRE:       CONSTANT VOLUME FLOW RATE FROM WITHDRAWAL TO RETURN
   NQWRSERQ: ID NUMBER OF ASSOCIATED VOLUME WITHDRAWAL - RETURN FLOW AND
                CONCENTRATION RISE TIME SERIES
   NQWRMFU:  IF NON-ZERO ACCOUNT FOR WITHDRAWAL FLOW MOMENTUM FLUX
             = 1  MOMENTUM FLUX ON NEGATIVE U FACE
             = 2  MOMENTUM FLUX ON NEGATIVE V FACE
             = 3  MOMENTUM FLUX ON POSITIVE U FACE
             = 4  MOMENTUM FLUX ON POSITIVE V FACE
   NQWRMFD:   IF NON-ZERO ACCOUNT FOR RETURN FLOW MOMENTUM FLUX
             = 1  MOMENTUM FLUX ON NEGATIVE U FACE
             = 2  MOMENTUM FLUX ON NEGATIVE V FACE
             = 3  MOMENTUM FLUX ON POSITIVE U FACE
             = 4  MOMENTUM FLUX ON POSITIVE V FACE
   BQWRMFU:  UPSTREAM MOMENTUM FLUX WIDTH (m)
   BQWRMFD:  UPSTREAM MOMENTUM FLUX WIDTH (m)
   ANGWRMFD: ANGLE FOR HORIZONTAL FOR RETURN FLOW MOMENTUM FLUX
C
C33 IWRU JWRU KWRU IWRD JCWRD KWRD QWRE NQW_RQ NQWR_U NQWR_D BQWR_U BQWR_D AN_D
-------------------------------------------------------------------------------
```

Card image 23 provides information for the NQWR volumetric source-sink class with the location of the upstream (withdrawal) and downstream (return) flow cell pairs specified by their I and J indices. The remaining parameters specify a constant flow rate and time series identified for variable flow rates and concentration rises. Time constant concentration rises associated with the constant flow rate are specified as shown below on Card image 28.

Card Image 34

```
-------------------------------------------------------------------------------
C34 TIME CONSTANT WITHDRAWAL AND RETURN CONCENTRATION RISES
C
   SAL:  SALINITY RISE
   TEM:  TEMPERATURE RISE
   DYE:  DYE CONCENTRATION RISE
   SFL:  SHELLFISH LARVAE CONCENTRATION RISE
   TOX#: NTOX TOXIC CONTAMINANT CONCENTRATION RISES
C
C34 SALT TEMP DYEC SFLC TOX1
-------------------------------------------------------------------------------
```

Card Image 35

```
-------------------------------------------------------------------------------
C35 TIME CONSTANT WITHDRAWAL AND RETURN CONCENTRATION RISES
C
   SED#: NSEDC COHESIVE SEDIMENT CONCENTRATION RISE
   SND#: NSEDN NON-COHESIVE SEDIMENT CONCENTRATION RISE
C
C35 SED1 SND1 SND2
-------------------------------------------------------------------------------
```

Card Image 36

```
------------------------------------------------------------------------------
C36 SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
   ISEDINT: 0 FOR CONSTANT INITIAL CONDITIONS
            1 FOR SPATIALLY VARIABLE WATER COLUMN INITIAL CONDITIONS
              FROM SEDW.INP AND SNDW.INP
            2 FOR SPATIALLY VARIABLE BED INITIAL CONDITIONS
              FROM SEDB.INP AND SNDB.INP
            3 FOR SPATIALLY VARIABLE WATER COLUMN AND BED INITIAL CONDITIONS
  ISEDBINT: 0 FOR SPATIALLY VARYING BED INITIAL CONDITIONS IN MASS/AREA
            1 FOR SPATIALLY VARYING BED INITIAL CONDITIONS IN MASS FRACTION
              OF TOTAL SEDIMENT MASS (REQUIRES BED LAYER THICKNESS
              FILE BEDLAY.INP)
    ISEDWC: 0 COH SEDIMENT WATER COLUMN/BED EXCHANGE BASED ON BOTTOM LAYER CONDITIONS
            1 COHESIVE SEDIMENT WATER COLUMN/BED EXCHANGE BASED ON
WAVE/CURRENT/SEDIMENT
              BOUNDARY LAYERS EMBEDDED IN BOTTOM LAYER
     ISMUD: 1 INCLUDE COHESIVE FLUID MUD VISCOUS EFFECTS USING EFDC
              FUNCTION CSEDVIS(SEDT)
    ISNDWC: 0 NON-COHESIVE SEDIMENT WATER COLUMN/BED EXCHANGE BASED ON BOTTOM LAYER
CONDITIONS
            1 NON-COHESIVE SEDIMENT WATER COLUMN/BED EXCHANGE BASED ON
WAVE/CURRENT/SEDIMENT
              BOUNDARY LAYERS EMBEDDED IN BOTTOM LAYER
    ISEDVW: 0 FOR CONSTANT OR SIMPLE CONCENTRATION DEPENDENT
              COHESIVE SEDIMENT SETTLING VELOCITY
           >1 CONCENTRATION AND/OR SHEAR/TURBULENCE DEPENDENT COHESIVE
              SEDIMENT SETTLING VELOCITY. VALUE INDICATES OPTION TO BE USED
              IN EFDC FUNCTION CSEDSET(SED,SHEAR,ISEDVWC)
            1 HUANG AND MEHTA - LAKE OKEECHOBEE
            2 SHRESTA AND ORLOB - FOR KRONE'S SAN FRANCISCO BAY DATA
            3 ZIEGLER AND NESBIT - FRESHWATER
           98 LICK FLOCCULATION
           99 LICK FLOCCULATION WITH FLOC DIAMETER ADVECTION
    ISNDVW: 0 USE CONSTANT SPECIFIED NON-COHESIVE SEDIMENT SETTLING VELOCITIES
              OR CALCULATE FOR CLASS DIAMETER IS SPECIFIED VALUE IS NEGATIVE
           >1 FOLLOW OPTION 0 PROCEDURE BUT APPLY HINDERED SETTLING
              CORRECTION. VALUE INDICATES OPTION TO BE USED WITH EFDC
              FUNCTION CSNDSET(SND,SDEN,ISNDVW) VALUE OF ISNDVW INDICATES
              EXPONENTIAL IN CORRECT (1-SDEN(NS)*SND(NS)**ISNDVW
        KB:   MAXIMUM NUMBER OF BED LAYERS (EXCLUDING ACTIVE LAYER)
  ISDTXBUG: 1 TO ACTIVATE SEDIMENT AND TOXICS DIAGNOSTICS
C
C36 ISEDINT ISEDBINT ISEDWC ISMUD ISNDWC ISEDVW ISNDVW KB ISDTXBUG
    3       1        0      0     0      5      0      10 1
------------------------------------------------------------------------------
```

Card Image 36A

```
------------------------------------------------------------------------------
C36a SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C    DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
  ISBEDSTR:  0 USE HYDRODYNAMIC MODEL STRESS FOR SEDIMENT TRANSPORT
             1 SEPARATE GRAIN STRESS FROM TOTAL IN COHESIVE AND NON-COHESIVE
                    COMPONENTS
             2 SEPARATE GRAIN STRESS FROM TOTAL. APPLY TO COHESIVE AND NON-COHESIVE
                    SEDIMENTS
```

```
              3 USE INDEPENDENT LOG LAW ROUGHNESS HEIGHT FOR SEDIMENT TRANSPORT.
                READ FROM FILE SEDROUGH.INP
              4 SEPARATE GRAIN STRESS FROM TOTAL USING COHESIVE/NON-COHESIVE WEIGHTED
                ROUGHNESS AND LOG LAW RESISTANCE (IMPLEMENTED 5/31/05)
              5 SEPARATE GRAIN STRESS FROM TOTAL USING COHESIVE/NON-COHESIVE WEIGHTED
                ROUGHNESS AND POWER LAW RESISTANCE (IMPLEMENTED 5/31/05)
  ISBSDIAM:   0 USE D50 DIAMETER FOR NON-COHESIVE ROUGHNESS
              1 USE 2*D50 FOR NON-COHESIVE ROUGHNESS
              2 USE D90 FOR NON-COHESIVE ROUGHNESS
              3 USE 2*D90 FOR NON-COHESIVE ROUGHNESS
  ISBSDFUF:   1 CORRECT GRAIN STRESS PARTITIONING FOR NON-UNIFORM FLOW EFFECTS.
                DO NOT USE FOR ISBEDSTR = 4 AND 5
  COEFTSBL:     COEFFICIENT SPECIFYING THE HYDRODYNAMIC SMOOTHNESS OF
                TURBULENT BOUNDARY LAYER OVER COHESIVE BED IN TERMS OF
                EQUIVALENT GRAIN SIZE FOR COHESIVE GRAIN STRESS
                CALCULATION, FULLY SMOOTH = 4, FULLY ROUGH = 100.
                NOT USED FOR ISBEDSTR = 4 AND 5
  VISMUDST:     KINEMATIC VISCOSITY TO USE IN DETERMINING COHESIVE GRAIN STRESS
  ISBKERO:    1 FOR BANK EROSION SPECIFIED BY EXTERNAL TIME SERIES
              2 FOR BANK EROSION INTERNALLY CALCULATED BY STABILITY ANALYSIS
C
C36a ISBEDSTR ISBSDIAM ISBSDFUF COEFTSBL VISMUDST ISBKERO
     5        3        0        4.       1.E-6    1
-------------------------------------------------------------------------------
```

Card Image 36B

```
-------------------------------------------------------------------------------
C36B SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C    DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
    ISEDAL:  1 TO ACTIVATE STATIONARY COHESIVE MUD ACTIVE LAYER
    ISNDAL:  1 TO ACTIVATE NON-COHESIVE ARMORING EFFECTS
             2 SAME AS 1 WITH ACTIVE-PARENT LAYER FORMULATION
    IALTYP:  0 CONSTANT THICKNESS ARMORING LAYER
             1 CONSTANT TOTAL SEDIMENT MASS ARMORING LAYER
    IALSTUP: 1 CREATE ARMORING LAYER FROM INITIAL TOP LAYER AT START UP
    ISEDEFF: 1 MODIFY NON-COHESIVE RESUSPENSION TO ACCOUNT FOR COHESIVE EFFECTS
               USING MULTIPLICATION FACTOR: EXP(-COEHEFF*FRACTION COHESIVE)
             2 MODIFY NON-COHESIVE CRITICAL STRESS TO ACCOUNT FOR COHESIVE EFFECTS
               USING MULT FACTOR: 1+(COEHEFF2-1)*(1-EXP(-COEHEFF*FRACTION COHESIVE))
    HBEDAL:    ACTIVE ARMORING LAYER THICKNESS
    COEHEFF:   COHESIVE EFFECTS COEFFICIENT
    COEHEFF2:  COHESIVE EFFECTS COEFFICIENT
C
C36B  ISEDAL ISNDAL IALTYP IALSTUP ISEDEFF HBEDAL COEHEFF COEHEFF2
      1      1      1      1       1       0.005  4.0     1.0
-------------------------------------------------------------------------------
```

Card Image 37

```
-------------------------------------------------------------------------------
C37 BED MECHANICAL PROPERTIES PARAMETER SET 1
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
   ISEDDT:   NUMBER OF SED BED PROCESSES STEPS PER HYDRO/WATER COLUMN TRANSPORT STEPS
   IBMECH: 0 TIME INVARIANT CONSTANT BED MECHANICAL PROPERITES
           1 SIMPLE CONSOLIDATION CALCULATION WITH CONSTANT COEFFICIENTS
           2 SIMPLE CONSOLIDATION WITH VARIABLE COEFFICIENTS DETERMINED
             EFDC FUNCTIONS CSEDCON1,2,3(IBMECH)
```

```
            3 COMPLEX CONSOLIDATION WITH VARIABLE COEFFICIENTS DETERMINED
              EFDC FUNCTIONS CSEDCON1,2,3(IBMECH). IBMECH > 0 SETS THE
              C38 PARAMETER ISEDBINT=1 AND REQUIRES INITIAL CONDITIONS
              FILES BEDLAY.INP, BEDBDN.INP AND BEDDDN.IN
            9 TYPE OF CONSOLIDATION VARIES BY CELL WITH IBMECH FOR EACH
              DEFINED IN INPUT FILE CONSOLMAP.INP
   IMORPH: 0 CONSTANT BED MORPHOLOGY (IBMECH=0, ONLY)
           1 ACTIVE BED MORPHOLOGY: NO WATER ENTRAINMENT/EXPULSION EFFECTS
           2 ACTIVE BED MORPHOLOGY: WITH WATER ENTRAINMENT/EXPULSION EFFECTS
   HBEDMAX:  TOP BED LAYER THICKNESS (m) AT WHICH NEW LAYER IS ADDED OR IF
             KBT(I,J)=KB, NEW LAYER ADDED AND LOWEST TWO LAYERS COMBINED
   BEDPORC:  CONSTANT BED POROSITY (IBMECH=0, OR NSED=0)
             ALSO USED AS POROSITY OF DEPOSITION NON-COHESIVE SEDIMENT
   SEDMDMX:  MAXIMUM FLUID MUD COHESIVE SEDIMENT CONCENTRATION (mg/L)
   SEDMDMN:  MINIMUM FLUID MUD COHESIVE SEDIMENT CONCENTRATION (mg/L)
   SEDVDRD:  VOID RATIO OF DEPOSITING COHESIVE SEDIMENT
   SEDVDRM:  MINIMUM COHESIVE SEDIMENT BED VOID RATIO (IBMECH > 0)
   SEDVDRT:  BED CONSOLIDATION RATED CONSTANT (1/SEC) (IBMECH = 1,2)
             GT 0 CONSOLIDATE OVER TIME TO SEDVDRM
             EQ 0 CONSOLIDATE INSTANTANEOUSLY TO SEDVDRM
             LT 0 CONSOLIDATE TO INITIAL VOID RATIOS
C
C37 ISEDDT IBMECH IMORPH HBEDMAX BEDPORC SEDMDMX SEDMDMN SEDVDRD SEDVDRM SEDVRDT
    16     1      2      0.074   0.6032  10000   5000    1.5202  0.0     -1.0000
------------------------------------------------------------------------------
```

Card Image 38

```
------------------------------------------------------------------------------
C38 BED MECHANICAL PROPERTIES PARAMETER SET 2 (CONSOLIDATION COEFFICIENTS)
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
     IBMECHK: 0 FOR HYDRAULIC CONDUCTIVITY, K, FUNCTION K=KO*EXP((E-EO)/EK)
              1 FOR HYD COND/(1+VOID RATIO),K', FUNCTION K'=KO'*EXP((E-EO)/EK)
      BMECH1:   REFERENCE EFFECTIVE STRESS/WATER SPECIFIC WEIGHT, SEO (m)
                IF BMECH1<0 USE INTERNAL FUNCTION, BMECH1,BMECH2,BMECH3 NOT USED
      BMECH2:   REFERENCE VOID RATIO FOR EFFECTIVE STRESS FUNCTION, EO
      BMECH3:   VOID RATIO RATE TERM ES IN SE=SEO*EXP(-(E-EO)/ES)
      BMECH4:   REFERENCE HYDRAULIC CONDUCTIVITY, KO (m/s)
                IF BMECH4<0 USE INTERNAL FUNCTION, BMECH1,BMECH2,BMECH3 NOT USED
      BMECH5:   REFERENCE VOID RATIO FOR HYDRAULIC CONDUCTIVITY, EO
      BMECH6:   VOID RATIO RATE TERM EK IN (K OR K')=(KO OR KO')*EXP((E-EO)/EK)
C
C38  IBMECHK BMECH1 BMECH2 BMECH3 BMECH4 BMECH5 BMECH6
     0       0      0      0      0      0      0
------------------------------------------------------------------------------
```

Card Image 39

```
------------------------------------------------------------------------------
C39 COHESIVE SEDIMENT PARAMETER SET 1 REPEAT DATA LINE NSED TIMES
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
   SEDO:  CONSTANT INITIAL COHESIVE SEDIMENT CONCENTRATION IN WATER COLUMN
           (mg/L = gm/m**3)
   SEDBO: CONSTANT INITIAL COHESIVE SEDIMENT IN BED PER UNIT AREA
           (gm/m**2)  i.e., 1 cm THICKNESS BED WITH SSG=2.5 AND
           N=.6, .5 GIVES SEDBO 1.E4, 1.25E4
   SDEN:  SEDIMENT SPECIFIC VOLUME (i.e., 1/2.25E6 m**3/gm)
```

```
   SSG:   SEDIMENT SPECIFIC GRAVITY
   WSEDO: CONSTANT OR REFERENCE SEDIMENT SETTLING VELOCITY
          IN FORMULA WSED=WSEDO*( (SED/SEDSN)**SEXP )
   SEDSN: NOT USED
   SEXP:  NOT USED
   TAUD:  BOUNDARY STRESS BELOW WHICH DEPOSITION TAKES PLACE ACCORDING
          TO (TAUD-TAU)/TAUD (M**2/S**2)
   ISEDSCOR: 1 TO CORRECT BOTTOM LAYER CONCENTRATION TO NEAR BED CONCENTRATION
   ISPROBDEP: 0 KRONE PROBABILITY OF DEPOSITION USING COHESIVE GRAIN STRESS
              1 KRONE PROBABILITY OF DEPOSITION USING TOTAL BED STRESS
              2 PARTHENIADES PROBABILITY OF DEPOSITION USING COHESIVE GRAIN STRESS
              3 PARTHENIADES PROBABILITY OF DEPOSITION USING TOTAL BED STRESS
C
C39 SEDO  SEDBO  SDEN      SSG   WSEDO  SEDSN  SEXP  TAUD    ISEDSCOR  ISPROBDEP
    10    10070  3.78E-07  2.65  1.e-6  0      0     0.0002  0         0
-------------------------------------------------------------------------------
```

Card Image 40

```
-------------------------------------------------------------------------------
C40 COHESIVE SEDIMENT PARAMETER SET 2 REPEAT DATA LINE NSED TIMES
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
   IWRSP: 0 USE RESUSPENSION RATE AND CRITICAL STRESS BASED ON PARAMETERS
            ON THIS DATA LINE
         >1 USE BED PROPERTIES DEPENDENT RESUSPENSION RATE AND CRITICAL
            STRESS GIVEN BY EFDC FUNCTIONS CSEDRESS,CSEDTAUS,CSEDTAUB
            FUNCTION ARGUMENTS ARE (BDENBED,IWRSP)
          1 HWANG AND MEHTA - LAKE OKEECHOBEE
          2 HAMRICK'S MODIFICATION OF SANFORD AND MAA USING ACTUAL VOID RATIO
          3 SAME AS 2 EXCEPT VOID RATIO OF COHESIVE SEDIMENT FRACTION IS USED
          4 SEDFLUME WITHOUT CRITICAL STRESS
          5 SEDFLUME WITH CRITICAL STRESS
      >= 99 SITE SPECIFIC
   IWRSPB:0 NO BULK EROSION
          1 USE BULK EROSION CRITICAL STRESS AND RATE IN FUNCTIONS
            CSEDTAUB AND CSEDRESSB
   WRSPO:   REFERENCE SURFACE EROSION RATE IN FORMULA
            WRSP=WRSP0*( ((TAU-TAUR)/TAUN)**TEX ) (gm/m**2-s)
   TAUR:    BOUNDARY STRESS ABOVE WHICH SURFACE EROSION OCCURS (m/s)**2
   TAUN:    NORMALIZING STRESS (EQUAL TO TAUR FOR COHESIVE SEDIMENT TRANSPORT)
   TEXP:    EXPONENTIAL (COHESIVE SEDIMENT)
   VDRRSPO: REFERENCE VOID RATIO FOR CRITICAL STRESS AND RESUSPENSION RATE
            IWRSP = 2,3
   COSEDHID: COHESIVE SEDIMENT RESUSPENSION HIDING FACTOR TO REDUCE COHESIVE
             RESUSPENSION BY FACTOR = (COHESIVE FRACTION OF SEDIMENT)**COSEDHID
C
C40  IWRSP  IWRSPB  WRSPO  TAUR    TAUN    TEXP  VDRRSPO  COSEDHID
     999    0       0.005  0.0002  0.0002  1.    1.       0.
-------------------------------------------------------------------------------
```

Card Image 41

```
-------------------------------------------------------------------------------
C41 NON-COHESIVE SEDIMENT PARAMETER SET 1 REPEAT DATA LINE NSND TIMES
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
       SNDO:    CONSTANT INITIAL NON-COHESIVE SEDIMENT CONCENTRATION IN WATER COLUMN
                 (mg/liter=gm/m**3)
       SNDBO:   CONSTANT INITIAL NON-COHESIVE SEDIMENT IN BED PER UNIT AREA
                 (gm/sq meter)  i.e., 1 cm THICKNESS BED WITH SSG=2.5 AND
                 N=.6,.5 GIVES SNDBO 1.0E4, 1.25E4
       SDEN:    SEDIMENT SPEC VOLUME (i.e., 1/2.65E6 m**3/gm)
```

```
       SSG:     SEDIMENT SPECIFIC GRAVITY
       SNDDIA:  REPRESENTATIVE DIAMETER OF SEDIMENT CLASS
       WSNDO:   CONSTANT OR REFERENCE SEDIMENT SETTLING VELOCITY. IF
                WSNDO < 0, SETTLING VELOCITY INTERNALLY COMPUTED
       SNDN:    MAX MASS/TOT VOLUME IN BED (NON-COHESIVE SED TRANS) (gm/m**3)
       SEXP:    DIMENSIONLESS RESUSPENSION PARAMETER GAMMA ZERO
       TAUD:    DUNE BREAK POINT STRESS (m/s)**2
    ISNDSCOR: 1 TO CORRECT BOTTOM LAYER CONCENTRATION TO NEAR BED CONC
C
C41 SNDO SNDBO  SDEN      SSG   SNDDIA    WSNDO  SNDN  SEXP  TAUD    ISNDSCOR
    10   10070  3.78E-07  2.65  0.000160  -1     0     0     0.0012  0
    10   10070  3.78E-07  2.65  0.000535  -1     0     0     0.0012  0
    10   10070  3.78E-07  2.65  0.005165  -1     0     0     0.0012  0
-------------------------------------------------------------------------------
```

Card Image 42

```
-------------------------------------------------------------------------------
C42 NON-COHESIVE SEDIMENT PARAMETER SET 2 REPEAT DATA LINE NSND TIMES
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
     ISNDEQ: >1 CALCULATE ABOVE BED REFERENCE NON-COHESIVE SEDIMENT
                EQUILIBRIUM CONCENTRATION USING EFDC FUNCTION
                CSNDEQC(SNDDIA,SSG,WS,TAUR,TAUB,SIGPHI,SNDDMX,IOTP)
                WHICH IMPLEMENT FORMULATIONS OF
              1 GARCIA AND PARKER
              2 SMITH AND MCLEAN
              3 VAN RIJN
              4 SEDFLUME WITHOUT CRITICAL STRESS
              5 SEDFLUME WITH CRITICAL STRESS
     ISBDLD:  0 BEDLOAD PHI FUNCTION IS CONSTANT, MEYER-PETER & MUELLER, BAGNOLD
              1 VAN RIJN PHI FUNCTION
              2 MODIFIED ENGULAND-HANSEN
              3 WU, WANG, AND JIA
              4 SEDFLUME WITHOUT CRITICAL STRESS
              5 SEDFLUME WITH CRITICAL STRESS
      TAUR:     CRITICAL STRESS IN (m/s)**2
                NOTE: IF TAUR < 0, THEN TAUR, TAUN, AND TEXP ARE INTERNALLY
                COMPUTED USING VAN RIJN'S FORMULAS
      TAUN:     EQUAL TO TAUR FOR NON-COHESIVE SED TRANS
   TCSHIELDS:   CRITICAL SHIELDS STRESS (DIMENSIONLESS)
     ISLTAUC: 1 TO IMPLEMENT SUSP LOAD ONLY WHEN STRESS EXCEEDS TAUC FOR EACH GRAIN
              2 TO IMPLEMENT SUSP LOAD ONLY WHEN STRESS EXCEEDS TAUCD50
              3 TO USE TAUC FOR NON-UNIFORM BEDS, APPLIES ONLY TO RESUSPENSION
                FORMULAS NOT CONTAINING CRITICAL SHIELDS STRESS SUCH AS GAR & PAR
     IBLTAUC: 1 TO IMPLEMENT BEDLOAD ONLY WHEN STRESS EXCEEDS TAUC FOR EACH GRAIN
              2 TO IMPLEMENT BEDLOAD ONLY WHEN STRESS EXCEEDS TAUCD50
              3 TO USE TAUC FOR NON-UNIFORM BEDS, APPLIES ONLY TO BEDLOAD FORMULAS
                NOT EXPLICITLY CONTAINING CRITICAL SHIELDS STRESS SUCH AS ENG-HAN
     IROUSE:  0 USE TOTAL STRESS FOR CALCULATING ROUSE NUMBER
              1 USE GRAIN STRESS FOR ROUSE NUMBER
    ISNDM1:   0 SET BOTH BEDLOAD AND SUSPENDED LOAD FRACTIONS TO 1.0
              1 SET BEDLOAD FRACTION TO 1. USE BINARY RELATIONSHIP FOR SUSPENDED
              2 SET BEDLOAD FRACTION TO 1, USE LINEAR RELATIONSHIP FOR SUSPENDED
              3 USE BINARY RELATIONSHIP FOR BEDLOAD AND SUSPENDED LOAD
              4 USE LINEAR RELATIONSHIP FOR BEDLOAD AND SUSPENDED LOAD
    ISNDM2:   0 USE TOTAL SHEAR VELOCITY IN USTAR/WSET RATIO
              1 USE GRAIN SHEAR VELOCITY IN USTAR/WSET RATIO
    RSNDM:      VALUE OF USTAR/WSET FOR BINARY SWITCH BETWEEN BED AND SUSPENDED LOAD
C
C42 ISNDEQ ISBDLD  TAUR   TAUN  TCSHIELDS ISLTAUC IBLTAUC IROUSE ISNDM1  ISNDM2  RSNDM
     1      2    -0.0005  .0005  .18        1        1        0     0       1      5.2
```

```
     1      2    -0.0006  .0006  .12        1        1        0     0       1      5.2
     1      2    -0.0006  .0006  .12        1        1        0     0       1      5.2
-------------------------------------------------------------------------------
```

Card Image 42A

```
-------------------------------------------------------------------------------
C42A NON-COHESIVE SEDIMENT PARAMETER SET 3 (BEDLOAD FORMULA PARAMETERS)
C    DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) = 0
C
      IBEDLD:  0 DISABLE BEDLOAD
               1 ACTIVATE BEDLOAD OPTION. MUST USE SEDBLBC.INP
     SBDLDA:     ALPHA EXPONENTIAL FOR BEDLOAD FORMULA,MPM=1.5,BAG=1,VR=2.1,EH=2.5
     SBDLDB:     BETA EXPONENTIAL FOR BEDLOAD FORMULA,BAG=1.0,MPM=VR=EH=WWJ=0.0
     SBDLDG1:    GAMMA1 CONSTANT FOR BEDLOAD FORMULA,BAG=MPM=VR=EH=WWJ=1.0
     SBDLDG2:    GAMMA2 CONSTANT FOR BEDLOAD FORMULA,EH=0.0,BAG=MPM=VR=WWJ=1.0
     SBDLDG3:    GAMMA3 CONSTANT FOR BEDLOAD FORMULA,BAG=MPM=VR=EH=WWJ=1.0
     SBDLDG4:    GAMMA4 CONSTANT FOR BEDLOAD FORMULA,BAG=1.0,MPM=VR=EH=WWJ=0.0
     SBDLDP:     CONSTANT PHI FOR BEDLOAD,BAG=CONST,MPM=7.6,VR=EH=WWJ=INTERNALY
     ISBLFUC:    BEDLOAD FACE FLUX: 0 FOR DOWNWIND PROJECTION, 1 FOR DOWNWIND
                 WITH CORNER CORRECTION, 2 FOR CENTERED AVERAGING
     BLBSNT:     ADVERSE BED SLOPE (POSITIVE VALUE) ACROSS A CELL FACE ABOVE
                 WHICH NO BEDLOAD TRANSPORT CAN OCCUR. NOT ACTIVE FOR BLBSNT=0.0
C
C42a IBEDLD SBDLDA SBDLDB SBDLDG1 SBDLDG2 SBDLDG3 SBDLDG4 SBDLDP ISBLFUC BLBSNT
     1      2.5    0      1       0       1       0       1      1       0.05
     1      2.5    0      1       0       1       0       1      1       0.05
     1      2.5    0      1       0       1       0       1      1       0.05
-------------------------------------------------------------------------------
```

Card Image 43

```
-------------------------------------------------------------------------------
C43 TOXIC CONTAMINANT INITIAL CONDITIONS AND PARAMETERS
C   USER MAY CHANGE UNITS OF WATER AND SEDIMENT PHASE TOXIC CONCENTRATIONS
C   AND PARTITION COEFFICIENT ON C44 - C46, BUT CONSISTENT UNITS MUST
C   BE USED FOR MEANINGFUL RESULTS.
C   DATA REQUIRED EVEN IF ISTRAN(5) = 0
C
     NTOXN: TOXIC CONTAMINANT NUMBER ID (1 LINE OF DATA BY DEFAULT)
    ITXINT: 0 FOR SPATIALLY CONSTANT WATER COLUMN AND BED INITIAL CONDITIONS
            1 FOR SPATIALLY VARIABLE WATER COLUMN INITIAL CONDITIONS
            2 FOR SPATIALLY VARIABLE BED INITIAL CONDITIONS
            3 FOR SPATIALLY VARIABLE WATER COL AND BED INITIAL CONDITION
   ITXBDUT: SET TO 0 FOR INITIAL BED GIVEN BY TOTAL TOX (mg/m^3)
            SET TO 1 FOR INITIAL BED GIVEN BY SORBED MASS TOX/MASS SED (mg/kg)
   TOXINTW: INIT WATER COLUMN TOTAL TOXIC VARIABLE CONCENTRATION (UGM/L)
   TOXINTB: INIT SED BED TOXIC CONC SEE ITXBDUT
    RKTOXW: FIRST ORDER WATER COLUMN DECAY RATE FOR TOX VARIABLE IN 1/SEC
    TKTOXW: REFERENCE TEMPERATURE FOR 1ST ORDER WATER COL DECAY DEG C
    RKTOXB: FIRST ORDER SED BED DECAY RATE FOR TOX VARIABLE IN 1/SEC
    TKTOXB: REF TEMPERATURE FOR 1ST ORDER SED BED DECAY DEG C
C
C43 NTOXN ITXINT ITXBDUT TOXINTW TOXINTB RKTOXW TKTOXW RKTOXB TRTOXB COMMENTS
    1     3      1       0.1     1E-20   0      20     0      20     nodecay
-------------------------------------------------------------------------------
```

Card Image 44

```
------------------------------------------------------------------------------
C44 ADDITIONAL TOXIC CONTAMINANT PARAMETERS
C   DATA REQUIRED EVEN IF ISTRAN(5) = 0
C
     NTOXN: TOXIC CONTAMINANT NUMBER ID (1 LINE OF DATA BY DEFAULT)
     ISTOC: 1 FOR DISSOLVED AND PARTICULATE ORGANIC CARBON SORPTION
            2 FOR DISSOLVED ORGANIC CARBON SORPTION AND POC FRACTIONALLY
              DISTRIBUTED TO INORGANIC SEDIMENT CLASSES
            3 FOR NO DISSOLVED ORGANIC CARBON SORPTION AND POC FRACTIONALLY
              DISTRIBUTED TO INORGANIC SEDIMENT CLASSES
    VOLTOX:   WATER SURFACE VOLATILIZATION RATE MULTIPLIER (0. OR 1.)
    RMOLTX:   MOLECULAR WEIGHT FOR DETERMINING VOLATILIZATION RATE
    RKTOXP:   REFERENCE PHOTOLYSIS DECAY RATE 1/SEC
    SKTOXP:   REFERENCE SOLAR RADIATION FOR PHOTOLYSIS (WATTS/m**2)
    DIFTOX:   DIFFUSION COEFF FOR TOXICANT IN SED BED PORE WATER (m**2/s)
    DIFTOXS:  DIFFUSION COEFF FOR TOXICANT BETWEEN WATER COLUMN AND
              PORE WATER IN TOP LAYER OF THE BED (m**2/s)
              > 0.0 INTERPRET AS DIFFUSION COEFFICIENT (m**2/s)
              < 0.0 INTERPRET AS FLUX VELOCITY (m/s)
    PDIFTOX:  PARTICLE MIXING DIFFUSION COEFF FOR TOXICANT IN SED BED (m**2/s)
              (if negative use zonal files PARTMIX.INP and PMXMAP.INP
    DPDIFTOX: DEPTH IN BED OVER WHICH PARTICLE MIXING IS ACTIVE (m)
C
C44 NTOXN ISTOC VOLTOX RMOLTX RKTOXP SKTOXP DIFTOX DIFTOXS   PDIFTOX DPDIFTOX COMMENTS
    1     2     0      0      0      0      1.e-9  -1.736e-7 -1.     0.08     1.3
------------------------------------------------------------------------------
```

Card Image 44A

```
------------------------------------------------------------------------------
C44A POREWATER TOXICS ADVECTION AND DIFFUSION SOLUTION SWITCHES
C    AND DIAGNOSTIC/MASS BALANCE FLUX SWITHCHES
C
       IADTOXDP:  0 FOR STANDARD SINGLE PRECISION SOLUTION
                  1 FOR DOUBLE PRECISION SOLUTION
      IADTOXCOR:  0 NO CORRECTION OF SINGLE PRECISION SOLUTION
                  1 MASS WEIGHTED CORRECTION OF SINGLE PRECISION SOLUTION
                  2 MASS CHANGE WEIGHTED CORRECTION OF SINGLE PRECISION SOLUTION
      ISTOXALL    1 TO ACTIVATE ACCUMULATION OF TOXIC FLUXES
      NSTOXALL      NUMBER OF WRITES OF ACCUMULATED FLUXES PER REFERENCE TIME PERIOD
C
C44A IADTOXDP  IADTOXCOR  ISTOXALL  NSTOXALL
     1         0          0         1
------------------------------------------------------------------------------
```

Card Image 45

```
------------------------------------------------------------------------------
C45 TOXIC CONTAMINANT SEDIMENT INTERACTION PARAMETERS
C   REQUIRES NTOX*(NSED+NSND) DATA LINES FIRST NSED LINES FOR COH SEDIMENT
C
     NTOXC: TOXIC CONTAMINANT NUMBER ID.  NSEDC+NSEDN LINES OF DATA
              FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
  NSEDN/NSNDN: FIRST NSED LINES COHESIVE, NEXT NSND LINES NON-COHESIVE.
            REPEATED FOR EACH CONTAMINANT
```

```
   ITXPARW: EQUAL 1 FOR SOLIDS DEPENDENT PARTITIONING (WC) GIVEN BY
            TOXPAR=PARO*(CSED**CONPAR)
   TOXPARW: WATER COLUMN PARO (ITXPARW=1) OR EQUILIBRIUM TOX CON PARTITION COEFFICIENT
              BETWEEN EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (L/mg)
   CONPARW: EXPONENT IN  TOXPAR=PARO*(CSED**CONPARW) IF ITXPARW=1
   ITXPARB: EQUAL 1 FOR SOLIDS DEPENDENT PARTITIONING (BED)
   TOXPARB: SEDIMENT BED PARO (ITXPARB=1) OR EQUIL TOX CON PART COEFF BETWEEN
            EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (LITERS/MG)
   CONPARB: EXPONENT IN  TOXPAR=PARO*(CSED**CONPARB) IF ITXPARB=1
C
C45 NTOXN NSEDN ITXPARW TOXPARW CONPARW ITXPARB TOXPARB CONPARB COMMENTS
    1     1     0       3.16    0       0       3.16    0       LogK=6.5
    1     2     0       3.16    0       0       3.16    0       LogK=6.5
    1     3     0       3.16    0       0       3.16    0       LogK=6.5
    1     4     0       3.16    0       0       3.16    0       LogK=6.5
-------------------------------------------------------------------------------
```

Card Image 45A

```
-------------------------------------------------------------------------------
C45A TOXIC CONTAMINANT ORGANIC CARBON INTERACTION PARAMETERS
C
   ISTDOCW: 0 CONSTANT DOC IN WATER COLUMN OF STDOCWC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING DOC IN WATER COLUMN FROM docw.inp
   ISTPOCW: 0 CONSTANT POC IN WATER COLUMN OF STPOCWC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING POC IN WATER COLUMN FROM pocw.inp
            2 TIME CONSTANT, FPOC IN WATER COLUMN, SEE C45C
            3 TIME CONSTANT, SPATIALLY VARYING FPOC IN WATER COLUMN FROM fpocw.inp
            4 FUNTIONAL SPECIFICATION OF TIME AND SPATIALLY VARYING
                FPOC IN WATER COLUMN
   ISTDOCB: 0 CONSTANT DOC IN BED OF STDOCBC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING DOC IN BED FROM docb.inp
   ISTPOCB: 0 CONSTANT POC IN BED OF STPOCBC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING POC IN BED FROM pocb.inp
            2 TIME CONSTANT, FPOC IN BED, SEE C45D
            3 TIME CONSTANT, SPATIALLY VARYING FPOC IN BED FROM fpocb.inp
            4 FUNTIONAL SPECIFICATION OF TIME AND SPATIALLY VARYING
                FPOC IN BED
  STDOCWC:  CONSTANT WATER COLUMN DOC (ISTDOCW=0)
  STPOCWC:  CONSTANT WATER COLUMN POC (ISTPOCW=0)
  STDOCBC:  CONSTANT BED DOC (ISTDOCB=0)
  STPOCBC:  CONSTANT BED POC (ISTPOCB=0)
C
C45A ISTDOCW ISTPOCW ISTDOCB ISTPOCB STDOCWC STPOCWC STDOCBC STPOCBC
     0       3       1       4       6.5     0.0     22.0    0.0
-------------------------------------------------------------------------------
```

Card Image 45B

```
-------------------------------------------------------------------------------
C45B TOXIC CONTAMINANT ORGANIC CARBON INTERACTION PARAMETERS
C    REQUIRES NTOX*(NSED+NSND) OR 2*NTOX DATA LINES
C
     NTOXC: TOXIC CONTAMINANT NUMBER ID.  NSEDC+NSEDN LINES OF DATA
              FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
      NOC : FIRST LINE FOR DISSOLVED ORGANIC CARBON, SECOND FOR PART OC
            REPEATED FOR EACH CONTAMINANT
   ITXPARW: -1 FOR NO ORGANIC CARBON, O FOR NORMAL PARTITION AND 1 FOR SOLIDS
            DEPENDENT TOXPAR=PARO*(CSED**CONPAR)
```

```
   TOXPARW: WATER COLUMN PARO (ITXPARW=1) OR EQUIL TOX CON PART COEFF BETWEEN
            EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (L/mg)
   CONPARW: EXPONENT IN  TOXPAR=PARO*(CSED**CONPARW) IF ITXPARW=1
   ITXPARB: CONVENTION FOLLOWS ITXPARW (BED)
   TOXPARB: SEDIMENT BED PARO (ITXPARB=1) OR EQUIL TOX CON PART COEFF BETWEEN
            EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (L/mg)
   CONPARB: EXPONENT IN  TOXPAR=PARO*(CSED**CONPARB) IF ITXPARB=1
C
C45B NTOXN  NOC ITXPARW TOXPARW CONPARW ITXPARB TOXPARB CONPARB  *CARBON*
     1      1   0       0.0316  0       0       0.316   0         Kdoc=0.1Koc
     1      2   0       3.16    0       0       3.16    0         Kpoc
-------------------------------------------------------------------------------
```

Card Image 45C

```
-------------------------------------------------------------------------------
C45C TOXIC CONTAMINANT POC FRACTIONAL DISTRIBUTIONS IN WATER COLUMN
C    ONE LINE OF DATA REQUIRED EVEN IF ISTRAN(5) = 0. DATA USED WHEN
C    ISTOC(NT) = 1 OR 2

      NTOXN:      TOXIC CONTAMINANT NUMBER ID.  NSEDC+NSEDN 1 LINE OF DATA
                  FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
   FPOCSED1-NSED: FRACTION OF ORGANIC CARBON ASSOCIATED WITH SED CLASSES 1,NSED
   FPOCSND1-NSND: FRACTION OF ORGANIC CARBON ASSOCIATED WITH SND CLASSES 1,NSND
C
C45C NTOXN  FPOCSED1  FPOCSND1  FPOCSND2  FPOCSND3
     1      0.100     0.100     0.100     0.100
-------------------------------------------------------------------------------
```

Card Image 45D

```
-------------------------------------------------------------------------------
C45D TOXIC CONTAMINANT POC FRACTIONAL DISTRIBUTIONS IN SEDIMENT BED
C    ONE LINE OF DATA REQUIRED EVEN IF ISTRAN(5) = 0. DATA USED WHEN
C    ISTOC(NT) = 1 OR 2

      NTOXN:      TOXIC CONTAMINANT NUMBER ID.  NSEDC+NSEDN 1 LINE OF DATA
                  FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
  FPOCSED1-NSED:  FRACTION OF ORGANIC CARBON ASSOCIATED WITH SED CLASSES 1,NSED
  FPOCSND1-NSND:  FRACTION OF ORGANIC CARBON ASSOCIATED WITH SND CLASSES 1,NSND
C
C45D NTOXN  FPOCSED1  FPOCSND1  FPOCSND2  FPOCSND3
     1      0.0472    0.0104    0.0031    0.0031
-------------------------------------------------------------------------------
```

Card Image 46

```
-------------------------------------------------------------------------------
C46  BUOYANCY, TEMPERATURE, DYE DATA AND CONCENTRATION BC DATA
C
       BSC:    BUOYANCY INFLUENCE COEFFICIENT 0 TO 1: BSC=1. FOR REAL PHYSICS
       TEMO:   REFERENCE, INITIAL, EQUILIBRUM AND/OR ISOTHERMAL TEMPERATURE IN DEG C
       HEQT:   EQUILIBRUM TEMPERTURE TRANSFER COEFFICIENT (M/S)
  ISBEDTEMI: 0 READ INITIAL BED TEMPERATURE FROM TEMPB.INP
             1 INITIALIZE AT START OF COLD RUN
       KBH:    NUMBER OF BED THERMAL LAYERS
     RKDYE:    FIRST ORDER DECAY RATE FOR DYE VARIABLE (1/SEC)
```

```
       NCBS:   NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON SOUTH OPEN
               BOUNDARIES
       NCBW:   NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON WEST OPEN
               BOUNDARIES
       NCBE:   NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON EAST OPEN
               BOUNDARIES
       NCBN:   NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON NORTH OPEN
               BOUNDARIES
C
C46   BSC TEMO HEQT  ISBEDTEMI KBH RKDYE NCBS NCBW NCBE NCBN
      0.0 20.0 0.E-6 1         21  0.    0    0    0    0
-------------------------------------------------------------------------------
```

Card image 46 is used to specify scalar constituent concentration informative on open boundaries as well as to provide additional scalar variable information. The first four parameters specify the number of concentration open boundary cells on the four computational grid direction faces and are identical to the first four parameters on Card image 17. The next five parameters specify the number of time series to be read from files sser.inp, tser.inp, dser.inp, sdser.inp, and sfser.inp, respectively. The parameter BSC controls the buoyancy forcing in the momentum equations. The temperature TEMO, in degrees C, is used as the initial temperature for cold starts or the isothermal temperature. When the temperature transport option ISTOPT on Card image 6 is specified as 3, TEMO is the time invariant equilibrium temperature. The parameter HEQT is the equilibrium surface heat transfer coefficient, in square meters per second, and is used only when the ISTOPT equals 3 option is set. The remaining parameter RKDYE is a first order decay rate of the dye tracer variable and must have units of 1/seconds.

Card Image 47

```
-------------------------------------------------------------------------------
C47 LOCATION OF CONC BC'S ON SOUTH BOUNDARIES
C
   ICBS:    I CELL INDEX
   JCBS:    J CELL INDEX
   NTSCRS:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
              TO INFLOW FROM OUTFLOW
   NSSERS:  SOUTH BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
   NTSERS:  SOUTH BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
   NDSERS:  SOUTH BOUNDARY CELL DYE CONC TIME SERIES ID NUMBER
   NSFSERS: SOUTH BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
   NTXSERS: SOUTH BOUNDARY CELL TOXIC CONTAMINANT CONCENTRATION TIME SERIES ID NUM.
   NSDSERS: SOUTH BOUNDARY CELL COHESIVE SEDIMENT CONCENTRATION TIME SERIES ID NUMBER
C  NSNSERS: SOUTH BOUNDARY CELL NON-COHESIVE SEDIMENT CONCENTRATION TIME SERIES ID
              NUMBER
C
C47 IBBS JBBS NTSCRS NSSERS NTSERS NDSERS NSFSERS NTXSERS NSDSERS NSNSERS
-------------------------------------------------------------------------------
```

Card Image 48

```
------------------------------------------------------------------------------
C48 TIME CONSTANT BOTTOM CONCENTRATION ON SOUTH CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING BOTTOM LAYER SALINITY
   TEM: ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C48 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 49

```
------------------------------------------------------------------------------
C49 TIME CONSTANT BOTTOM CONCENTRATION ON SOUTH CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING BOTTOM LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C49 SED1 SND1 SND2 SND3
------------------------------------------------------------------------------
```

Card Image 50

```
------------------------------------------------------------------------------
C50 TIME CONSTANT SURFACE CONCENTRATION ON SOUTH CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING SURFACE LAYER SALINITY
   TEM: ULTIMATE INFLOWING SURFACE LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING SURFACE LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING SURFACE LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING SURFACE LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C50 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 51

```
------------------------------------------------------------------------------
C51 TIME CONSTANT SURFACE CONCENTRATION ON SOUTH CONC BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING SURFACE LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING SURFACE LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C51 SED1 SND1 SND2 SND3
------------------------------------------------------------------------------
```

Card Image 52

```
------------------------------------------------------------------------------
C52 LOCATION OF CONCENTRATION BC'S ON WEST BOUNDARIES AND SERIES IDENTIFIERS
C
   ICBW:    I CELL INDEX
   JCBW:    J CELL INDEX
   NTSCRW:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
              TO INFLOW FROM OUTFLOW
   NSSERW:  WEST BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
   NTSERW:  WEST BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
   NDSERW:  WEST BOUNDARY CELL DYE CONCENTRATION TIME SERIES ID NUMBER
   NSFSERW: WEST BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
   NTXSERW: WEST BOUNDARY CELL TOXIC CONTAMINANT CONCENTRATION TIME SERIES ID NUMBER
   NSDSERW: WEST BOUNDARY CELL COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
   NSNSERW: WEST BOUNDARY CELL NON-COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
C
C52 IBBW JBBW NTSCRW NSSERW NTSERW NDSERW NSFSERW NTXSERW NSDSERW NSNSERW
------------------------------------------------------------------------------
```

Card Image 53

```
------------------------------------------------------------------------------
C53 TIME CONSTANT BOTTOM CONCENTRATION ON WEST CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING BOTTOM LAYER SALINITY
   TEM: ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C53 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 54

```
------------------------------------------------------------------------------
C54 TIME CONSTANT BOTTOM CONCENTRATION ON WEST CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING BOTTOM LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C54 SED1 SND1
------------------------------------------------------------------------------
```

Card Image 55

```
------------------------------------------------------------------------------
C55 TIME CONSTANT SURFACE CONCENTRATION ON WEST CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING SURFACE LAYER SALINITY
   TEM: ULTIMATE INFLOWING SURFACE LAYER TEMPERATURE
```

```
   DYE: ULTIMATE INFLOWING SURFACE LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING SURFACE LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING SURFACE LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C55 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 56

```
------------------------------------------------------------------------------
C56 TIME CONSTANT SURFACE CONCENTRATION ON WEST CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING SURFACE LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING SURFACE LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C56 SED1 SND1
------------------------------------------------------------------------------
```

Card Image 57

```
------------------------------------------------------------------------------
C57 LOCATION OF CONCENTRATION BC'S ON EAST BOUNDARIES AND SERIES IDENTIFIERS
C
   ICBE:    I CELL INDEX
   JCBE:    J CELL INDEX
   NTSCRE:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
             TO INFLOW FROM OUTFLOW
   NSSERE:  EAST BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
   NTSERE:  EAST BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
   NDSERE:  EAST BOUNDARY CELL DYE CONCENTRATION TIME SERIES ID NUMBER
   NSFSERE: EAST BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
   NTXSERE: EAST BOUNDARY CELL TOXIC CONTAMINANT CONCENTRATION TIME SERIES ID NUM.
   NSDSERE: EAST BOUNDARY CELL COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
   NSNSERE: EAST BOUNDARY CELL NON-COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
C
C57 IBBE JBBE NTSCRE NSSERE NTSERE NDSERE NSFSERE NTXSERE NSDSERE NSNSERE
------------------------------------------------------------------------------
```

Card Image 58

```
------------------------------------------------------------------------------
C58 TIME CONSTANT BOTTOM CONCENTRATION ON EAST CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING BOTTOM LAYER SALINITY
   TEM: ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C58 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 59

```
------------------------------------------------------------------------------
C59 TIME CONSTANT BOTTOM CONCENTRATION ON EAST CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING BOTTOM LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C59 SED1 SND1
------------------------------------------------------------------------------
```

Card Image 60

```
------------------------------------------------------------------------------
C60 TIME CONSTANT SURFACE CONCENTRATION ON EAST CONCENTRATION BOUNDARIES
*
   SAL: ULTIMATE INFLOWING SURFACE LAYER SALINITY
   TEM: ULTIMATE INFLOWING SURFACE LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING SURFACE LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING SURFACE LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING SURFACE LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C60 SAL TEM DYE SFL TOX1
------------------------------------------------------------------------------
```

Card Image 61

```
------------------------------------------------------------------------------
C61 TIME CONSTANT SURFACE CONCENTRATION ON EAST CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING SURFACE LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING SURFACE LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C61 SED1 SND1
------------------------------------------------------------------------------
```

Card Image 62

```
------------------------------------------------------------------------------
C62 LOCATION OF CONCENTRATION BC'S ON NORTH BOUNDARIES AND SERIES IDENTIFIERS
C
   ICBN:    I CELL INDEX
   JCBN:    J CELL INDEX
   NTSCRN:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
              TO INFLOW FROM OUTFLOW
   NSSERN:  NORTH BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
   NTSERN:  NORTH BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
   NDSERN:  NORTH BOUNDARY CELL DYE CONCENTRATION TIME SERIES ID NUMBER
   NSFSERN: NORTH BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
```

```
   NTXSERN: NORTH BOUNDARY CELL TOXIC CONTAMINANT CONCENTRATION TIME SERIES ID NUMBER
   NSDSERN: NORTH BOUNDARY CELL COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
   NSNSERN: NORTH BOUNDARY CELL NON-COHESIVE SED CONCENTRATION TIME SERIES ID NUMBER
C
C62 IBBN JBBN NTSCRN NSSERN NTSERN NDSERN NSFSERN NTXSERN NSDSERN NSNSERN
------------------------------------------------------------------------------
```

Card Image 63

```
------------------------------------------------------------------------------
C63 TIME CONSTANT BOTTOM CONCENTRATION ON NORTH CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING BOTTOM LAYER SALINITY
   TEM: ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C63 SAL TEM DYE SFL TOX1-20
------------------------------------------------------------------------------
```

Card Image 64

```
------------------------------------------------------------------------------
C64 TIME CONSTANT BOTTOM CONCENTRATION ON NORTH CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING BOTTOM LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C64 SED1 SED2 SND1 SND2 SND3
------------------------------------------------------------------------------
```

Card Image 65

```
------------------------------------------------------------------------------
C65 TIME CONSTANT SURFACE CONCENTRATION ON NORTH CONCENTRATION BOUNDARIES
C
   SAL: ULTIMATE INFLOWING SURFACE LAYER SALINITY
   TEM: ULTIMATE INFLOWING SURFACE LAYER TEMPERATURE
   DYE: ULTIMATE INFLOWING SURFACE LAYER DYE CONCENTRATION
   SFL: ULTIMATE INFLOWING SURFACE LAYER SHELLFISH LARVAE CONCENTRATION
   TOX: NTOX ULTIMATE INFLOWING SURFACE LAYER TOXIC CONTAMINANT
        CONCENTRATIONS. NTOX VALUES TOX(N), N=1,NTOX
C
C65 SAL TEM DYE SFL TOX1-20
------------------------------------------------------------------------------
```

Card Image 66

```
------------------------------------------------------------------------------
C66 TIME CONSTANT SURFACE CONCENTRATION ON NORTH CONCENTRATION BOUNDARIES
C
   SED: NSED ULTIMATE INFLOWING SURFACE LAYER COHESIVE SEDIMENT
        CONCENTRATIONS. FIRST NSED VALUES SED(N), N=1,NSND
   SND: NSND ULTIMATE INFLOWING SURFACE LAYER NON-COHESIVE SEDIMENT
        CONCENTRATIONS. LAST NSND VALUES SND(N), N=1,NSND
C
C66 SED1 SED2 SND1 SND2 SND3
------------------------------------------------------------------------------
```

Card images 47 through 66 specify scalar inflowing concentrations on open boundaries. The open boundary condition for salinity, temperature and other transported constituents is based on the specification of inflowing values. The inflowing values may be specified as depth dependent and either time constant or time variable, if concentration time series are available at open boundaries. Outflowing values are calculated using upwinded values immediately inside the open boundary. When the flow at the open boundary changes from outflow to inflow, the model provides for a linear interpolation of inflowing concentration, over a user specified number of timesteps, (NTSCR_ on Card images 47, 52, 57, and 62) between the last outflowing value and the ultimate inflowing value of concentration, which allows for a smooth transition of concentration values at the open boundary. The ultimate inflowing concentration is the sum of a time constant value and a time series specified inflowing concentration value (either of which may be zero). Card images 47, 52, 57, and 62 define the location of open boundary cells by the indices ICB_ and JCB_. The next parameter on these four card images, NTSCR_, defines the number of time steps to recover the specified boundary concentration value after the change from outflow to inflow. For tidal flows, NTSCR_ might typically be the number of time steps corresponding to one hour. Alternately NTSCR_ can be adjusted during model calibration. The remaining five parameters on these four cards specify scalar concentration time series identifier numbers if the inflow concentrations are to be specified by time series. The time series specification of inflowing concentrations allows a unique concentration in each layer of the boundary cell. When the open boundary inflow concentrations are specified by constant values, bottom layer values on the four computational domain face directions are specified on Card images 48, 49, 53, 54, 58, 59, 63 and 64, while surface layer values are specified on Card images 50, 51, 55, 56, 60, 61, 65 and 66. If the number of layers exceeds two, values for the interior layers are linearly interpolated between the bottom and surface layer values.

Card Image 66A

```
------------------------------------------------------------------------------
C66A CONCENTRATION DATA ASSIMILATION
C
   NLCDA: NUMBER OF HORIZONTAL LOCATIONS FOR DATA ASSIMILATION
   TSCDA: WEIGHTING FACTOR, 0.-1., 1. = FULL ASSIMILATION
   ISCDA: 1 FOR CONCENTRATION DATA ASSIMILATION (NC=1.7 VALUES)
C
C66A NLCDA TSCDA ISCDA
     0     0.5   0     0     0     0     0     0     0
------------------------------------------------------------------------------
```

Card Image 66B

```
------------------------------------------------------------------------------
C66B CONCENTRATION DATA ASSIMILATION
C
   ITPCDA: 0 ASSIMILATE DATA FROM TIME SERIES
           1 ASSIMILATE DATA FROM ANOTHER CELL IN GRID
     ICDA: I INDEX OF CELL ASSIMILATING DATA
     JCDA: J INDEX OF CELL ASSIMILATING DATA
    ICCDA: I INDEX OF CELL PROVIDING DATA, ITPCDA=1
    JCCDA: J INDEX OF CELL PROVIDING DATA, ITPCDA=1
  IDIRCDA: 0 NO DIRECTIONAL ASSIMILATION EFFECT
           1 POSITIVE EAST-WEST, 2 NEGATIVE EAST-WEST VELOCITY
           3 POSITIVE NORTH-SOUTH, 4 NEGATIVE NORTH-SOUTH VELOCITY
   NCSERA:   ID OF TIME SERIES PROVIDING DATA
C
C66B ITPCDA  ICDA  JCDA ICCDA  JCCDA  IDIRCDA   NCSERA(NS=1,7)
------------------------------------------------------------------------------
```

Card Image 67

```
------------------------------------------------------------------------------
C67 DRIFTER DATA (FIRST 4 PARAMETERS FOR SUBROUTINE DRIFTER, SECOND 6 FOR SUBROUTINE
C   LAGRES)
C
   ISPD:   1 TO ACTIVE SIMULTANEOUS RELEASE AND LAGRANGIAN TRANSPORT OF
             NEUTRALLY BUOYANT PARTICLE DRIFTERS AT LOCATIONS INPUT ON C66B
   NPD:      NUMBER OF PARTICLE DRIFTERS
   NPDRT:    TIME STEP AT WHICH PARTICLES ARE RELEASED
   NWPD:     NUMBER OF TIME STEPS BETWEEN WRITING TO TRACKING FILE
             DRIFTER.OUT
   ISLRPD: 1 TO ACTIVATE CALCULATION OF LAGRANGIAN MEAN VELOCITY OVER TIME
             INTERVAL TREF AND SPATIAL INTERVAL ILRPD1<I<ILRPD2,
             JLRPD1<J<JLRPD2, 1<K<KC, WITH MLRPDRT RELEASES. ANY AVERAGE
             OVER ALL RELEASE TIMES IS ALSO CALCULATED.
           2 SAME BUT USES A HIGHER ORDER TRAJECTORY INTEGRATION
   ILRPD1    WEST BOUNDARY OF REGION
   ILRPD2    EAST BOUNDARY OF REGION
   JLRPD1    NORTH BOUNDARY OF REGION
   JLRPD2    SOUTH BOUNDARY OF REGION
   MLRPDRT   NUMBER OF RELEASE TIMES
   IPLRPD    1,2,3 WRITE FILES TO PLOT ALL, EVEN, ODD HORIZ LAGRANGIAN VEL VECTORS
C
C67 ISPD NPD NPDRT NWPD ISLRPD ILRPD1 ILRPD2 JLRPD1 JLRPD2 MLRPDRT IPLRPD
    0    0   0     12   0      6      47     6      17     12      1
```

```
------------------------------------------------------------------------------
```

Card image 67 activates and controls two types of Lagrangian particle trajectory calculations, which may be simultaneously activated. The first Lagrangian trajectory calculation, activated by ISPD=1, releases NPD particles at time step NPDRT. The released particles are then tracked for the remainder of the model simulation, with the nearest cell center positions (I,J,K) written to the file drifter.out every NWPD time steps. The initial position of the NPD particles is specified on Card image 44, shown below. The second Lagrangian trajectory calculation, activated by ISLRD greater than zero, releases particles at active water cell centers for all vertical layers, in the region of the computational grid bound in the x or I direction by (ILRD1.LE.I.LE.ILRD2), and in the y or J direction by (JLRD1.LE.J.LE.JLRD2). MLRPDRT releases, evenly spaced in the reference time period, card 8, occur during the next to last reference time period of the model simulation (i.e., NTC.GE.2). Each group of particles is tracked for one reference time period and their net vector displacements from their release positions are determined. The net vector displacements are then divided by the reference time period to give Lagrangian mean velocity vectors (Hamrick, 1994a), which are written to the file lmvvech.out. The average Lagrangian mean of the MLRPDRT release times is also calculated and written to the file almvvech.out. For ISLRD equal to 1 or 2, the Lagrangian mean velocity vectors are associated with their release positions for plotting. For ISLRD equal to 3 or 4, the Lagrangian mean velocity vectors are associated with the mean position of the corresponding particle during its trajectory. To assure a uniform distribution of vectors for plotting, the trajectory centroid located vectors are interpolated back to the cell centers and the results written to the file lmvech.out for the MLRPDRT releases with the average of the releases written to the file almvech.out. Values of 1 or 3 for ISLRD implement first order explicit forward Euler integrator for the trajectory calculation, while values of 2 and 4 implement a second order implicit trapezoidal integrator (Bennett and Clites, 1987) incurring increased computational time. If the trajectory calculation is executed over the entire grid for 10 to 12 release times, the computational effort for the last two time cycles is increased by approximately 20 to 40 percent.

Card Image 68

```
------------------------------------------------------------------------------
C68 INITIAL DRIFTER POSITIONS (FOR USE WITH SUB DRIFTER)
C
   RI: I CELL INDEX IN WHICH PARTICLE IS RELEASED IN
   RJ: J CELL INDEX IN WHICH PARTICLE IS RELEASED IN
   RK: K CELL INDEX IN WHICH PARTICLE IS RELEASED IN
C
C68 RI RJ RK
------------------------------------------------------------------------------
```

Card Image 69

```
------------------------------------------------------------------------------
C69 CONSTANTS FOR CARTESIAN GRID CELL CENTER LONGITUDE AND LATITUDE
C
   CDLON1: 6 CONSTANTS TO GIVE CELL CENTER LATITUDE AND LONGITUDE OR OTHER
   CDLON2: COORDINATES FOR CARTESIAN GRIDS USING THE FORMULAS
   CDLON3: DLON(L)=CDLON1+(CDLON2*FLOAT(I)+CDLON3)/60.
   CDLAT1: DLAT(L)=CDLAT1+(CDLAT2*FLOAT(J)+CDLAT3)/60.
   CDLAT2:
   CDLAT3:
C
C69 CDLON1 CDLON2 CDLON3 CDLAT1 CDLAT2 CDLAT3
    0      0      0      0      0      0
------------------------------------------------------------------------------
```

This card image allows cell center coordinates for graphics output files to be generated for Cartesian grids where the grid, bathymetric and roughness are specified in the cell.inp and depth.inp files.

Card Image 70

```
------------------------------------------------------------------------------
C70 CONTROLS FOR WRITING ASCII OR BINARY DUMP FILES
C
   ISDUMP: GREATER THAN 0 TO ACTIVATE
           1 SCALED ASCII INTEGER (0<VAL<65535)
           2 SCALED 16BIT BINARY INTEGER (0<VAL<65535) OR (-32768<VAL<32767)
           3 UNSCALED ASCII FLOATING POINT
           4 UNSCALED BINARY FLOATING POINT
   ISADMP: GREATER THAN 0 TO APPEND EXISTING DUMP FILES
   NSDUMP: NUMBER OF TIME STEPS BETWEEN DUMPS
   TSDUMP: STARTING TIME FOR DUMPS - DAYS (NO DUMPS BEFORE THIS TIME)
   TEDUMP: ENDING TIME FOR DUMPS - DAYS (NO DUMPS AFTER THIS TIME)
   ISDMPP: GREATER THAN 0 FOR WATER SURFACE ELEVATION DUMP
   ISDMPU: GREATER THAN 0 FOR HORIZONTAL VELOCITY DUMP
   ISDMPW: GREATER THAN 0 FOR VERTICAL VELOCITY DUMP
   ISDMPT: GREATER THAN 0 FOR TRANSPORTED VARIABLE DUMPS
   IADJDMP: 0 FOR SCALED BINARY INTEGERS (0<VAL<65535)
            -32768 FOR SCALED BINARY INTEGERS (-32768<VAL<32767)
C
C70 ISDUMP ISADMP NSDUMP TSDUMP TEDUMP ISDMPP ISDMPU ISDMPW ISDMPT IADJDMP
    0      0     36000   0      731    0      0      0      1      -32768
------------------------------------------------------------------------------
```

Card Image 71

```
------------------------------------------------------------------------------
C71 CONTROLS FOR HORIZONTAL PLANE SCALAR FIELD CONTOURING
C
      ISSPH:  1 TO WRITE FILE FOR SCALAR FIELD CONTOURING IN HORIZONTAL PLANE
              2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      NPSPH:    NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISRSPH: 1 TO WRITE FILE FOR RESIDUAL SALINITY PLOTTING IN
                HORIZONTAL
      ISPHXY: 0 DOES NOT WRITE I,J,X,Y IN ***cnh.out and r***cnh.out FILES
              1 WRITES I,J ONLY IN ***cnh.out and r***cnh.out FILES
```

```
              2 WRITES I,J,X,Y  IN ***cnh.out and r***cnh.out FILES
              3 WRITES EFDC EXPLORER BINARY FORMAT FILES
      DATA LINE REPEATS 7 TIMES FOR SAL,TEM,DYE,SFL,TOX,SED,SND
C
C71 ISSPH  NPSPH  ISRSPH  ISPHXY
    0      1      0       0      !SAL
    0      1      0       0      !TEM
    0      1      0       0      !DYE
    0      1      0       0      !SFL
    0      1      0       1      !TOX
    0      1      0       1      !SED
    0      1      0       1      !SND
------------------------------------------------------------------------------
```

Card image 71 activates the creation of output files xxxconh.out and rxxxconh.out (where xxx is sal, tem, dye, sed, or sfl) for horizontal plane contour plotting of surface and bottom layer scalar field distributions. For sediment (sed) and shellfish larvae (sfl) bottom bed concentrations are also output. The switch ISSPH generated the non-r-prefixed files for transport scalar fields at NPSPH times during the last time cycle of the model run. The switch ISRSPH activates the output of time averaged or residual fields representing an average over NTSMMT time steps (see Card image 7). If ISSSMMT on Card image 4 is 0 residual fields are written for each averaging period in the model run, while a value of 1 results in writing the results of only the last averaging period.

Card Image 71A

```
------------------------------------------------------------------------------
C71A CONTROLS FOR HORIZONTAL PLANE SEDIMENT BED PROPERTIES CONTOURING
C
      ISBPH:  1 TO WRITE FILES FOR SED BED PROPERTY CONTOURING IN HORIZONTAL
              2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
     ISBEXP:  0 ASCII FORMAT, 1 EFDC EXPLORER BINARY FORMAT
      NPBPH:    NUMBER OF WRITES PER REFERENCE TIME PERIOD
     ISRBPH:  1 TO WRITE FILES FOR RESIDUAL SED BED PROPERTY CONTOURING
     ISBBDN:  1 WRITE LAYER BULK DENSITY
     ISBLAY:  1 WRITE LAYER THICKNESSES
     ISBPOR:  1 WRITE LAYER POROSITY
     ISBSED:  1 WRITE COHESIVE SEDIMENT (MASS PER UNIT AREA)
              2 WRITE COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT)
              3 WRITE COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT+WATER)
     ISBSED:  1 WRITE NON-COHESIVE SEDIMENT (MASS PER UNIT AREA)
              2 WRITE NON-COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT)
              3 WRITE NON-COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT+WATER)
     ISBVDR:  1 WRITE LAYER VOID RATIOS
     ISBARD:  1 WRITES ACCUMULATED MASS/AREA RESUSPENSION AND DEPOSITION FOR
                EACH SEDIMENT CLASS TO ASCII FILE BEDARD.OUT FOR ISBEXP=0 OR 1
C
C71A ISBPH ISBEXP NPBPH ISRBPH ISBBDN ISBLAY ISBPOR ISBSED ISBSND ISBVDR ISBARD
     0     0      1     0      1      1      1      1      1      1      1
------------------------------------------------------------------------------
```

Card Image 71B

```
------------------------------------------------------------------------------
C71B FOODCHAIN MODEL OUTPUT CONTROL
C
     ISFDCH: 1 TO WRITE OUTPUT FOR HOUSATONIC RIVER FOODCHAIN MODEL
     NFDCHZ: NUMBER OF SPATIAL ZONES
     HBFDCH: AVERAGING DEPTH FOR TOP PORTION OF BED (METERS)
     TFCAVG: TIME AVERAGING INTERVAL FOR FOODCHAIN OUTPUT (SECONDS)
C
C71B ISFDCH  NFDCHZ  HBFDCH  TFCAVG
     1       5       0.04    86400.
------------------------------------------------------------------------------
```

Card Image 72

```
------------------------------------------------------------------------------
C72 CONTROLS FOR HORIZONTAL SURFACE ELEVATION OR PRESSURE CONTOURING
C
      ISPPH:  1 TO WRITE FILE FOR SURFACE ELEVATION CONTOURING
              2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      NPPPH:    NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISRPPH: 1 TO WRITE FILE FOR RESIDUAL SURFACE ELEVATION CONTOURNG IN
                HORIZONTAL PLANE
      IPPHXY: 0 DOES NOT WRITE I,J,X,Y IN surfplt.out and rsurfplt.out FILES
              1 WRITES I,J ONLY IN surfplt.out and rsurfplt.out FILES
              2 WRITES I,J,X,Y  IN surfplt.out and rsurfplt.out FILES
              3 WRITES EFDC EXPLORER BINARY FORMAT FILES
C
C72 ISPPH  NPPPH  ISRPPH  IPPHXY
    0      1      0       3
------------------------------------------------------------------------------
```

Card image 72 controls output for contour plotting instantaneous and residual or averaged water surface elevation fields to files surfconh.out and rsurfconh.out. The control switches have similar definitions as those for Card image 47.

Card Image 73

```
------------------------------------------------------------------------------
C73 CONTROLS FOR HORIZONTAL PLANE VELOCITY VECTOR PLOTTING
C
      ISVPH:  1 TO WRITE FILE FOR VELOCITY PLOTTING IN HORIZONTAL PLANE
              2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      NPVPH:    NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISRVPH: 1 TO WRITE FILE FOR RESIDUAL VELOCITY PLOTTING IN
                HORIZONTAL PLANE
      IVPHXY: 0 DOES NOT WRITE I,J,X,Y IN velplth.out and rvelplth.out FILES
              1 WRITES I,J ONLY IN velplth.out and rvelplth.out FILES
              2 WRITES I,J,X,Y  IN velplth.out and rvelplth.out FILES
              3 WRITES EFDC EXPLORER BINARY FORMAT FILES
C
C73 ISVPH  NPVPH  ISRVPH  IVPHXY
    0      1      0       1
------------------------------------------------------------------------------
```

Card image 73 activates the creation of the output file velvech.out, containing instantaneous surface and bottom horizontal velocity vectors for ISVPH = 1, 2, or 3 at NPVPH times during the last reference time period for vector plotting. The switch ISRVPH = 1, 2, or 3 activates the creation of three files, xvelconh.out (where x is r, p, or m) containing surface and bottom layer residual velocity vectors corresponding to the Eulerian mean transport velocity (r prefix), the nondivergent component of the Stokes' drift (p prefix) and the first order Lagrangian mean or mean mass transport velocity (m prefix) for horizontal plane vector plotting. If ISSSMMT on Card image 4 is 0, residual fields are written for each averaging period in the model run, while a value of 1 results in writing the results of only the last averaging period. The choice of 1, 2, or 3 for ISVPH and ISRVPH writes all cell vectors, I+J is even vectors, or I+J is odd vectors. For grids with a large number of cells, the 2 or 3 options often result in less dense and more pleasing to the eye plots.

Card Image 74

```
------------------------------------------------------------------------------
C74 CONTROLS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
C
      ISECSPV:  N AN INTEGER NUMBER OF VERTICAL SECTIONS (N.LE.9) TO WRITE N
                  FILES FOR SCALAR FIELD CONTOURING
      NPSPV:      NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISSPV:    1 TO ACTIVATE INSTANTANEOUS SCALAR FIELDS
                2 TO WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      ISRSPV:   1 TO ACTIVATE FOR RESIDUAL SCALAR FIELDS
      ISHPLTV:  1 FOR VERTICAL PLANE PLOTTING FOR MSL DATUMS, ZERO; OTHERWISE
                  DATA LINE REPEATS 7 TIMES FOR SAL,TEM,DYE,SFL,TOX,SED,SND
      ISECSPV IS DETERMINED FOR ALL 7 VARIABLES BY VALUE ON FIRST DATA LINE
C
C74 ISECSPV  NPSPV  ISSPV  ISRSPV  ISHPLTV
    0        1      0      0       1          !SAL
    0        1      0      0       1          !TEM
    0        1      0      0       1          !DYE
    0        1      0      0       1          !SFL
    0        1      0      0       1          !TOX
    0        1      0      0       1          !SED
    0        1      0      0       1          !SND
------------------------------------------------------------------------------
```

Card image 74 activates output of information for vertical plane scalar field contouring for ISCESPV vertical sections or transects. The switch ISSPV activates output of instantaneous values NPSPV times during the last reference time period to the files xxxcnvN.out (xxx equals sal, tem, dye, sed, or sfl, and N represents the section number currently limited to a maximum of 9). The switch ISRSPV activates output of time-averaged or residual variables to similar r-prefixed files after each averaging period (ISSSMMT = 0) or only the last averaging period (ISSMMT = 1) with the time steps in the averaging period defined by NTSMMT on Card image

7. The last parameter configures the plotting information for tidal or other datums. Additional information is specified on Card images 75 and 76.

Card Image 75

```
-------------------------------------------------------------------------------
C75 MORE CONTROLS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
C
      ISECSPV:  SECTION NUMBER
      NIJSPV:   NUMBER OF CELLS OR I,J PAIRS IN SECTION
      SEC ID:   CHARACTER FORMAT SECTION TITLE
C
C75 ISECSPV NIJSPV  SEC ID
       1        14       'JR BRIDGE'
       2        10       'NN PT 45'
-------------------------------------------------------------------------------
```

Card image 75 provides information to define the vertical plane transects. A line of data is required for each vertical section. The maximum number of vertical sections is currently limited to 9. The first parameter identifies the section number, the second parameter specifies the number of cells comprising the section, and the last character string provides an identifier which is also written to the output files.

Card Image 76

```
-------------------------------------------------------------------------------
 C76 I,J LOCATIONS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
 C
       ISECSPV: SECTION NUMBER
       ISPV:    I CELL
       JSPV:    J CELL
 C
 C76 ISECSPV  ISPV  JSPV
     1        117   52
     1        118   53
     1        119   54
     1        120   55
     1        121   56
     1        122   57
     1        123   58
     1        124   59
     1        125   60
     1        126   61
     1        127   62
     1        128   63
     1        129   64
     1        130   65
     2        141   39
     2        142   40
     2        143   41
     2        144   42
     2        145   43
```

```
     2        146   44
     2        147   45
     2        148   46
     2        149   47
     2        150   48
------------------------------------------------------------------
```

Card image 76 defines the sequence of cells comprising the section, with the first parameter being for user identification. The other two parameters define the section sequenced by I and J cell indices. It is noted that cells in the sequence do not need to be adjacent, nor do they need to follow a straight line. For example, they may represent instrument locations, longitudinal moving survey locations, or interesting cross sections of the flow field or a typical longitudinal section up an estuary.

Card Image 77

```
------------------------------------------------------------------------------
C77 CONTROLS FOR VERTICAL PLANE VELOCITY VECTOR PLOTTING
C
      ISECVPV:  N AN INTEGER NUMBER (N.LE.9) OF VERTICAL SECTIONS
                  TO WRITE N FILES FOR VELOCITY PLOTTING
      NPVPV:      NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISVPV:    1 TO ACTIVATE INSTANTANEOUS VELOCITY
                2 TO WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      ISRSPV:   1 TO ACTIVATE FOR RESIDUAL VELOCITY
C
C77  ISECVPV  NPVPV  ISVPV  ISRSPV
    2        12     0     1
------------------------------------------------------------------------------
```

Card image 77 activates output of information three types of vector plotting in ISECVPV (currently limited to 9) vertical planes. The switch ISVPV activates output of instantaneous data at NPVPV times during the reference time period, while ISRSPV activates output of time averaged or residual data after each averaging period (ISSSMMT = 0), defined by NTSMMT on Card image 7, or the last averaging period (ISSSMMT = 1). The first class of output files provides data for plotting vectors tangential to the vertical plane. Instantaneous data are written to the files velvcvN.out, while residual data are written to the files rvelvcvN.out, pvelvcvN.out, mvelvcvN.out, lmvvcvN.out, and almvvcvN.out, where N indicates the second number. The last two files are written only if ISLRD is not zero. The second class of output files provides data for contour plotting the component of the horizontal velocity normal to the vertical planes. Instantaneous data are written to the files velcnvN.out, while residual data are written to the files rvelcnvN.out, pvelcnvN.out, mvelcnvN.out, lmvcnvN.out, and almvcnvN.out. The last two files are written only if ISLRD is not zero. The final class of output files provides data for contour plotting the component of the horizontal residual velocities tangential to the vertical plane.

Time-averaged or residual data are written to the files rvelcvtN.out, pvelcvtN.out, mvelcvtN.out, lmvcvtN.out, and almvcvtN.out, again with the last two files written to as ISLRD is not zero.

Card Image 78

```
------------------------------------------------------------------
C78 MORE CONTROLS FOR VERTICAL PLANE VELOCITY VECTOR PLOTTING
C
       ISCEVPV:  SECTION NUMBER
       NIJVPV:   NUMBER IS CELLS OR I,J PAIRS IN SECTION
       ANGVPV:   CCW POSITIVE ANGLE FROM EAST TO SECTION NORMAL
       SEC ID:   CHARACTER FORMAT SECTION TITLE
C
C78  ISECVPV   NIJVPV  ANGVPV   SEC ID
     1         14      -45.0    'JR BRIDGE'
     2         10      -45.0    'NN PT 45'
------------------------------------------------------------------
```

Card image 78 provides additional information to specify the vertical planes for plotting velocity vectors and contours, with the first parameter identifying the section number and the second parameter specifying the number of horizontal cells defining the section. The third parameter, ANGVPV defines the angle counterclockwise from east to the section normal. For meaningful results, the sequence of cells defining the vertical plane should approximate a straight line. For a section oriented at 45 degrees CC from east, the normal angle could be defined as 135 degrees or -45 degrees. For these two choices, the definitions of the positive normal and tangential directions are reversed. The remaining character parameter defines a title to be written on the output file headers.

Card Image 79

```
------------------------------------------------------------------
C79 CONTROLS FOR VERTICAL PLANE VELOCITY PLOTTING
C
       ISECVPV:  SECTION NUMBER (REFERENCE USE HERE)
       IVPV:     I CELL INDEX
       JVPV:     J CELL INDEX
C
C79   ISECVPV  IVPV  JVPV
      1        117   52
      1        118   53
      1        119   54
      1        120   55
      1        121   56
      1        122   57
      1        123   58
      1        124   59
      1        125   60
      1        126   61
```

```
      1        127   62
      1        128   63
      1        129   64
      1        130   65
      2        141   39
      2        142   40
      2        143   41
      2        144   42
      2        145   43
      2        146   44
      2        147   45
      2        148   46
      2        149   47
      2        150   48
-----------------------------------------------------------------
```

Card image 79 specifies the sequence of I and J indices defining the vertical plane sections.

Card Image 80

```
-------------------------------------------------------------------------------
C80 CONTROLS FOR 3D FIELD OUTPUT
C
   IS3DO:  1 TO WRITE TO 3D ASCI INTEGER FORMAT FILES, JS3DVAR.LE.2     SEE
           1 TO WRITE TO 3D ASCI FLOAT POINT FORMAT FILES, JS3DVAR.EQ.3 C57
           2 TO WRITE TO 3D CHARACTER ARRAY FORMAT FILES (NOT ACTIVE)
           3 TO WRITE TO 3D HDF IMAGE FORMAT FILES (NOT ACTIVE)
           4 TO WRITE TO 3D HDF FLOATING POINT FORMAT FILES (NOT ACTIVE)
   ISR3DO:   SAME AS IS3DO EXCEPT FOR RESIDUAL VARIABLES
   NP3DO:    NUMBER OF WRITES PER LAST REF TIME PERIOD FOR INST VARIABLES
   KPC:      NUMBER OF UNSTRETCHED PHYSICAL VERTICAL LAYERS
   NWGG:     IF NWGG IS GREATER THAN ZERO, NWGG DEFINES THE NUMBER OF
             WATER CELLS IN CARTESIAN 3D GRAPHICS GRID OVERLAY OF THE
             CURVILINEAR GRID.  FOR NWGG>0 AND EFDC RUNS ON A CURVILINEAR
             GRID, I3DMI,I3DMA,J3DMI,J3DMA REFER TO CELL INDICES ON THE
             ON THE CARTESIAN GRAPHICS GRID OVERLAY DEFINED BY FILE
             GCELL.INP.  THE FILE GCELL.INP IS NOT USED BY EFDC, BUT BY
             THE COMPANION GRID GENERATION CODE GEFDC.F.  INFORMATION
             DEFINING THE OVERLAY IS READ BY EFDC.F FROM THE FILE
             GCELLMP.INP. IF NWGG=0, I3DMI,I3DMA,J3DMI,J3DMA REFER
             TO INDICES ON THE EFDC GRID DEFINED BY CELL.INP.
             ACTIVATION OF THE REWRITE OPTION I3DRW=1 WRITES TO THE FULL
             GRID DEFINED BY CELL.INP AS IF CELL.INP DEFINES A CARTESIAN
             GRID.  IF NWGG=0 AND THE EFDC COMP GRID IS CO, THE REWRITE
             OPTION IS NOT RECOMMENDED AND A POST PROCESSOR SHOULD BE USED
             TO TRANSFER THE SHORT FORM, I3DRW=0, OUTPUT TO AN APPROPRIATE
             FORMAT FOR VISUALIZATION. CONTACT DEVELOPER FOR MORE DETAILS
   I3DMI:    MINIMUM OR BEGINNING I INDEX FOR 3D ARRAY OUTPUT
   I3DMA:    MAXIMUM OR ENDING I INDEX FOR 3D ARRAY OUTPUT
   J3DMI:    MINIMUM OR BEGINNING J INDEX FOR 3D ARRAY OUTPUT
   J3DMA:    MAXIMUM OR ENDING J INDEX FOR 3D ARRAY OUTPUT
   I3DRW:  0 FILES WRITTEN FOR ACTIVE CO WATER CELLS ONLY
           1 REWRITE FILES TO CORRECT ORIENTATION DEFINED BY GCELL.INP
             AND GCELLMP.INP FOR CO WITH NWGG.GT.O OR BY CELL.INP IF THE
             COMPUTATIONAL GRID IS CARTESIAN AND NWGG.EQ.0
   SELVMAX:  MAXIMUM SURFACE ELEVATION FOR UNSTRETCHING (ABOVE MAX SELV )
   BELVMIN:  MINIMUM BOTTOM ELEVATION FOR UNSTRETCHING (BELOW MIN BELV)
C
C80 IS3DO ISR3DO NP3DO KPC NWGG I3DMI I3DMA J3DMI J3DMA I3DRW SELVMAX BELVMIN
    0     0      0     1   0    1     42    1     118   0     15      -315
```

Card image 80 controls the output of three-dimensional data for graphics and visualization. The switches IS3D and ISR3D activate output of instantaneous data at NP3D times during the last reference time period and time averaged or residual data respectively. The residual data are output after each averaging period (ISSSMMT = 0), defined by NTSMMT on Card image 7, or only the last averaging period (ISSMMT = 1). However the current configuration allows only 24 averaged output files, and if the number of averaging periods for a run exceeds 24, only the last 24 periods are output. The only currently active option (IS3D=1 and ISR3D=1) writes output as eight bit ASCII integers (0 to 255). This choice was made for flexibility and the minimization of disk storage. A post processor is available via ftp to translate the 8 bit ASCII integer data to a number of alternate forms including 8 bit ASCII character data, 8 bit binary, and HDF image or floating point format for compatibility with various visualization software. Although the 8 bit three-dimensional integer array files may be very large, they can be efficiently compressed on most systems. On UNIX systems, the UNIX .Z compressed version of the output files may be up to a factor 10 times smaller.

The output format is a three-dimensional array which can be conceptualized as a stack of KPC layers, of equal thickness, which slice the model domain at constant elevation plane, progressing from above the maximum water surface elevation to below the minimum bottom elevation. Each layer (or plane) comprises a two-dimensional array with a true east-north alignment. The most rapid variation in the two-dimensional plane is from west to east analogous to the columns of a spread sheet. The sequence of columns is written from north to south analogous to the rows of a spread sheet. Thus if a layer of the 3 matrix is viewed in a spread sheet type form, it will have the proper geographic orientation. The KPC constant elevation slices are generated by constant elevation interpolation equivalent to an unstretching of the model's internal stretched or sigma coordinate system. The upper bounding elevation of the first layer is specified by elevation SELMX, which should be slightly larger than the maximum water surface elevation during the entire data sampling period. The lower bounding elevation of the last layer is specified by BELMN, which should correspond to an elevation slightly below the bottom of the deepest cell in the model domain. The values SELMX and BELMN shown in the example data line above are referenced to a sea level datum, hence the negative value of BELMN. For constant spacing Cartesian grids, the rectangular two-dimensional arrays or matrices corresponding to the constant elevation layers directly coincide with the model grid.

For curvilinear, or variable-spacing, Cartesian grids, a Cartesian graphics grid overlay, which can be generated by the preprocessor code GEFDC, and is input into EFDC by the file gcellmap.inp and is used to define the horizontal layers. The parameter NWGG defines the number of water cells in the Cartesian graphic grid. If NWGG is zero, the computation grid is assumed to be Cartesian, while a nonzero value indicates an overlay and activates the reading of the file gcellmap.inp. The input file gcellmap.inp includes information from interpolating the curvilinear grid data to the Cartesian graphic grid. The extent of the horizontal region over which three-dimensional data are to be extracted is defined by I3DMI<IG< I3DMA, and J3DMI<JG< J3DMA, where IG and JG are east and north indices in the Cartesian graphics grid overlay or the I and J indices of an equal spacing Cartesian computational grid. The parameter I3DRW allows the three-dimensional output to be written in a temporary compressed form. If I3DRW is set to 1, the output files are in the three-dimensional array structure described above. However, from many model applications to irregular regions, a large percent of the three-dimensional output matrix represents dry land. Setting I3DRW to zero results in output of information for active water cells in either the graphics overlay or computation grid. This output can later be expanded into the aforementioned fully three-dimensional format by a post processing utility, available via ftp.

Card Image 81

```
------------------------------------------------------------------------------
C81 OUTPUT ACTIVATION AND SCALES FOR 3D FIELD OUTPUT
C
   VARIABLE:     DUMMY VARIABLE ID (DO NOT CHANGE ORDER)
   IS3(VARID): 1 TO ACTIVATE THIS VARIABLES
   JS3(VARID): 0 FOR NO SCALING OF THIS VARIABLE
               1 FOR AUTO SCALING OF THIS VARIABLE OVER RANGE 0<VAL<255
                 AUTO SCALES FOR EACH FRAME OUTPUT IN FILES OUT3D.DIA AND
                 ROUT3D.DIA  OUTPUT IN I4 FORMAT
               2 FOR SCALING SPECIFIED IN NEXT TWO COLUMNS WITH OUTPUT
                 DEFINED OVER RANGE  0<VAL<255 AND WRITTEN IN I4 FORMAT
               3 FOR MULTIPLIER SCALING BY MAX SCALE VALUE WITH OUTPUT
                 WRITTEN IN F7.1 FORMAT (IS3DO AND ISR3DO MUST BE 1)
C
C81 VARIABLE IS3D JS3D SMAX  SMIN
    'U VEL'       0     0     0     0
    'V VEL'       0     0     0     0
    'W VEL'       0     0     0     0
    'SALINITY'    0     0     0     0
    'TEMP'        0     0     0     0
    'DYE'         0     0     0     0
    'COH SED'     0     0     0     0
    'NCH SED'     0     0     0     0
    'TOX CON'     0     0     0     0
------------------------------------------------------------------------------
```

Card image 81 controls the fields for three-dimensional data output. Current fields for output, corresponding to the data lines above include the true east and north horizontal velocity vectors, the physical vertical velocity vector, (as opposed to the internally used stretched coordinate vertical velocity), and the salinity, temperature, dye tracer and sediment concentration scalar fields. The switch IS3 activates the output of the particular variable, while the switch JS3 defines its conversion to 8 bit integer form. The option JS3 equals 2 which uses minimum and maximum values corresponding to 1 and 255 (recommended). Dry land positions in the three-dimensional array are by default set to 0. The output filenames corresponding to the data lines on card 57 are:

Output Variable	Instantaneous	Residual
U VEL	uuu3dNN.asc	ruuu3dNN.asc
V VEL	vvv3dNN.asc	rvvv3dNN.asc
W VEL	www3dNN.asc	rwww3dNN.asc
SALINITY	sal3dNN.asc	rsal3dNN.asc
TEMP	tem3dNN.asc	rtem3dNN.asc
DYE	dye3dNN.asc	rdye3dNN.asc
SEDIMENT	sed3dNN.asc	rsed3dNN.asc

where NN represents a two digit time sequence identified between 1 and 24. Two additional files, out3d.dia and rout3d.dia, provide summary information including the actual minimum and maximum values of each variable for the output files.

Card Image 82

```
--------------------------------------------------------------------------------
C82 INPLACE HARMONIC ANALYSIS PARAMETERS
C
   ISLSHA:  1 FOR IN PLACE LEAST SQUARES HARMONIC ANALYSIS
   MLLSHA:  NUMBER OF LOCATIONS FOR LSHA
   NTCLSHA: LENGTH OF LSHA IN INTEGER NUMBER OF REFERENCE TIME PERIODS
   ISLSTR:  1 FOR TREND REMOVAL
   ISHTA :  1 FOR SINGLE TREF PERIOD SURFACE ELEVATION ANALYSIS
C
C82 ISLSHA MLLSHA NTCLSHA ISLSTR ISHTA
    0      0      0       0      0
--------------------------------------------------------------------------------
```

Card Image 83

```
------------------------------------------------------------------------------
C83 HARMONIC ANALYSIS LOCATIONS AND SWITCHES
C
   ILLSHA:   I CELL INDEX
   JLLSHA:   J CELL INDEX
   LSHAP:  1 FOR ANALYSIS OF SURFACE ELEVATION
   LSHAB:  1 FOR ANALYSIS OF SALINITY
   LSHAUE: 1 FOR ANALYSIS OF EXTERNAL MODE HORIZONTAL VELOCITY
   LSHAU:  1 FOR ANALYSIS OF HORIZONTAL VELOCITY IN EVERY LAYER
   CLSL:     LOCATION AS A CHARACTER VARIABLE
C
C83 ILLSHA JLLSHA LSHAP LSHAB LSHAUE LSHAU CLSL
------------------------------------------------------------------------------
```

Card Image 84

```
------------------------------------------------------------------------------
C84 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ISTMSR:  1 OR 2 TO WRITE TIME SERIES OF SURFACE ELEVATION, VELOCITY, NET
            INTERNAL AND EXTERNAL MODE VOLUME SOURCE-SINKS, AND
            CONCENTRATION VARIABLES; VALUE OF 2 APPENDS EXISTING TIME SERIES FILES
   MLTMSR:  NUMBER OF HORIZONTAL LOCATIONS TO WRITE TIME SERIES OF SURFACE ELEVATION,
            VELOCITY, AND CONCENTRATION VARIABLES
   NBTMSR:  TIME STEP TO BEGIN WRITING TO TIME SERIES FILES (Inactive)
   NSTMSR:  TIME STEP TO STOP WRITING TO TIME SERIES FILES (Inactive)
   NWTMSR:  NUMBER OF TIME STEPS TO SKIP BETWEEN OUTPUT
   NTSSTSP: NUMBER OF TIME SERIES START-STOP SCENARIOS, 1 OR GREATER
   TCTMSR:  UNIT CONVERSION FOR TIME SERIES TIME. FOR SECONDS, MINUTES,
            HOURS, DAYS USE 1.0, 60.0, 3600.0, 86400.0, RESPECTIVELY
     IDUM:  2 DUMMY INTEGER VARIABLES REQUIRED, BOTH = 0
C
C84 ISTMSR MLTMSR NBTMSR NSTMSR   NWTMSR NTSSTSP TCTMSR IDUM IDUM
    1      15     1      99000000 40000  1       86400
------------------------------------------------------------------------------
```

Card Image 85

```
------------------------------------------------------------------------------
C85 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ITSSS:   START-STOP SCENARIO NUMBER 1.GE.ISSS.LE.NTSSTSP
   MTSSTSP: NUMBER OF STOP-START PAIRS FOR SCENARIO ISSS
C
C85 ITSSS MTSSTSP
    1     1
------------------------------------------------------------------------------
```

Card Image 86

```
------------------------------------------------------------------------------
C86 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ITSSS:  START-STOP SCENARIO NUMBER 1.GE.ISSS.LE.NTSSTSP
   MTSSS:  NUMBER OF STOP-START PAIRS FOR SCENARIO ISSS
   TSSTRT: STARTING TIME FOR SCENARIO ITSSS, SAVE INTERVAL MTSSS
   TSSTOP: STOPPING TIME FOR SCENARIO ITSSS, SAVE INTERVAL MTSSS
C
C86 ISSS MTSSS TSSTRT TSSTOP COMMENT
    1    1     -1000  10000
------------------------------------------------------------------------------
```

Card image 84 activates and controls the writing of time series files. The parameter ISTMSR = 1 activates the creation of new time series files, while ISTMSR = 2 writes to the end of existing time series files and is useful in certain cases where the model is restarted to continue a long simulation. Instantaneous data for various model variables may be output at MLTMSR locations (the current limit is 99 locations). The parameters NBTMSR and NSTMSR specify the beginning and ending time steps of a time interval where data are output at every NWTMSR time steps. The conversion factor TCTMSR specifies the time units for the time column in the time series output files.

Card Image 87

```
------------------------------------------------------------------------------
C87 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ILTS:    I CELL INDEX
   JLTS:    J CELL INDEX
   NTSSSS:  WRITE SCENARIO FOR THIS LOCATION
   MTSP:  1 FOR TIME SERIES OF SURFACE ELEVATION
   MTSC:  1 FOR TIME SERIES OF TRANSPORTED CONCENTRATION VARIABLES
   MTSA:  1 FOR TIME SERIES OF EDDY VISCOSITY AND DIFFUSIVITY
   MTSUE: 1 FOR TIME SERIES OF EXTERNAL MODE HORIZONTAL VELOCITY
   MTSUT: 1 FOR TIME SERIES OF EXTERNAL MODE HORIZONTAL TRANSPORT
   MTSU:  1 FOR TIME SERIES OF HORIZONTAL VELOCITY IN EVERY LAYER
   MTSQE: 1 FOR TIME SERIES OF NET EXTERNAL MODE VOLUME SOURCE/SINK
   MTSQ:  1 FOR TIME SERIES OF NET EXTERNAL MODE VOLUME SOURCE/SINK
   CLTS:    LOCATION AS A CHARACTER VARIABLE
C
C87 ILTS JLTS NTSSSS MTSP MTSC MTSA MTSUE MTSUT MTSU MTSQE MTSQ CLTS
    10   305  1      1    1    0    1     1     0    1     0    'Pomeroy Ave'    1
     8   305  1      1    1    0    1     1     0    1     0    'West Br'        2
    34   260  1      1    1    0    1     1     0    1     0    'qser3'          3
    24   155  1      1    1    0    1     1     0    0     0    'New Lenox'      4
------------------------------------------------------------------------------
```

Card image 87 specifies the I and J indices of horizontal locations for writing time series data and the class of data. The generic file names created by the activation of the output switches are:

Switch	File Name
MTSP	seltmsrNN.out
MTSC	saltmsrNN.out temtmsrNN.out dyetmsrNN.out sedtmsrNN.out sfltmsrNN.out
MTSA	avvtmsrNN.out avbtmsrNN.out
MTSUE	uvetmsrNN.out
MTSUT	uvttmsrNN.out
MTSU	u3dtmsrNN.out v3dtmsrNN.out
MTSQE	qqetmsrNN.out
MTSQ	q3dtmsrNN.out

with NN, between 01 and 99, indicating the location. The last column provides a character string identifier for the location, which is written to the output file header.

Card Image 88

```
------------------------------------------------------------------
C88 CONTROLS FOR EXTRACTING INSTANTANEOUS VERT SCALAR FIELD PROFILES
C
      ISVSFP: 1 FOR EXTRACTING INSTANTANEOUS VERTICAL FIELD PROFILES
      MDVSFP:   MAXIMUM NUMBER OF DEPTHS FOR SAMPLING VALUES
      MLVSFP:   NUMBER OF HORIZONTAL SPACE-TIME LOCATION PAIRS TO BE
                SAMPLED
      TMVSFP:   MULTIPLIER TO CONVERT SAMPLING TIMES TO SECONDS
      TAVSFP:   ADDITIVE ADJUSTMENT TO SAMPLING TIME BEFORE
                CONVERSION TO SEC
C
```

```
C60 ISVSFP  MDVSFP  MLVSFP  TMVSFP  TAVSFP
    1       8       10      3600.   0.0
-----------------------------------------------------------------
```

Card image 88 provides for the extraction of instantaneous vertical scalar field profiles at specified times an locations. This option is designed to mimic field sampling surveys and produce a smaller volume of output data than the time series output option. The switch ISVSFP = 1 activates the option. The parameter MDVSFP specifies the maximum number of depths (measured downward from the instantaneous free surface for sampling, while MLVSFP specifies the number of discrete time and space locations for sampling. The parameter TMVSFP converts the sampling times specified on Card image 62 to seconds. The time origin for specifying sampling should be consistent with information specified on Card image 8. The parameter TAVSFP is an additive adjustment to the sampling times on Card image 63, and is useful for dealing with sampling times recorded during daylight savings conditions. Output for this option is written to the file vsfp.out.

Card Image 89

```
-----------------------------------------------------------------
C61 SAMPLING DEPTHS FOR EXTRACTING INST VERT SCALAR FIELD PROFILES
C
      MMDVSFP:  Mth SAMPLING DEPTH
      DMSFP:    SAMPLING DEPTH BELOW SURFACE, IN METERS
C
C61 MMDVSFP  DMVSFP
      1       1.0
      2       3.0
      3       5.0
      4       7.0
      5       9.0
      6      11.0
      7      13.0
      8      15.0
-----------------------------------------------------------------
```

Card image 89 specifies the MDVSFP sampling depths below the water surface at the specified times and locations. If the local depth to the bottom is less than a sample depth, output data are not written for that depth.

Card Image 90

```
------------------------------------------------------------------
C62 HORIZONTAL SPACE-TIME LOCATIONS FOR SAMPLING
C
      MMLVSFP:  Mth SPACE TIME SAMPLING LOCATION
      TIMVSFP:  MAXIMUM NUMBER OF DEPTHS FOR SAMPLING VALUES
      IVSFP:    I HORIZONTAL LOCATION INDEX
      JVSFP:    J HORIZONTAL LOCATION INDEX
C
C62 MMLVSFP  TIMVSFP  IVSFP  JVSFP
      1      3221.60   151     42
      2      3222.00   140     46
      3      3222.40   124     59
      4      3222.60   102     72
      5      3223.00    94     86
      6      3223.30    87    102
      7      3221.60    88    117
      8      3223.90    70    112
      9      3224.10    54    120
     10      3224.50    37    121
------------------------------------------------------------------
```

Card image 90 specifies the times and I and J cell indices for sampling.

Card Image 91

```
-------------------------------------------------------------------------------
C91 Reference settling velocity and concentration above which concentration
C   enhanced occurs and below which constant settling velocity
C   ISHOUSATONIC=1 ONLY
C
     SED_CRIT
        CONSTWS1
        CONSTWS2
C
C   SED_CRIT  CONSTWS1  CONSTWS2
    5.0       0.100     30.0
-------------------------------------------------------------------------------
```

Card Image 92

```
-------------------------------------------------------------------------------
C92 MAINTAIN minimum TSS in SELECTED cells
C   ISHOUSATONIC=1 ONLY
C
       LABKWTR
       SED_MIN
C
    LABKWTR  SED_MIN
    939      1.0
-------------------------------------------------------------------------------
```

Card Image 93

```
-------------------------------------------------------------------------------
C93 Spatially varying coefficient and exponent for cohesive erosion function
C   ISHOUSATONIC=1 ONLY
C
       COEFF_US
       EXPO_US
       COEFF_DS
       EXPO_DSC
C      Reach 5A and 5B      Reach 5C, 5D and 6
C      COEFF_US  EXPO_US  COEFF_DS  EXPO_DS
       6.98      1.59     9.88      0.949
-------------------------------------------------------------------------------
```

Card Image 94

```
-------------------------------------------------------------------------------
C94 Spatially varying foodchain exposure depths
C   ISHOUSATONIC=1 ONLY
C
       FCMHBDUS
       FCMHBDDS
       FCMHBDWP
C     Reach 5A      Reach 5B,5C,5D and 6
C     FCMHBDUS  FCMHBDDS  FCMHBDWP
      0.04      0.07      0.1524
-------------------------------------------------------------------------------
```

5. Additional Hydrodynamic and Transport Input Files

This chapter describes additional input files required to run the hydrodynamic and transport components of the EFDC model. File specific to the water quality and eutrophication component are described in the next chapter. Before describing the various files, it is useful to re- summarize them, noting the conditions and model options under which the model will need the file to execute.

File Name	Comments
aser.inp	Required for all model runs
cell.inp	Required for all model runs
celllt.inp	Required for all model runs
depth.inp	Required if ISCLO = 0 on Card image 9 of file efdc.inp
dser.inp	Required if NDSER .GE.1 on Card image 30 of file efdc.inp
dxdy.inp	Required if ISCLO = 1 or if ISCLO = 0 and LC-LVC GT.2 on Card image 9 of file efdc.inp
dye.inp	Required if ISTOPT = 1 on line 4, Card image 9 of file efdc.inp
efdc.inp	Required for all model runs
efdc.wsp	Required if ISWASP .GE.1 on Card image 5 of file efdc.inp
fldang.inp	Required if ISSFLFE = 1 on file sfbser.inp
gcellmap.inp	Not Required if ISCLO = 0 on Card image 9 OR if NWGG = 0 on Card image 80 of file efdc.inp

gwater.inp	Required for all model runs
lxly.inp	Required if ISCLO = 1 or if ISCLO = 0 and LC-LVC GT.2 on Card image 9 of file efdc.inp
mappns.inp	Required if ISPGNS = 1 on Card image 9 of file efdc.inp
mask.inp	Required if ISMASK = 1 on Card image 9 of file efdc.inp
modchan.inp	Required if ISCHAN = 1 on Card image 14 of file efdc.inp
moddxdy.inp	Required if IMD = 1 on Card image 11 of file efdc.inp
pser.inp	Required if NPSER .GE.1 on Card image 17 of file efdc.inp
qctl.inp	Required if NQCTL .GE.1 on Card image 23 of file efdc.inp
qser.inp	Required if NQSER .GE.1 on Card image 23 of file efdc.inp
restart.inp	Required if ISRESTI =1 on Card image 2 of file efdc.inp
restran.inp	Required if ISLTMT = 1 on Card image 4 of file efdc.inp
salt.inp	Required if ISTOPT = 1 on line 2, Card image 6 of file efdc.inp
sdser.inp	Required if NSDSER .GE.1 on Card image 22 of file efdc.inp
show.inp	Required if ISHOW = 1 on Card image 2 of file efdc.inp
sser.inp	Required if NSSER .GE.1 on Card image 22 of file efdc.inp
sfser.inp	Required if NSFSER .GE.1 on Card image 22 of file efdc.inp

sfbser.inp	Required if ISTRAN .EQ. 1 on data line 6, Card image 6 of file efdc.inp
tser.inp	Required if NTSER .GE.1 on Card image 22 of file efdc.inp
vege.inp	Required if ISVEG .GE.1 on Card image 5 of file efdc.inp
wave.inp	Required if ISWAVE .GE.1 on Card image 14 of file efdc.inp

The files cell.inp, celllt.inp, dxdy.inp and lxly.inp have been discussed and illustrated in Chapter 2, and reference is made to that chapter. The field depth.inp was used in early versions of the model and its functions has been superseded by the dxdy.inp; therefore it will not be discussed. Examples of the remaining input files will now be presented and discussed in alphabetical order.

5.1 Input file aser.inp

The input file aser.inp specifies atmospheric, wind and thermal forcings as well as precipitation and evapotranspiration. For ISTOPT = 1 on line 3 of Card image 6, the full set of environmental parameters for an internal-to-the-model calculation of thermal sources and sinks is specified in the file. An example of the aser.inp file for this case is:

```
C aser.inp file, in free format across line, repeats naser=1 times
C
C  MASER   TCASER   TAASER   WINDSCT  RAINCVT  EVAPCVT
C
C TASER   WINDS   WINDD   PATM    TDRY   TWET   RAIN      EVAP   SOLSWR
C
   4       86400.   0.0      1.0      1.0      1.0
  73.46   4.13    161.   1000.    25.    20.   .28E-08   .29E-07   500.
  73.50   3.96    148.   1000.    25.    20.   .00E+00   .29E-07   500.
  73.54   4.25    144.   1000.    25.    20.   .56E-08   .29E-07   500.
  73.58   3.82    132.   1000.    25.    20.   .17E-07   .29E-07   500.
```

Parameters on the first data line specify the number of time points (MASER), a factor to convert the time units to seconds (TCASER), a constant time to be added before unit conversion (TAASER), a factor to convert wind speed to meters/second (WINDSCT), and factors to convert rainfall and evapotranspiration rates to meters per second (RAINCVT, EVAPCVT). Each line of time series data after the first data line contains (in order): time (TASER), wind speed (WINDS), wind direction (WINDD) in bearing angle to the direction the wind is blowing (oceanographic as

opposed to meteorological convention), atmospheric pressure (PATM) in millibars, dry and wet bulb temperature (TDRY, TWET) in degrees C, rainfall rate (RAIN), evapotranspiration rate (EVAP) and incident solar short-wave radiation (SOLSWR) in Joules per seconds per square meter. For ISTOPT = 2 on line 3 of Card image 6, a time variable equilibrium temperature surface heat exchange formulation is implemented in the model. The form of the aser.inp file for this case is identical to that above, except that now the equilibrium temperature (degrees C) is entered under the TDRY column and the net surface heat exchange coefficient in square meters per second is entered under the SOLSWR column. Data entered under PATM and TWET are not used for this case. For ISTOPT = 3 on line 3 of Card image 6, a time-invariant equilibrium temperature surface heat exchange formulation is implemented with a constant equilibrium temperature and heat exchange coefficient provided on Card image 46 of the file efdc.inp. In this case, wind speed and direction data and rainfall and evapotranspiration data form the aser.inp file used by the model. If no atmospheric forcings are used to drive the model, a null aser.inp file should be provided of the form:

```
C aser.inp file, in free format across line, repeats naser=1 times
C
C  MASER   TCASER   TAASER   WINDSCT  RAINCVT  EVAPCVT
C
C TASER   WINDS   WINDD   PATM    TDRY   TWET   RAIN      EVAP   SOLSWR
C
   2       86400.   0.0      1.0      1.0      1.0
 -1.E+6   0.      0.      0.      0.     0.     0.        0.     0.
  1.E+6   0.      0.      0.      0.     0.     0.        0.     0.
```

5.2 Input files dser.inp, sser.inp, sdser.inp, sfser.inp, and tser.inp

The scalar constituent time series files have identical formats, and thus it suffices to discuss them in a generic sense. An example of the sser.inp time series file containing one time series is shown below.

```
C  sser.inp file, salt is nc=1 conc, in free format across line,
C  repeats ncser(1) times, test case
C
C ISTYP MCSER(NS,1) TCCSER(NS,1) TACSER(NS,1) RMULADJ(NS,1) ADDADJ(NS,1)
C
C if istyp.eq.1 then read depth weights and single value of CSER
C
C (WKQ(K),K=1,KC)
C
C TCSER(M,NS,1) CSER(M,NS,1) !(mcser(ns,1) sets ns=1,ncser(1) series)
C
```

```
C  else read a value of qser for each layer
C
C  TCSER(M,NS,1)   (CSER(M,K,NS,1),K=1,KC) !(mcser(ns,1) pairs)
C
  0      7        86400.       0.0         1.0            0.0
  35.791668   29.57  29.57  29.57  29.57  29.57  29.57  29.57  29.57
  35.833336   29.93  29.93  29.93  29.93  29.93  29.93  29.93  29.93
  35.875000   29.88  29.88  29.88  29.88  29.88  29.88  29.88  29.88
  35.916668   30.89  30.89  30.89  30.89  30.89  30.89  30.89  30.89
  35.958336   31.24  31.24  31.24  31.24  31.24  31.24  31.24  31.24
  36.000000   31.12  31.12  31.12  31.12  31.12  31.12  31.12  31.12
  36.041668   31.28  31.28  31.28  31.28  31.28  31.28  31.28  31.28
```

A concentration time series input file may contain multiple time series. Each time series set begins with the single data line specifying ISTYP (the time series format identifier), MCSER (the number of time data points), TCCSER (a multiplying conversion factor changing the input time units to seconds), TACSER (an additive time adjustment, applied before unit conversion), RMULADJ (a multiplying conversion for the concentration), and ADDADJ (an additive conversion for concentration, applied before the multiplier). If the ISTYP parameter is 0, the MCSER time data points must have a concentration value for each layer. If ISTYP is 1, an additional line of data providing interpolating factors is read, and the time data lines should have only one concentration value. An example of an ISTYP=1 dser.inp file is shown below:

```
C  dser.inp file, dye is nc=3 conc, in free format across line,
C  repeats ncser(3) times, test case
C
C ISTYP MCSER(NS,3) TCCSER(NS,3) TACSER(NS,3) RMULADJ(NS,3) ADDADJ(NS,3)
C
C if istyp.eq.1 then read depth weights and single value of CSER
C
C (WKQ(K),K=1,KC)
C
C TCSER(M,NS,3) CSER(M,NS,3) !(mcser(ns,3) sets ns=3,ncser(3) serseries)
C
C  else read a value of dser for each layer
C
C  TCSER(M,NS,3)   (CSER(M,K,NS,3),K=1,KC) !(mcser(ns,3) pairs)
C
   1    10     3600.0     0.     1.    0.
    0.0     0.00   0.00   0.00   0.00   1.00
-2000.0000         0.00
  713.39           0.00
  713.41         2263374.5
  726.89         2263374.5
  726.91           0.00
 7076.49           0.00
 7076.51         2657004.85
 7087.99         2657004.85
```

```
 7088.01          0.00
 10000.00         0.00
```

This example specifies 6 weights (for a 6 layer model) on the second data line, which is read when ISTYP=1. The weights are read from the bottom to the top layer. For the example shown above, the dye is being released into the surface layer. (see the qser.inp file for the corresponding dye release flow rate formulation).

5.3 Input files dye.inp, salt.inp, and temp.inp

The input files dye.inp and salt.inp are used to initialize the dye and salinity fields for cold start runs if an appropriate ISTOPT switch is set on Card image 6 of the efdc.inp file. An example of a portion of the salt.inp field is shown below.

```
C salt.inp file, in free format across line, for IRLTC Final Grid
C first data line ISALTYP =0 no L,I,J  =1 read L,I,J
C L=2,LA rows of SALINIT(L,K),K=1,KC across columns
C
    1
    1   40    2   30.62  30.62  30.62  30.62  30.62  30.62  30.62  30.62
    2   41    2   30.62  30.62  30.62  30.62  30.62  30.62  30.62  30.62
    3   42    2   30.62  30.62  30.62  30.62  30.62  30.62  30.62  30.62
    4   43    2   30.62  30.62  30.62  30.62  30.62  30.62  30.62  30.62
    5   40    3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
    6   41    3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
    7   42    3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
    8   43    3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
```

The file has four header lines, followed by a line specifying the format type switch, ISALTYP. If ISALTYP is equal to 1, LC-2 data lines follow in the order L=2,LA, which is the single index sequence of active water cells. For ISALTYP=1, the first three columns give L (the single horizontal internal cell index), and I and J (the two external indices). These are then followed by KC (the number of model layers) values of salinity read from the bottom to the surface. For ISALTYP=0, the L, I, and J indices are absent from the data lines. A template for the salt.inp file, of ISALTYP=1 form, is generated by GEFDC. However, the four header lines and ISALTYP=1 must be manually added. The ISALTYP=0 format is carried over from older versions of the model. To allow conversion from older versions, the EFDC model outputs a file, newsalt.inp, of the ISALTYP=1 form.

5.4 Input file efdc.wsp

The file efdc.wsp provides data for controlling the linkage of EFDC and the WASPS series of water quality models (Ambrose *et al*., 1993) writing WASP format input files specifying cell volumes, flow and diffusion linkages and flow files in either generic or DYNHYD format. An example of the efdc.wsp input file is shown below.

```
C1    CELL VOLUME PARAMETERS for WASP-EFDC Linkage
C1    IVOPT IBDEV SCALV CONVV VMULT VEXP DMULT DEXP
      2     0     1.0   1.0   1.0   0.   1.0   0.
C2    DIFFUSION AND DISPERSION PARAMETERS
C2    NRFLD SCALR CONVR ISNKH
      2     1.0   1.0   1
C3    ADVECTION PARAMETERS (iqopt=3 ASCII HYD, =4 for binary HYD file)
C3    IQOPT NFIELD SCALQ CONVQ  HYDFIL           ISWASPD   ISDHD
      3     5      1.0   1.0    'NORWALK.HYD'     0         0
C4    DEPTH OF SEDIMENT LAYER (METERS)
C4    DEPSED  TDINTS   SEDIFF         WSS1       WSS2       WSS3
      0.1     366      2.315E-09      0.05       0.10       0.15
```

The parameters on Card images 1 and 2 are identical to those defined in the WASP user's manuals. Card images 3 and 4 provide information for the flow and diffusive transport fields and the sediment submodel. EFDC users considering activating the WASP linkage option should contact the author for further information and guidance.

5.5 Input file fldang.inp

The file fldang.inp is used to specify the direction of tidal flood flow and is used in shellfish larvae transport simulations (see file sfbser.inp) to cue larvae swimming behavior. It is a headerless file with LC-2 lines of data. The first few lines of an example are shown below.

```
  98    3    131.46    133.67
  99    3    166.15    165.82
 100    3    173.50    175.51
 101    3    210.48    211.48
  96    4    148.08    144.86
  97    4    166.50    161.98
  98    4    149.75    145.43
  99    4    169.05    167.36
```

The data on each line correspond to the I and J horizontal cell indices, followed by a bottom and surface layer flood direction angle. The angles, measured counter clockwise (CCW) from east

specify the maximum tidal flood flow direction determined by an analysis of bottom and surface layer tidal velocity ellipses for a single dominant tidal constituent (usually M2 on the U. S. east coast). Tidal ellipse directions are obtained from the output files tidelkb.out and tidelkc.out generated by a preliminary model run. Contact the author for software to generate the fldang.inp file from the tidelkb.out and tidelkc.out files.

5.6 Input file gcellmap.inp

The input file gcellmap.inp is read if NWGG on Card image 80 of the efdc.inp file is greater than zero. The gcellmap.inp file specifies a square cell Cartesian graphic grid overlay of a horizontal curvilinear grid. The file is used in the generation of three-dimensional graphics and visualization output in 3D array form. The file is optionally generated by GEFDC (also see efdc.inp file, Card image 80 description). The file has four header lines, followed by a single data line specifying IG and JG, the number of I and J cells in the Cartesian graphics grid. This line is then followed by NWGG lines of data specifying the water cell indices IGRAPHIC and JGRAPHIC, in the graphics grid and the corresponding indices ICOMP and JCOMP in the curvilinear computational grid. An example of a portion of the gcellmap.inp file is shown below.

```
C gcellmap.inp file, in free format across columns
C
C IGRAPHIC  JGRAPHIC     ICOMP     JCOMP
C
         50         92
         40          3        16         2
         41          3        17         2
         39          4        16         2
         40          4        16         2
         41          4        17         2
         42          4        18         2
         43          4        19         2
```

5.7 Input file gwater.inp

A simple soil moisture model (Hamrick and Moustafa, 1995a) is activated by the input file gwater.inp, shown below.

```
C gwater.inp file, in free format across columns
C   ISGWIE
C     gt.1 for on
C   DAGWZ       RNPOR         RIFTRM
C dep act gw  eff porosity  max infilt rate
```

```
C
    1
    0.4          0.3           0.0001
```

The soil moisture model is generally implemented for wetland simulations (Moustafa and Hamrick, 1995). The switch ISGWIE activates a simple soil moisture mass balance, which does not include horizontal flow. The soil moisture mass balance is calculated in an active zone which extends to a depth DAGWZ (in meters) below the bottom of each horizontal cell. The maximum available soil water, in volume of soil water per unit total volume is specified by the effective porosity, RNPOR, which is the physical porosity reduced by a factor accounting for capillary retention under unsaturated conditions. If the overlying water cell is wet, and the soil moisture is less than its maximum available value, infiltration occurs at a maximum rate RIFTRM (in meters per second). If the overlying water cell is dry, and soil moisture is available, the soil moisture is reduced at each time step by evapotranspiration. For a cold start run, the soil moisture is set to its maximum available value below wet cells. Below dry cells, an initial value is set using the mean of the water surface elevation in the wet cells of the simulated region.

5.8 Input file mappgns.inp

The input file mappgns.inp is used to configure the EFDC model for the simulations of regions presumed to be periodic or infinite in the computational y or north-south direction, the prime example being an infinite continental shelf or nearshore region, or the same region under the assumption of spatially periodic forcing. An example of a portion of the file is shown below.

```
C  ISPNS,JSPNS =  I,J INDICES OF A SOUTH CELL
C  INPNS,JNPNS =  I,J INDICES OF A CORRESPONDING NORTH CELL
C   NPNSBP
C   ISPNS    JSPNS   INPNS    JNPNS  (REPEATED NPNSBP TIMES)
C
    4
       2        2       2       126
       3        2       3       126
       4        2       4       126
       5        2       5       126
```

The parameter NPNSBP specifies the number of north-south pairs. This is followed by NPNSBP pairs of south and north I and J indices. North and south open boundary conditions must not be specified for these cell pairs in the efdc.inp files.

5.9 Input file mask.inp

The file mask.inp is used to insert thin barriers, which block flow across specified cell faces. This option is useful to simulate structural obstacles such as breakwaters and causeways locally aligning with the model grid, but have widths much less than the cell size or grid spacing in one direction. An example of the mask.inp file is shown below.

```
C  mask.inp file, in free format across line, MMASK LINES
C
C  MMASK
C
C  I      J      MTYPE
C
    3
   53      5     1  ! Block flow across west ( u face )
   38     28     2  ! Block flow across south ( v face )
   36     56     3  ! Block flow across all four cell faces
```

The parameter MMASK identifies the number of data lines. Each data line consists of the I and J indices of the cell to be masked, while the parameter MTYPE identifies the face to be blocked. The mask option can be activated on both cold starts and restarts (with no previous masking).

5.10 Input file modchan.inp

The input file modchan.inp is used to activate and specify data for a subgrid scale channel model. The subgrid scale channel model (Hamrick and Moustafa, 1995a,b; Moustafa and Hamrick, 1995) allows narrow, one-dimensional in the horizontal plane, channels to pass through larger scale, two-dimensional in the horizontal, cells, referred to as host cells. Up to two subgrid channels at arbitrary orientations may pass through a host cell. The two channels are referred to as u and v channel (the u and v notation is arbitrary and does not define the alignment of the subgrid channels in an arbitrary direction). The subgrid scale channels interact with the host cells through an exchange flow. If the host cell is wet, the exchange flows are determined such that the water surface elevations in the host cell and the channel cells are identical. If the host cell becomes dry, flow is allowed to continue in the subgrid scale channels. An example of the modchan.inp file is shown below for 4 channel sections passing through 4 host cells.

```
C modchan.inp file, in free format across columns
C # host cells  MDCHHD=1 wet host from chan  MDCHHD2=1 dry ck first
C MDCHH         MDCHHD             MDCHHD2
C max iters     MDCHHQ=1 int Q=0   QCHERR= abs error for flow cms
```

```
C MDCITM        MDCHHQ              QCHERR
C type      i host   j host   i uchan   j uchan   i vchan   j vchan
C MDCHTYP   IMDCHH   JMDCHH   IMDCHU    JMDCHU    IMDCHV    JMDCHH
C
      4           1                    1
     40           2                    0.001
      1       2       4       6       31        1       1
      1       3       4       7       31        1       1
      1       4       4       8       31        1       1
      1       5       4       9       31        1       1
```

The parameter MDCHH specifies the number of host cells, MDCHHD switches on wetting of a dry host cell when the water surface elevation in the channel exceeds the bottom elevation in the host. MDCHHD2 specifies a drying iteration before the solution for the exchange flows. The maximum number of iterations allowed in the solution for the exchange flows is specified by MDCITM. MDCHHQ = 0 initializes the iterative exchange flow with its value at the previous time step, while MDCHHQ =1 initializes the iteration with zero values for the exchange flows. QCHERR is the convergence criteria for determining the exchange flows. The two lines of control parameters are followed by MDCHH lines of data defining the host cell and subgrid channel linkage mapping. The first parameter MDCHTYP equals 1, 2, or 3 for a single u orientation channel, a single v orientation channel, or two channels. IMDCHH and JMDCHH are the I and J indices of the host cell. IMDCHU and JMDCHU are the I and J indices of the u type channel. IMDCHV and JMDCHV are the I and J indices of the v type channel. For MDCHTYP equals 1 or 2, the indices 1,1 specified either null u or v type channels. The flow example data lines show a set of host cells running for I equals 2 to 5 at a constant J of 4. These cells host a u type channel running from I equal 6 to 9 at a constant J equal to 31. The u type subgrid channels are generally located along a constant J index line in the computational grid, while the v type channels are located along a constant I index line in the computation grid.

5.11 Input file moddxdy.inp

The file moddxdy.inp allows for quick modification of cell sizes, specified as dx and dy in the dxdy.inp file. Its primary use is for the quick adjustment of subgrid channel sections lengths and widths. The example below is self-explanatory.

```
C moddxdy.inp file, in free format across columns
C  NMDXDY = # of cells for DX(I,J)=RMDX*DX(I,J) & DY(I,J)=RMDX*DX(I,J)
C    I     J      RMDX       RMDY
C
     4
```

```
     6    31      1.0       2.5
     7    31      1.0       2.5
     8    31      1.0       2.5
     9    31      1.0       2.5
```

5.12 Input file pser.inp

The input file pser.inp is used to specify surface elevation time series primarily for use at open boundaries. The file may contain multiple time series, each having a single control and conversion data line followed by a sequence of MPSER time data lines. An example is shown below.

```
C  pser.inp file, in free format across line, repeats npser times
C
C  MPSER(NS)   TCPSER(NS)   TAPSER(NS)   RMULADJ(NS)     ADDADJ(NS)
C
C  TPSER(M,NS)  PSER(M,NS)   !(mpser(ns) pairs for ns=1,npser series)
C
    4          86400.       0.           1.0              0.0
    265.00      4.90
    270.00      4.90
    273.00      4.90
    275.00      2.06
```

The parameter MPSER specifies the number of time data lines. TCPSER and TAPSER provide for adjustment and conversion of the time data units to seconds. RMULADJ and ADDADJ provide for conversion and adjustment of the elevation data to meters.

5.13 Input file qctl.inp

The input file qctl.inp specifies data to implement flow between pairs of cells controlled by hydraulic structures. The flow is unidirectional between an upstream and downstream cell. Bi-directional flow is implemented by a control structure for each direction. An example of the file, which contains data sequences for an arbitrary number of structures is shown below:

```
C  qctl.inp file, in free format across line, repeats nqctl times
C
C  ISTYP MQCTL(NS) HCTLUA HCTLUM HCTLDA HCTLDM RMULADJ ADDADJ
C
C if istyp.eq.1 then read depth weights and single value of QCTL
C
C (WKQ(K),K=1,KC)
C
```

```
C HDIFCTL(M,NS)  QCTL(M,1,NS)  !(mqctl(ns) pairs for ns=1,nqser series)
C
C  else read a value of qser for each layer
C
C  HDIFCTL(M,NS)    (QCTL(M,K,NS),K=1,KC) !(mqctl(ns) pairs)
C
  1      5        0.0     1.0     0.0    1.0    1.76E-05     0.0
  1.0
   0.0       0.0
   0.0001    2.0
   5.0      12.485
   5.0001    0.0
   1.E+12    0.0
```

The parameter ISTYPE is either zero or one, corresponding to a flow for each model layer or a set of layer weights used to distribute a single flow over the layers. MQCTL specifies the number of data point in the control table, which is essentially a flow versus head difference rating curve. HCTLUA and HCTLDA are additive adjustments to the surface elevation in the upstream and downstream cells respectively. HCTLUM and HCTLDM are multiplying factors applied to the adjusted upstream and downstream water surface elevations respectively. ADDADJ and RMULADJ are additive and multiplier conversions applied directly to the flow data and are useful for unit conversion. MQCTL data lines follow the one or two control data lines. The data pairs are elevation difference and flow. The data in the above example implements the formula

$$\frac{Q}{L} = (1.7595\ E-5)\left(2.0+0.9(0.3048)(H_u + B_u - H_d - B_d)\right)$$
$$H_u + B_u > H_d + B_d$$

where *Q/L* is discharge or flow per unit length and *H* and *B* are the water depth and bottom elevations in the upstream and downstream cells.

To illustrate the capabilities of the surface elevation or pressure flow control option it is convenient to summarize the sequence of steps involved in calculating the flow between the upstream and downstream cells. The FORTRAN statement sequence involves looping over all control structure pairs, NQCTL, and is shown in Table 6. The flow from the upstream cell to the downstream cell is determined by the difference, DELH, between the upstream pressure plus elevation head, HUP relative to -HCTLUA, adjusted by multiplying by HCTLUM, and the downstream pressure plus elevation head, HDW relative to -HCTLDA, adjusted by multiplying by HCTLDM. For flows controlled entirely by surface elevation differences, HCTLUA and

HCTLDA would both be zero. For a spillway or weir, -HCTLUA would be the spillway or weir crest elevation. For upstream only control, HCTLDM would be set to zero. Given the adjusted head difference, DELH, which must be greater than zero, the discharge or discharge per unit width, QCTLT, is determined from an interpolation table. A final multiplying adjustment, by RQCMUL, is applied to convert discharge per unit width to discharge if required. The hydraulic control structure option is also suitable for simulating water surface elevation controlled pump station operation.

Table 6. FORTRAN Implementation of Control Structures

```
      DO NCTL=1,NQCTL
      RQDW=1.
      IU=IQCTLU(NCTL)                      ! I CELL INDEX UPSTREAM
      JU=JQCTLU(NCTL)                      ! J CELL INDEX UPSTREAM
      LU=LIJ(IU,JU)                        ! L CELL INDEX UPSTREAM
      HUP=HP(LU)+BELV(LU)+HCTLUA(NCTL)     ! UPSTREAM SUF ELEV + HCTLUA
      ID=IQCTLD(NCTL)                      ! I CELL INDEX DOWNSTREAM
      JD=JQCTLD(NCTL)                      ! J CELL INDEX DOWNSTREAM
      IF (ID.EQ.0.AND.JD.EQ.0) THEN
        LD=LC                              ! FLOW OUT OF MODEL DOMAIN
        HDW=0.                             !  WITH UPSTREAM FLOW
        RQDW=0.                            !  CONTROL
       ELSE
        LD=LIJ(ID,JD)                      ! L CELL INDEX DOWNSTREAM
        HDW=HP(LD)+BELV(LD)+HCTLDA(NCTL)   ! UPSTREAM SUF ELEV + HCTLDA
      END IF
      DELH=HCTLUM(NCTL)*HUP-HCTLDM(NCTL)*HDW ! ADJUSTED DIFFERENCE
      IF (DELH.LE.0.) THEN                 ! NO FLOW
        DO K=1,KC
        QCTLT(K,NCTL)=0.
        END DO
       ELSE                                ! ENTER INTERPOLATION TABLE
        M1=0                               !  TO DETERMINE FLOW IN
        M2=1                               !  EACH LAYER AS A FUNCTION
 500    M1=M1+1                            !  OF DELH
        M2=M2+1
        IF(DELH.GE.HDIFCTL(M1,NCTL).AND.DELH.LE.HDIFCTL(M2,NCTL))THEN
          TDIFF=HDIFCTL(M2,NCTL)-HDIFCTL(M1,NCTL)
          WTM1=(HDIFCTL(M2,NCTL)-DELH)/TDIFF
          WTM2=(DELH-HDIFCTL(M1,NCTL))/TDIFF
          DO K=1,KC
           QCTLT(K,NCTL)=WTM1*QCTL(M1,K,NCTL)+WTM2*QCTL(M2,K,NCTL)
          END DO                           ! FLOW ASSIGNED TO LAYERS,K
         ELSE
          GO TO 500
        END IF
      END IF
       DO K=1,KC                           ! ADD CONTROL FLOW TO OTHERS
       QSUM(LU,K)=QSUM(LU,K)-RQCMUL(NCTL)*QCTLT(K,NCTL)
       QSUM(LD,K)=QSUM(LD,K)+RQCMUL(NCTL)*RQDW*QCTLT(K,NCTL)
       END DO
      END DO
C
       HP( ):   CELL CENTER DEPTH
       BELV( ): CELL CENTER BOTTOM ELEVATION
```

```
      NQCTL:   NUMBER OF CONTROLLED FLOW SETS
      MQCTL:   NUMBER OF DEPTH FLOW PAIRS IN SET NS
      HCTLUA:  CONSTANT ADDED TO UPSTREAM ELEVATION
      HCTLUM:  UPSTREAM MULTIPLIER
      HCTLDA:  CONSTANT ADDED TO UPSTREAM ELEVATION
      HCTLDM:  DONWSTREAM MULTIPLIER
      HDIFCTL: DEPTH AND

      QCTL:    VOLUMETRIC FLOW PAIRS
      RQCMUL:  CONVERTS DISCHARGE/LENGTH TO DISCHARGE, =1 FOR
               DISCHARGE, = DX OR DY FOR DISCHARGE PER LENGTH
```

5.14 Input file qser.inp

An example of the qser.inp file is shown below.

```
C  qser.inp file, in free format across line, repeats nqser times
C
C  ISTYP   MQSER(NS)   TCQSER(NS)  TAQSER(NS)  RMULADJ(NS)  ADDADJ(NS)
C
C  if istyp.eq.1 then read depth weights and single value of QSER
C
C  (WKQ(K),K=1,KC)
C
C  TQSER(M,NS)  QSER(M,1,NS)  !(mqser(ns) pairs for ns=1,nqser series)
C
C  else read a value of qser for each layer
C
C  TQSER(M,NS)    (QSER(M,K,NS),K=1,KC) !(mqser(ns) pairs)
C
   1    10     3600.0     0.     1.    0.     0
   0.166  0.167  0.167  0.167  0.167  0.166
-2000.0000          0.00
  713.39            0.00
  713.41            0.001
  726.89            0.001
  726.91            0.00
 7076.49            0.00
 7076.51            0.001
 7087.99            0.001
 7088.01            0.00
 10000.00           0.00
  1     9    3600.0    0.0   1.0    0.     0
   0.166  0.167   0.167  0.167  0.167  0.166
    708.0    260.3
    732.0    243.3
    756.0    230.2
    780.0    215.9
    804.0    202.3
    828.0    192.9
    852.0    181.1
    876.0    182.9
```

```
    900.0    173.5
```

5.15 Input file restart.inp

The file restart.inp is used to specify initial conditions for running the EFDC model in the restart mode. The file is obtained by renaming the restart.out file.

5.16 Input file restran.inp

The file restran.inp is used to specify advective and diffusive transport files when the EFDC model is executed in the transport only mode. The file is obtained by renaming the restran.out file.

5.17 Input file show.inp

The file show.inp, shown below, is used to control screen writing of information at the horizontal location specified by the horizontal cell indices ISHOW and JSHOW. The parameter NSTYPE determines the type of screen displace. For NSTYPE equal to 1, the screen display emulates

```
C  show.inp file, in free format across line
C
C  NSTYPE    NSHOWR    ISHOWC   JSHOWC
C
C  ZSSMIN    ZSSMAX    SSALMAX
C
   2         30       7       65
  -3.        3.        8.
```

a strip chart recording of water surface elevation and surface and bottom salinity. In this mode, and lower and upper scale for the surface elevation, ZSSMIN and ZSSMAX and an upper scale for salinity, SSALMAX must be specified on the third data line. The file is reread every NSHOWR time steps. Between the rereads of the file, it may be edited (only on multiple window UNIX systems) to move locations and the type of display. For NSTYPE equal 2, 3, or 4, column format data on time or timestep, surface and bottom layer velocity, salinity or sediment concentration, and vertical diffusion coefficients are displayed. NSTYPE = 2 displays timestep and salinity. NSTYPE = 3 displays time in days and salinity. NSTYPE = 4 displays timestep and sediment concentration. Activating this option is generally recommended for

diagnostics of new applications and may result in noticeable decreases in model execution speeds on systems with slow IO capabilities.

5.18 Input file sfbser.inp

The file sfbser.inp specifies behavioral information for shellfish larvae when the shellfish larvae transport is activated. The header lines explain the meaning to the various time dependent behavior control information.

```
C  sfbser.inp file, shellfish larvae behavior time series in free format
C  MSFSER=no of time data points.  TCSFSER=converts time values to sec
C  TASFSER=additive adjustment to time values
C  TSRSF,TSSSF=times of sunrise and sun set as a fraction of 24 hours
C  ISSFLDN=1 to activate daylight,darkness dependent behavior
C  ISSFLFE=1 to activate flood,ebb dependent behavior
C  TSFSER=time of data   RKDSFL=first order decay rate in 1/sec
C  WSFLST=settling velocity in m/s  WSFLSM=vert swim velocity in m/s
C  DSFLMN=minimum depth below surface in daylight, meters
C  DSFLMX=maximum depth below surface in daylight, meters
C  SFNTBE=restricts advection in bottom layer during ebb
C          0. equals full restriction, 1. equals no restriction
C  SFATBT=1. allows larvae to settle to bottom and attach
C
C  MSFSER   TCSFSER   TASFSER  TSRSF   TSSSF  ISSFLDN  ISSFLFE
C
C  TSFSER RKDSFL WSFLST WSFLSM DSFLMN DSFLMX SFNTBE SFATBT
C
   4        86400.    0.       0.25    0.84    1       1
 -10000.  0.     0.    0.        0.        0.        0.        0.
  0.      0.     0.    0.        0.        0.        0.        0.
  0.01    0.     0.    0.        0.        0.        0.        0.
  10000.  0.     0.    0.        0.        0.        0.        0.
```

5.19 Input file vege.inp

The input file vege.inp specifies information on vegetation resistance. An example is shown below.

```
C  vege.inp file, in free format across line,  WCA2A
C
C  MVEGTYP(# vege classes) MVEGOW(open water class) UVEGSCL(vel scale)
C
C  after reading MVEGTYP, MVEGOW and UVEGVSCL read MVEGTYP lines of vars
```

```
C
C     M    RDLPSQ    BPVEG      HPVEG    ALPVEG    BETVEG    GAMVEG    SCVEG
C   typ#   1/m**2    meters     meters   no dim    no dim    no dim    nodim
C
     20      17        0.01
      1     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      2     18.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      3      8.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      4     26.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      5     12.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      6     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      7     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      8     18.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
      9     12.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     10     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     11     18.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     12      8.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     13     26.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     14     18.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     15     26.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     16     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     17     0.25     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     18     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     19     32.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
     20      8.0     0.1E-0      2.5     0.7854     1.0       0.0      0.50
```

The parameter MVEGTYP specifies the number of vegetation types. The vegetation is represented as cylindrical elements of height HPVEG and width or diameter BPVEG having a spatial density of RDLPSQ resistance elements per square meter. The parameter ALPVEG, BETVEG, GAMVEG, and SCVEG are dimensionless shape factors (see Hamrick and Moustafa, 1995a) with the values shown being typical of cattail and sawgrass.

5.20 Input file wave.inp

The file wave.inp is used to specify forcings for modeling wave induced currents and wave-current boundary layers. The definitions on the header lines define and explain the various data types. A pre-processor is available from the author to generate the two layer data sets required in this file using the output of various wave prediction and transformation models.

```
c  file wave.inp to specify information for wave-current boundary layer
c  and wave induced flow
c
c  *first line data
c  NWVDAT=number of cells receiving wave data
c  WVPRD=wave period in secs
c  CVTWHA=mult convert wave height to amplidute in m
c  ISWCBL=1 activates wave current boundary layer model
```

```
c  ISWRSR=1 activates inclusion of rotational component of rad stress
c  ISWRSI=1 activates inclusion of irrotational component of rad stress
c  NWUPDT=number of time steps between updating wave forcing
c  NTSWV=number of time steps for gradual introduction of wave forcing
c  WVDISV=fraction of wave dissipation as source in vertical TKE closure
c  WVDISH=fraction of wave dissipation as source in horiz SSG closure
c  WVLSH=weight for depth as the horiz SSG eddy viscosity length scale
c  WVLSX=weight for sqrt(dxdy) as the horiz SSG eddy vis length scale
c  ISWVSD=1, include nondiverg wave stokes drift in mass transport
c  ISDZBR=1,write diagnos for effect wave current bndry layer roughness
c
c  *second NWVDAT lines data
c  I,J cell indices
c  HMP,HMC cell center & corner depths for consistent disper evaluation
c  WVENE wave energy 0.5*g*abs(amp)*abs(amp)
c  SXX rotational depth integrated wave radiation stress <huu>
c  SYY rotational depth integrated wave radiation stress <hvv>
c  SXY rotational depth integrated wave radiation stress <huv>
c  WVDISP wave energy dissipation in (m/s)**3
c
c  *third NWVDAT lines data
c  I,J cell indices
c  HMU,HMV cell u and v face depths for consistent disper evaluation
c  UWVRE real part of u component of wave orbital velocity magnitude
c  UWVIM imag part of u component of wave orbital velocity magnitude
c  VWVRE real part of v component of wave orbital velocity magnitude
c  VWVIM imag part of v component of wave orbital velocity magnitude
c
c NWVDAT WVPRD CVTWHA ISWCBL ISWRSR ISWRSI NWUPDT NTSWV WVDISV WVDISH
continuation of first head (not sep line)\  WVLSH WVLSX ISWVSD ISDZBR
c I  J    HMP   HMC     WVENE      SXX       SYY       SXY     WVDISP
c I  J    HMU   HMV     UWVRE      UWVIM     VWVRE     VWVIM
c
  5500  10.9  1.0     1      1      1    1000000  120    1.0    1.0   continuation of
first head (not sep line)\  0.0  1.0    0     1
  2  2  .001  .001  .5845E-05  .0000E+00 .1288E-09  .0000E+00 .0000E+00
  3  2  .001  .001  .2276E-04  .1472E-04 .9844E-09  .8752E-07 .0000E+00
  4  2  .001  .001  .2367E-04  .3217E-05 .7498E-09  .8203E-06 .6821E-07
   .    .      .        .          .                .              .                .
.
   .    .      .        .          .                .              .                .
.
   .    .      .        .          .                .              .                .
.
  2  2  .001  .001  .0000E+00  .0000E+00  .282849E-03  .773267E-03
  3  2  .001  .001  .6392E-01 -.1561E+00  .184260E-02  .212868E-03
  4  2  .001  .001 -.1471E+00 -.2958E+00 -.566360E-03 -.154184E-02
```

6. Water Quality and Eutrophication Input Files

This chapter describes input files for the water quality and eutrophication component of the EFDC model. The file structure includes a master input file, time series boundary condition files, and files specifying spatial variation in certain model parameters.

6.1 The Water Quality Master Input File (wq3dwc.inp)

This chapter describes the master input, *wq3dwc.inp*, which contains 51 card images and is always required when water quality is activated in EFDC. The information in *wq3dwc.inp* provides run control parameters, output control and external forcing functions for the water quality simulation on the domain described by the *efdc.inp* file. The file is internally documented providing a template for setting up a water quality simulation. The file consists of card image sections, with each section having header lines which define the relevant input parameter in that section. The function of the various card image sections is best illustrated by a sequential discussion of each section. Before proceeding, a number of conventions should be discussed. Many options in the code are activated by integer switches, unless otherwise noted, setting theses switches to zero deactivates the option. Nonzero integer values will activate different option as specified in the card image description.

Card Image 1

```
C-----------------------------------------------------------------------
C01  MAIN TITLE CARDS
C
C  TITLE(M), M=1,3
C
C01 THREE TITLE CARDS FOLLOW:
'Rectangular Basin - Test 001'
'2004 Dataset'
'4-layers'
C-----------------------------------------------------------------------
```

This 3 line title serves to identify the water quality characteristics of the application. If 3 title lines are not needed, keep an empty title line otherwise the model will encounter a read error.

Card Image 2

```
C-------------------------------------------------------------------
C02 I/O CONTROL VARIABLE CARD
C
C02 ONE TITLE CARD FOLLOWS:
$$ C02 I/O control variables $$
C02
C ISWQLVL = kinetic complexity level
C           0  WASP5 LEVEL KINETICS (SINGLE ORGANIC CARBON, PHOSPHOROUS, AND
C              NITROGEN CLASSES + REACTIVE DOC/CBOD VARIABLE)
C           1  INTERMEDIATE LEVEL KINETICS (TOTAL REFRACTORY AND TOTAL LABILE
C              ORGANIC CARBON, PHOSPHOROUS, AND NITROGEN CLASSES
C              + REACTIVE DOC/CBOD)
C           2  CE-QUAL-ICM (ORIGINAL CHES BAY VARIABLES)
C           3  EXTENDED CE-QUAL-ICM (4 ORGANIC CARBON, PHOSPHOROUS, AND
C              NITROGEN CLASSES + REACTIVE DOC/CBOD VARIABLE)
C    NWQV = number of water quality water column variables
C    NWQZ = max. number of spatial zones having varying water quality parameters
C   NWQPS = max. number of water quality point source locations
C   NWQTD = number of data points in the temperature lookup table
C   NWQTS = max. number of water quality time-series output locations
C  NTSWQV = max. number of water quality time-series output variables
C    NSMG = number of sediment model groups (= 3)
C    NSMZ = max. number of sediment model spatial variation zones
C  NTSSMV = max. number of sediment model time-series output variables
C   NSMTS = not used
C NWQKDPT = number of kinetic updates per transport update
C
C02 ISWQLVL NWQV NWQZ NWQPS NWQTD NWQTS NTSWQV NSMG  NSMZ NTSSMV NSMTS NWQKDPT
    3       21   3    168   1824  15    8      3     1    3      0     1
C-------------------------------------------------------------------------
```

Card Image 2 specifies the water quality model setup. The ISWQLVL switch controls the kinetic complexity level of the simulation. For a value of ISWQLVL=0 the model uses a kinetic similar to WASP5, with single organic carbon, organic phosphorous and organic nitrogen classes. An intermediate kinetic for ISWQLVL=1 which includes labile and refractory classes for organic carbon, organic phosphorous and organic nitrogen. For a value of ISWQLVL=2 the kinetics is equivalent to CE-QUAL-ICM in its original setup for the Chesapeake Bay. For a value of ISWQLVL=3 the kinetics correspond to an extended version of CE-QUAL-ICM that includes labile and refractory classes for dissolved and particulate organic carbon, organic phosphorous and organic nitrogen. NWQV is the number of water quality variables in the water column simulation.

The simulation domain may be divided into zones with different water quality parameters specified in the file *kinetics.inp*. NWQZ specifies the maximum number of water quality zones that the domain may have. NWQPS specifies the maximum number of water quality point sources. NWQTD specifies the number of data point in the temperature lookup table. NWQTS specifies the maximum number of water quality time-series output locations. NTSWQV

specifies the maximum number of variables in the water quality time-series output. NSMG specifies the number of sediment model groups (usually 3). The simulation domain may be divided into zones with different sediment characteristics, NSMZ specifies the maximum number of sediment spatial zones. NTSSMV specifies the maximum number of sediment variables that can be output in time-series. NSMTS is not used, used a value of 0. NWQKDPT specifies the number of kinetic updates per transport update.

Card Image 2a

```
C-------------------------------------------------------------------------
C02A TRANSPORT BYPASS FLAGS
C   B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
C   c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
C            O  O  C  O  O  P  4  O  O  N  4  3        D     M
C            C  C     P  P     t  N  N
    0  0  1  1  0  1  1  0  1  1  1  0  1  1  1  0  0  0  1  0  1

C-------------------------------------------------------------------------
```

For each of the 21 water quality variables set a flag to bypass (flag=0) or simulate (flag=1) the corresponding variable. The variables are

1) cyanobacteria
2) diatom algae
3) green algae
4) refractory particulate organic carbon
5) labile particulate organic carbon
6) dissolved carbon
7) refractory particulate organic phosphorus
8) labile particulate organic phosphorus
9) dissolved organic phosphorus
10) total phosphate
11) refractory particulate organic nitrogen
12) labile particulate organic nitrogen
13) dissolved organic nitrogen
14) ammonia nitrogen
15) nitrate nitrogen
16) particulate biogenic silica
17) dissolved available silica
18) chemical oxygen demand
19) dissolved oxygen
20) total active metal
21) fecal coliform bacteria

Card Image 3

```
C-------------------------------------------------------------------------
C03
C  IWQDT   = number of water quality time steps per hydrodynamic time step
C            =1 for 2 time level hydrodynamic and =2 for three time level
C  IWQM    = full or reduced model switch (1=full model; 2=reduced model)
C  IWQBEN  = benthic flux model switch (0=specified flux; 1=predictive flux)
C  IWQSI   = switch to activate silica state variables (0=off; 1=activated)
C  IWQFCB  = switch to activate fecal coliform bacteria (0=off; 1=activated)
C  IWQSRP  = switch for sediment sorption (1=TAM sorption; 2=sediment sorption)
C  IWQSTOX = cyanobacteria salinity toxicity switch (0=no toxicity; 1=toxicity)
C  IWQKA   = reaeration option
C           = 0, constant reaeration (WQKRO), no wind reaeration
C           = 1, constant reaeration (WQKRO) plus wind reaeration
C           = 2, use O'Connor-Dobbins (1958) formula
C           = 3, use Owens & Gibbs (1964) formula
C           = 4, modified Owens & Gibbs (1964) formula (for Christina River)
C  IWQVLIM = option for velocity limitation of macroalgae growth
C           = 0, macroalgae growth is not limited by stream velocity
C           = 1, macroalgae growth limited using Michaelis-Menton formula
C           = 2, macroalgae growth limited using 5-parameter Logistic Function
C
C03 IWQDT   IWQM    IWQBEN  IWQSI   IWQFCB  IWQSRP  IWQSTOX  IWQKA IWQVLIM
     1       1       2       0       1       0       0        2     0
C-------------------------------------------------------------------------
```

The information input on Card Image 3 has more controls on the general setup of the water quality simulation. IWQDT is a flag to specify the water quality time steps per hydrodynamic time steps. IWQDT=1 for a 2 time level hydrodynamic and IWQDT=2 for a 3 time level hydrodynamics. IWQM is no longer active. The flag IWQBEN specifies the type of benthic flux in the simulation. For value of 0 a spatially and temporally constant flux is read in Card image 47. For a value of 1 the sediment process model is activated. For a value of 2 spatially and temporally varying benthic fluxes are specified. The time series of the benthic fluxes for the different sediment zones are given in the input file for benthic fluxes (BENFN) specified in Card image 51. The sediment zones are defined in the file *wqbenmap.inp*. The flag IWQSI activates silica state variables, variables 16 and 17. For a value of the flag of 0 the variables are deactivated and for a value of the flag of 1 both variables are activated. This flag has to be 1 together with the corresponding flags in card 2a in order to variable 16 and 17 be activated. Flag IWQFCB (0=off; 1=activated) activates fecal coliform bacteria, variable 21. This flag has to be 1 together with the corresponding flag in Card image 2a in order for variable 21, i.e., fecal coliform bacteria, to be activated. Flag IWQSRP specifies orthophosphate and dissolved silica sorption by Total Active Metal (IWQSRP =1) and by Total Suspended Sediment (IWQSRP =2). Flag IWQSTOX activates salinity toxicity for cyanobacteria (0=no toxicity; 1=toxicity). Flag IWQKA specifies the reaeration option used by the simulation. A value of 0 stipulates a constant reaeration given by variable K_{r0} in Card image 28. This constant reaeration is assumed

to be the total reaeration. A value of 1 specifies a constant hydraulic reaeration, given by variable K_{r0} in Card image 28. A computed wind reaeration is added to the hydraulic constant reaeration. For a value of IWQKA=2, the model uses O'Connor-Dobbins (1958) formula to calculate the hydraulic reaeration. For a value of IWQKA=3, the model uses Owens and Gibbs (1964) formula to calculate the hydraulic reaeration. For a value of IWQKA=4, the model uses a modified version of Owens and Gibbs (1964) formula for the hydraulic reaeration. Flag IWQVLIM specifies the option for velocity limitation of macroalgae growth. For a value of WQVLIM=0, macroalgae growth is not limited by stream velocity. For a value of WQVLIM=1, macroalgae growth is limited using Michaelis-Menton formula. For a value of WQVLIM=2, macroalgae growth is limited using a 5-parameter Logistic Function.

Card Image 4

```
C-----------------------------------------------------------------------
C04
C     IWQZ = number of zones for spatially varying WQ parameters
C    IWQNC = switch to save negative concentrations to WQ3DNC.LOG (0=OFF; 1=ON)
C   IWQRST = switch to save WQ restart data to WQWCRST.OUT (0=OFF; 1=ON)
C    NDMWQ = number of horizontal spatial domains for decomposition calc. (=1)
C    LDMWQ = number of horizontal cells in the WQ computational domain (=LC-2)
C  NDDOAVG = no longer used
C  NDLTAVG = no longer used
C IDNOTRVA = ID number of macroalgae water quality variable
C
C04 IWQZ    IWQNC   IWQRST  NDMWQ   LDMWQ   NDDOAVG  NDLTAVG IDNOTRVA
     3      1       0       1       1487    0        0       22
C-----------------------------------------------------------------------
```

Card Image 4 continues with general setup controls of the water quality simulation. Flag IWQZ specifies the number of zones in domain with different water quality parameters. The zones are specified in the file *wqwcmap.inp* and the parameters for the different zones in file *kinetics.inp*. Flag IWQNC activates (0=OFF; 1=ON) the debugging of negative concentrations in the simulation by saving to a file when and where negative concentrations occurs. These values are save to a file (NCOFN) which name is specified in Card image 51. Flag IWQRST activates (0=OFF; 1=ON) the saving of water quality data to file *wqwcrst.out* that can be used as the water quality restart file in a later simulation. Flag NDMWQ specifies the number of horizontal spatial domains for decomposition calculation on a parallel multiple processor system. Not activated in this version, used only NDMWQ =1. LDMWQ specifies number of horizontal cells in the water quality computational domain, is equal to LC-2. Flags NDDOAVG and NDLTAVG are no longer used, use a value of 0 for both. IDNOTRVA indicates the ID number of macroalgae water quality variable.

Card Image 5

```
C-----------------------------------------------------------------------
C05
C   IWQICI = initial condition switch
C            0=spatially constant initial conditions (card C44)
C            1=read initial condition file ICIFN (see card C51)
C            2=read initial conditions from restart file WQWCRST.INP
C   IWQAGR = algae growth kinetics switch
C            0=use constant kinetics on card C45
C            1=read spatial/time-varying kinetics from file AGRFN (card C51)
C   IWQSTL = settling velocity switch
C            0=use spatially/temporally constant settling velocities (card C46)
C            1=use spatial/time-varying settling vel. from STLFN (card C51)
C   IWQSUN = solar radiation switch
C            0=use constant solar radiation (I0) and FD from card C10
C            1=use daily average solar rad. and FD from file SUNDAY.INP
C            2=use hourly solar rad. from ASER.INP file
C   IWQPSL = point source load switch
C            0=use constant point source loads
C            1=use time-variable point source loads from file WQPSL.INP
C   IWQNPL = not used
C isDIURDO = switch for saving diurnal DO data
C            0=do not save diurnal DO data to file
C            1=save diurnal DO data to binary file WQDIURDO.BIN
C              if WQDIURDO.BIN already exists, delete it
C            2=save diurnal DO data to binary file WQDIURDO.BIN
C              if WQDIURDO.BIN already exists, append to it
C  WQDIUDT = time interval for writing to diurnal DO file (hours)
C   IWQKIN = switch for using spatially-varying kinetic rate constants
C            0=do not use spatially-varying kinetics
C            1=use spatially-varying kinetics in file KINETICS.INP
C              Only applies to IWQKA, KRO, KTR, REAC, KDC, KDCALGm, KHRm
C              DOPTm, KCD, and KHCOD.
C
C05 IWQICI  IWQAGR  IWQSTL  IWQSUN  IWQPSL  IWQNPL  isDIURDO WQDIUDT IWQKIN
     0       1       0       2       1       0       0       1.0     1
C-----------------------------------------------------------------------
```

This card image continues with general setup controls of the water quality simulation. Flag IWQICI specifies the type of initial condition. For a value of 0, spatially constant water quality initial conditions are specified in Card image 44. For a value of 1, initial conditions are read from file ICIFN, which name is given in Card image 51. For a value of 2, initial conditions are read from restart file *wqwcrst.inp*. Flag IWQAGR indicates the type of algae growth kinetics used in the simulation. For a value of 0, a constant kinetics, given on Card image 45, is used throughout the domain. For a value of 1, spatially and temporarily varying kinetics is given in file AGRFN, which name is given in Card image 51. The number of spatial zones is indicated by IWQZ in Card image 4 and defined in file *wqwcmap.inp*. Flag IWQSTL indicates the kind of settling velocity values used in the simulation. For a value of 0, spatially and temporally constant settling velocities are specified in Card image C46. For a value of 1, spatial and time-varying settling velocities are specified in file STLFN which name is given in Card image 51. The spatial zones are the same as for kinetics and algae growth defined by IWQZ in Card image 4

and file *wqwcmap.inp*. Flag IWQSUN indicates the solar radiation conditions for the water quality model, specifically photosynthesis activity. For a value of 0, the simulation uses a constant solar radiation given by I_0 and daily fraction of daytime, F_D, both specified in Card image 10. For a value of 1, daily average solar radiation and daytime fraction F_D are read from file *Sunday.inp*. For a value of 2 the model uses hourly solar radiation given in file *Aser.inp*. Flag IWQPSL indicates the type of point source load input to the model. For a value of 0 only constant point source loads are given in Card image 48. For a value of 1, time-variable point source loads are read from file *Wqpsl.inp*. Flag IWQNPL is no longer used. Flag isDIURDO controls the saving of diurnal dissolved oxygen output data. For a value of 0, diurnal DO data are not save to file. For a value of 1, diurnal DO data are saved to a new binary file *Wqdiurdo.bin*. For a value of 2, diurnal DO data are appended to a binary file *Wqdiurdo.bin*. Parameter WQDIUDT is the time interval for writing to diurnal DO file in hours. Flag IWQKIN indicates the type of kinetic rate constants used in the model. For a value of 0, constant values valid for the whole simulation domain and given in different cards of this file are used. For a value of 1, spatially-varying kinetic rate constant are used. These constants are specified in file *Kinetics.inp* for the different zones specified in the file *Wqwcmap.inp*. Only a certain number of kinetic rate constants can be spatially varied as explain in the description of file *Kinetics.inp* given later in this manual.

Card Image 6

```
C------------------------------------------------------------------------------
C06
C    IWQTS = number of time-series locations to output to ASCII file WQWCTS.OUT
C   TWQTSB = beginning time for recording time-series data (Julian Day)
C   TWQTSE = ending    time for recording time-series data (Julian Day)
C   WQTSDT = write interval (hours), also averaging interval for binary files
C            use 24.0 hours for daily averages (solar day)
C            use 24.8412 hours to average over the M2 tide period (lunar day)
C  isWQAVG = switch to save WQ averages to binary file WQWCAVG.BIN
C            0=OFF; 1=ON, overwrite existing file; 2=ON, append to existing file
C  isWQMIN = switch to save WQ minimums to binary file WQWCMIN.BIN
C            0=OFF; 1=ON, overwrite existing file; 2=ON, append to existing file
C  isWQMAX = switch to save WQ minimums to binary file WQWCMAX.BIN
C            0=OFF; 1=ON, overwrite existing file; 2=ON, append to existing file
C   isCOMP = switch to save DO components to file WQDOCOMP.BIN
C            0=OFF; 1=ON, overwrite existing file; 2=ON, append to existing file
C   17      28.0
C06 IWQTS   TWQTSB  TWQTSE  WQTSDT  isWQAVG isWQMIN isWQMAX  isCOMP
     1     28.0     9999.   6.0     0       0       0        0
C------------------------------------------------------------------------------
```

The information input on Card image 6 controls the general output for the water quality simulation. Parameter IWQTS indicates the number of time-series locations to output to ASCII

file *Wqwcts.out*. Parameter TWQTSB gives the beginning time for recording time-series data in Julian Days and parameter TWQTSE the ending time for recording time-series data in Julian Day. Parameter WQTSDT indicates the write interval, in hours, for the ASCII output file, as well as the averaging interval time for binary files described in the next paragraph. Flag WQAVG controls the ouput to binary file *Wqwcavg.bin*. For a value of 0, file *Wqwcavg.bin* is not created. For a value of 1 a file *Wqwcavg.bin*, with water quality variables averaged over WQTSDT period, is created. Any existing file with that name is overwritten. For a value of 2, water quality averages are appended to an existing *Wqwcavg.bin* file. Flag isWQMIN controls the ouput to binary file *Wqwcmin.bin*. For a value of 0, file *Wqwcmin.bin* is not created. For a value of 1 a file *Wqwcmin.bin* is created. This file contains the minimum value of water quality variables over the period WQTSDT. Any existing file with that name is overwritten. For a value of 2, water quality minimums are appended to an existing *Wqwcmin.bin* file. Flag isWQMAX controls the ouput to binary file *Wqwcmax.bin*. For a value of 0, file *Wqwcmax.bin* is not created. For a value of 1 a file *Wqwcmax.bin* is created. This file contains the maximum value of water quality variables over the period WQTSDT. Any existing file with that name is overwritten. For a value of 2, water quality maximums are appended to an existing *Wqwcmax.bin* file. Flag COMP controls the ouput to binary file *Wqdocomp.bin*. For a value of 0, file *Wqdocomp.bin* is not created. For a value of 1 a file *Wqdocomp.bin* is created. This file contains the DO values specific to different kinetic terms, such as reaeration, photosynthesis, sediment oxygen demand, etc. Any existing file with that name is overwritten. For a value of 2, DO component values are appended to an existing *Wqwcmin.bin* file.

Card Image 7

```
C-------------------------------------------------------------------------------
C07  TIME-SERIES WRITE CONTROLS
C    CHL = total chlorohyll
C    TOC = total organic carbon
C    DOC = dissolved organic carbon
C     TP = total phosphorus
C    DOP = dissolved organic phosphorus
C   PO4t = total orthophosphate
C   PO4d = dissolved orthophosphate
C    APC = algae phosphorus-to-carbon ratio
C     TN = total nitrogen
C    DON = dissolved organic nitrogen
C    NH4 = ammonia nitrogen
C    NO3 = nitrite + nitrate nitrogen
C    TSI = total silica
C     SU = unavailable dissolved silica
C     SA = total available biogenic dissolved silica
C    SAd = dissolved available biogenic dissolved silica
C    COD = chemical oxygen demand
C    TAM = total active metal
C   TAMp = total active metal
```

```
C    FCB = fecal coliform bacteria
C     Fm = macroalgae
C
C   ICWQTS(NW,M), NW=1,NTSWQV, M=1,IWQTS
C
C07  Two title cards follow:
$I   J    CHL  TOC  DOC  TP   DOP  PO4t PO4d APC  TN   DON  NH4  NO3  TSI
$         SU   SA   SAd  COD  O2   TAM  TAMp FCB  Fm
 52 16    1    1    1    1    1    1    1    1    1    1    1    1    0
          0    0    0    0    1    0    0    1    0
C-------------------------------------------------------------------------
```

The information input on Card Image 7 controls which variables are save to the ASCII time series output. For the IWQTS number of location indicated in Card image C6, the location and variables output at that location are given in this card. For each location the I and J of the corresponding cell are given. For the following list of output variables, a flag indicates whether that variable is saved to the output time series. A flag value of 1 will save the variable to the output file while a value of 0 will not. The variable list of possible outputs is:

total chlorohyll
total organic carbon
dissolved organic carbon
total phosphorus
dissolved organic phosphorus
total orthophosphate
dissolved orthophosphate
algae phosphorus-to-carbon ratio
total nitrogen
dissolved organic nitrogen
ammonia nitrogen
nitrite + nitrate nitrogen
total silica
unavailable dissolved silica
total available biogenic dissolved silica
dissolved available biogenic dissolved silica
chemical oxygen demand
total active metal
total active metal
fecal coliform bacteria
macroalgae

Card Image 8

```
C------------------------------------------------------------------------------
C08 ONE TITLE CARD FOLLOWS:
$$ C08 constant parameters for ALGAE (see Table 3-1) $$
C08
C    KHNc = nitrogen half-saturation for cyanobacteria (mg/L)
C    KHNd = nitrogen half-saturation for algae diatoms (mg/L)
C    KHNg = nitrogen half-saturation for algae greens algae (mg/L)
C    KHNm = nitrogen half-saturation for macroalgae (mg/L)
C    KHPc = phosphorus half-saturation for cyanobacteria (mg/L)
C    KHPd = phosphorus half-saturation for algae diatoms (mg/L)
C    KHPg = phosphorus half-saturation for algae greens algae (mg/L)
C    KHPm = phosphorus half-saturation for macroalgae (mg/L)
C     KHS = silica half-saturation for algae diatoms (mg/L)
C    STOX = salinity at which microsystis growth is halved for cyanobacteria
C
C08 KHNc   KHNd   KHNg   KHNm   KHPc   KHPd   KHPg   KHPm   KHS   STOX
    0.01   0.01   0.01   0.01   0.001  0.001  0.001  0.001  0.035  1.0
C------------------------------------------------------------------------------
```

Card Image 8 specifies a number of parameters related to algae kinetics. KHN_c, KHN_d, KHN_g, and KHN_m are the half-saturation constants for Nitrogen uptake, in mg/L, for cyanobacteria, algae diatoms, green algae and macroalgae, respectively. KHP_c, KHP_d, KHP_g, and KHP_m are the half-saturation constants for Phosphorus uptake, in mg/L, for cyanobacteria, algae diatoms, green algae and macroalgae, respectively. These constants affect the nutrient limitation in algae growth as specified by equation 2.7 in Tetra Tech (2007c). KHS is the half-saturation constant for Silica uptake for diatom algae in mg/L. As specified in equation 2.7, diatom algae are limited in growth not only by nutrients but Silica as well. Cyanobacteria is a freshwater algae and its growth is limited in salt water as indicated by equation 2.26 in Tetra Tech (2007c). STOX is the salinity at which microsystis growth of cyanobacteria is halved from that of freshwater.

Card Image 9

```
C------------------------------------------------------------------------
C09 constant parameters for ALGAE (see Table 3-1)
C   KeTSS = light extinction fr total suspended solids (1/m per g/m3)
C   KeCHL = light extinction for total suspended chlorophyll (1/m per g/m3)
C     Note: if KeCHL is negative, the Riley (1956) formula is used to
C           compute the extinction coefficient due to chlorophyll:
C             KeCHL = 0.054*CHL^0.6667 + 0.0088*CHL
C             where CHL = total chloryphyll concentration (ug/L)
C   CChlc = carbon-to-chlorophyll ratio for cyanobacteria (mg C / ug Chl)
C   CChld = carbon-to-chlorophyll ratio for algae diatoms (mg C / ug Chl)
C   CChlg = carbon-to-chlorophyll ratio for algae greens (mg C / ug Chl)
C   CChlm = carbon-to-chlorophyll ratio for macroalgae (mg C / ug Chl)
C   DOPTc = optimal depth (m) for cyanobacteria growth
C   DOPTd = optimal depth (m) for algae diatoms growth
C   DOPTg = optimal depth (m) for algae greens growth
C   DOPTm = optimal depth (m) for macroalgae growth
C
C09 KeTSS  KeChl  CChlc  CChld  CChlg  CChlm  DOPTc  DOPTd DOPTg DOPTm
    0.0    -0.017  0.060  0.060  0.060  0.060  1.0    1.0   1.0   0.10
```

```
C-------------------------------------------------------------------------
```

Card Image 9 specifies a number of parameters related to algae kinetics. As specified by equation 2.11 in Tetra Tech (2007c), light extinction in the water column consists of three fractions in the model: a background value dependent on water color, extinction due to suspended particles, and extinction due to light absorption by ambient chlorophyll. Ke_{TSS} is the light extinction coefficient for total suspended solids, in m^{-1} per g m^{-3}. Ke_{CHL} is the light extinction coefficient for total suspended chlorophyll, in m^{-1} per g m^{-3}. If a negative value of Ke_{CHL} is specified, the model uses the Riley (1956) formula to compute the light extinction coefficient for total suspended chlorophyll:

$$Ke_{CHL} = 0.054*CHL^{0.6667} + 0.0088*CHL$$

where CHL = total chlorophyll concentration in µg/L

$CChl_c$, $CChl_d$, $CChl_g$, and $CChl_m$ are the carbon-to-chlorophyll ratio for cyanobacteria, diatom algae, green algae, and macroalgae, respectively, in mgC/µgChl. Maximum algal growth occurs at a constant depth (approximately 1 m) in the water as reported by Kremer and Nixon (1981). This approach is adopted in equation 2.12, where $(D_{OPT})_c$, $(D_{OPT})_d$, $(D_{OPT})_g$, and $(D_{OPT})_m$ are the depth of maximum algal growth, in m, for cyanobacteria, diatoms, green algae, and macroalgae, respectively.

Card Image 10

```
C-------------------------------------------------------------------------
C10 constant parameters for ALGAE (see Table 3-1)
C      I0 = initial solar radiation (Langley/day) at water surface
C   IsMIN = minimum optimum solar radiation (Langley/day)
C      FD = fraction of day that is daylight
C     CIa = weighting factor for solar radiation at current day
C     CIb = weighting factor for solar radiation at (-1) days
C     CIc = weighting factor for solar radiation at (-2) days
C     CIm = not used
C     Rea = global reaeration adjustment factor
C  PARadj = solar radiation multiplied by this factor to get the
C           photoactive available radiation (PAR) for algae growth
C
C10  I0    IsMIN  FD     CIa    CIb    CIc    CIm    Rea   PARadj
     28.0  40.0   0.6    0.7    0.2    0.1    0.7    1.0   0.43
C-------------------------------------------------------------------------
```

Card Image 10 specifies a number of parameters related to the effect of light on algae kinetics. I_0 is the constant solar radiation at the water surface, in Langley/day, used in equations 2.16 to 2.18 in Tetra Tech (2007c) when flag IWQSUN=0 in Card image 5. A minimum solar radiation $(I_s)_{min}$, in Langley/day, is specified for equation 2.11 so that algae do not thrive at extremely low

light levels. F_D is the constant fraction of day that is daylight used in equations 2.16 to 2.18 when flag IWQSUN=0 in Card image 5. The time required for algae to adapt to changes in light intensity is recognized by estimating the effective light intensity for algal growth based on a time-weighted average of daily light intensities:

$(I_o)_{avg} = CI_a \cdot I_o + CI_b \cdot I_1 + CI_c \cdot I_2$ (2-20 in Tetra Tech (2007c))

where

I_0 = daily light intensity at current day of simulation (langleys day^{-1})

I_1 = daily light intensity 1 day preceding model day (langleys day^{-1})

I_2 = daily light intensity 2 days preceding model day (langleys day^{-1})

CI_a, CI_b, CI_c = weighting factors for I_0, I_1 and I_2, respectively.

CI_a, CI_b, and CI_c specified in this card image must complied with $CI_a + CI_b + CI_c = 1$.

CI_m is no longer used.

Rea is a global reaeration adjustment factor (inactive, use Reac in Card image 46).

PARadj is a factor used to convert total solar radiation into photoactive available radiation (PAR) for algae growth.

Card Image 11

```
C-------------------------------------------------------------------------------
C11 constant parameters for ALGAE (see Table 3-1)
C    TMc1 = lower optimal temperature for cyanobacteria growth (degC)
C    TMc2 = upper optimal temperature for cyanobacteria growth (degC)
C    TMd1 = lower optimal temperature for algae diatoms growth (degC)
C    TMd2 = upper optimal temperature for algae diatoms growth (degC)
C    TMg1 = lower optimal temperature for algae greens growth (degC)
C    TMg2 = upper optimal temperature for algae greens growth (degC)
C    TMm1 = lower optimal temperature for macroalgae growth (degC)
C    TMm2 = upper optimal temperature for macroalgae growth (degC)
C    TMp1 = lower optimal temperature for diatom predation (degC)
C    TMp2 = upper optimal temperature for diatom predation (degC)
C                                   25.0
C11 TMc1  TMc2   TMd1   TMd2   TMg1   TMg2   TMm1   TMm2   TMp1   TMp2
    20.   20.    20.0   20.0   25.0   35.0   20.0   20.0   20.0   20.0
C-------------------------------------------------------------------------------
```

Card Image 11 specifies a number of parameters related to the effect of temperature on algae kinetics. A Gaussian probability curve, equation 2.25 in Tetra Tech (2007c), is used to represent temperature dependency of algal growth. $(TM_c)_1$, $(TM_d)_1$, $(TM_g)_1$, and $(TM_m)_1$ are the lower optimal temperature for cyanobacteria, diatoms, green algae, and macroalgae growth, respectively. $(TM_c)_2$, $(TM_d)_2$, $(TM_g)_2$, and $(TM_m)_2$ are the upper optimal temperature for cyanobacteria, diatoms, green algae, and macroalgae growth, respectively. $(TM_p)_1$ and $(TM_p)_2$ are the lower and upper optimal temperatures for diatom predation. All temperatures are given in degree C.

Card Image 12

```
C-------------------------------------------------------------------
C12 constant parameters for ALGAE (see Table 3-1)
C   KTG1c = suboptimal   temperature effect coef. for cyanobacteria growth
C   KTG2c = superoptimal temperature effect coef. for cyanobacteria growth
C   KTG1d = suboptimal   temperature effect coef. for algae diatoms growth
C   KTG2d = superoptimal temperature effect coef. for algae diatoms growth
C   KTG1g = suboptimal   temperature effect coef. for algae greens growth
C   KTG2g = superoptimal temperature effect coef. for algae greens growth
C   KTG1m = suboptimal   temperature effect coef. for macroalgae growth
C   KTG2m = superoptimal temperature effect coef. for macroalgae growth
C   KTG1p = suboptimal   temperature effect coef. for diatom predation growth
C   KTG2p = superoptimal temperature effect coef. for diatom predation growth
C                              0.008  0.01
C12 KTG1c KTG2c  KTG1d  KTG2d  KTG1g  KTG2g  KTG1m  KTG2m  KTG1p  KTG2p
    0.01  0.01   0.01   0.01   0.005  0.008   0.01   0.01   0.01   0.01
C-------------------------------------------------------------------
```

Card Image 12 specifies a number of parameters related to the effect of temperature on algae kinetics. $KTG1_c$, $KTG1_d$, $KTG1_g$, and $KTG1_m$ are the coefficients for cyanobacteria, diatoms, green algae and macroalgae, respectively, that express the effect of temperature for temperatures below the lower optimal temperatures in equation 2.25 in Tetra Tech (2007c). $KTG2_c$, $KTG2_d$, $KTG2_g$, and $KTG2_m$ are the coefficients for cyanobacteria, diatoms, green algae and macroalgae, respectively, that express the effect of temperature for temperatures over the upper optimal temperatures in equation 2.25. $KTG1_p$ and $KTG2_p$ are the coefficient for temperature effect on diatom predation for temperatures below and over the lower and upper optimal temperatures for diatom predation.

Card Image 13

```
C-------------------------------------------------------------------------
C13 constant parameters for ALGAE (see Table 3-1)
C     TRc = reference temperature for cyanobacteria metabolism (degC)
C     TRd = reference temperature for algae diatoms metabolism (degC)
C     TRg = reference temperature for algae greens metabolism (degC)
C     TRm = reference temperature for macroalgae metabolism (degC)
C    KTBc = temperature effect coef. for cyanobacteria metabolism
C    KTBd = temperature effect coef. for algae diatoms metabolism
C    KTBg = temperature effect coef. for algae greens metabolism
C    KTBm = temperature effect coef. for macroalgae metabolism
C                                        0.069
C13 TRc   TRd   TRg   TRm   KTBc   KTBd   KTBg   KTBm
    20.0  20.0  20.0  20.0  0.069  0.069  0.032  0.069
C-------------------------------------------------------------------------
```

Card Image 13 specifies the parameters related to the effect of temperature on basal metabolism algal kinetics. Basal metabolism is considered to be an exponentially increasing function of

temperature as expressed by equation 2.27 in Tetra Tech (2007c). TR_c, TR_d, TR_g, and TR_m are the reference temperature for basal metabolism for cyanobacteria, diatoms, green algae and macroalgae respectively, in degree C. KTB_c, KTB_d, KTB_g, and KTB_m are the coefficients that express the exponential effect of temperature on metabolism for cyanobacteria, diatoms, green algae and macroalgae respectively.

Card Image 14

```
C------------------------------------------------------------------------
C14 ONE TITLE CARD FOLLOWS:
$$ C14 constant parameters for CARBON (see Table 3-2) $$
C14
C    FCRP = carbon distribution coef. for algae predation: refractory POC
C    FCLP = carbon distribution coef. for algae predation: labile POC
C    FCDP = carbon distribution coef. for algae predation: DOC   all to DOC for wasp
mode
C    FCDc = carbon distribution coef. for cyanobacteria metabolism
C    FCDd = carbon distribution coef. for algae diatoms metabolism
C    FCDg = carbon distribution coef. for algae greens metabolism
C    KHRc = half-sat. constant (gO2/m3) for cyanobacteria DOC excretion
C    KHRd = half-sat. constant (gO2/m3) for algae diatoms DOC excretion
C    KHRg = half-sat. constant (gO2/m3) for algae greens  DOC excretion
C Note:  FCRP + FCLP + FCDP = 1.0
C
C14 FCRP   FCLP   FCDP   FCDc  FCDd   FCDg   KHRc  KHRd  KHRg
    0.2    0.0    0.8    0.0   0.0    0.0    0.5   0.5   0.5
C------------------------------------------------------------------------
```

Card Image 14 specifies a number of parameters related to carbon kinetics. FCRP, FCLP and FCDP are the fractions of predated algae (see equations 2.29 to 2.31 in Tetra Tech (2007c)) produced as refractory particulate organic carbon, labile particulate organic carbon and dissolved organic carbon respectively. The sum of these three predation fractions should be unity (FCRP + FCLP + FCDP = 1.0). FCD_c, FCD_d, and FCD_g are the fraction of basal metabolism exuded as dissolved organic carbon at infinite dissolved oxygen concentration for cyanobacteria, diatoms and green algae respectively (see equation 2.31). KHR_c, KHR_d, and KHR_g are the half-saturation constants of dissolved oxygen for algal dissolved organic carbon excretion for cyanobacteria, diatoms and green algae respectively, in mg/L of O_2 (see equation 2.31).

Card Image 15

```
C------------------------------------------------------------------------------
C15 ONE TITLE CARD FOLLOWS:
$$ C15 constant parameters for CARBON (macroalgae)
C15
C   FCRPm = carbon distribution coef. for macroalgae predation: refractory POC
C   FCRPm = carbon distribution coef. for macroalgae predation: labile POC
C   FCRPm = carbon distribution coef. for macroalgae predation: DOC
```

```
C    FCDm = carbon distribution coef. for macroalgae metabolism
C    KHRm = half-sat. constant (gO2/m3) for macroalgae DOC excretion
C Note:  FCRPm + FCLPm + FCDPm = 1.0
C
C15 FCRPm  FCLPm  FCDPm  FCDm  KHRm
    0.0    0.0    1.0    0.0   0.5
C-------------------------------------------------------------------------
```

Card Image 15 specifies a number of parameters related to carbon kinetics. $FCRP_m$, $FCLP_m$ and $FCDP_m$ are the fractions of predated macroalgae (see equations 2.29 to 2.31 in Tetra Tech (2007c)) produced as refractory particulate organic carbon, labile particulate organic carbon and dissolved organic carbon respectively. The sum of these three predation fractions should be unity ($FCRP_m + FCLP_m + FCDP_m = 1.0$). FCD_m is the fraction of basal macroalgae metabolism exuded as dissolved organic carbon at infinite dissolved oxygen concentration (see equation 2.31). KHR_m is the half-saturation constant of dissolved oxygen for algal dissolved organic carbon excretion for macroalgae, in mg/L of O_2 (see equation 2.31).

Card Image 16

```
C-------------------------------------------------------------------
C16 constant parameters for CARBON (see Table 3-2)
C     KRC = minimum dissolution rate (1/day) of refractory POC
C     KLC = minimum dissolution rate (1/day) of labile POC
C     KDC = minimum dissolution rate (1/day) of DOC
C  KRCalg = constant relating refractory POC dissolution rate to total chla
C  KLCalg = constant relating labile POC dissolution rate to total chla
C  KDCalg = constant relating DOC dissolution rate to total chla
C KDCalgm = constant relating DOC dissolution rate to macroalgae
C
C16 KRC     KLC     KDC     KRCalg  KLCalg  KDCalg KDCalgm
    0.013   1.0     0.13    0.0     0.0     0.0    0.0
C-------------------------------------------------------------------
```

Card Image 16 specifies a number of parameters related to carbon kinetics. K_{RPOC} and K_{LPOC} are the minimum dissolution rate (1/day) of refractory and labile POC to DOC (see equations 2.54 to 2.55). K_{DOC} is the heterotrophic respiration rate of dissolved organic carbon at infinite dissolved oxygen concentration, in day^{-1} (see equation 2.56). K_{RCalg} and K_{LCalg} are constants that relate dissolution of refractory and labile particulate organic carbon, respectively, to algal biomass, in day^{-1} per mg/L of C (see equation 2.54 and 2.55). K_{DCalg} and K_{DCalgm} are constants that relate respiration to algal and macroalgae biomass, respectively, in day^{-1} per mg/L of C (see equation 2.56).

Card Image 17

```
C-------------------------------------------------------------------------------
C17 constant parameters for CARBON (see Table 3-2)
C   TRHDR = reference temperature for hydrolysis (degC)
C   TRMNL = reference temperature for mineralization (degC)
C   KTHDR = temperature effect constant for hydrolysis
C   KTMNL = temperature effect constant for mineralization
C  KHORDO = oxic respiration half-sat. constant for DO (gO2/m3)
C   KHDNN = half-sat. constant for denitrification (gN/m3)
C   AANOX = ratio of denitrification rate to oxic DOC respiration rate
C
C17 TRHDR   TRMNL   KTHDR   KTMNL   KHORDO  KHDNN   AANOX
    20.0    20.0    0.069   0.069   0.5     0.1     0.5
C-------------------------------------------------------------------------------
```

Card Image 17 specifies a number of parameters related to carbon kinetics. TR_{HDR} and TR_{MNL} are the reference temperatures, in degree C, for hydrolysis and mineralization, respectively (see equations 2.54 to 2.56 in Tetra Tech (2007c)). $KHOR_{DO}$ is the oxic respiration half-saturation constant for dissolved oxygen, in mg/L of O_2 (see equation 2.39). $KHDN_N$ is the denitrification half-saturation constant for nitrate, in mg/L of N (see equation 2.44). AANOX is the ratio of denitrification rate to oxic dissolved organic carbon respiration rate in equation 2.44.

Card Image 18

```
C-------------------------------------------------------------------------
C18 ONE TITLE CARD FOLLOWS:
$$ C18 constant parameters for PHOSPHORUS (see Table 3-3) $$
C18
C    FPRP = phos. distribution coef. for algae predation: refractory POP
C    FPLP = phos. distribution coef. for algae predation: labile POP
C    FPDP = phos. distribution coef. for algae predation: DOP
C    FPIP = phos. distribution coef. for algae predation: Inorganic P
C    FPRc = phos. distribution coef. of RPOP for cyanobacteria metabolism
C    FPRd = phos. distribution coef. of RPOP for algae diatoms metabolism
C    FPRg = phos. distribution coef. of RPOP for algae greens metabolism
C    FPLc = phos. distribution coef. of LPOP for cyanobacteria metabolism
C    FPLd = phos. distribution coef. of LPOP for algae diatoms metabolism
C    FPLg = phos. distribution coef. of LPOP for algae greens metabolism
C Note, the following must sum to 1.0:
C         FPRP + FPLP + FPDP + FPIP = 1.0
C         FPRc + FPLc + FPDc + FPIc = 1.0
C         FPRd + FPLd + FPDd + FPId = 1.0
C         FPRg + FPLg + FPDg + FPIg = 1.0
C
C18 FPRP FPLP  FPDP  FPIP  FPRc  FPRd FPRg FPLc FPLd FPLg
    0.12  0.0  0.48  0.40  0.0   0.0  0.16  0.0  0.0  0.0
C-------------------------------------------------------------------------
```

Card Image 18 specifies a number of parameters related to phosphorus kinetics. FPRP, FPLP, FPDP and FPIP are the fractions of predated algae (see equations 2.47 to 2.50 in Tetra Tech

(2007c)) produced as refractory particulate organic phosphorus, labile particulate organic phosphorus, dissolved organic phosphorus, and inorganic phosphorus, respectively. The sum of these four predation fractions should be unity (FPRP + FPLP + FPDP + FPIP = 1.0). FPR_c, FPR_d, and FPR_g are the fraction of metabolized phosphorus by cyanobacteria, diatoms and green algae, respectively, produced as refractory particulate organic phosphorus (equation 2.47). FPL_c, FPL_d, and FPL_g are the fraction of metabolized phosphorus by cyanobacteria, diatoms and green algae, respectively, produced as labile particulate organic phosphorus (equation 2.48).

The following fractions must sum to 1.0:

$$FPR_c + FPL_c + FPD_c + FPI_c = 1.0$$

$$FPR_d + FPL_d + FPD_d + FPI_d = 1.0$$

$$FPR_g + FPL_g + FPD_g + FPI_g = 1.0$$

Fractions shown in italic are defined in Card image 20.

Card Image 19

```
C------------------------------------------------------------------------------
C19 ONE TITLE CARD FOLLOWS:
$$ C19 constant parameters for PHOSPHORUS (macroalgae)
C19
C   FPRPM = phos. distribution coef. for macroalgae predation: RPOP
C   FPLPM = phos. distribution coef. for macroalgae predation: LPOP
C   FPDPM = phos. distribution coef. for macroalgae predation: DOP
C   FPIPM = phos. distribution coef. for macroalgae predation: Inorganic P
C    FPRm = phos. distribution coef. of RPOP for macroalgae metabolism
C    FPLm = phos. distribution coef. of LPOP for macroalgae metabolism
C    APCM = factor to modify APC for macroalgae
C Note, the following must sum to 1.0:
C         FPRPM + FPLPM + FPDPM + FPIPM = 1.0
C         FPRm + FPLm + FPDm + FPIm = 1.0
C
C19 FPRPM  FPLPM  FPDPM  FPIPM   FPRm   FPLm   APCM
    0.40   0.40   0.1    0.1     0.2    0.3    0.50
C------------------------------------------------------------------------------
```

Card Image 19 specifies a number of parameters related to phosphorus kinetics. $FPRP_m$, $FPLP_m$, $FPDP_m$,and $FPIP_m$ are the fractions of predated macroalgae (see equations 2.47 to 2.50 in Tetra Tech (2007c)) produced as refractory particulate organic phosphorus, labile particulate organic phosphorus, dissolved organic phosphorus and inorganic phosphorus, respectively. The sum of these four predation fractions should be unity ($FPRP_m + FPLP_m + FPDP_m + FPIP_m = 1.0$). FPR_m and FPL_m are the fraction of metabolized phosphorus by macroalgae produced as refractory and labile particulate organic phosphorus, respectively. The following fractions must sum to 1.0:

$$FPR_m + FPL_m + FPD_m + FPI_m = 1.0$$

Fractions shown in italic are defined in Card image 20. APC_m is a factor to modify the algal phosphorus to carbon ratio for macroalgae.

Card Image 20

```
C-------------------------------------------------------------------
C20 constant parameters for PHOSPHORUS (see Table 3-3)
C    FPDc = phosphorus distribution coef. of DOP for cyanobacteria metabolism
C    FPDd = phosphorus distribution coef. of DOP for algae diatoms metabolism
C    FPDg = phosphorus distribution coef. of DOP for algae greens metabolism
C    FPDm = phosphorus distribution coef. of DOP for macroalgae metabolism
C    FPIc = phosphorus distribution coef. of P4T for cyanobacteria metabolism
C    FPId = phosphorus distribution coef. of P4T for algae diatoms metabolism
C    FPIg = phosphorus distribution coef. of P4T for algae greens metabolism
C    FPIm = phosphorus distribution coef. of P4T for macroalgae metabolism
C   KPO4p = partition coefficient for sorbed/dissolved PO4
C
C Notes, the following must sum to 1.0:
C         FPRc + FPLc + FPDc + FPIc = 1.0
C         FPRd + FPLd + FPDd + FPId = 1.0
C         FPRg + FPLg + FPDg + FPIg = 1.0
C
C20 FPDc   FPDd   FPDg   FPDm    FPIc   FPId   FPIg   FPIm   KPO4p
    1.0    1.0    0.64   1.0     0.0    0.0    0.2    0.0    1.00
C-------------------------------------------------------------------
```

Card Image 20 specifies a number of parameters related to phosphorus kinetics. FPD_c, FPD_d, FPD_g, and FPD_m are the fraction of metabolized phosphorus by cyanobacteria, diatoms, green algae, and macroalgae, respectively, produced as dissolved organic phosphorus (equation 2.49 in Tetra Tech (2007c)). FPI_c, FPI_d, FPI_g, and FPI_m are the fraction of metabolized phosphorus by cyanobacteria, diatoms, green algae, and macroalgae, respectively, produced as inorganic phosphorus (equation 2.50). The following fractions must sum to 1.0:

$$FPR_c + FPL_c + FPD_c + FPI_c = 1.0$$
$$FPR_d + FPL_d + FPD_d + FPI_d = 1.0$$
$$FPR_g + FPL_g + FPD_g + FPI_g = 1.0$$
$$FPR_m + FPL_m + FPD_m + FPI_m = 1.0$$

Fractions shown in italic are defined in Card images 18 and 19. K_{PO4p} is an empirical coefficient relating phosphate sorption to total suspended solid (per mg/L) or particulate total active metal (per mol m^{-3}) concentration.

Card Image 21

```
C-------------------------------------------------------------------------------
C21 constant parameters for PHOSPHORUS (see Table 3-3)
C     KRP = minimum hydrolysis rate (1/day) of RPOP
C     KLP = minimum hydrolysis rate (1/day) of LPOP
C     KDP = minimum hydrolysis rate (1/day) of DOP
C  KRPalg = constant relating hydrolysis rate of RPOP to algae
C  KLPalg = constant relating hydrolysis rate of LPOP to algae
C  KDPalg = constant relating hydrolysis rate of DOP to algae
C  CPprm1 = constant used in determining algae Phos-to-Carbon ratio
C  CPprm2 = constant used in determining algae Phos-to-Carbon ratio
C  CPprm3 = constant used in determining algae Phos-to-Carbon ratio
C
C21 KRP    KLP    KDP    KRPalg  KLPalg KDPalg CPprm1 CPprm2 CPprm3
    0.01   0.0    0.1    0.0     0.0    0.5    30.0   20.0   350.0
C-------------------------------------------------------------------------------
```

Card Image 21 specifies a number of parameters related to phosphorus kinetics. K_{RPOP} and K_{LPOP} are the minimum hydrolysis rate of refractory and labile particulate organic phosphorus, respectively, in day^{-1} (equations 2.47 and 2.48 in Tetra Tech (2007c)). K_{DOP} is the minimum mineralization rate of dissolved organic phosphorus, in day^{-1} (see equation 2.49). K_{RPalg} and K_{LPalg} are the constants that relate hydrolysis of refractory and labile particulate organic phosphorus, respectively, to algal biomass, in day^{-1} per mg/L of C (see equations 2.54 and 2.55 in Tetra Tech (2007c)). K_{DPalg} is a constant that relates phosphorus mineralization to algal biomass, in day^{-1} per mg/L of C (see equation 2.56). CP_{prm1} is the minimum carbon-to-phosphorus ratio (g C per g P), CP_{prm2} is the difference between minimum and maximum carbon-to-phosphorus ratio (g C per g P) and CP_{prm3} is the effect of dissolved phosphate concentration on carbon-to-phosphorus ratio (per mg/L of P) (see equation 2.53).

Card Image 22

```
C-------------------------------------------------------------------------
C22 ONE TITLE CARD FOLLOWS:
$$ C22 constant parameters for NITROGEN (see Table 3-4) $$
C22
C    FNRP = nitrogen distribution coef. for algae predation: RPON
C    FNLP = nitrogen distribution coef. for algae predation: LPON
C    FNDP = nitrogen distribution coef. for algae predation: DON
C    FNIP = nitrogen distribution coef. for algae predation: Inorganic N
C    FNRc = nitrogen distribution coef. of RPON for cyanobacteria metabolism
C    FNRd = nitrogen distribution coef. of RPON for algae diatoms metabolism
C    FNRg = nitrogen distribution coef. of RPON for algae greens  metabolism
C    FNLc = nitrogen distribution coef. of LPON for cyanobacteria metabolism
C    FNLd = nitrogen distribution coef. of LPON for algae diatoms metabolism
C    FNLg = nitrogen distribution coef. of LPON for algae greens  metabolism
C
C22 FNRP  FNLP  FNDP  FNIP  FNRc  FNRd  FNRg FNLc  FNLd  FNLg
    0.2   0.0   0.7   0.1   0.0   0.0   0.2  0.0   0.0   0.0
C-------------------------------------------------------------------------
```

Card Image 22 specifies a number of parameters related to Nitrogen kinetics. FNRP, FNLP, FNDP and FNIP are the fractions of predated algae (see equations 2.63 to 2.65 in Tetra Tech (2007c)) produced as refractory particulate organic nitrogen, labile particulate organic nitrogen, dissolved organic nitrogen, and inorganic nitrogen, respectively. The sum of these four predation fractions should be unity (FNRP + FNLP + FNDP + FNIP = 1.0). FNR_c, FNR_d, and FNR_g are the fraction of metabolized nitrogen by cyanobacteria, diatoms and green algae, respectively, produced as refractory particulate organic nitrogen (equation 2.63). FNL_c, FNL_d, and FNL_g are the fraction of metabolized nitrogen by cyanobacteria, diatoms and green algae, respectively, produced as labile particulate organic nitrogen (equation 2.64). The following fractions must sum to 1.0:

$$FNR_c + FNL_c + FND_c + FNI_c = 1.0$$
$$FNR_d + FNL_d + FND_d + FNI_d = 1.0$$
$$FNR_g + FNL_g + FND_g + FNI_g = 1.0$$

Fractions shown in italic are defined in Card image 24.

Card Image 23

```
C-------------------------------------------------------------------------------
C23 ONE TITLE CARD FOLLOWS:
$$ C23  constant parameters for NITROGEN (MACROALGAE)
C23
C   FNRPM = nitrogen distribution coef. for marcoalgae predation: RPON
C   FNLPM = nitrogen distribution coef. for marcoalgae predation: LPON
C   FNDPM = nitrogen distribution coef. for marcoalgae predation: DON
C   FNIPM = nitrogen distribution coef. for marcoalgae predation: Inorganic N
C    FNRm = nitrogen distribution coef. of RPON for macroalgae metabolism
C    FNLm = nitrogen distribution coef. of LPON for macroalgae metabolism
C
C23 FNRPM FNLPM  FNDPM  FNIPM  FNRm  FNLm
    0.4   0.5    0.1    0.0    0.2   0.4
C-------------------------------------------------------------------------------
```

Card Image 23 specifies a number of parameters related to Nitrogen kinetics.p of the $FNRP_m$, $FNLP_m$, $FNDP_m$,and $FNIP_m$ are the fractions of predated macroalgae (see equations 2.63 to 2.64 in Tetra Tech (2007c)) produced as refractory particulate organic nitrogen, labile particulate organic nitrogen, dissolved organic nitrogen and inorganic nitrogen, respectively. The sum of these four predation fractions should be unity ($FNRP_m + FNLP_m + FNDP_m + FNIP_m = 1.0$). FNR_m and FNL_m are the fraction of metabolized nitrogen by macroalgae produced as refractory and labile particulate organic nitrogen, respectively. The following fractions must sum to 1.0:

$$FNR_m + FNL_m + FND_m + FNI_m = 1.0$$

Fractions shown in italic are defined in Card image 24.

Card Image 24

```
C------------------------------------------------------------------------
C24 constant parameters for NITROGEN (see Table 3-4)
C    FNDc = nitrogen distribution coef. of DON for cyanobacteria metabolism
C    FNDd = nitrogen distribution coef. of DON for algae diatoms metabolism
C    FNDg = nitrogen distribution coef. of DON for algae greens metabolism
C    FNDm = nitrogen distribution coef. of DON for macroalgae metabolism
C    FNIc = nitrogen distribution coef. of DIN for cyanobacteria metabolism
C    FNId = nitrogen distribution coef. of DIN for algae diatoms metabolism
C    FNIg = nitrogen distribution coef. of DIN for algae greens metabolism
C    FNIm = nitrogen distribution coef. of DIN for macroalgae metabolism
C    ANCc = nitrogen-to-carbon ratio for cyanobacteria
C    ANCd = nitrogen-to-carbon ratio for algae diatoms
C    ANCg = nitrogen-to-carbon ratio for algae greens
C    ANCm = nitrogen-to-carbon ratio for macroalgae
C Note: FNRx + FNLx + FNDx + FNIx = 1.0
C
C24 FNDc  FNDd  FNDg  FNDm  FNIc  FNId  FNIg  FNIm  ANCc  ANCd  ANCg  ANCm
    1.0   1.0   .7    1.0   0.0   0.0   0.1   0.0   0.167 0.167 0.167 0.167
C------------------------------------------------------------------------
```

Card Image 24 specifies a number of parameters related to Nitrogen kinetics. FND_c, FND_d, FND_g, and FND_m are the fraction of metabolized nitrogen by cyanobacteria, diatoms, green algae, and macroalgae, respectively, produced as dissolved organic nitrogen (equation 2.65 in Tetra Tech (2007c)). FNI_c, FNI_d, FNI_g, and FNI_m are the fraction of metabolized nitrogen by cyanobacteria, diatoms, green algae, and macroalgae, respectively, produced as inorganic nitrogen (equation 2.66 in Tetra Tech (2007c)). The following fractions must sum to 1.0:

$$FNR_c + FNL_c + FND_c + FNI_c = 1.0$$
$$FNR_d + FNL_d + FND_d + FNI_d = 1.0$$
$$FNR_g + FNL_g + FND_g + FNI_g = 1.0$$
$$FNR_m + FNL_m + FND_m + FNI_m = 1.0$$

Fractions shown in italic are defined in Card images 22 and 23. ANC_c, ANC_d, ANC_g, and ANC_m are the nitrogen-to-carbon ratio in cyanobacteria, diatoms, green algae and macroalgae, respectively, in g N per g C (see equations 2.63 to 2.66).

Card Image 25

```
C-------------------------------------------------------------------------------
C25 constant parameters for NITROGEN (see Table 3-4)
C    ANDC = mass NO3 reduces per DOC oxidized (gN/gC)
C   rNitM = maximum nitrification rate (gN/m3/day)
C KHNitDO = nitrification half-sat. constant for DO
C  KHNitN = nitrification half-sat. constant for NH4
C    TNit = reference temperature for nitrification (degC)
C   KNit1 = suboptimal temperature effect constant for nitrification
C   Knit2 = superoptimal temperature effect constant for nitrification
C
C
C25 ANDC    rNitM   KHNitDO KHNitN  TNit    KNit1   KNit2
    0.933   0.35    1.0     1.0     55.0   0.0012  0.0012
C-------------------------------------------------------------------------------
```

Card Image 25 specifies a number of parameters related to Nitrogen kinetics. ANDC is the mass of nitrate nitrogen reduced per mass of dissolved organic carbon oxidized (0.933 g N per g C from equation 2.43 in Tetra Tech (2007c)). Nit_m is the maximum nitrification rate at temperature TNit, in mg/L of per day (see equation 2.74). $KHNit_{DO}$ is the nitrification half-saturation constant for dissolved oxygen, in mg/L of O_2 (see equation 2.74). $KHNit_N$ is the nitrification half-saturation constant for ammonium, in mg/L of N(see equation 2.74). TNit is the optimum temperature for nitrification, in degree C, where nitrification is maximum (see equation 2.77). KNit1 is the effect of temperature below TNit on nitrification rate ($^oC^{-2}$) and KNit2 is the effect of temperature above TNit on nitrification rate ($^o C^{-2}$) (see equation 2.77).

Card Image 26

```
C-------------------------------------------------------------------------
C26 constant parameters for NITROGEN (see Table 3-4)
C     KRN = minimum hydrolysis rate (1/day) of RPON
C     KLN = minimum hydrolysis rate (1/day) of LPON
C     KDN = minimum hydrolysis rate (1/day) of DON
C  KRNalg = constant relating hydrolysis rate of RPON to algae
C  KLNalg = constant relating hydrolysis rate of LPON to algae
C  KDNalg = constant relating hydrolysis rate of DON to algae
C    0.0085          0.085
C26 KRN     KLN     KDN     KRNalg  KLNalg  KDNalg
    0.008   0.0     0.08    0.0     0.0     0.0
C-------------------------------------------------------------------------
```

Card Image 26 specifies a number of parameters related to Nitrogen kinetics. K_{RPON} and K_{LPON} are the minimum hydrolysis rate of refractory and labile particulate organic nitrogen, respectively, in day^{-1} (equations 2.63 and 2.64 in Tetra Tech (2007c)). K_{DOP} is the minimum mineralization rate of dissolved organic nitrogen, in day^{-1} (see equation 2.65). K_{RNalg} and K_{LNalg} are the constants that relate hydrolysis of refractory and labile particulate organic nitrogen,

respectively, to algal biomass, in day^{-1} per mg/L of C (see equations 2.69 and 2.70 in Tetra Tech (2007c)). K_{DNalg} is a constant that relates nitrogen mineralization to algal biomass, in day^{-1} per mg/L of C (see equation 2.71).

Card Image 27

```
C-------------------------------------------------------------------------------
C27 ONE TITLE CARD FOLLOWS:
$$ C27 constant parameters for SILICA (see Table 3-5) $$
C27
C    FSPP = silica distribution coef. for diatom predation
C    FSIP = silica distribution coef. for diatom predation
C    FSPd = silica distribution coef. for diatom metabolism
C    FSId = silica distribution coef. for diatom metabolism
C    ASCd = silica-to-carbon ratio for algae diatoms
C    KSAp = partition coef. for sorbed/dissolved SA
C     KSU = dissolution rate (1/day) of particulate silica (PSi)
C   TRSUA = reference temperature (degC) for PSi dissolution
C   KTSUA = temperature effect on PSi dissolution
C
C27 FSPP    FSIP    FSPd    FSId    ASCd    KSAp    KSU     TRSUA   KTSUA
    1.0     0.0     1.0     0.0     0.36    0.16    0.05    20.0    0.092
C-------------------------------------------------------------------------------
```

Card Image 27 specifies a number of parameters related to Silica kinetics. FSPP and FSIP are the fraction of predated diatom silica produced as particulate biogenic silica and as available silica, respectively (see equations 2.80 and 2.81 in Tetra Tech (2007c)). FSP_d and FSI_d are the fraction of metabolized silica by diatoms produced as particulate biogenic silica and as available silica, respectively (see equations 2.80 and 2.81). ASC_d is the silica-to-carbon ratio of diatoms (g Si per g C). K_{SAp} is an empirical coefficient relating available silica sorption to total suspended solid (per g m^{-3}) or particulate total active metal (per mol m^{-3}) concentration (see equations 2.82 and 2.83 in Tetra Tech (2007c)). K_{SUA} is the dissolution rate of particulate biogenic silica (day^{-1}) (equations 2.80 and 2.81). TR_{SUA} is the reference temperature for dissolution of particulate biogenic silica (^oC) and KT_{SUA} is the effect of temperature on dissolution of particulate biogenic silica ($^oC^{-1}$) (see equation 2.84).

Card Image 28

```
C-------------------------------------------------------------------------
C28 ONE TITLE CARD FOLLOWS:
$$ C28 constant parameters for COD & DO (see Table 3-6) $$
C28
C    AOCR = stoichiometric algae oxygen-to-carbon ratio (gO2/gC)
C    AONT = stoichiometric algae oxygen-to-nitrate ratio (gO2/gN)
C     KRO = reaeration constant (3.933 for OConnor-Dobbins; 5.32 for Owen-Gibbs)
C     KTR = temperature rate constant for reaeration
C   KHCOD = oxygen half-saturation constant for COD decay (mg/L O2)
```

```
C     KCD = COD decay rate (per day)
C   TRCOD = reference temperature for COD decay (degC)
C   KTCOD = temperature rate constant for COD decay
C  AOCRpm = macroalgae photosynthesis oxygen-to-carbon ratio
C  AOCRrm = macroalgae respiration oxygen-to-carbon ratio
C
C28 AOCR    AONT    KRO     KTR     KHCOD   KCD     TRCOD   KTCOD AOCRpm AOCRrm
    2.67    4.33    3.933  1.028    1.5     1.00    20.0    0.041 2.67   2.67
C-------------------------------------------------------------------------------
```

Card Image 28 specifies a number of parameters related to Chemical Oxygen Demand and Dissolved Oxygen kinetics. AOCR is the dissolved oxygen-to-carbon ratio in respiration (2.67 g O_2 per g C; see Section 2.4.7.1 in Tetra Tech (2007c)). AONT is the mass of dissolved oxygen consumed per unit mass of ammonium nitrogen nitrified (4.33 g O_2 per g N; see Section 2.4.7.2). K_{r0} is the reaeration coefficient (day^{-1}). If IWQKA=0 in Card image 3, K_{r0} is the total reaeration at 20 ^oC. If IWQKA=1, K_{r0} is the total hydraulic reaeration at 20 ^oC. If IWQKA=2, O'Connor Dobbins is used to compute hydraulic reaeration and K_{r0} should be equal to 3.933. If IWQKA=3, Owen Gibbs is used to calculate hydraulic reaeration and K_{r0} should be equal to 5.32. KT_r is the constant for temperature adjustment of DO reaeration rate. KH_{COD} is the half-saturation constant of dissolved oxygen required for oxidation of chemical oxygen demand (g O_2 m^{-3}) (see equation 4-67). K_{CD} is the oxidation rate of chemical oxygen demand at the reference temperature TR_{COD} (day^{-1}) and KT_{COD} is the effect of temperature on oxidation of chemical oxygen demand ($^oC^{-1}$) (see equation 2.86 in Tetra Tech (2007c)). $AOCR_{pm}$ and $AOCR_{rm}$ are the dissolved oxygen-to-carbon ratio in photosynthesis and respiration, respectively, for macroalgae (2.67 g O_2 per g C).

Card Image 29

```
C-------------------------------------------------------------------------------
C29 ONE TITLE CARD FOLLOWS:
$$ C29 constant parameters for TAM & FCB (see Table 3-7) $$
C29
C   KHbmf = DO concentration where TAM release is half the anoxic rate
C   BFTAM = anoxic release rate of TAM (mol/m2/day)
C    Ttam = reference temperature for TAM release (degC)
C    Ktam = temperature effect constant for TAM release
C  TAMdmx = TAM solubility at anoxic conditions (mol/m3)
C  Kdotam = constant relating TAM solubility to DO
C    KFCB = first-order fecal coliform bacteria decay rate (1/day)
C    TFCB = temperature effect constant for KFCB decay rate
C
C29 KHbmf   BFTAM   Ttam    Ktam    TAMdmx  Kdotam  KFCB    TFCB
    0.5     0.1     20.0    0.2     0.015   1.0     0.0     1.0
C-------------------------------------------------------------------------------
```

Card Image 29 specifies the parameters related to Total Active Metal and Fecal Coliform Bacteria kinetics. KHbmf is the dissolved oxygen concentration at which total active metal release is half the anoxic release rate, in mg/L of O_2 (see equation 2.95 in Tetra Tech (2007c)). BFTAM is the anoxic sediment release rate of total active metal, in mol m^{-2} day^{-1} (see equation 2.95). Ktam is the effect of temperature ($^oC^{-1}$) and Ttam (^oC)is the reference temperature for sediment release of total active metal (see equation 2.95). TAMdmx is the solubility of total active metal under anoxic conditions (mol m^{-3}) and Kdotam is the constant that relates total active metal solubility to dissolved oxygen (per g O_2 m^{-3}) (see equation 2.96). KFCB is a first order fecal coliform bacteria die-off (decay) rate at 20^oC (day^{-1}) and TFCB is the effect of temperature on decay of fecal coliform bacteria ($^oC^{-1}$) (see equation 2.98).

Card Image 30

```
C------------------------------------------------------------------------
C30 SIX TITLE CARDS FOLLOW:
$$ C30 CONCENTRATION TIME SERIES DATA $$
$$ NUMBER OF TIME SERIES FOR EACH STATE VARIABLE
$  B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
$  c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
$           O  O  C  O  O  P  4  O  O  N  4  3        D     M
$           C  C     P  P     t  N  N
   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0
C------------------------------------------------------------------------
```

In Card Image 30 the number of concentration time series for each variable boundary conditions are specified. The time series input files corresponding to each variable are:

1) cyanobacteria (Bc): cwqsr01.inp.
2) diatom algae (Bd): cwqsr02.inp.
3) green algae (Bg): cwqsr03.inp.
4) refractory particulate organic carbon (RPOC): cwqsr04.inp.
5) labile particulate organic carbon (LPOC): cwqsr05.inp.
6) dissolved carbon (DOC): cwqsr06.inp.
7) refractory particulate organic phosphorus (RPOP): cwqsr07.inp.
8) labile particulate organic phosphorus (LPOP): cwqsr08.inp.
9) dissolved organic phosphorus (DOP): cwqsr09.inp.
10) total phosphate (PO4): cwqsr10.inp.
11) refractory particulate organic nitrogen (RPON): cwqsr11.inp.
12) labile particulate organic nitrogen (LPON): cwqsr12.inp.
13) dissolved organic nitrogen (DON): cwqsr13.inp.
14) ammonia nitrogen (NH4): cwqsr14.inp.

15) nitrate nitrogen (NO3): cwqsr15.inp.
16) particulate biogenic silica (SU): cwqsr16.inp.
17) dissolved available silica (SA): cwqsr17.inp.
18) chemical oxygen demand (COD): cwqsr18.inp.
19) dissolved oxygen (DO): cwqsr19.inp.
20) total active metal (TAM): cwqsr20.inp.
21) fecal coliform bacteria (FC): cwqsr21.inp.
These files are also described in this manual.

Card Image 31

```
C------------------------------------------------------------------------------
C31 ONE TITLE CARD FOLLOWS:
$$ C31 parameters for OPEN BDRY CONDITIONS $$
C31
C  NWQOBS = number of WQ open boundary cells on SOUTH boundary
C  NWQOBW = number of WQ open boundary cells on WEST boundary
C  NWQOBE = number of WQ open boundary cells on EAST boundary
C  NWQOBN = number of WQ open boundary cells on NORTH boundary
C
C31 NWQOBS  NWQOBW  NWQOBE  NWQOBN
    1       0        24      0
C------------------------------------------------------------------------------
```

This card image is used to specify concentration information on open boundaries. The four parameters (NWQOBS, NWQOBW, NWQOBE, and NWQOBN) specify the number of water quality open boundary cells on the South, West, East, and North computational grid direction faces, and should be identical to the values of the first four parameters on Card image 16 of file *efdc.inp*.

Card Image 32

```
C------------------------------------------------------------------------
C32 SIX TITLE CARDS FOLLOW:
$$ C32 SOUTH OPEN BOUNDARY $$
$$ TIME SERIES ID'S FOR EACH STATE VARIABLE
$  I   J   B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
$          c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
$                   O  O  C  O  O  P  4  O  O  N  4  3        D     M
$                   C  C     P  P     t  N  N
   2  13   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

C------------------------------------------------------------------------
```

Card Image 32 specifies the time series concentration corresponding to the NWQOBS south open boundaries. The locations of the open boundary cells are specify by the indices I and J.

For each variable the time series number in input files *cwqsrNN.inp* corresponding to the defined location are given.

Card Image 33

```
C------------------------------------------------------------------------------
C33 FIVE TITLE CARDS FOLLOW:
$$ C33 SOUTH OPEN BOUNDARY $$
$$ CONSTANT BOTTOM CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
   2  13   0       0       0.06    0.1     0       0.4
           0.006   0       0.024   0.02    0.075   0       0.3
           0.025   0.01    0       0       0       6.0     0        1
C------------------------------------------------------------------------------
```

Card Image 33 specifies constant concentration values (mg/L) for the bottom layer of the NWQOBS south open boundaries.

Card Image 34

```
C------------------------------------------------------------------------
C34 FIVE TITLE CARDS FOLLOW:
$$ C34 SOUTH OPEN BOUNDARY $$
$$ CONSTANT SURFACE CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
   2  13   0       0       0.06    0.1     0       0.4
           0.006   0       0.024   0.02    0.075   0       0.3
           0.025   0.01    0       0       0       6.0     0        1
C------------------------------------------------------------------------
```

Card Image 34 specifies constant concentration values (mg/L) for the surface layer of the NWQOBS south open boundaries. If the number of layers exceeds two, values for the interior layers are linearly interpolated between the bottom and surface layer values.

Card Image 35

```
C------------------------------------------------------------------------------
C35 SIX TITLE CARDS FOLLOW:
$$ C35 WEST OPEN BOUNDARY $$
$$ TIME SERIES ID'S FOR EACH STATE VARIABLE
$  I   J   B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
$          c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
$                   O  O  C  O  O  P  4  O  O  N  4  3        D     M
$                   C  C     P  P     t  N  N
C------------------------------------------------------------------------------
```

Same as Card image 32 for the NWQOBW west open boundaries.

Card Image 36

```
C-------------------------------------------------------------------
C36 FIVE TITLE CARDS FOLLOW:
$$ C36 WEST OPEN BOUNDARY $$
$$ CONSTANT BOTTOM CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
C-------------------------------------------------------------------
```

Same as Card image 33 for the NWQOBW west open boundaries.

Card Image 37

```
C-------------------------------------------------------------------------------
C37 FIVE TITLE CARDS FOLLOW:
$$ C37 WEST OPEN BOUNDARY $$
$$ CONSTANT SURFACE CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
C-------------------------------------------------------------------------------
```

Same as Card image 34 for the NWQOBW west open boundaries.

Card Image 38

```
C-------------------------------------------------------------------
C38 SIX TITLE CARDS FOLLOW:
$$ C38 EAST OPEN BOUNDARY $$
$$ TIME SERIES ID'S FOR EACH STATE VARIABLE
$  I   J   B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
$          c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
$                   O  O  C  O  O  P  4  O  O  N  4  3        D     M
$                   C  C     P  P     t  N  N
69   3     0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0
C-------------------------------------------------------------------
```

Same as Card image 32 for the NWQOBE east open boundaries.

Card Image 39

```
C-------------------------------------------------------------------------------
C39 FIVE TITLE CARDS FOLLOW:
```

```
$$ C39 EAST OPEN BOUNDARY $$
$$ CONSTANT BOTTOM CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
  69   3   0       0       0.06    0.3     0       0.2
           0.006   0       0.024   0.02    0.2     0       0.13
           0.016   0.01    0       0       0       0       0        1
C-------------------------------------------------------------------------
```

Same as Card image 33 for the NWQOBE east open boundaries.

Card Image 40

```
C-------------------------------------------------------------------
C40 FIVE TITLE CARDS FOLLOW:
$$ C40 EAST OPEN BOUNDARY $$
$$ CONSTANT SURFACE CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
  69   3   0       0       0.06    0.3     0       0.2
           0.006   0       0.024   0.02    0.2     0       0.13
           0.016   0.01    0       0       0       0       0        1
C-------------------------------------------------------------------
```

Same as Card image 34 for the NWQOBE east open boundaries.

Card Image 41

```
C-----------------------------------------------------------------------
C41 SIX TITLE CARDS FOLLOW:
$$ C41 NORTH OPEN BOUNDARY $$
$$ TIME SERIES ID'S FOR EACH STATE VARIABLE
$  I   J   B  B  B  R  L  D  R  L  D  P  R  L  D  N  N  S  S  C  D  T  F
$          c  d  g  P  P  O  P  P  O  O  P  P  O  H  O  U  A  O  O  A  C
$                   O  O  C  O  O  P  4  O  O  N  4  3        D     M
$                   C  C     P  P     t  N  N
C-----------------------------------------------------------------------
```

Same as Card image 32 for the NWQOBN north open boundaries.

Card Image 42

```
C-------------------------------------------------------------------
C42 FIVE TITLE CARDS FOLLOW:
$$ C42 NORTH OPEN BOUNDARY $$
$$ CONSTANT BOTTOM CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$          RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$          NH4     NO3     SU      SA      COD     DO      TAM     FCB
C-------------------------------------------------------------------
```

Same as Card image 33 for the NWQOBN north open boundaries.

Card Image 43

```
C------------------------------------------------------------------------------
C43 FIVE TITLE CARDS FOLLOW:
$$ C43 NORTH OPEN BOUNDARY $$
$$ CONSTANT SURFACE CONCENTRATION BC'S
$  I   J   Bc      Bd      Bg      RPOC    LPOC    DOC
$           RPOP    LPOP    DOP     PO4t    RPON    LPON    DON
$           NH4     NO3     SU      SA      COD     DO      TAM     FCB
C------------------------------------------------------------------------------
```

Same as Card image 34 for the NWQOBN north open boundaries.

Card Image 44

```
C--------------------------------------------------------------------
C44 ONE TITLE CARD FOLLOWS:
$$ C44 constant ICs (g/m^3): TAM(mol/m^3), FCB(MPN/100mL) $$
C44
C Definitions:
C   Bc = cyanobacteria
C   Bd = algae diatoms
C   Bg = algae greens
C RPOC = refractory particulate carbon
C LPOC = labile particulate carbon
C  DOC = dissolved organic carbon
C RPOP = refractory particulate organic phosphorus
C LPOP = labile particulate organic phosphorus
C  DOP = dissolved organic phosphorus
C PO4t = total orthophosphate
C RPON = refractory particulate organic nitrogen
C LPON = labile particulate organic nitrogen
C  DON = dissolved organic nitrogen
C  NH4 = ammonia nitrogen
C  NO3 = nitrite + nitrate nitrogen
C   SU = unavailable silica
C   SA = available biogenic silica
C  COD = chemical oxygen demand
C   DO = dissolved oxygen
C  TAM = total active metal
C  FCB = fecal coliform bacteria
C   Bm = macroalgae
C Bmin = minimum macroalgae biomass
C
C  Bc      Bd      Bg      RPOC    LPOC    DOC
C  RPOP    LPOP    DOP     PO4t    RPON    LPON    DON           2.0  0.2
C  NH4     NO3     SU      SA      COD     DO      TAM     FCB   Bm  Bmin
   0.000   0.000   0.358   0.840   0.000   0.560
   0.004   0.000   0.018   0.028   0.150   0.000   0.100
   0.049   0.123   0.000   0.000   0.000    8.00   0.0     0.000 0.00 0.00
C--------------------------------------------------------------------
```

Card image 44 specifies constant values for initial condition concentration (mg/L). These values are used when IWQICI =0 in Card image 5.

Card Image 45

```
C------------------------------------------------------------------------------
C45 ONE TITLE CARD FOLLOWS:
$$ C45 spatially/temporally constant ALGAL PARAMETERS (/d except Keb in /m) $$
C45
C    PMc = max. growth rate for cyanobacteria (1/day)
C    PMd = max. growth rate for algae diatoms (1/day)
C    PMg = max. growth rate for algae greens  (1/day)
C    PMm = max. growth rate for macroalgae    (1/day)
C   BMRc = basal metabolism rate for cyanobacteria (1/day)
C   BMRd = basal metabolism rate for algae diatoms (1/day)
C   BMRg = basal metabolism rate for algae greens  (1/day)
C   BMRm = basal metabolism rate for macroalgae    (1/day)
C   PRRc = predation rate on cyanobacteria (1/day)
C   PRRd = predation rate on algae diatoms (1/day)
C   PRRg = predation rate on algae greens  (1/day)
C   PRRm = predation rate on macroalgae    (1/day)
C    Keb = background light extinction coefficient (1/m)
C                                                        0.17
C45   PMc  PMd  PMg  PMm BMRc BMRd  BMRg  BMRm PRRc  PRRd  PRRg  PRRm   Keb
      0.0  0.0  2.00 0.0 0.0  0.0   0.02  0.0  0.0   0.0   0.1   0.0    0.4
C------------------------------------------------------------------------------
```

Card Image 45 specifies spatially and temporally constant algal growth and death parameters, used when IWQAGR=0 in Card image 5. PM_c, PM_d, PM_g, and PM_m are the maximum growth rate under optimal conditions for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.6 in Tetra Tech (2007c)). BMR_c, BMR_d, BMR_g, and BMR_m are the basal metabolism rate at the reference temperatures specified in Card image 13 for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.27). PRR_c, PRR_d, PRR_g, and PRR_m are the predation rate at the reference temperatures specified in Card image 13 for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.28). Ke_b is the background light extinction coefficient, in m^{-1} (see equation 2.11).

Card Image 46

```
C------------------------------------------------------------------------
C46 ONE TITLE CARD FOLLOWS:
$$ C46 spatially/temporally constant SETTLING VELOCITIES (m/d) $$
C46
C    WSc = settling velocity for cyanobacteria (m/day)
C    WSd = settling velocity for algae diatoms (m/day)
C    WSg = settling velocity for algae greens  (m/day)
C   WSrp = settling velocity for refractory POM (m/day)
C   WSlp = settling velocity for labile POM (m/day)
```

```
C    WSs = settling velocity for particles sorbed to TAM (m/day)
C    WSM = settling velocity for macroalgae (m/day = 0.0)
C   REAC = reaeration adjustment factor
C
C46 WSc     WSd     WSg     WSrp    WSlp    WSs     WSM   REAC
    0.0     0.0     0.25     0.25    0.0     0.0    0.0   1.0
C-------------------------------------------------------------------
```

Card Image 46 specifies spatially and temporally constant settling velocities, used when IWQSTL=0 in Card image 5. WS_c, WS_d, and WS_g are the settling velocities of cyanobacteria, diatoms and green algae, respectively, in m day^{-1} (see equation 2.5 in Tetra Tech (2007c)). WS_{RP}, and WS_{LP} are the settling velocities of refractory and labile particulate organic matter, respectively, in m day^{-1}. WS_s is the settling velocity of particulate metal, in m day^{-1} (see equation 2.95). WS_m is the settling velocity of macroalgae, in m day^{-1} and should be set to 0.0. REAC is a global reaeration adjustment factor.

Card Image 47

```
C-------------------------------------------------------------------------------
C47 ONE TITLE CARD FOLLOWS:
$$ C47 constant benthic flux rates (g/m^2/d) $$
C47
C   FPO4 = benthic flux rate of phosphate
C   FNH4 = benthic flux rate of ammonia nitrogen
C   FNO3 = benthic flux rate of nitrite+nitrite nitrogen
C   FSAD = benthic flux rate of silica
C   FCOD = benthic flux rate of chemical oxygen demand
C    SOD = sediment oxygen demand rate
C     0.018   0.059
C47  FPO4    FNH4    FNO3    FSAD    FCOD    SOD
     0.0     0.0     0.000   0.000   0.000   -1.0
C-------------------------------------------------------------------------------
```

Card Image 47 specifies spatially and temporally constant benthic fluxes, used when IWQBEN=0 in Card image 3. FPO4, FNH4, FNO3, FSAD, and FCOD are the benthic fluxes rate of phosphate, ammonia, nitrate-nitrite, silica, and chemical oxygen demand, respectively, in g m^{-2} day^{-1}. Positive values represent a flux from the sediment into the water column (source) and negative values represent a flux from the water column into the sediment (sink). SOD is the sediment oxygen demand rate, in g m^{-2} day^{-1}. It is always negative and represents a sink of dissolved oxygen from the water column.

Card Image 48

```
C-------------------------------------------------------------------------
C48 ONE TITLE CARD FOLLOWS:
$$ C48 const PS (kg/d): PSQ(m^3/s),DO(g/m^3),TAM(kmol/d),FCB(MPN/100mL)
```

```
C48
C   IWQPS = number of point sources
C NPSTMSR = number of point source time series
C
C48 const PS (kg/d): PSQ(m^3/s),DO(g/m^3),TAM(kmol/d),FCB(MPN/100mL)
C IWQPS   NPSTMSR
  1       1
C   I    J    K    N  PSQ     Bc   Bd   Bg RPOC LPOC  DOC
C             S      RPOP   LPOP  DOP PO4t RPON LPON  DON
C             R       NH4    NO3   SU   SA  COD   DO  TAM  FCB
   36   73    0    1  0.0    0.0  0.0  0.0  0.0  0.0  0.0
                      0.0    0.0  0.0  0.0  0.0  0.0  0.0
                      0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0
C-----------------------------------------------------------------
```

Card Image 48 specifies point source loads. IWQPS is the number of point sources and NPSTMSR the number of point sources time series in file *wqpsl.inp*. Next, IWQPS locations are specified by indices I and J. KSR indicate in which layer the load enter the domain. If KSR=0 the load is evenly distributed among all the layers. N specifies the time series number in file *wqpsl.inp* corresponding to this I and J location. Follows constant load values for all constituents. PSQ is the constant flow corresponding to the load, in m3/s. If PSQ is larger than zero, then dissolved oxygen is given as a concentration, in mg/L, corresponding to this flow. All other loads are in kg/day, except total active metal in kmol/day and fecal coliform in MPN/100mL.

Card Image 49

```
C-------------------------------------------------------------------------
C49 FOUR TITLE CARDS FOLLOW:
$$ C49 Constant Dry Atmospheric Deposition (g/m2/day; MPN/m2/day)
$ DSQ       Bc        Bd        Bg        RPOC      LPOC      DOC
$ RPOP      LPOP      DOP       PO4t      RPON      LPON      DON
$ NH4       NO3       SU        SA        COD       DO        TAM       FCB
  0.0       0.0       0.0       0.0       0.00035   0.0       0.00035
  0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0003    0.002     0.0       0.0       0.0       0.0       0.0       0.0
C-------------------------------------------------------------------------
```

Card Image 49 specifies constant dry weather atmospheric deposition for all the variables, in g m^{-2} day^{-1}.

Card Image 50

```
C-------------------------------------------------------------------------
C50 FOUR TITLE CARDS FOLLOW:
$$ C50 Wet Atmospheric Deposition concentrations (mg/L; MPN/L)
$           Bc        Bd        Bg        RPOC      LPOC      DOC
$ RPOP      LPOP      DOP       PO4t      RPON      LPON      DON
$ NH4       NO3       SU        SA        COD       DO        TAM       FCB
```

```
            0.0       0.0       0.0       0.3       0.0       0.3
  0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.11      0.73      0.0       0.0       0.0       7.0       0.0       0.0
C-------------------------------------------------------------------
```

Card Image 50 specifies constant wet weather atmospheric deposition concentration for all the variables, in mg/L. These concentrations are associated to the rain flow specified in file *aser.inp*.

Card Image 51

```
C-------------------------------------------------------------------------------
C51 ONE TITLE CARD FOLLOWS:
$$ C51 File names for spatially/temporally varying parameters: lower case only $$
Restart file for end spatial distribution = NONE
File for initial conditions (ICIFN)       = NONE
File for algal growth, resp, pred (AGRFN) = algaegro.inp
File for settling of algae, POM (STLFN)   = NONE
Input file for Io, FD, KT, Te (SUNFN)     = NONE
Input file for benthic fluxes (BENFN)     = benticflux.inp
Input file for point source input (PSLFN) = NONE
File for NPS input inc/atm input (NPLFN)  = NONE
Diagnostic file-negative conc. (NCOFN)    = wq3dnc.log
C-------------------------------------------------------------------------------
```

Card Image 51 specify the names of files for spatially and temporally varying parameters. First file name for a restart output file is no longer active. If IWQRST=1 in Card image 4, the restart information will be saved to file *Wqwcrst.out*. ICIFN is the name of the file with initial conditions when IWQICI=1 in Card image 5. AGRFN is the name of the file with spatially and temporally varying algal parameters when IWQAGR=1 in Card image 5. STLFN is the name of the file with spatially and temporally varying settling velocities when IWQSTL=1 in Card image 5.

SUNFN is the name of the file with daily solar radiation and fraction of daylight when IWQSUN=1 in Card image 5. BENFN is the name of the file with spatially and temporally varying benthic fluxes when IWQBEN=2 in Card image 3. The benthic zones are defined in a file named *wqwcbenmap.inp*. PSLFN and NPLFN are no longer used. NCOFN is name of the output file where negative concentrations are saved for diagnostic purposes.

6.2 Input File wqpsl.inp

This file defines the time series for point sources loads. It is required when IWQPSL=1 in Card image 5 of *wq3dwc.inp*. The loads are given in kg/day except for fecal coliform which is in MPN/day. Algal group loads are given in kg/day of Carbon.

```
C WQPSL.INP, time-variable point source loads for EFDC
C
C Loads are in kg/day except coliform var=21 which is mpn/day
C Bc, Bd, Bg  groups are in kgC/day
C
C WQPSR(NS) TCWQPSR(NS) TAWQPSR(NS) RMULADJ(NS) ADDADJ(NS)
C   1st line  TWQPSER(M,NS)  WQPSSER(M,NWV= 1: 7,NS)
C   2nd line  WQPSSER(M,NWV= 8:14,NS) 3rd line  WQPSSER(M,NWV=15:21,NS)
C
C          1)Bc      2)Bd      3)Bg      4)RPOC     5)LPOC      6)DOC     7)RPOP
C          8)LPOP    9)DOP     10)PTO4   11)RPON    12)LPON     13)DON    14)NH4
C         15)NO3     16)SU     17)SA     18)COD     19)DO       20)TAM    21)FCB   22)Malg
C
    365  86400.0  0.0  1.0  0.0
 0.0        0.000     0.000     0.160    15.550     0.000    10.370     0.010
            0.000     0.030     0.040     0.540     0.000     0.360     0.060
            0.050     0.000     0.000     0.000    23.670     0.000     2.590     0.000
 200.0      0.000     0.000     0.160    15.550     0.000    10.370     0.010
            0.000     0.030     0.040     0.540     0.000     0.360     0.060
            0.050     0.000     0.000     0.000    23.700     0.000     2.590     0.000
```

A point source load time series input file may contain multiple time series. Each time series set begins with the single data line specifying WQPSR (the number of time data points for this time series), TCWQPSR (a multiplying conversion factor changing the input time units to seconds), TAWQPSR (an additive time adjustment, applied before unit conversion), RMULADJ (a multiplying conversion factor for the loads), and ADDADJ (an additive conversion for loads, applied before the multiplier). Follows WQPSR sets of three lines. The first line specifies the time and the load for cyanobacteria, diatom algae, green algae, refractory particulate organic carbon, labile particulate organic carbon, dissolved carbon, and refractory particulate organic phosphorus. The second line specifies loads for labile particulate organic phosphorus, dissolved organic phosphorus, total phosphate, refractory part. organic nitrogen, labile part. organic nitrogen, dissolved organic nitrogen, and ammonia nitrogen. The third line specifies loads for nitrate nitrogen, particulate biogenic silica, dissolved available silica, chemical oxygen demand, dissolved oxygen, total active metal, fecal coliform bacteria and macroalgae.

6.3 Input Files cwqsr01.inp to cwqsr21.inp

The boundary concentration time series files, specified in Card image 30 of *wq3dwc.inp*, have identical formats, and thus it suffices to discuss them in a generic sense. An example of the cwqsr01.inp time series file containing one time series is shown below.

```
C  cwqsr01.inp, Cyanobacteria (mg/L as C)
C
C
C  ISTYP  MCSER(NS,8)  TCCSER(NS,8)  TACSER(NS,8)  RMULADJ(NS,8)   ADDADJ(NS,8)
C
```

```
C  if istyp.eq.1 then read depth weights and single value of CSER
C
C  (WKQ(K),K=1,KC)
C
C  TCSER(M,NS,8)   CSER(M,NS,8)  !(mcser(ns,8) pairs for ns=8,ncser(8) series)
C
C  else read a value of dser for each layer
C
C  TCSER(M,NS,8)   (CSER(M,K,NS,8),K=1,KC) !(mcser(ns,8) pairs)
C
   1   2      86400.0        0.     0.060        0
   1.0     1.0        1.0         1.0
   1.0     0.02
 365.0     0.03
   0   2      86400.0        0.     0.060        0
   1.0     0.02  0.02  0.02  0.02
 365.0     0.03  0.03  0.03  0.03
```

A concentration time series input file may contain multiple time series. Each time series set begins with the single data line specifying ISTYP (the time series format identifier), MCSER (the number of time data points), TCCSER (a multiplying conversion factor changing the input time units to seconds), TACSER (an additive time adjustment, applied before unit conversion), RMULADJ (a multiplying conversion for the concentration), and ADDADJ (an additive conversion for concentration, applied before the multiplier). If the ISTYP parameter is 0, the MCSER time data points must have a concentration value for each layer. If ISTYP = 1, an additional line of data providing multiplying factors is read, and the time data lines should have only one concentration value. Follow MCSER lines of time and concentration values. The first time series of the example shown is for ISTYP=0, for a 4 layer model. Four weight values are given in the second line and one concentration value in the time series. The second time series shows an example of time series when ISTYP = 1. No weight line is specified but for each time four values of concentration, for a 4 layer model, are specified. Weights and concentration are read from the bottom to the top layer.

6.4 Input File wqbenmap.inp

This file defines the benthic sediment zones for spatially variable benthic fluxes. For each domain cell defined by the indices I and J, a percentage (0 to 100) of mud sediment for that cell is assign. Next, indices IZMUD and IZSAND indicate the zone number for the mud and sand fractions of the cell, respectively. The total number of zones and the time varying values of the fluxes are specified in file (BENFN) defined in Card image 51 of *wq3dwc.inp*. The actual flux at each cell is determined as a composite value between the mud and sand fractions flux.

```
c
c
c     with  channel     changed     from  zone  3     to    1
c
#     I     J     XMUD  IZMUD IZSAND
      2     2     0     0     2
      3     2     0     0     2
      4     2     0     0     2
      5     2     0     0     2
      6     2     0     0     2
      7     2     0     0     2
      8     2     0     0     2
      9     2     0     0     2
      10    2     0     0     2
      9     3     0     0     4
      10    3     0     0     4
      11    3     0     0     4
      12    3     0     0     4
      13    3     0     0     4
      14    3     0     0     4
      15    3     0     0     4
      59    3     0     0     1
      60    3     0     0     1
```

6.5 Input File wqwcmap.inp

This file defines the zones for spatially variable water column kinetics. For each domain cell define by the indices I, J and K, a water quality zone is assign by the zone index IWQZX. IWQZX is between 1 and IWQZ defined in Card image 4 of the water quality control file *wq3dwc.inp*.

```
c WQWCMAP.INP - maps I,J,K water column cells to a water quality zone
c maps spatially-variable kinetics
c 1=MAIN CHANNELS; 2=MARSHES  3=upper ashley  4=harbor and offshore
c     i     j     k     IWQZX
      2     2     1     1
      3     2     1     1
      4     2     1     1
      5     2     1     1
      6     2     1     1
      7     2     1     1
      8     2     1     1
      9     2     1     1
      10    2     1     1
      11    2     1     1
      9     3     1     2
      10    3     1     2
      11    3     1     2
      12    3     1     2
```

13	3	1	2
14	3	1	2
15	3	1	2
59	3	1	4
60	3	1	4

6.6 Input File kinetics.inp

This file gives the spatially variable water column kinetic parametes for the IWQZ zones indicated in Card image 4 of the water quality control file *wq3dwc.inp*.

```
C KINETICS.INP
C Spatially-varying kinetic rate constants
C
C   IWQKA = reaeration option
C          = 0, constant reaeration (WQKRO), no wind reaeration
C          = 1, constant reaeration (WQKRO) plus wind reaeration
C          = 2, use O'Connor-Dobbins (1958) formula
C          = 3, use Owens & Gibbs (1964) formula
C          = 4, modified Owens & Gibbs (1964) formula (for Christina River)
C          = 5, Melching & Flores (1999) for pool and riffle streams
C          = 6, Melching & Flores (1999) for channel control streams
C     KRO = reaeration constant (3.933 for OConnor-Dobbins; 5.32 for Owen-Gibbs)
C     KTR = temperature rate constant for reaeration
C     REAC = reaeration adjustment factor (applied to the sum of the wind
C                  and velocity reaeration terms)
C     KDC = minimum dissolution rate (1/day) of DOC
C     KDCalgm = constant relating DOC dissolution rate to macroalgae
C     KHRm = half-sat. constant (gO2/m3) for macroalgae DOC excretion
C     DOPTm = optimal depth (m) for macroalgae growth
C     KCD = COD decay rate (per day)
C     KHCOD = oxygen half-saturation constant for COD decay (mg/L O2)
C     SLOPE = stream slope for reaeration equation option IWQKA = 5 or 6
C
C Zone 1 = MAIN CHANNELS
C          2 = MARSHES
C          3 = UPPER ASHLEY
C          4 = HARBOR AND OFFSHORE
C          5 =
C          6 =
C          7 =
C          8 =
C          9 =
C         10 =
C         11 =
C
CZONE IWQKA  KRO   KTR  REAC   KDC   KDCalgm  KHRm DOPTm   KCD  KHCOD SLOPE
  1     2    3.933  1.024 1.00   0.13   0.015   2.0   1.00   0.0     1.0    0.001
  2     0    0.8    1.024 1.00   0.13   0.025   2.0   1.00   0.0     1.0    0.001
  3     0    0.8    1.024 1.00   0.13   0.025   2.0   1.00   0.0     1.0    0.001
  4     2    3.933  1.024 1.00   0.13   0.015   2.0   1.00   0.0     1.0    0.001
```

The parameters that can be varied spatially are: IWQKA, reaeration option flag. A value of 0 stipulates a constant reaeration given by variable K_{r0}. This constant reaeration is assumed to be the total reaeration. A value of 1 specifies a constant hydraulic reaeration, given by variable K_{r0}.

A computed wind reaeration is added to the hydraulic constant reaeration. For a value of IWQKA=2, the model uses O'Connor-Dobbins (1958) formula to calculate the hydraulic reaeration. For a value of IWQKA=3, the model uses Owens and Gibbs (1964) formula to calculate the hydraulic reaeration. For a value of IWQKA=4, the model uses a modified version of Owens and Gibbs (1964) formula for the hydraulic reaeration. Options IWQKA=5 and 6 are no longer active. K_{r0} is the reaeration coefficient (day^{-1}). If IWQKA=0, K_{r0} is the total reaeration at 20°C. If IWQKA=1, K_{r0} is the total hydraulic reaeration at 20°C. If IWQKA=2, O'Connor Dobbins is used to compute hydraulic reaeration and K_{r0} should be equal to 3.933. If IWQKA=3 or 4, Owen Gibbs is used to calculate hydraulic reaeration and K_{r0} should be equal to 5.32. KT_r is the constant for temperature adjustment of DO reaeration rate. REAC is a global reaeration adjustment factor K_{DOC} is the heterotrophic respiration rate of dissolved organic carbon at infinite dissolved oxygen concentration, in day^{-1} (see equation 2.39 in Tetra Tech (2007c)). K_{DCalgm} is the constant that relates respiration to macroalgae biomass, in day^{-1} per mg/L of C (see equation 2.42). KHR_m is the half-saturation constant of dissolved oxygen for algal dissolved organic carbon excretion for macroalgae, in mg/L of O_2 (see equation 2.31). $(D_{OPT})_m$ is the depth of maximum algal growth, in m, for macroalgae. K_{CD} is the oxidation rate of chemical oxygen demand at the reference temperature TR_{COD} (given in Card image 28 of *wq3dwc.inp*) (see equation 2.86). KH_{COD} is the half-saturation constant of dissolved oxygen required for oxidation of chemical oxygen demand (g O_2 m^{-3}) (see equation 2.85). SLOPE is no longer used.

6.7 Input File BENFN

The name of this file is given in Card image 51 of *wq3dwc.inp*. This file specifies the benthic fluxes zones and the time varying values of the fluxes of total phosphate, ammonium, nitrate-nitrite, dissolved silica, chemical oxygen demand and sediment oxygen demand (as a flux of oxygen).

```
# Time and spatially varying benthic fluxes
# PO4  NH4  NOx  SAD COD SOD
# IZ
 4
 0.000
 1  0.003 0.025 -0.002  0.0  0.0  -0.8       !dominate sand
 2  0.005 0.01   0.001  0.0  0.0  -0.7        !scoured sand
 3  0.003 0.04   0.0    0.0  0.0  -1.2          !sand and mud
 4  0.0   0.0    0.0    0.0  0.0  -1.2             !marshes
 20000.000
 1  0.003 0.025 -0.002  0.0  0.0  -0.8       !dominate sand
```

```
 2  0.005 0.01   0.001  0.0  0.0  -0.7          !scoured sand
 3  0.003 0.04   0.0    0.0  0.0  -1.2            !sand and mud
 4  0.0   0.0    0.0    0.0  0.0  -1.2               !marshes
```

The file has 3 lines of title, the fourth line indicate the number of benthic zones (IZ). Next line is a day when the following fluxes become active. Follows IZ lines of benthic fluxes. Each line has the zone number and the flux values for total phosphate, ammonium, nitrate-nitrite, dissolved silica, chemical oxygen demand and sediment oxygen demand. The flux values are positive when constituents moved from the sediment into the water column. As sediment oxygen demand is a flux of oxygen from the water column into the sediment, its value is always negative.

6.8 Input File AGRFN

The name of this file is given in Card image 51 of *wq3dwc.inp*. This file gives the spatially variable algal growth parameters.

```
c ALGAEGRO.INP -
c Time and spatially varying ALGAL GROWTH PARAMETERS
c
c
cIZ  PMc  PMd  PMg  PMm  BMRc BMRd  BMRg  BMRm PRRc  PRRd  PRRg  PRRm  Keb
 1   0.0  0.0  1.8  0.0  0.0  0.0   0.03  0.0  0.0   0.0   0.07  0.0  0.400
 2   0.0  0.0  1.0  0.0  0.0  0.0   0.03  0.0  0.0   0.0   0.1   0.0  0.600
 3   0.0  0.0  1.8  0.0  0.0  0.0   0.03  0.0  0.0   0.0   0.07  0.0  0.400
 4   0.0  0.0  1.8  0.0  0.0  0.0   0.03  0.0  0.0   0.0   0.07  0.0  0.400
```

For each of the IWQZ zones determined in Card image 4 of *wq3dwc.inp* and assigned in in file *wqwcmap.inp* algal growth parameters are defined. PM_c, PM_d, PM_g, and PM_m are the maximum growth rate under optimal conditions for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.6 in Tetra Tech (2007c)). BMR_c, BMR_d, BMR_g, and BMR_m are the basal metabolism rate at the reference temperatures specified in Card image 13 for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.27). PRR_c, PRR_d, PRR_g, and PRR_m are the predation rate at the reference temperatures specified in Card image 13 for cyanobacteria, diatoms, green algae and macroalgae, respectively, in day^{-1} (see equation 2.28). Ke_b is the background light extinction coefficient, in m^{-1} (see equation 2.11).

6.9 Input File STLFN

The name of this file is given in Card image 51 of *wq3dwc.inp*. This file gives the spatially variable settling velocities.

```
c ALGAESET.INP
c Time and spatially varying ALGAL SETTLING RATES (m/day)
c
c
c IZ   WSc     WSd     WSg     WSrp    WSlp    WSs     WSM
   1   0.0     0.20    0.20    1.00    1.00    0.50    0.0
   2   0.0     0.25    0.25    1.00    1.00    0.50    0.0
   3   0.0     0.25    0.20    1.00    1.00    0.50    0.0
   4   0.0     0.25    0.20    1.00    1.00    0.50    0.0
```

For each of the IWQZ zones determined in Card image 4 of *wq3dwc.inp* and assigned in in file *wqwcmap.inp* settling velocities are defined. WS_c, WS_d, and WS_g are the settling velocities of cyanobacteria, diatoms and green algae, respectively, in m day^{-1} (see equation 2.5 in Tetra Tech (2007c)). WS_{RP}, and WS_{LP} are the settling velocities of refractory and labile particulate organic matter, respectively, in m day^{-1}. WS_s is the settling velocity of particulate metal, in m day^{-1} (see equation 2.95). WS_m is the settling velocity of macroalgae, in m day^{-1}. Should be set to 0.0.

7. Compiling and Executing the Code

To compile the EFDC model, the FORTRAN 77 source code efdc.for and the include files efdc.com, which contains global common blocks, and efdc.par, which contains a global parameter statement are necessary and should reside in the same directory. Extensive efforts have been made to ensure cross-platform compatibility of the EFDC model, however, a number of minor modifications are required for various platforms. The source code efdc.for contains calls to the VMS time utility secnds. For compilers which support the secnds function through systems libraries, (DEC and Hewlett-Packard UNIX systems and Absoft and LSI Macintosh FORTRAN compilers), no modifications to the standard source efdc.f are required if appropriate compiler options are specified. (To determine if your compiler supports the secnds functions, look for secnds or VMS compatibility in the compiler reference manuals.) For compilers which do not support the secnds function, (Cray cf77, Sun UNIX) the real function subroutine secnds.for should be appended to the end of the standard source code. A somewhat less desirable fix is to comment out calls to the secnds function. Many of the IO operations in the efdc.for source code use the open file statement form:

OPEN(1,FILE='fname', STATUS='UNKNOWN',ACCESS='APPEND')

To the writer's knowledge, the only systems which do not support the ACCESS='APPEND' modifier are Cray and IBM Risc6000 UNIX Systems. For Cray compilation, the ACCESS='APPEND' should be globally replaced by POSITION='APPEND'. A Cray-compatible version of the source, cefdc.for is continually maintained and available by ftp as described in the foreword of this report.

Except for the optional function subroutine secnds.f, the source code consisting of approximately 112 subroutines at last count is maintained as a single text file, efdc.for or cefdc.for. A number of compilers, including the Cray and Silicon Graphics UNIX compilers and the Lahey Intel based PC compiler, are able to produce optimized executable code by operating the entire source using, for example, the Cray and SGI commands:

```
cf77 -Zv cefdc.for
f77 -O3 efdc.for
```

which produce the executable a.out. (Note the option -Zv for the Cray compilation produces optimum vectorization, using -Zp would produce both optimum vectorization and autotasking). Other compilers, such as the HP and SUN UNIX compilers and the Absoft and LSI Macintosh compilers, are capable of producing only nonoptimized executables working with the entire source code. An example command line for the HP is:

f77 -K +E1 -C -o hpefdcnopt efdc.for

which produces the non-optimized executable hpefdcnopt. The options -K +E1 invoke support of the secnds function, while -C implements array range checking. To produce optimized code on these systems, recourse to makefiles or batch command files which compile each subroutine separately is necessary. Batch command files for HP and SUN UNIX compilers and Makefiles for Absoft and LSI Macintosh compilers are available via ftp.

To achieve minimum memory requirements for running a specific application, it is recommended that the parameter file be customized for that application. The parameter file is of the form:

```
C
C     EFDC PARAMETER FILE
C     LAST MODIFIED ON 7 FEBRUARY 1995
C
C     IMPLICIT REAL*8 (A-H,O-Z)
C
      PARAMETER (KSM=7,KCM=8,KGM=8,LCM=5502,ICM=52,JCM=112,
     $      IGM=52,JGM=112,KPCM=1,NWGGM=5502,NTSM=12000,NPDM=10,
     $      NPBSM=50,NPBWM=2,NPBEM=110,NPBNM=50,LCMW=5502,
     $      NVBSM=1,NVBNM=1,NUBWM=1,NUBEM=1,NGLM=2,LCGLM=2,
     $      NQSIJM=20,NQSERM=20,NCSERM=20,NQCTLM=20,
     $      NQWRM=2,NPSERM=20,NDQSER=2000,NVEGTPM=2,
     $      NBBSM=50,NBBWM=2,NBBEM=110,NBBNM=50,
     $      MTM=12,MLM=10,MGM=24,NPFORM=12,MLTMSRM=99)
C
```

```
C      ICM= MAXIMUM X OR I CELL INDEX TO SPECIFIC GRID IN
C           FILE cell.inp
C      IGM= MAXIMUM I CELL INDEX FOR GRAPHICS GRID SPECIFIED
C           BY GCELLMAP.INP
C      JCM= MAXIMUM Y OR J CELL INDEX TO SPECIFIC GRID IN
C           FILE cell.inp
C      JGM= MAXIMUM J CELL INDEX FOR GRAPHICS GRID SPECIFIED
C           BY GCELLMAP.INP
C      KCM= MAXIMUM NUMBER OF LAYERS, MAX LOOP INDEX KC
C      KGM= KCM
C      KSM= KCM-1
C     KPCM= MAXIMUM NUMBER OF CONSTANT ELEVATION LEVEL FOR
C           THREE DIMENSION GRAPHIC OUTPUT
C      LCM= MAXIMUM NUMBER OF WATER CELLS + 2
C           OR 1 + THE MAX LOOP INDEX LA
C     LCMW= SET TO LCM IF ISWAVE.GE.1 OTHERWISE =2
C    LCGLM= SET TO LCM IF ISLRD.GE.1 OTHERWISE =2
C      MGM= 2*MTM
C      MLM= MAXIMUN NUMBER OF HARMONIC ANALYSIS LOCATION
C      MTM= MAXIMUM NUMBER OF PERIODIC FORCING CONSTITUENTS
C  MLTMSRM= MAXIMUM NUMBER OF TIME SERIES SAVE LOCATIONS
C   NCSERM= MAXIMUM NUMBER OF CONCENTRATION TIME SERIES FOR
C           ANY CONCENTRATION VARIABLE
C     NGLM= NUMBER OF ISLRD PARTICLE RELEASE TIMES
C    NBBEM= NPBEM
C    NBBNM= NPBNM
C    NBBSM= NPBSM
C    NBBWM= NPBWM
C   NDQSER= MAXIMUM NUMBER OF TIME POINTS IN THE LONGEST TIME SERIES
C    NPBEM= MAXIMUM NUMBER OF EAST OPEN SURFACE ELEV BOUNDARIES
C    NPBNM= MAXIMUM NUMBER OF EAST OPEN SURFACE ELEV BOUNDARIES
C    NPBSM= MAXIMUM NUMBER OF EAST OPEN SURFACE ELEV BOUNDARIES
C    NPBWM= MAXIMUM NUMBER OF EAST OPEN SURFACE ELEV BOUNDARIES
C     NPDM= MAXIMUM NUMBER OF ISPD TYPE PARTICLE DRIFTERS
C   NPFORM= MAXIMUM NUMBER OF PERIODIC FORCING FUNCTIONS
C   NPSERM= MAXIMUM NUMBER OF SURFACE ELEVATION TIME SERIES
C   NQCTLM= MAXIMUM NUMBER OF FLOW CONTROL STRUCTURES
C   NQSERM= MAXIMUM NUMBER OF FLOW TIME SERIES
C   NQSIJM= MAXIMUM NUMBER OF NQSIJ VOLUMETRIC SOURCE-SINKS
C    NQWRM= MAXIMUM NUMBER OF FLOW WITH-RETURN PAIRS
C     NTSM= MAXIMUM NUMBER OF TIME STEP PER REFERENCE TIME PERIOD
C    NUBEM= 1
C    NUBWM= 1
C    NVBNM= 1
C    NVBSM= 1
C  NVEGTPM= MAXIMUM NUMBER OF VEGETATION TYPE CLASSES
C    NWGGM= NUMBER OF WATER CELLS IN CARTESIAN GRAPHIC OVERLAY
C           GRID, EQUAL TO LCM-2 FOR CARTESIAN GRIDS
C
```

For a given model application, the parameters, which dimension arrays in efdc.com, should be set to the lowest value that accommodates the grid and data for the application. When starting to run a new application, it is recommended to use a nonoptimized executable compiled with the range checking option (usually -C on UNIX compilers) to determine if arrayed variables are within the range specified by the parameter dimensioned arrays.

8. Diagnostic Options and Output

adjmmt.dia
bal.out
balo.out
bale.out
buoy.dia
disdia.out
modchan.dia
rbcm.dia
sinval.out
efdc.log
time.log
drywet.log
lijmap.out
zvolbal.out
cfl.out
eqcoef.out
eqterm.out
fp.out
eqcoef1.out
diaq.out

9. Time Series Output and Analysis

lsha.out
saltmsr01.out
temtmsr01.out
dyetmsr01.out
sedtmsr01.out
sfltmsr01.out
avvtmsr01.out
avbtmsr01.out
uvetmsr01.out
uvttmsr01.out
u3dtmsr01.out
v3dtmsr01.out
qqetmsr01.out
q3dtmsr01.out
vsfp.out

10. Two-Dimensional Graphics Output and Visualization

10.1 Two-Dimensional Horizontal Plane Scalar Format

belvcon.out
wcustrh.out wave current shear velocity
ccustrh.out current shear velocity
zbreffh.out
surfamp.out
surfpha.out
majaxis.out
majapha.out
salconh.out
temconh.out
dyeconh.out
sedconh.out
sflconh.out
rsalconh.out
rtemconh.out
rdyeconh.out
rsedconh.out
rsflconh.out
surfcon.out
rsurfcon.out

10.2 Two-Dimensional Horizontal Plane Vector Format

tstvech.out
stvech.out
tauvech.out
tidelkc.out
tidelkb.out
velvech.out
rvelvech.out
pvelvech.out
mvelvech.out

lmvvech.out
almvvech.out

10.3 Two-Dimensional Vertical Plane Scalar Format

salcnv1.out
temcnv1.out
dyecnv1.out
sedcnv1.out
sflcnv1.out
rsalcnv1.out
rviscnv1.out
rvefcnv1.out
rsflcnv1.out
velcnv1.out
rvelcnv1.out
pvelcnv1.out
mvelcnv1.out
lmvcnv1.out
almvcnv1.out
rvelcvt1.out
pvelcvt1.out
mvelcvt1.out
lmvcvt1.out
almvcvt1.out

10.4 Two-Dimensional Vertical Plane Vector Format

velvcv1.out
rvelvcv1.out
pvelvcv1.out
mvelvcv1.out
lmvvcv1.out
almvvcv1.out

11. Three-Dimensional Graphics Output and Visualization

sal3d01.asc up to 24 files
tem3d01.asc
dye3d01.asc
sed3d01.asc
uuu3d01.asc
vvv3d01.asc
www3d01.asc
out3d.dia
rsal3d01.asc up to 24 files
rtem3d01.asc
rdye3d01.asc
rsed3d01.asc
ruuu3d01.asc
rvvv3d01.asc
rwww3d01.asc
rout3d.dia

12. Miscellaneous Output Files

efdc.out
avsel.out
gwelv.out
cell9.out
drifter.out
restran.out
restart.out
waspp.out
waspc.out
waspb.out
waspd.out
waspdhd.out
waspdh.out
waspdhu.out
advmod.wsp
disten.out
uvtsc.out
uverv.out

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A. EFDC Source Code Subroutines and Their Functions

Subroutine	Function
ADJMMT.f	Adjust mean transport field for transport only simulations
AINIT.f	Initializes Variables
ASOLVE.f	Utility solver for bi-conjugate gradient solver
ATIMES.f	Utility sparse matrix multiplier for bi-conjugate gradient solver
CALAVB.f	Calculates vertical turbulent viscosity and diffusivity
CALBAL1.f	Calculates mass, momentum and energy balances
CALBAL2.f	Calculates mass, momentum and energy balances
CALBAL3.f	Calculates mass, momentum and energy balances
CALBAL4.f	Calculates mass, momentum and energy balances
CALBAL5.f	Calculates mass, momentum and energy balances
CALBUOY.f	Calculates buoyancy or density anomaly using UNESCO equation of state
CALCONC.f	Calculates scalar field (concentration) transport
CALCSER.f	Concentration time series processor
CALDIFF.f	Calculates horizontal diffusion of scalar fields
CALDISP2.f	Calculates time average horizontal shear dispersion tensor
CALDISP3.f	Calculates time average horizontal shear dispersion tensor
CALEBI.f	Calculates buoyancy integral in external mode equations
CALEXP.f	Calculates explicit terms in momentum equations
CALFQC.f	Calculates mass (scalar concentration field) sources and sinks
CALHDMF.f	Calculates horizontal diffusion in momentum equations

CALHEAT.f	Calculates surface and internal heat sources and sinks
CALHTA.f	Performs harmonic analysis for single frequency periodically forced flow
CALMMT.f	Calculates time mean mass transport field including Stokes' drift
CALPSER.f	Processes surface elevation time series
CALPUV.f	External mode solver for rigid lid or small surface displacement flows
CALPUV2.f	External mode solver for larger surface displacements, but no drying or wetting
CALPUV5.f	External mode solver for flows with drying and wetting and subgrid scale channels
CALPUV7.f	External mode solver for kinematic wave approximation
CALQQ1.f	Calculates transport of turbulent kinetic energy and length scale
CALQQ2.f	Calculates transport of turbulent kinetic energy and length scale (research version)
CALQVS.f	Processes volumetric source and sink time series
CALSED.f	Calculates cohesive sediment settling, deposition and resuspension
CALSED2.f	Calculates cohesive sediment settling, deposition and resuspension
CALSED3.f	Calculates noncohesive sediment settling, deposition and resuspension
CALSFT.f	Calculates diffusion, sources and sinks and vertical migration of shellfish larvae.
CALTBXY.f	Calculates bottom drag coefficients for bottom stress calculation and calculates certain vegetation resistance parameters.
CALTRAN.f	Calculates explicitly advective transport of scalar field concentration) variables
CALTRANI.f	Calculates implicit advective transport of scalar field concentration) variables
CALTRANQ.f	Calculates advective transport of turbulent kinetic energy and length scale
CALTRWQ.f	Calculates explicit advection of water quality variables

CALTSXY.f	Processes wind and atmospheric condition time series and calculates surface wind stress.
CALUVW.f	Solves the internal mode momentum equations and continuity equation
CALWQC.f	Calculates diffusion and sources and sinks of water quality variables
CBALEV1.f	Calculates mass, momentum and energy balances for even time steps
CBALEV2.f	Calculates mass, momentum and energy balances for even time steps
CBALEV3.f	Calculates mass, momentum and energy balances for even time steps
CBALEV4.f	Calculates mass, momentum and energy balances for even time steps
CBALEV5.f	Calculates mass, momentum and energy balances for even time steps
CBALOD1.f	Calculates mass, momentum and energy balances for odd time steps
CBALOD2.f	Calculates mass, momentum and energy balances for odd time steps
CBALOD3.f	Calculates mass, momentum and energy balances for odd time steps
CBALOD4.f	Calculates mass, momentum and energy balances for odd time steps
CBALOD5.f	Calculates mass, momentum and energy balances for odd time steps
CELLMAP.f	Maps I,J horizontal indexes to single L index
CELLMASK.f	Inserts barriers across cell flow faces
CGRS.f	Red-Black reduced system conjugated gradient solver for two-dimensional Helmholtz equation
CONGRAD.f	Diagonally preconditioned conjugated gradient solver for two-dimensional Helmholtz equation
DEPPLT.f	Generates file for bathymetry contouring in ASCII column format
DEPSMTH.f	Smoothes bottom elevation and initial depth fields
DRIFTER.f	Releases and tracks Lagrangian drifters at specified times and locations
EFDC.f	Main program
FILTRAN.f	Performs vertical filtering of mean mass transport field

GLMRES.f	Calculates generalized Lagrangian mean velocities
HDMT.f	Controls hydrodynamic and mass transport solution
INPUT.f	Processes input files
LAGRES.f	Calculates Lagrangian mean velocities by forward trajectories
LINBCG.f	Bi-conjugate gradient linear equation solver
LSQHARM.f	Performs least squares harmonic analysis
LTMT.f	Controls mass transport only solution
LUBKSB.f	Back substitution utility for LU decomposition equation solver
LUDCMP.f	LU decomposition equation solver
LVELPLTH.f	Writes ASCII column files for visualization of Lagrangian mean velocity field in horizontal stretched layer
LVELPLTV.f	Writes ASCII column files for visualization of Lagrangian mean velocity field in vertical transects
OUT3D.f	Writes files for two-dimensional slice and three-dimensional volume visualization of vector and scalar fields in 8 bit ASCII integer format or 8 bit HDF integer format
OUTPUT1.f	Writes printer output files in crude printer character contouring form
OUTPUT2.f	Writes printer output files in crude printer character contouring form
PPLOT.f	Processes printer character contour plots
REDKC.f	Reduces layers by 1/2 in mass transport only simulations (not active)
RELAX.f	Solve two-dimensional Helmholtz equation by Red-Black SOR (successive over relaxation)
RELAXV.f	A more vectorizabe version of RELAX.f
RESTIN1.f	Reads restart.inp file for restarting a run
RESTIN10.f	Reads older versions of restart.inp
RESTIN2.f	Reads a K layer restart.inp file to initialize a 2*K layer simulation
RESTMOD.f	Reads restart.inp field and deactivates specified horizontal cell

RESTOUT.f	Writes restart file restart.out
RESTRAN.f	Reads transport file restran.inp for transport only simulations
ROUT3D.f	Writes files for two-dimensional slice and three-dimensional volume visualization of time mean vector and scalar fields in 8 bit ASCII integer format or 8 bit HDF integer format
RSALPLTH.f	Writes ASCII column files for time means scalar field visualization in horizontal stretched layers
RSALPLTV.f	Writes ASCII column files for time mean scalar field visualization in vertical transects
RSURFPLT.f	Writes ASCII column file for visualization of time mean surface displacement field
RVELPLTH.f	Writes ASCII column files for visualization of time mean velocity field in horizontal stretched layers
RVELPLTV.f	Writes ASCII column files for visualization of time mean velocity field in vertical transects
SALPLTH.f	Writes ASCII column files for instantaneous scalar field visualization in horizontal stretched layers
SALPLTV.f	Writes ASCII column files for instantaneous scalar field visualization in vertical transects
SALTSMTH.f	Smoothes or interpolates an initial salinity field for cold start runs
SECNDS.f	Emulates VMS library function secnds on compilers not supporting this function. This is the only optional subroutine in the code and is normally appended to the end of the efdc.f file for compilation on certain UNIX and Intel based PC compilers.
SETBCS.f	Set horizontal boundary conditions
SHOWVAL.f	Writes screen display of instantaneous conditions at a specified horizontal location
SNRM.f	Computes error norm for bi-conjugate gradient equation solver
SURFPLT.f	Writes ASCII column files for instantaneous surface displacement visualization

SVBKSB.f	Back substitution utility of SVD equation solver
SVDCMP.f	SVD (Singular value decomposition) linear equation solver
TMSR.f	Writes time series files
VALKH.f	Real function subroutine to solve high frequency surface gravity wave dispersion relationship for kh.
VELPLTH.f	Writes ASCII column files for visualization of instantaneous velocity field in horizontal stretched layer
VELPLTV.f	Writes ASCII column files for visualization of instantaneous velocity field in vertical transects
VMSLIB.f	Library of VMS system subroutines for the function SECNDS (required for compiling code on Power Macintosh Systems using Absoft FORTRAN compiler)
VSFP.f	Extracts and writes files of vertical scalar field profiles at specified times and locations to mimic field sampling
WASP4.f	Writes grid and transport files to drive the WASP4 water quality simulation model
WASP5.f	Writes grid and transport files to drive the WASP5 water quality simulation model
WASP6.f	Writes grid and transport files to drive the WASP5 water quality simulation model as modified by Tetra Tech, Inc. Fairfax, VA.
WAVE.f	Processes input high frequency surface gravity field specified in file wave.inp for calculating near bottom wave velocities for the wave-current bottom boundary layer formulation and/or calculating the three-dimensional wave Reynolds' stress and wave Stokes' drift for wave induced current simulation.

B. Grid Generation Examples

This appendix contains a number of example grids generated by the gefdc.f grid generating preprocessor code. Each sub section contains a plot of the grid in physical space and images of the cell.inp and gefdc.inp files.

B.1 Lake Okeechobee, Florida

This section describes a 1 kilometer (km) square cell Cartesian grid of Lake Okeechobee, Florida. The physical domain grid is shown in Figure B1, the cell.inp file in Figure B2, and the gefdc.inp file in Figure B3. The grid was generated with the NTYPE = 0, option by gefdc.f. A FORTRAN program for the generation of the gridext.inp file is shown if Figure B4. It is noted that for square cell grids, the physical and computational domains are geometrically identical and differ by a scale factor equal to the cell side length, which in this case is 1 km.

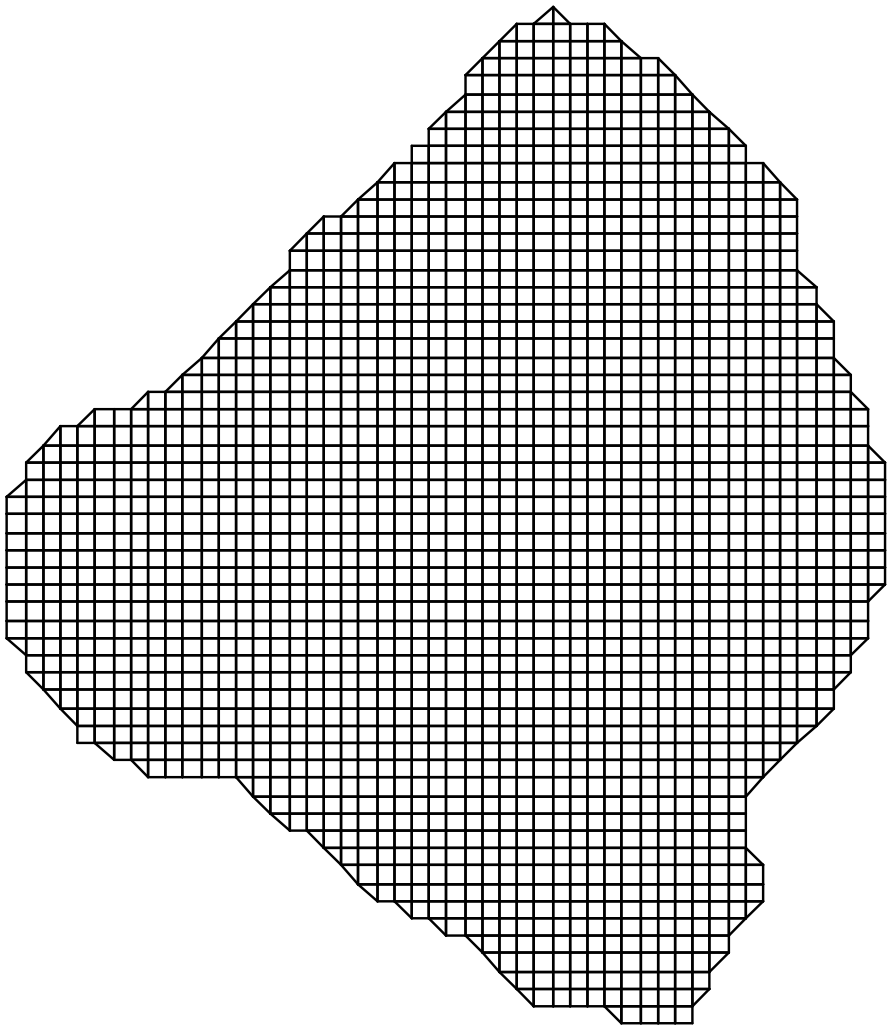

Figure B1. Physical and computational domain grid of Lake Okeechobee, Florida. Grid spacing is 1 km.

```
C cell.inp file, i columns and j rows, for LAKE OKEE
C             1         2         3         4         5
C    123456789012345678901234567890123456789012345678901234
C
 62  00000000000000000000000000000000000000000000000000000000
 61  00000000000000000000000000000009999000000000000000000000
 60  00000000000000000000000000000999419999000000000000000000
 59  00000000000000000000000000009945555519900000000000000000
 58  00000000000000000000000000099455555551999000000000000000
 57  00000000000000000000000000945555555555199000000000000000
 56  00000000000000000000000009955555555555519900000000000000
 55  00000000000000000000000099455555555555551990000000000000
 54  00000000000000000000000945555555555555519900000000000000
 53  00000000000000000000009955555555555555555190000000000000
 52  00000000000000000000099955555555555555555599900000000000
 51  00000000000000000000994555555555555555555555199000000000
 50  00000000000000000009945555555555555555555555519000000000
 49  00000000000000000999455555555555555555555555559000000000
 48  00000000000000009945555555555555555555555555559000000000
 47  00000000000000094555555555555555555555555555559000000000
 46  00000000000000995555555555555555555555555555559900000000
 45  00000000000000994555555555555555555555555555551900000000
 44  00000000000009945555555555555555555555555555990000000000
 43  00000000000099455555555555555555555555555555190000000000
 42  00000000000994555555555555555555555555555555590000000000
 41  00000000009945555555555555555555555555555555599000000000
 40  00000000099455555555555555555555555555555555519000000000
 39  00000009994555555555555555555555555555555555559900000000
 38  00009999455555555555555555555555555555555555551900000000
 37  00099945555555555555555555555555555555555555555900000000
 36  00994555555555555555555555555555555555555555555990000000
 35  00945555555555555555555555555555555555555555555190000000
 34  09955555555555555555555555555555555555555555555590000000
 33  09455555555555555555555555555555555555555555555590000000
 32  09555555555555555555555555555555555555555555555590000000
 31  09555555555555555555555555555555555555555555555590000000
 30  09555555555555555555555555555555555555555555555590000000
 29  09555555555555555555555555555555555555555555555590000000
 28  09555555555555555555555555555555555555555555555590000000
 27  09555555555555555555555555555555555555555555555290000000
 26  09555555555555555555555555555555555555555555555990000000
 25  09555555555555555555555555555555555555555555555900000000
 24  09355555555555555555555555555555555555555555552900000000
 23  09955555555555555555555555555555555555555555559900000000
 22  00935555555555555555555555555555555555555555529000000000
 21  00993555555555555555555555555555555555555555599000000000
```

Figure B2a. File cell.inp for Lake Okeechobee Grid.

```
 20  00099355555555555555555555555555555555555555555290000
 19  00009955555555555555555555555555555555555555552990000
 18  00000993555555555555555555555555555555555555529900000
 17  00000099935555555555555555555555555555555555299000000
 16  00000000999999935555555555555555555555555552990000000
 15  00000000000000993555555555555555555555555559900000000
 14  00000000000000099355555555555555555555555559000000000
 13  00000000000000009993555555555555555555555559900000000
 12  00000000000000000099355555555555555555555551900000000
 11  00000000000000000009935555555555555555555555900000000
 10  00000000000000000009935555555555555555555555900000000
  9  00000000000000000000999355555555555555555552900000000
  8  00000000000000000000009993555555555555555529900000000
  7  00000000000000000000000999355555555555555599000000000
  6  00000000000000000000000009935555555555555290000000000
  5  00000000000000000000000000993555555555555990000000000
  4  00000000000000000000000000009935555555552900000000000
  3  00000000000000000000000000000999999355559900000000000
  2  00000000000000000000000000000000009999990000000000000
  1  00000000000000000000000000000000000000000000000000000
C            1         2         3         4         5
C    12345678901234567890123456789012345678901234567890123
```

Figure B2b. Continuation of file cell.inp for Lake Okeechobee Grid.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     lake okeechobee
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    0      0      1     54    1     62    54   62
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
    0     96   180  1850. 1850.  1
C4  CARTESION AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     -77.5   1.25    -0.625  36.7    1.0     -0.5
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM  DEPMIN
     100    100    100    100    4000   1.0
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      15.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFID INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      1799    2.  .5    2        5.0     0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
     0   0   0.0         0.0
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure B3. File gefdc.inp for Lake Okeechobee.

```
      PROGRAM GENGRID
      OPEN(1,FILE='gridext.inp',STATUS='UNKNOWN')
      DO J=1,62
      DO I=1,54
      X=FLOAT(I-1)
      Y=FLOAT(J-1)
      WRITE(1,100)I,J,X,Y
      END DO
      END DO
  100 FORMAT(2I5,2(2X,F12.3))
      CLOSE(1)
      STOP
      END
```

Figure B4. FORTRAN program for generation of the gridext.inp file for the Lake Okeechobee grid shown in Figure B1.

B.2 Kings Creek and Cherry Stone Inlet, Virginia

This section describes a rectangular Cartesian grid of Kings Creek and Cherry Stone Inlet, located on the Eastern Shore of the Chesapeake Bay, north of Cape Charles, Virginia. The physical domain grid is shown in Figure B5, the cell.inp file in Figure B6, and the gefdc.inp file, Figure B7. The grid was generated with the NTYPE = 0, option by gefdc.f. The FORTRAN program for generation of the gridext.inp file is shown in Figure B8.

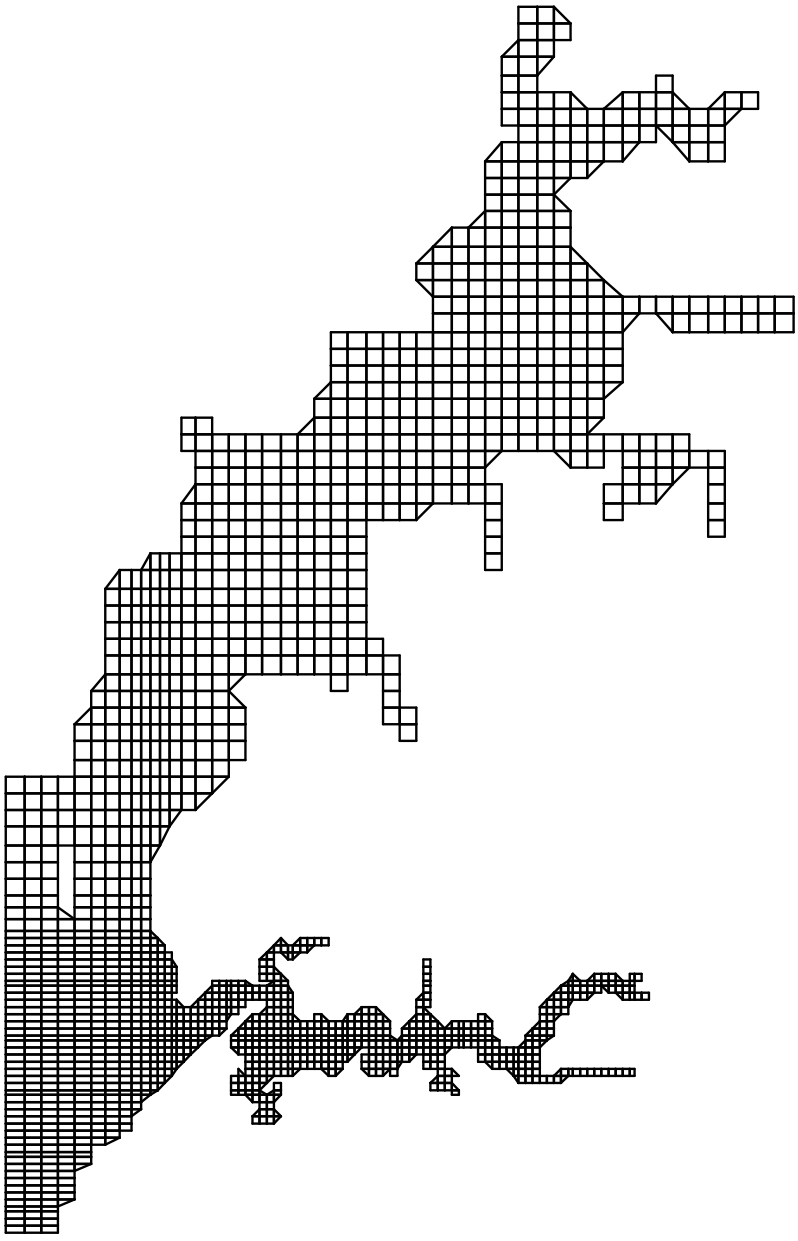

Figure B5. Physical domain grid of Kings Creek and Cherry Stone Inlet, Virginia. Grid spacing ranges from 40 to 100 Meters.

```
C cell.inp file, i columns and j rows, for Kings Creek and Cherry Stone Inlet
C             1         2         3         4         5         6         7         7         9
C    12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123
C
109  000000000000000000000000000000000000000000000999990000000000000000000000000000000000000000000000000000000000000
108  000000000000000000000000000000000000000000095519000000000000000000000000000000000000000000000000000000000000000
107  000000000000000000000000000000000000000000995559000000000000000000000000000000000000000000000000000000000000000
106  000000000000000000000000000000000000000000945599000000000000000000000000000000000000000000000000000000000000000
105  000000000000000000000000000000000000000000955290000999000000000000000000000000000000000000000000000000000000000
104  000000000000000000000000000000000000000000955999999959999990000000000000000000000000000000000000000000000000000
103  000000000000000000000000000000000000000000955551945551945590000000000000000000000000000000000000000000000000000
102  000000000000000000000000000000000000000000955555555555552990000000000000000000000000000000000000000000000000000
101  000000000000000000000000000000000000000000999555555553555990000000000000000000000000000000000000000000000000000
100  000000000000000000000000000000000000000000945555555299355900000000000000000000000000000000000000000000000000000
 99  000000000000000000000000000000000000000000955555529999999900000000000000000000000000000000000000000000000000000
 98  000000000000000000000000000000000000000000955552999000000000000000000000000000000000000000000000000000000000000
 97  000000000000000000000000000000000000000000995555190000000000000000000000000000000000000000000000000000000000000
 96  000000000000000000000000000000000000000000999455555900000000000000000000000000000000000000000000000000000000000
 95  000000000000000000000000000000000000000000994555555599000000000000000000000000000000000000000000000000000000000
 94  000000000000000000000000000000000000000000945555555519900000000000000000000000000000000000000000000000000000000
 93  000000000000000000000000000000000000000000955555555551990000000000000000000000000000000000000000000000000000000
 92  000000000000000000000000000000000000000000935555555555199999999999000000000000000000000000000000000000000000000
 91  000000000000000000000000000000000000000000995555555555555555555559000000000000000000000000000000000000000000000
 90  000000000000000000000000000000000000000000999999955555555555293555555590000000000000000000000000000000000000000
 89  000000000000000000000000000000000000000000955555555555555555999999999900000000000000000000000000000000000000000
 88  000000000000000000000000000000000000000000955555555555555555900000000000000000000000000000000000000000000000000
 87  000000000000000000000000000000000000000000995555555555555555900000000000000000000000000000000000000000000000000
 86  000000000000000000000000000000000000000000945555555555555552900000000000000000000000000000000000000000000000000
 85  000000000000000000000999900009955555555555555559900000000000000000000000000000000000000000000000000000000000000
 84  000000000000000000009559999945555555555555555299999900000000000000000000000000000000000000000000000000000000000
 83  000000000000000000009555555555555555555555555555599900000000000000000000000000000000000000000000000000000000000
 82  000000000000000000009955555555555555555299355955555590000000000000000000000000000000000000000000000000000000000
 81  000000000000000000009955555555555555555990999995552959000000000000000000000000000000000000000000000000000000000
 80  000000000000000000009455555555555555555900095552995900000000000000000000000000000000000000000000000000000000000
 79  000000000000000000009555555555555552999590009599999590000000000000000000000000000000000000000000000000000000000
 78  000000000000000000009555555555559999095900009990009590000000000000000000000000000000000000000000000000000000000
 77  000000000000000009999955555555555900009590000000009990000000000000000000000000000000000000000000000000000000000
 76  000000000000009999455555555555555900009590000000000000000000000000000000000000000000000000000000000000000000000
 75  000000000000094555555555555555559000099900000000000000000000000000000000000000000000000000000000000000000000000
 74  000000000000095555555555555555590000000000000000000000000000000000000000000000000000000000000000000000000000000
 73  000000000000095555555555555555590000000000000000000000000000000000000000000000000000000000000000000000000000000
 72  000000000000095555555555555555599000000000000000000000000000000000000000000000000000000000000000000000000000000
 71  000000000000095555555555555555599000000000000000000000000000000000000000000000000000000000000000000000000000000
 70  000000000000995555555555555555559000000000000000000000000000000000000000000000000000000000000000000000000000000
 69  000000000000945555555555299999599590000000000000000000000000000000000000000000000000000000000000000000000000000
 68  000000000009955555555555190009999599000000000000000000000000000000000000000000000000000000000000000000000000000
 67  000000000009455555555555590000095590000000000000000000000000000000000000000000000000000000000000000000000000000
 66  000000000009555555555555590000009959000000000000000000000000000000000000000000000000000000000000000000000000000
 65  000000000009555555555555590000000999000000000000000000000000000000000000000000000000000000000000000000000000000
 64  000099999999955555555555599000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 63  000095555555555555555552900000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 62  000095555555555555555529900000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 61  000095555555555555552999000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 60  000095555555555555529900000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 59  000095555555955555529900000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 58  000095555555955555599000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 57  000095555555955555590000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 56  000095555555955555590000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 55  000095555555155555590000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

Figure B6a. File cell.inp for Kings Creek and Cherry Stone Inlet.

```
 54  000095555555555555599000000000000000000000000000000000000000000000000000000000000000000000000000
 53  000095555555555555519900000000000000999999999900000000000000000000000000000000000000000000000000
 52  000095555555555555519000000000000099419455559000000000000000000000000000000000000000000000000000
 51  000095555555555555559900000000000994555552999000000000000000000000000000000000000000000000000000
 50  000095555555555555559900000000000945935299900000000000000999000000000000000000000000000000000000
 49  000095555555555555551900000000000955999990000000000000000959000000000000000000000000000000000000
 48  000095555555555555555900000000000955199000000000000000000959000000000000000000099999999999990
 47  000095555555555555555900099999999555190000000000000000000959000000000000000000994194555195590
 46  000095555555555555555900995555519945599000000000000000000959000000000000000000994555555555990
 45  000095555555555555555909945555555555519000000000000000000995900000000000000000994555555355559 99
 44  000095555555555555555999945555555555559000000000000000000945900000000000000000994555552999355559
 43  000095555555555555555519455555559995555900000000999999000955900000000000000000945552999909999999
 42  000095555555555555555555555555599945555999999999455199099519900009999000000955559900000000000
 41  000095555555555555555555555555299455555519951994555551999455199999951900009955299000000000000
 40  000095555555555555555555555555994555555555555555555555994555514555555900099455990000000000000
 39  000095555555555555555555555555294555555555555555555555995555555555555990094555900000000000000
 38  000095555555555555555555555529995555555555555555555555514555555555555519099555290000000000000
 37  000095555555555555555555555299095555555555555555555555555555555555555555999455299000000000000000
 36  000095555555555555555555529900935555555555555555529555555555552999955555555599000000000000000
 35  000095555555555555555555299000999555555555555555529555555529555990095555555559000000000000000
 34  000095555555555555555552990000099555555555555555999555552999555999099355555559999999999999900
 33  000095555555555555555529900000991555555529993529093552599099955190099993555599455555555555900
 32  000095555555555555555299000000955555299999099999099999990009455990000099355555529999999999900
 31  000095555555555555552990000000955552959000000000000000000000955519000000999999999900000000000
 30  000095555555555555529900000000955551459000000000000000000000999959000000000000000000000000000
 29  000095555555555555299000000000999355529000000000000000000000000999000000000000000000000000000
 28  000095555555555555990000000000000999559900000000000000000000000000000000000000000000000000000000
 27  000095555555555552900000000000000945519000000000000000000000000000000000000000000000000000000000
 26  000095555555555559900000000000000955529000000000000000000000000000000000000000000000000000000000
 25  000095555555555559000000000000000999999000000000000000000000000000000000000000000000000000000000
 24  000095555555555599000000000000000000000000000000000000000000000000000000000000000000000000000000
 23  000095555555555290000000000000000000000000000000000000000000000000000000000000000000000000000000
 22  000095555555555999000000000000000000000000000000000000000000000000000000000000000000000000000000
 21  000095555555555900000000000000000000000000000000000000000000000000000000000000000000000000000000
 20  000095555555555900000000000000000000000000000000000000000000000000000000000000000000000000000000
 19  000095555555552900000000000000000000000000000000000000000000000000000000000000000000000000000000
 18  000095555555599000000000000000000000000000000000000000000000000000000000000000000000000000000000
 17  000095555555590000000000000000000000000000000000000000000000000000000000000000000000000000000000
 16  000095555555590000000000000000000000000000000000000000000000000000000000000000000000000000000000
 15  000095555555590000000000000000000000000000000000000000000000000000000000000000000000000000000000
 14  000095555555290000000000000000000000000000000000000000000000000000000000000000000000000000000000
 13  000095555555990000000000000000000000000000000000000000000000000000000000000000000000000000000000
 12  000095555555900000000000000000000000000000000000000000000000000000000000000000000000000000000000
 11  000095555555900000000000000000000000000000000000000000000000000000000000000000000000000000000000
 10  000095555555900000000000000000000000000000000000000000000000000000000000000000000000000000000000
  9  000099999999900000000000000000000000000000000000000000000000000000000000000000000000000000000000
  8  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  7  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  6  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  5  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  4  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  3  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  2  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  1  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
C
C            1         2         3         4         5         6         7         7         9
C    123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123
```

Figure B6b. Continuation of File cell.inp for Kings Creek and Cherry Stone Inlet.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Kings Creek and Cherry Stone Inlet
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    0      0      1     93    1     109    93  109
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50   92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM  DEPMIN
     100    100    100    100    4000   0.2
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      5.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      545    2.  .5    1        0.0     0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
    1   1   0.0         0.0
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure B7. File gefdc.inp for Kings Creek and Cherry Stone Inlet.

```
      PROGRAM GVARCGRID
C
      DIMENSION X(93,109),Y(93,109)
C
      DO J=1,53
      DO I=1,93
      Y(I,J)=40.*FLOAT(J)+630.
      END DO
      END DO
C
      DO I=1,93
      Y(I,54)=2800.
      Y(I,55)=2860.
      Y(I,56)=2930.
      Y(I,57)=3010.
      END DO
C
      DO J=58,109
      DO I=1,93
      Y(I,J)=100.*FLOAT(J-58)+3100.
      END DO
      END DO
C
      DO J=1,109
      DO I=1,14
      X(I,J)=100.*FLOAT(I)
      END DO
      X(15,J)=1490.
      X(16,J)=1580.
      X(17,J)=1660.
      X(18,J)=1730.
      X(19,J)=1790.
      X(20,J)=1840.
      END DO
C
      DO J=1,54
      DO I=21,93
      X(I,J)=40.*FLOAT(I-21)+1880.
      END DO
      END DO
C
      DO J=55,109
      X(21,J)=1890.
      X(22,J)=1950.
      X(23,J)=2020.
      DO I=24,93
      X(I,J)=100.*FLOAT(I-24)+2100.
      END DO
      END DO
```

Figure B8a. FORTRAN program for generation of gridext.inp file.

```
C
      OPEN (1,FILE='gridext.inp',STATUS='UNKNOWN')
      DO J=1,109
      DO I=1,93
      X(I,J)=(X(I,J)/1000.)+408.
      Y(I,J)=(Y(I,J)/1000.)+124.
      WRITE(1,20)I,J,X(I,J),Y(I,J)
      END DO
      END DO
      CLOSE(1)
C
      OPEN (1,FILE='maskij.dat',STATUS='UNKNOWN')
      OPEN (2,FILE='shoremask',STATUS='UNKNOWN')
      OPEN (3,FILE='shoredep',STATUS='UNKNOWN')
      DEP=0.1
      DO N=1,337
      READ(1,*)J,I
      WRITE(2,2000)X(I,J),Y(I,J)
      IF(I.NE.6.OR.J.NE.10) THEN
        WRITE(3,3000)X(I,J),Y(I,J),DEP
        XTMP=X(I,J)+.01
        YTMP=Y(I,J)+.01
        WRITE(3,3000)X(I,J),YTMP,DEP
        WRITE(3,3000)XTMP,Y(I,J),DEP
        XTMP=X(I,J)-.01
        YTMP=Y(I,J)-.01
        WRITE(3,3000)X(I,J),YTMP,DEP
        WRITE(3,3000)XTMP,Y(I,J),DEP
      END IF
      END DO
      CLOSE(1)
      CLOSE(2)
      CLOSE(3)
C
   20 FORMAT(2I5,2X,F12.6,2X,F12.6)
 2000 FORMAT(2X,F12.6,2X,F12.6)
 3000 FORMAT(2X,F12.6,2X,F12.6,2X,F6.2)
C
      STOP
      END
C
```

Figure B8b. Continuation of FORTRAN program for generation of gridext.inp file.

B.3 Rose Bay, Florida

This section describes a curvilinear orthogonal grid of Rose Bay, on the Halifax River, near New Smyrna Beach, Florida. The physical domain grid is shown in Figure B9, the cell.inp file in Figure B10, and the gefdc.inp file in Figure B11. The grid was generated with the NTYPE = 5, option by gefdc.f.

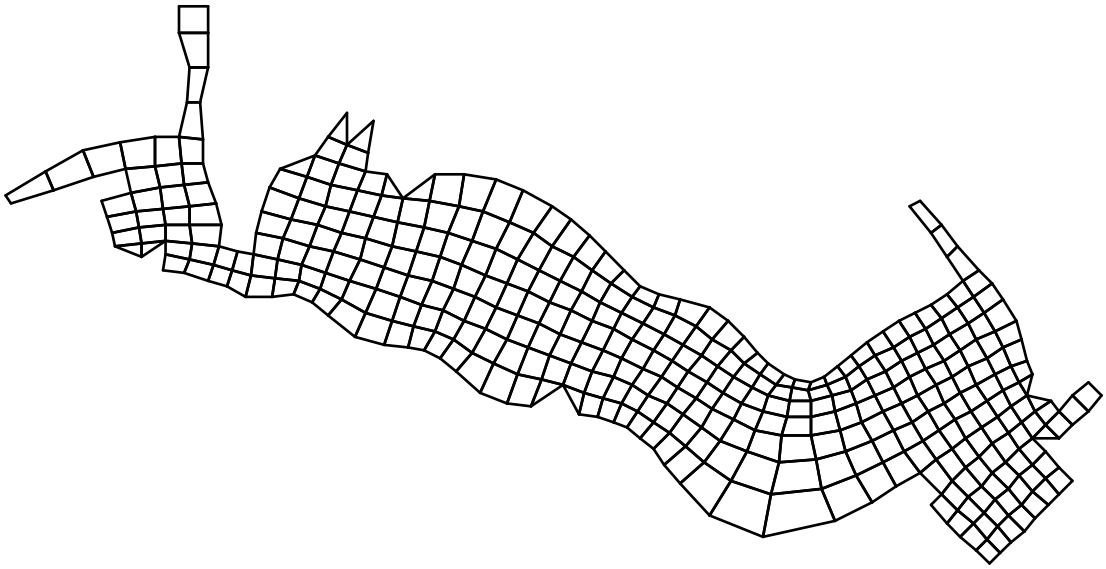

Figure B9. Physical domain grid of Rose Bay, Florida. Grid spacing ranges between approximately 20 and 90 meters.

```
C cell.inp file, i columns and j rows, for Rose Bay
C             1         2         3         4         5
C    12345678901234567890123456789012345678901234567890
C
 25  00000000000000000000000000000000000000000000000000
 24  00000000000000000000000000000000000000000000000000
 23  00000000000000000000000000000000000000000000000000
 22  00000009990000000000000000000000000000000000000000
 21  00000009590000000000000000000000000000000099900
 20  00000009590999900000000000000000000000000095900
 19  00000009590914900000000000000000000000000095900
 18  00999999599955999999999999999999999999999995900
 17  00955555599455514555555555555555555555555555900
 16  00999955599555555555555555555555555555555555900
 15  00009555599555555555555555555555555555555555900
 14  00009555599555555555555555555555555555555555900
 13  00009555599555555555555555555555555555555555900
 12  00009325555555555555555555555555555555555555900
 11  00009995555555555555555235555555555555555552900
 10  00000999999999999999999999999999999955555551900
  9  00000000000000000000000000000000009555555555999
  8  00000000000000000000000000000000009555555535559
  7  00000000000000000000000000000000009555555599999
  6  00000000000000000000000000000000009555555590000
  5  00000000000000000000000000000000009999999990000
  4  00000000000000000000000000000000000000000000000
  3  00000000000000000000000000000000000000000000000
  2  00000000000000000000000000000000000000000000000
  1  00000000000000000000000000000000000000000000000
C
C             1         2         3         4         5
C    12345678901234567890123456789012345678901234567895
```

Figure B10. File cell.inp for Rose Bay.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     rose bay
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    5      148    1     50    1     25    50   25
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
    0     96   180  1850. 1850.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     -77.5   1.25    -0.625  36.7    1.0     -0.5
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM  DEPMIN
     100    100    100    100    1000   1.0
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1.    1.      9.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      62      2.  .5    1        5.0     0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
   40    6      1456.   16.
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
   39    6      1440.000         0.000
   39    7      1420.000        20.000
   39    8      1400.000        40.000
   39    9      1380.000        60.000
   39   10      1356.000        84.000
   40   10      1372.000       100.000
   40   11      1340.000       132.000
   39   11      1308.480       112.080
   38   11      1270.640        89.200
   37   11      1218.480        60.400
```

Figure B11a. File gefdc.inp for Rose Bay.

```
 36   11      1116.000        40.000
 35   11      1038.720        67.680
 34   11       995.840       114.320
 33   11       976.240       143.280
 32   11       957.520       165.680
 31   11       942.080       182.160
 30   11       920.000       196.320
 29   11       901.760       203.600
 28   11       877.920       209.440
 27   11       850.480       216.640
 26   11       818.080       220.400
 25   11       784.960       226.800
 24   11       750.480       228.480
 23   11       712.080       244.160
 22   11       677.040       276.400
 21   11       654.320       293.520
 20   11       631.200       304.720
 19   11       607.600       309.200
 18   11       575.040       315.600
 17   11       532.160       326.640
 16   11       494.080       356.960
 15   11       468.960       376.400
 14   11       444.720       385.040
 13   11       413.680       384.320
 12   11       375.920       384.240
 11   11       348.020       397.000
 10   11       320.160       406.240
  9   11       288.800       416.480
  8   11       256.480       421.120
  8   12       259.440       442.720
  7   12       226.720       440.400
  6   12       192.400       434.160
  6   13       187.760       453.920
  6   14       182.080       476.000
  6   15       178.080       497.040
  6   16       169.360       520.080
  7   16       212.240       530.880
  7   17       203.360       566.720
  6   17       156.000       556.000
  5   17       100.000       536.000
  4   17        40.000       516.000
  4   18        32.000       528.000
  5   18        87.000       562.000
  6   18       142.000       594.000
  7   18       194.320       605.600
  8   18       243.520       611.000
```

Figure B11b. Continuation of file gefdc.inp for Rose Bay.

```
 9   18       280.000       611.000
 9   19       290.000       660.000
 9   20       294.000       710.000
 9   21       280.000       760.000
 9   22       280.000       800.000
10   22       320.000       800.000
10   21       320.000       760.000
10   20       320.000       710.000
10   19       310.000       660.000
10   18       312.000       610.000
10   17       315.440       573.680
10   16       321.840       547.200
10   15       331.440       516.880
10   14       338.800       487.040
10   13       336.480       456.960
11   13       362.960       447.280
12   13       384.560       442.880
12   14       389.120       473.280
12   15       396.720       504.720
12   16       408.320       538.480
12   17       423.920       567.040
12   18       441.600       598.960
13   18       475.000       585.000
13   19       492.000       612.000
13   20       520.000       647.000
14   20       540.000       640.000
15   20       560.000       633.000
15   19       552.000       590.000
15   18       547.000       564.000
16   18       575.920       559.360
17   18       605.520       558.400
18   18       644.800       557.360
19   18       689.200       558.000
20   18       734.800       551.120
21   18       773.280       536.080
22   18       812.560       512.800
23   18       840.080       493.440
24   18       866.880       470.800
25   18       891.920       447.920
26   18       915.920       422.080
27   18       941.200       399.840
28   18       967.200       386.160
29   18       998.400       378.960
30   18      1038.000       366.880
31   18      1066.320       348.640
32   18      1088.480       326.880
```

Figure B11c. Continuation of file gefdc.inp for Rose Bay.

```
33   18      1107.040       302.640
34   18      1124.320       285.680
35   18      1144.560       272.320
36   18      1162.480       264.800
37   18      1182.800       260.560
38   18      1204.640       266.640
39   18      1224.720       284.400
40   18      1240.640       298.880
41   18      1265.440       316.240
42   18      1289.040       333.440
43   18      1311.280       348.960
44   18      1332.960       360.480
45   18      1356.800       372.560
46   18      1379.280       388.240
47   18      1403.000       404.000
47   19      1380.000       440.000
47   20      1355.000       475.000
47   21      1326.000       512.000
48   21      1340.000       520.000
48   20      1370.000       485.000
48   19      1395.000       455.000
48   18      1425.920       422.800
48   17      1444.000       401.120
48   16      1460.880       379.840
48   15      1477.200       349.440
48   14      1488.240       320.480
48   13      1494.800       293.040
48   12      1501.680       272.640
48   11      1512.560       253.920
48   10      1528.400       235.040
48    9      1540.000       220.000
49    9      1560.000       240.000
50    9      1580.000       260.000
50    8      1600.000       240.000
49    8      1580.000       220.000
48    8      1560.000       200.000
47    8      1540.000       180.000
46    8      1520.000       160.000
46    7      1540.000       140.000
46    6      1560.000       120.000
45    6      1541.000       101.000
44    6      1523.000        83.000
43    6      1505.500        65.500
42    6      1488.500        48.500
41    6      1470.000        32.000
40    6      1456.000        16.000
```

Figure B11d. Continuation of file gefdc.inp for Rose Bay.

B.4 Indian River Lagoon, Florida

This section describes the construction of a composite grid of a section of the Indian River Lagoon, near Melborne, Florida, from five subgrids. Figures B12-B14 show the composite grid, and the corresponding cell.inp and gefdc.inp files. The composite grid was generated with the NTYPE = 0 option by gefdc.f. The input file, gridext.inp, specifying the composite grid was formed by combining the five gridext.out files generated for the five subgrid regions. Figures B15 & B16, B17 & B18, B19 & B20, B21 & B22, and B23 & B24 show the subgrids and the corresponding gefdc.inp files. The cell.inp file for each sub grid is similar to the cell.inp file shown in Figure B13, with only the water cells in the particular subgrid activated. The first subgrid, Figures B15&B16, and the fourth subgrid, Figure B21&B22, were generated with the NTYPE = 0 option. The remaining subgrids are curvilinear-orthogonal and were generated with the NTYPE = 5 option.

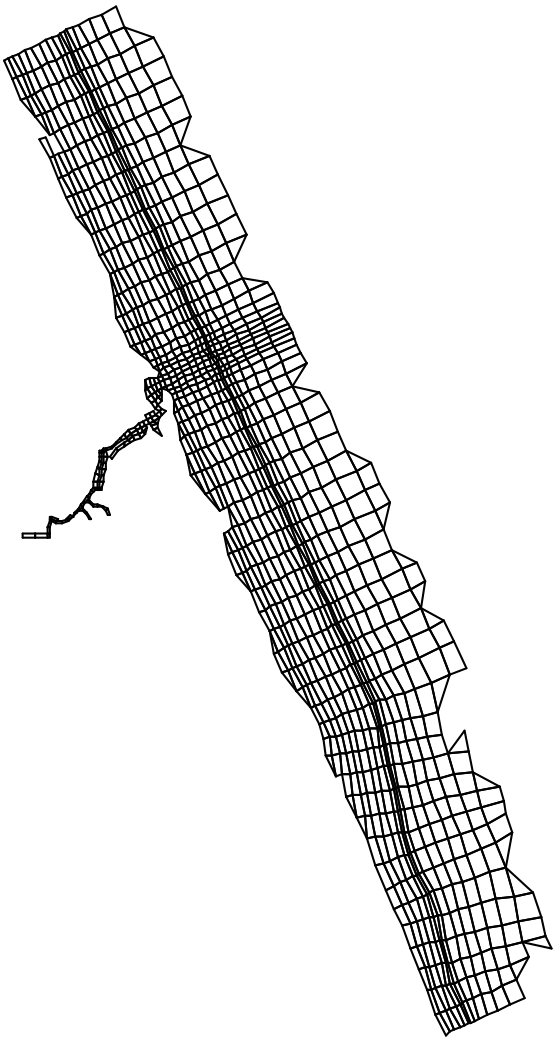

Figure B12. Grid of a section of the Indian River Lagoon near Melbourne, FL. Grid is a composite of five subgrids.

```
C cell.inp file, i columns and j rows, for Indian River Lag
C             1         2         3         4         5
C    123456789012345678901234567890123456789012345678901234
C
 60  000000000000000000000000000000000099999999999999999900
 59  000000000000000000000000000000000955555555555555555990
 58  000000000000000000000000000000000955555555555555555190
 57  000000000000000000000000000000000935555555555555555590
 56  000000000000000000000000000000000993555555555555555590
 55  000000000000000000000000000000000959955555555555555590
 54  000000000000000000000000000000000955555555555555555590
 53  000000000000000000000000000000000955555555555555555290
 52  000000000000000000000000000000000955555555555555555190
 51  000000000000000000000000000000000935555555555555555590
 50  000000000000000000000000000000000995555555555555555590
 49  000000000000000000000000000000000995555555555555555590
 48  000000000000000000000000000000000994555555555555555590
 47  000000000000000000000000000000000945555555555555555290
 46  000000000000000000000000000000000955555555555555555990
 45  000000000000000000000000000000000955555555555555555190
 44  000000000000000000000000000000000935555555555555555590
 43  000000000000000000000000000000000993555555555555555590
 42  000000000000000000000000000000000995555555555555555590
 41  000000000000000000000000000000000935555555555555555590
 40  000000000000000000000000000000009999945555555555555590
 39  000000000000000000000000000000009455555555555555555590
 38  000000000000000000000000000000009555555555555555555590
 37  000000000000000000000000000000009555235555555555555590
 36  000000000000000000000000000999955299555555555555555590
 35  000000000000009999999999999559599995555555555555555590
 34  000000000000009555555555555555909455555555555555555590
 33  000000000000009595999955559529999955555555555555555590
 32  000000000000009595955555529599009455555555555555555290
 31  000000000000009595999999999390099555555555555555555190
 30  000000000000009595900000009990094555555555555555555590
 29  009999999000009595900000000000935555555555555555555590
 28  009559959999999959590000000000993555555555555555555599
 27  009555555555555555590000000000099994555555555555555519
 26  009599999959599999990000000000094555555555555555555559
 25  999590000959590000000000000000095555555555555555555559
 24  955590000959590000000000000000093555555555555555555529
 23  999990000999590000000000000000099555555555555555555599
 22  000000000095900000000000000000099555555555555555555519
 21  000000000095900000000000000000094555555555555555555559
```

Figure B13a. File cell.inp for the Indian River Lagoon grid shown in Figure B12.

```
20  00000000000999000000000000000000955555555555555555529
19  00000000000000000000000000000000935555555555555555519
18  00000000000000000000000000000000993555555555555555559
17  00000000000000000000000000000000995555555555555555559
16  00000000000000000000000000000000955555555555555555299
15  00000000000000000000000000000000955555555555555555990
14  00000000000000000000000000000000935555555555555555490
13  00000000000000000000000000000000999555555555555555599
12  00000000000000000000000000000000935555555555555555519
11  00000000000000000000000000000000993555555555555555559
10  00000000000000000000000000000000999555555555555555559
 9  00000000000000000000000000000000955555555555555555559
 8  00000000000000000000000000000000955555555555555555529
 7  00000000000000000000000000000000955555555555555555519
 6  00000000000000000000000000000000955555555555555555559
 5  00000000000000000000000000000000955555555555555555559
 4  00000000000000000000000000000000955555555555555555539
 3  00000000000000000000000000000000955555555555555555299
 2  00000000000000000000000000000000955555555555555555990
 1  00000000000000000000000000000000999999999999999999900
```

Figure B13b. Continuation of File cell.inp for the Indian River Lagoon grid shown in Figure B12.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
    0      0      1     54    1     60    54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     1     50   92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      5.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      995     2.  .5    3        0.3517   0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
     1   1   0          0
C13 BOUNDARY POINT INFORMATION
C13 I  J  X(I,J)  Y(I,J)
```

Figure B14. File gefdc.inp for the Indian River Lagoon grid shown in Figure B12.

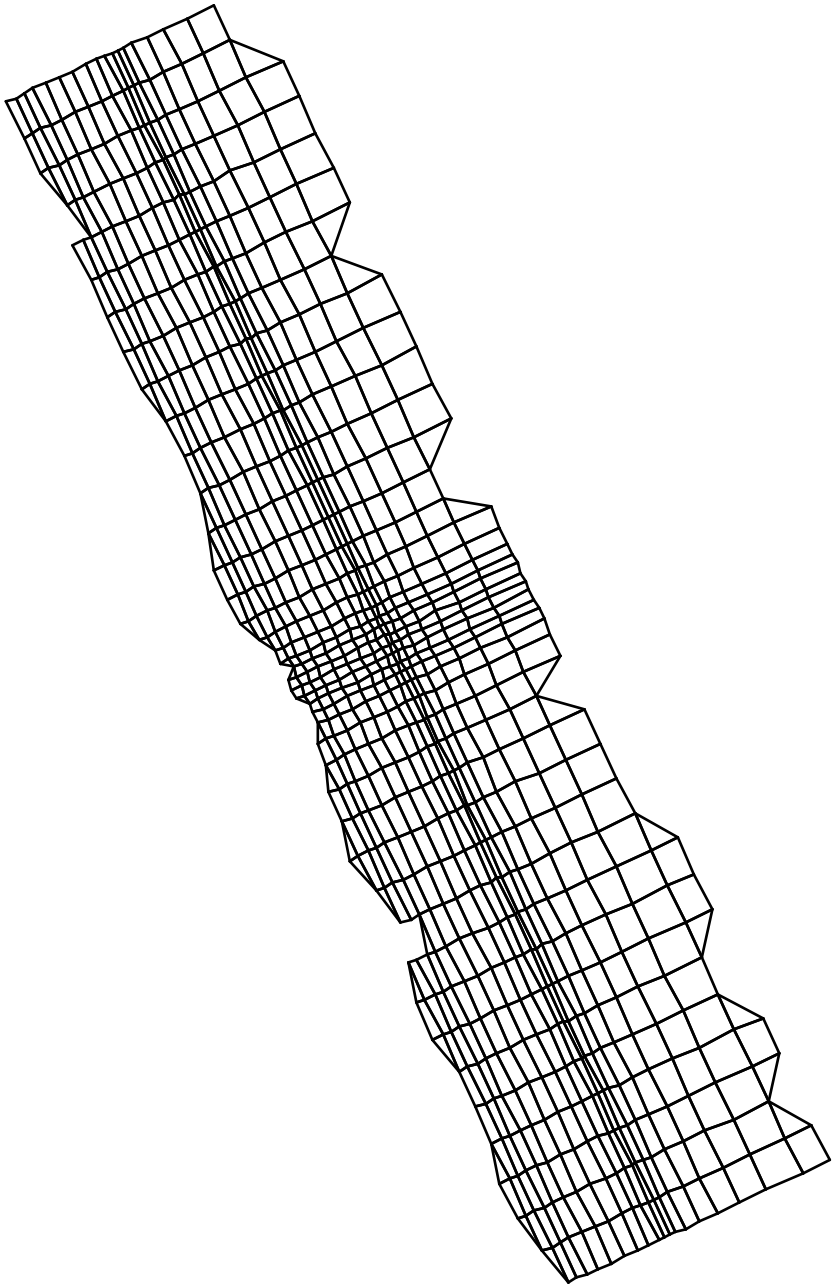

Figure B15. Subgrid 1 of the Indian River Lagoon grid shown in Figure B12. This grid is a variable spacing Cartesian grid generated with NTYPE = 0, option by gefdc.f.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon, sub grid 1
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     0      146    1     54    1     60   54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50    92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
    0.        0.       1000.   1.      1.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
    0       0       1        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      896     2.  .5    3        0.35    0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
     0   0   0.0         0.0
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure B16. File gefdc.inp for subgrid 1, shown in Figure B15.

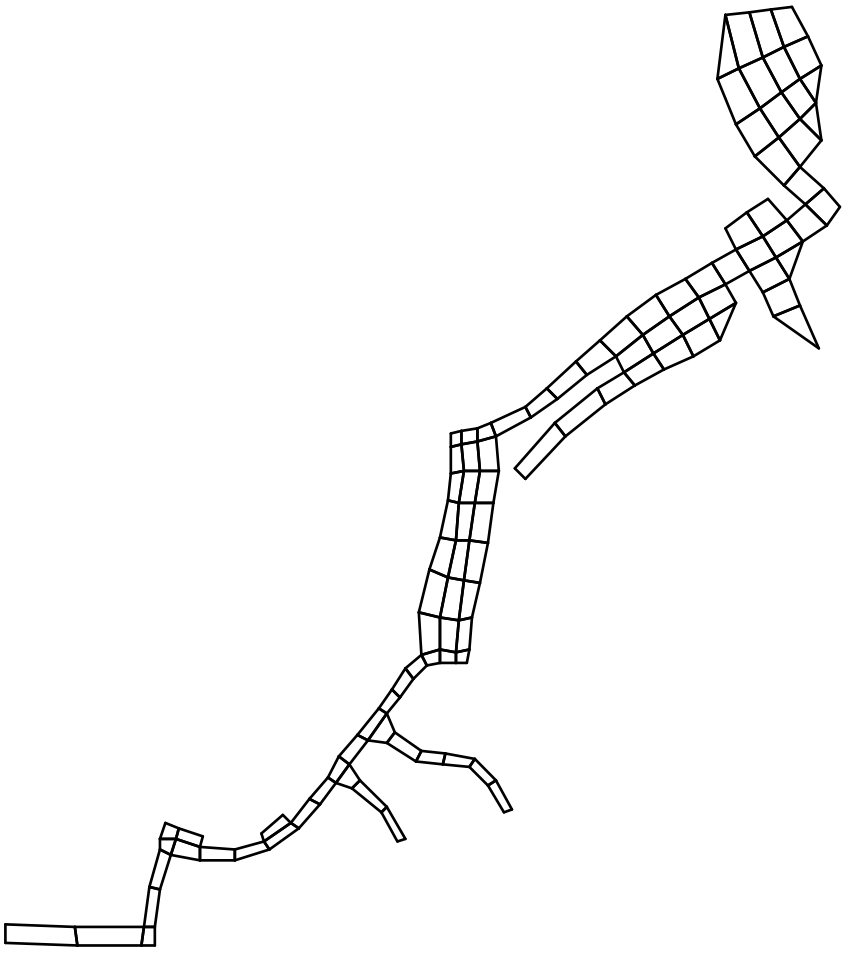

Figure B17. Subgrid 2 of the Indian River Lagoon grid shown in Figure B10. This grid is a curvilinear-orthogonal grid generated with NTYPE = 5.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon, Subgrid 2
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     5      140    1     54    1     60    54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50    92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.     10.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      1054    2.  .5    3        0.167   0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
    36   39   5.416584   32.868687
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
   36   38    5.458846   32.778057
   36   37    5.501108   32.687428
   35   37    5.446730   32.662067
   35   36    5.514679   32.611004
   34   36    5.459079   32.540939
   33   36    5.396529   32.462120
   33   35    5.468399   32.390812
   33   34    5.520639   32.337936
   32   34    5.476520   32.278748
```

Figure B18a. File gefdc.inp for subgrid 2, shown in Figure B17.

```
31   34    5.403405   32.222584
31   33    5.452924   32.151886
30   33    5.364405   32.105095
30   32    5.395795   32.025944
30   31    5.452544   31.892416
29   31    5.370976   31.854382
29   32    5.312114   31.992439
29   33    5.276192   32.069473
29   34    5.239964   32.135338
28   34    5.165042   32.094883
28   33    5.199157   32.033554
28   32    5.235079   31.956518
27   32    5.148980   31.916368
26   32    5.060462   31.869576
25   32    4.971944   31.822783
24   32    4.878895   31.773876
23   32    4.790073   31.715906
22   32    4.664386   31.618679
21   32    4.537784   31.487925
21   33    4.500639   31.520256
22   33    4.625128   31.655542
23   33    4.762297   31.763639
24   33    4.846588   31.819498
24   34    4.818812   31.867229
23   34    4.725458   31.807148
22   34    4.636329   31.738003
21   34    4.549620   31.675501
20   34    4.440557   31.613609
20   33    4.451099   31.508188
20   32    4.437174   31.407907
20   31    4.415995   31.287693
20   30    4.396928   31.162949
20   29    4.373633   31.047266
20   28    4.360015   30.948162
20   27    4.355037   30.905406
19   27    4.318927   30.908500
18   27    4.269384   30.905899
17   27    4.226488   30.901413
16   27    4.189625   30.862158
15   27    4.145506   30.802967
14   27    4.103806   30.750420
14   26    4.131277   30.691509
14   25    4.207983   30.633492
14   24    4.287153   30.627129
14   23    4.375015   30.606558
```

Figure B18b. Continuation of file gefdc.inp for subgrid 2, shown in Figure B17.

```
 14   22    4.447190   30.546427
 14   21    4.496096   30.453379
 13   21    4.473438   30.442812
 13   22    4.424227   30.524685
 13   23    4.358696   30.582397
 13   24    4.280768   30.595711
 13   25    4.198070   30.602991
 13   26    4.103477   30.656477
 13   27    4.043370   30.667067
 12   27    3.989883   30.592476
 12   26    4.019771   30.540209
 12   25    4.100399   30.461952
 12   24    4.158063   30.361954
 11   24    4.135406   30.351387
 11   25    4.086499   30.444435
 11   26    3.996809   30.518467
 11   27    3.945765   30.533283
 10   27    3.894697   30.465336
  9   27    3.830034   30.391047
  8   27    3.734261   30.324322
  7   27    3.626115   30.295958
  6   27    3.518578   30.289949
  5   27    3.425249   30.312630
  5   26    3.393198   30.203899
  5   25    3.376549   30.085796
  5   24    3.377136   30.025385
  4   24    3.339077   30.024187
  3   24    3.133373   30.027571
  2   24    2.909850   30.033678
  2   25    2.909263   30.094091
  3   25    3.128256   30.085871
  4   25    3.345134   30.082182
  4   26    3.362088   30.211458
  4   27    3.392026   30.324722
  4   28    3.397473   30.360365
  4   29    3.414402   30.406878
  5   29    3.451852   30.390721
  6   29    3.531892   30.367876
  6   28    3.521913   30.330122
  7   28    3.629143   30.324955
  8   28    3.723696   30.346979
  8   29    3.711017   30.374166
  9   29    3.775374   30.437279
  9   28    3.805872   30.407366
 10   28    3.863892   30.484074
 11   28    3.919492   30.554134
```

Figure B18c. Continuation of file gefdc.inp for subgrid 2, shown in Figure B17.

```
12   28    3.956964   30.615744
13   28    4.008034   30.683691
14   28    4.077534   30.771271
15   28    4.117120   30.828348
16   28    4.159126   30.892069
17   28    4.209583   30.937666
17   29    4.204185   31.067553
17   30    4.236845   31.198639
17   31    4.273123   31.298307
17   32    4.296415   31.413992
17   33    4.300971   31.498867
17   34    4.302171   31.581327
17   35    4.301000   31.623074
18   35    4.338164   31.632065
19   35    4.384400   31.645300
20   35    4.430603   31.658621
21   35    4.532715   31.711754
22   35    4.605831   31.767914
23   35    4.695264   31.848236
24   35    4.773217   31.917688
25   35    4.855700   31.989252
26   35    4.944829   32.058399
27   35    5.035765   32.111835
28   35    5.124283   32.158630
29   35    5.199204   32.199085
29   36    5.160864   32.269474
30   36    5.227030   32.316879
31   36    5.295308   32.359753
31   35    5.356001   32.288750
32   35    5.408877   32.340988
32   36    5.347880   32.400818
32   37    5.254269   32.495087
32   38    5.196604   32.595085
32   39    5.135629   32.737679
32   40    5.082215   32.911377
33   40    5.163478   32.938236
34   40    5.232954   32.943050
35   40    5.306961   32.949978
36   40    5.374322   32.959320
36   39    5.416584   32.868687
```

Figure B18d. Continuation of file gefdc.inp for subgrid 2, shown in Figure B17.

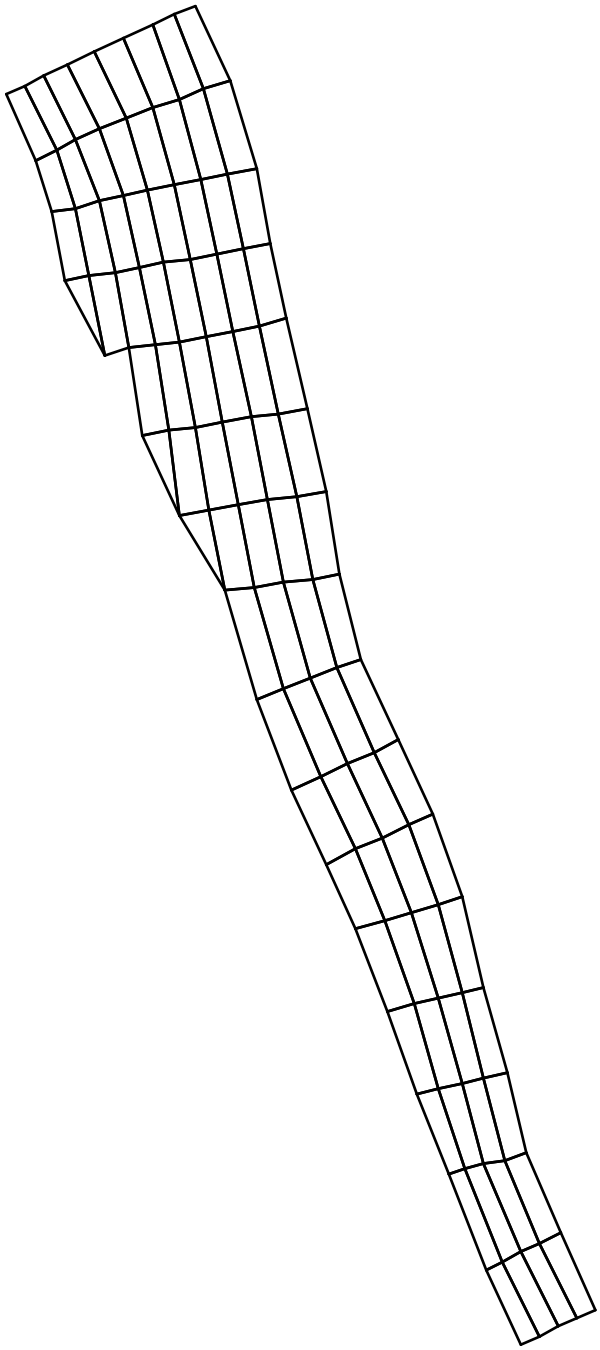

Figure B19. Subgrid 3 of the Indian River Lagoon grid shown in Figure B12. This grid is a curvilinear-orthogonal grid generated with NTYPE = 5.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon, Sub Grid 3
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     5     48     1     54    1     60    54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50    92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     200    200    200    200    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.     5.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      896     2.  .5    3        0.167   0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
   41    2   10.771623   20.911531
C13 BOUNDARY POINT INFORMATION
C13 I    J   X(I,J)  Y(I,J)
   40    2   10.680992   20.869270
   40    3   10.511944   21.231794
   40    4   10.332051   21.688562
   40    5   10.185966   22.072828
   40    6   10.044719   22.470383
   40    7    9.894407   22.863710
   40    8    9.746491   23.180916
   40    9    9.581670   23.534378
   40   10    9.410230   23.973021
   40   11    9.254519   24.496237
```

Figure B20a. File gefdc.inp for subgrid 3, shown in Figure B19.

```
39   11    9.088380   24.473932
39   12    9.040770   24.859980
38   12    8.901817   24.850355
38   13    8.859043   25.249693
38   14    8.798752   25.662931
37   14    8.681543   25.630342
36   14    8.573397   25.601980
36   15    8.490144   25.993475
36   16    8.427410   26.317305
36   17    8.353781   26.569849
36   18    8.205865   26.887056
37   18    8.296495   26.929317
38   18    8.387127   26.971581
39   18    8.500415   27.024408
40   18    8.636361   27.087799
41   18    8.772307   27.151192
42   18    8.908255   27.214586
43   18    9.021543   27.267414
44   18    9.112172   27.309675
44   17    9.281219   26.947151
44   16    9.412794   26.523020
44   15    9.479142   26.167774
44   14    9.558780   25.807695
44   13    9.654101   25.366657
44   12    9.746417   24.979389
44   11    9.811546   24.579441
44   10    9.916542   24.164982
44    9   10.098267   23.775270
44    8   10.263088   23.421810
44    7   10.404335   23.024256
44    6   10.508718   22.587444
44    5   10.613714   22.172985
44    4   10.706031   21.785717
44    3   10.874467   21.400841
44    2   11.043514   21.038317
43    2   10.952884   20.996056
42    2   10.862254   20.953794
41    2   10.771623   20.911531
```

Figure B20b. Continuation of file gefdc.inp for sub grid 3, shown in Figure B19.

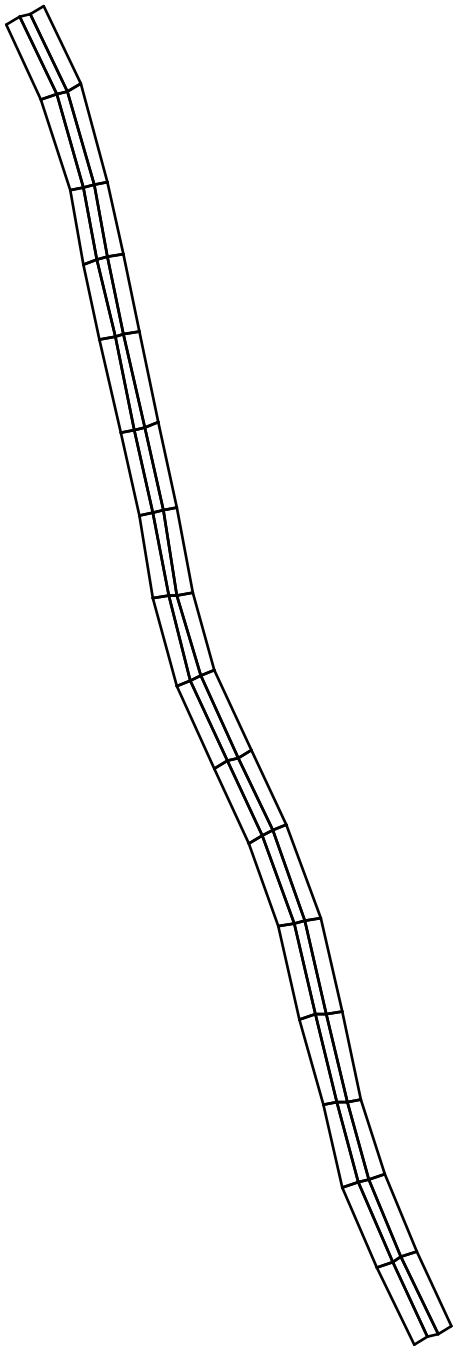

Figure B21. Subgrid 4 of the Indian River Lagoon grid shown in Figure B12. This grid is a curvilinear-orthogonal grid generated with NTYPE = 0.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon, Subgrid 4
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     0      0     1     54    1     60    54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50    92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      7.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      1054    2.  .5    3        0.167   0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
     1   1    0.0         0.0
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure B22. File gefdc.inp for subgrid 4, shown in Figure B21, generated with NTYPE = 0.

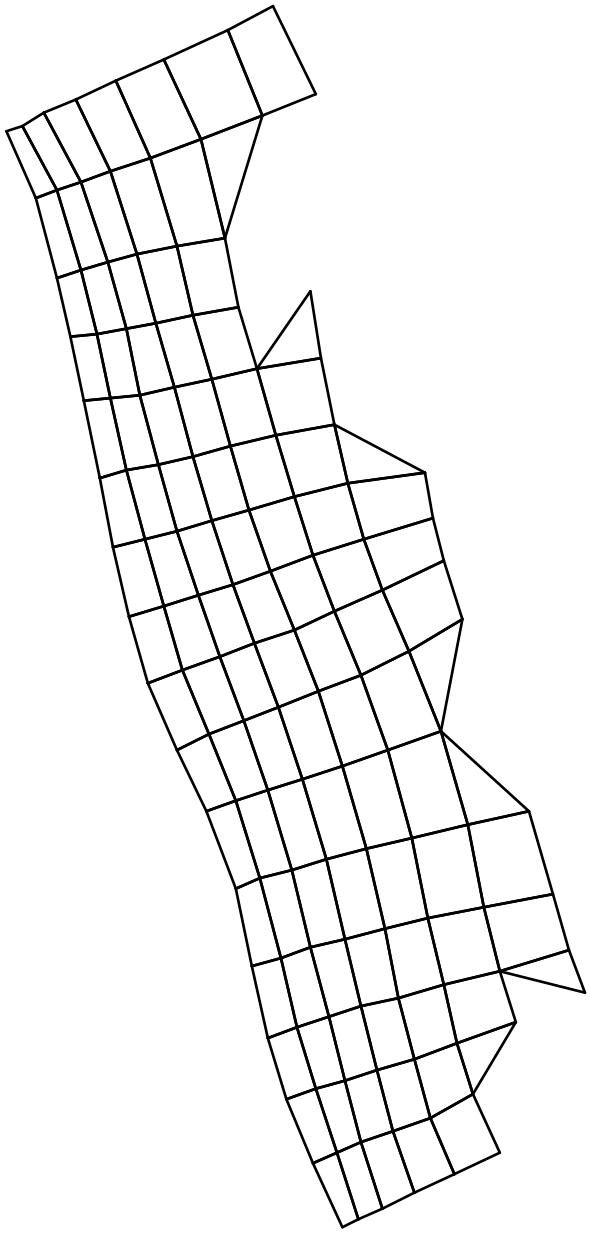

Figure B23. Subgrid 5 of the Indian River Lagoon grid shown in Figure B12. This grid is a curvilinear-orthogonal grid generated with NTYPE = 5.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     Indian River Lagoon, Subgrid 5
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     5      50    1     54    1     60    54   60
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     0     50    92  250.  250.  1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     1.875   15.0    0.0     17.875  15.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100    1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      5.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    0      1054    2.  .5    3        0.167   0     0       0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
   48    2   11.315408   21.165104
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
   47    2   11.224776   21.122841
   47    3   11.055729   21.485365
   47    4   10.909035   21.847277
   47    5   10.797980   22.203743
   47    6   10.702049   22.622427
   47    7   10.606728   23.063465
   47    8   10.444349   23.506332
   47    9   10.279528   23.859795
   47   10   10.102028   24.240444
```

Figure B24a. File gefdc.inp for subgrid 5, shown in Figure B23, generated with NTYPE = 5.

```
47   11    9.995811   24.610197
47   12    9.917395   25.014980
47   13    9.829916   25.415539
47   14    9.738821   25.847515
47   15    9.664020   26.220884
47   16    9.592834   26.562840
47   17    9.466708   27.022612
47   18    9.293435   27.394197
48   18    9.384066   27.436460
49   18    9.520012   27.499853
50   18    9.701274   27.584377
51   18    9.927851   27.690031
52   18   10.199742   27.816816
53   18   10.562265   27.985865
54   18   10.834159   28.112650
54   17   11.070825   27.605118
53   17   10.763290   27.483780
53   16   10.961871   26.892284
52   16   10.556476   26.791515
52   15   10.621604   26.391569
53   15   11.044516   26.478437
53   14   11.101190   26.096615
54   14   11.559133   26.155685
54   13   11.637548   25.750900
54   12   11.696055   25.436136
54   11   11.747332   25.184202
54   10   11.807670   24.936493
54    9   11.919335   24.602381
54    8   12.111296   24.096069
54    7   12.300815   23.500349
54    6   12.431167   23.031511
54    5   12.529542   22.702236
54    4   12.621296   22.458145
53    4   12.223131   22.294544
53    3   12.324560   22.077030
52    3   11.974715   21.880795
52    2   12.131084   21.545460
51    2   11.859191   21.418674
50    2   11.632614   21.313019
49    2   11.451354   21.228497
48    2   11.315408   21.165104
```

Figure B24b. Continuation of file gefdc.inp for subgrid 5, shown in Figure B23, generated with NTYPE = 5.

B.5 SFWMD Water Conservation Area 2A, Florida

This section describes a curvilinear-orthogonal grid of the South Florida Water Management District's Water Conservation Area 2A southwest of West Palm Beach, Florida. The physical domain grid is shown in Figure B25, the cell.inp file in Figure B26, and the gefdc.inp file in Figure B27. The Cartesian graphic grid overlay file, gcell.inp, is shown in Figure B28, and its equivalent square cell Cartesian grid is shown in Figure B29. The main portion of the curvilinear grid, excluding the lower four cells is based on a quasi-conformal mapping using the NTYPE = 7, option by gefdc.f. The four lower cells were then appended to the grid by hand. The four boundary function subroutines required by the NTYPE = 7, option are shown in Figure B30-B33.

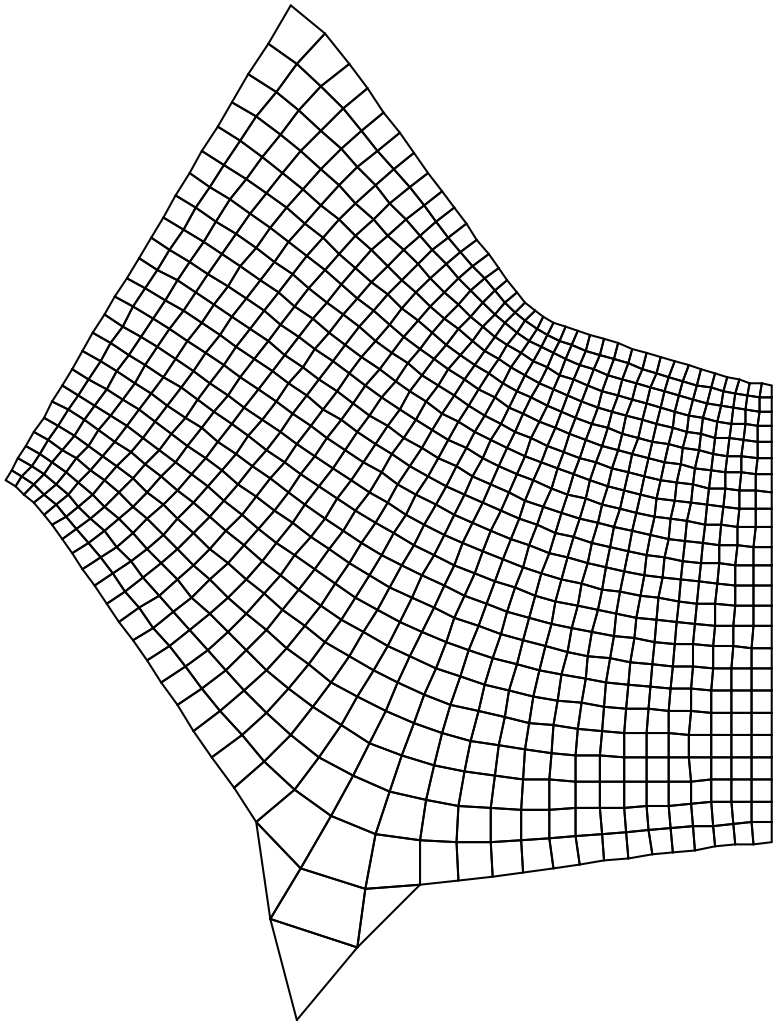

Figure B25. Physical domain grid of SFWMD's Water Conservation Area 2A. Grid spacing ranges from approximately 400 to 2500 meters.

```
C cell.inp file, i columns and j rows, for WCA2A
C             1         2         3         4
C    12345678901234567890123456789012345678901
C
 32  99999999999999999999999999999999999999999
 31  95555555555555555555555555555555555555559
 30  99999999999999999999999999999999999999999
 29  00000000000009555555555555555555555555559
 28  99999999999999999999999999999999999999999
 27  95555555555555555555555555555555555555559
 26  95555555555555555555555555555555555555559
 25  95555555555555555555555555555555555555559
 24  95555555555555555555555555555555555555559
 23  95555555555555555555555555555555555555559
 22  95555555555555555555555555555555555555559
 21  95555555555555555555555555555555555555559
 20  95555555555555555555555555555555555555559
 19  95555555555555555555555555555555555555559
 18  95555555555555555555555555555555555555559
 17  95555555555555555555555555555555555555559
 16  95555555555555555555555555555555555555559
 15  95555555555555555555555555555555555555559
 14  95555555555555555555555555555555555555559
 13  95555555555555555555555555555555555555559
 12  95555555555555555555555555555555555555559
 11  95555555555555555555555555555555555555559
 10  95555555555555555555555555555555555555559
  9  95555555555555555555555555555555555555559
  8  95555555555555555555555555555555555555559
  7  95555555555555555555555555555555555555559
  6  95555555555555555555555555555555555555559
  5  95555555555555555555555555555555555555559
  4  95555555555555555555555555555555555555559
  3  99999999999999999999352999999999999999999
  2  00000000000000000009939900000000000959
  1  00000000000000000000999000000000000999
C             1         2         3         4
C    12345678901234567890123456789012345678901
```

Figure B26. File cell.inp for WCA2A Grid Shown in Figure B25.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
     SWFWMD WCA2A
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     7      106   1     38    1     28    38   28
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG  NWTGG
     1     44   55  600.  600. 1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
    5.1     36.0    0.0     3.9     36.0    0.0
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM  NDEPSM
     100    100    100    100   1000
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
    1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      5.04
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     0       0       1        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB  IE  JB  JE  N7RLX NXYIT ITN7M IJSMD ISMD JSMD RP7  SERRMAX
     2  38   4  28  1000  1     500   0     0    26   1.0  1.E-8
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
    6.76  20.6
    31.   9.1
    31.   23.6
   15.76  35.6
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP NDEPDAT CDEP RADM ISIDPTYP SURFELV ISVEG NVEGDAT NVEGTYP
    1      783     2.   .5   2        4.00    1     10710   12
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
    1    1  0.0         0.0
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)  Y(I,J)
```

Figure B27. File gefdc.inp for WCA2A Grid Shown in Figure B25.

```
C gcell.inp file, i columns and j rows, for WCA2A
C             1         2         3         4         5
C    123456789012345678901234567890123456789012345678901234567890
C
 55  000000000000000000000000000000000000000000000000
 54  000000000000000999900000000000000000000000000000
 53  000000000000000955990000000000000000000000000000
 52  000000000000009955599000000000000000000000000000
 51  000000000000009555559000000000000000000000000000
 50  000000000000099555559900000000000000000000000000
 49  000000000009955555559900000000000000000000000000
 48  000000000009555555555990000000000000000000000000
 47  000000000099555555555590000000000000000000000000
 46  000000000095555555555599000000000000000000000000
 45  000000000995555555555559900000000000000000000000
 44  000000009955555555555555900000000000000000000000
 43  000000009555555555555555990000000000000000000000
 42  000000099555555555555555599000000000000000000000
 41  000000095555555555555555559000000000000000000000
 40  000000995555555555555555599000000000000000000000
 39  000000955555555555555555559900000000000000000000
 38  000009955555555555555555555900000000000000000000
 37  000099555555555555555555555999900000000000000000
 36  000095555555555555555555555555999990000000000000
 35  000995555555555555555555555555555599990000000000
 34  000955555555555555555555555555555555599990000000
 33  009955555555555555555555555555555555555590000000
 32  009555555555555555555555555555555555555590000000
 31  099555555555555555555555555555555555555590000000
 30  995555555555555555555555555555555555555590000000
 29  955555555555555555555555555555555555555590000000
 28  995555555555555555555555555555555555555590000000
 27  099555555555555555555555555555555555555590000000
 26  009555555555555555555555555555555555555590000000
 25  009955555555555555555555555555555555555590000000
 24  000995555555555555555555555555555555555590000000
 23  000099555555555555555555555555555555555590000000
 22  000009555555555555555555555555555555555590000000
 21  000009955555555555555555555555555555555590000000
 20  000000995555555555555555555555555555555590000000
 19  000000095555555555555555555555555555555590000000
 18  000000099555555555555555555555555555555590000000
 17  000000009955555555555555555555555555555590000000
 16  000000000955555555555555555555555555555590000000
```

Figure B28a. File cell.inp for WCA2A Grid Shown in Figure B25.

```
 15  0000000009955555555555555555555555555590
 14  0000000000995555555555555555555555555590
 13  0000000000095555555555555555555555555590
 12  0000000000099555555555555555555555555590
 11  0000000000009955555555555555555555555590
 10  0000000000000955555555555555555555555590
  9  0000000000000955555555555555555999999990
  8  0000000000000995555555555559999999000000000
  7  0000000000000009555555599999900000000000000
  6  0000000000000009555555990000000000000000000
  5  0000000000000009555559900000000000000000000
  4  0000000000000009555599000000000000000000000
  3  0000000000000009955590000000000000000000000
  2  0000000000000000999900000000000000000000000
  1  0000000000000000000000000000000000000000000
C
C    12345678901234567890123456789012345678901234567890
C             1         2         3         4         5
```

Figure B28b. Continuation of file cell.inp for WCA2A Grid Shown in Figure B25.

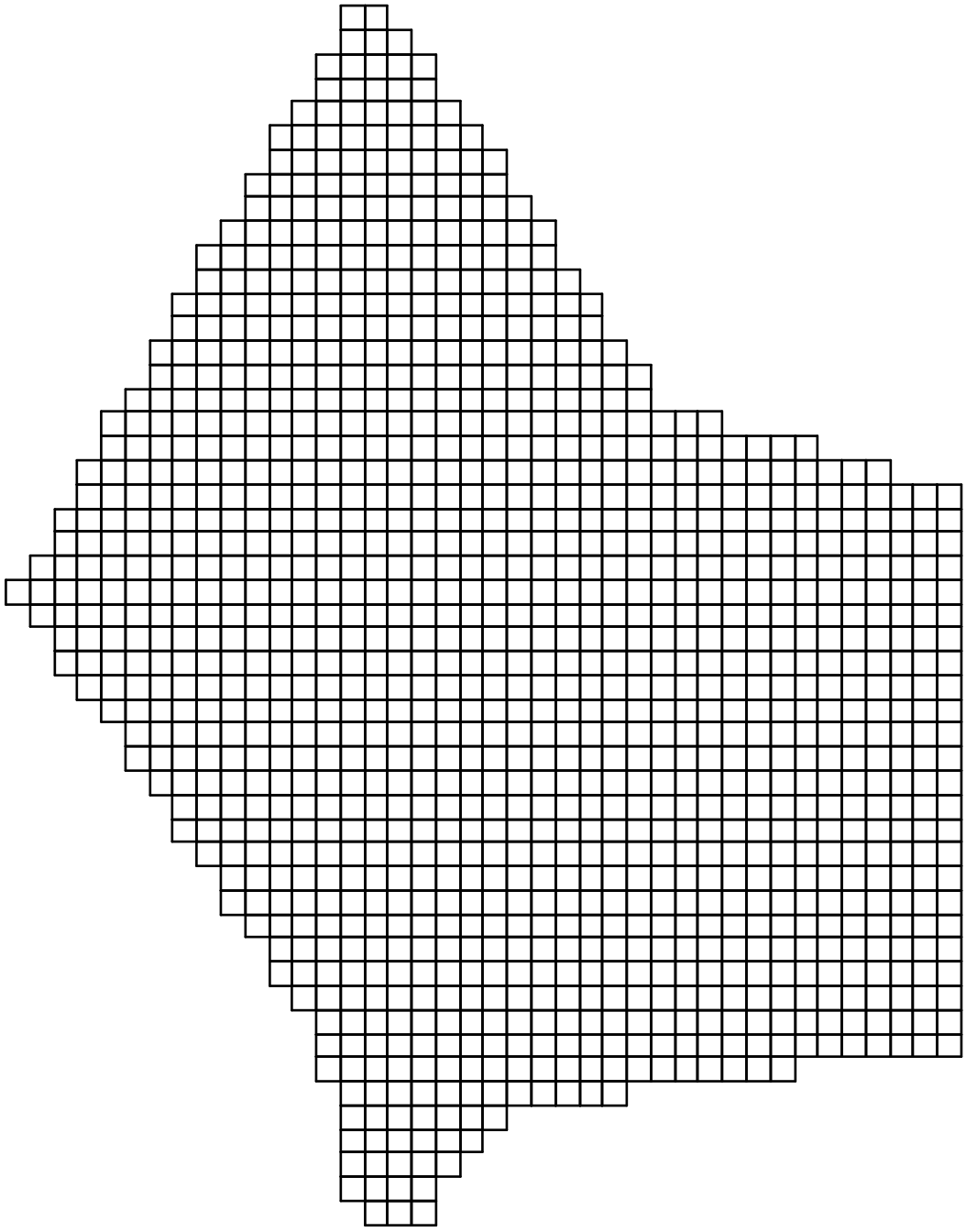

Figure B29. Square cell Cartesian grid representing same region as shown in Figure B25. This grid corresponds to the file gcell.inp in Figure B28.

```
C
      REAL*8 FUNCTION FIB(YY,J)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 YY
C
      IF(YY.GE.20.6.AND.YY.LE.35.6) THEN
       FIB=9.*(YY-21.)/15. + 7.
       RETURN
      END IF
C
      WRITE(6,601) YY,J
  601 FORMAT(' FUNCTION FIB OUT OF BOUNDS YY,J = ',F10.4,I8/)
C
      RETURN
      END
C
```

Figure B30. FORTRAN function subroutine for physical domain true east or X coordinate (FIB), along beginning I boundary as a function of physical domain true north or Y coordinate (YY) on that boundary.

```
C
      REAL*8 FUNCTION FIE(YY,J)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 YY
C
      IF(YY.GE.9.1.AND.YY.LE.23.6) THEN
       FIE=31.
       RETURN
      END IF
C
      WRITE(6,601) YY,J
  601 FORMAT(' FUNCTION FIE OUT OF BOUNDS YY,J = ',F10.4,I8/)
C
      RETURN
      END
```

Figure B31. FORTRAN function subroutine for physical domain true east or X coordinate (FIE), along ending I boundary as a function of physical domain true north or Y coordinate (YY) on that boundary.

```
C
      REAL*8 FUNCTION GJB(XX,I)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 XX
C
      IF(XX.GE.6.76.AND.XX.LT.8.76) THEN
       X=XX-6.76
       GJB=20.6-0.6*X-(2.254-0.203*X)*X*X/7.7
       RETURN
      END IF
C
      IF(XX.GE.8.76.AND.XX.LT.14.7) THEN
       GJB=-11.2*(XX-7.)/7.7 + 21.
       RETURN
      END IF
C
      IF(XX.GE.14.7.AND.XX.LT.19.4) THEN
C      GJB=-2.1*(XX-14.7)/4.7 + 9.8
       X=XX-14.7
       CTMP=6.764968/(4.7*4.7)
       DTMP=-2.028605/(4.7*4.7*4.7)
       GJB=9.8-11.2*X/7.7+(CTMP+DTMP*X)*X*X
       RETURN
      END IF
C
      IF(XX.GE.19.4.AND.XX.LE.29.0) THEN
       GJB=1.5*(XX-19.4)/11.6 + 7.7
       RETURN
      END IF
C
      IF(XX.GE.29.0.AND.XX.LE.31.) THEN
       X=XX-31.
       GJB=9.1-(0.63+0.085*X)*X*X/11.6
       RETURN
      END IF
C
      WRITE(6,601) XX,I
  601 FORMAT(' FUNCTION GJB OUT OF BOUNDS XX,I = ',F10.4,I8/)
C
      RETURN
      END
C
```

Figure B32. FORTRAN function subroutine for physical domain true north or Y coordinate (GJB), along beginning J boundary as a function of physical domain true east or X coordinate (XX) on that boundary.

```
C
      REAL*8 FUNCTION GJE(XX,I)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 XX
C
      IF(XX.GE.15.76.AND.XX.LT.17.76) THEN
       X=XX-15.76
       GJE=35.6-0.6*X-(1.696-0.082*X)*X*X/7.5
       RETURN
      END IF
C
      IF(XX.GE.17.76.AND.XX.LT.22.5) THEN
       GJE=-10.3*(XX-16.)/7.5 + 36.
       RETURN
      END IF
C
      IF(XX.GE.22.5.AND.XX.LT.24.5) THEN
       X=XX-22.5
       GJE=(203.05-10.3*X+2.*X*X)/7.5
       RETURN
      END IF
C
      IF(XX.GE.24.5.AND.XX.LT.29.0) THEN
       GJE=-2.3*(XX-23.5)/7.5 + 25.7
       RETURN
      END IF
C
      IF(XX.GE.29.0.AND.XX.LE.31.0) THEN
       X=XX-31.
       GJE=23.6+(1.175+0.2*X)*X*X/7.5
       RETURN
      END IF
C
      WRITE(6,601) XX,I
  601 FORMAT(' FUNCTION GJE OUT OF BOUNDS XX,I = ',F10.4,I8/)
C
C
      RETURN
      END
C
```

Figure B33. FORTRAN function subroutine for physical domain true north or Y coordinate (GJE), along ending J boundary as a function of physical domain true east or X coordinate (XX) on that boundary.

B.6 Chesapeake Bay

This section describes a square cell Cartesian grid of the Chesapeake Bay. The physical domain grid is shown in Figure B34, the cell.inp file, Figure B35, and the gefdc.inp file, Figure B36. The grid was generated with the NTYPE = 9, option by gefdc.f.

Figure B34. Physical and computational domain grid of the Chesapeake Bay. Grid spacing is approximately 1850 meters.

```
C cell.inp file, i across and j up, for ches bay
C    0        1         2         3         4         5         6         7         8         9
C    12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456
C
180  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
179  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
178  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
177  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
176  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
175  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
174  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
173  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
172  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
171  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
170  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
169  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
168  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
167  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
166  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
165  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
164  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
163  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
162  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
161  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
160  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
159  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
158  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
157  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
156  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
155  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
154  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
153  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
152  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
151  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
150  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
149  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
148  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
147  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
146  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
145  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
144  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
143  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
142  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
141  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
140  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
139  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
138  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
137  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
136  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
135  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
134  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
133  000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
132  000000000000000000000999000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
131  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
130  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
129  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
128  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
127  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
126  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
125  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
124  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
123  000000000000000000000959000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

Figure B35a. File cell.inp for Chesapeake Bay Grid Shown in Figure B34.

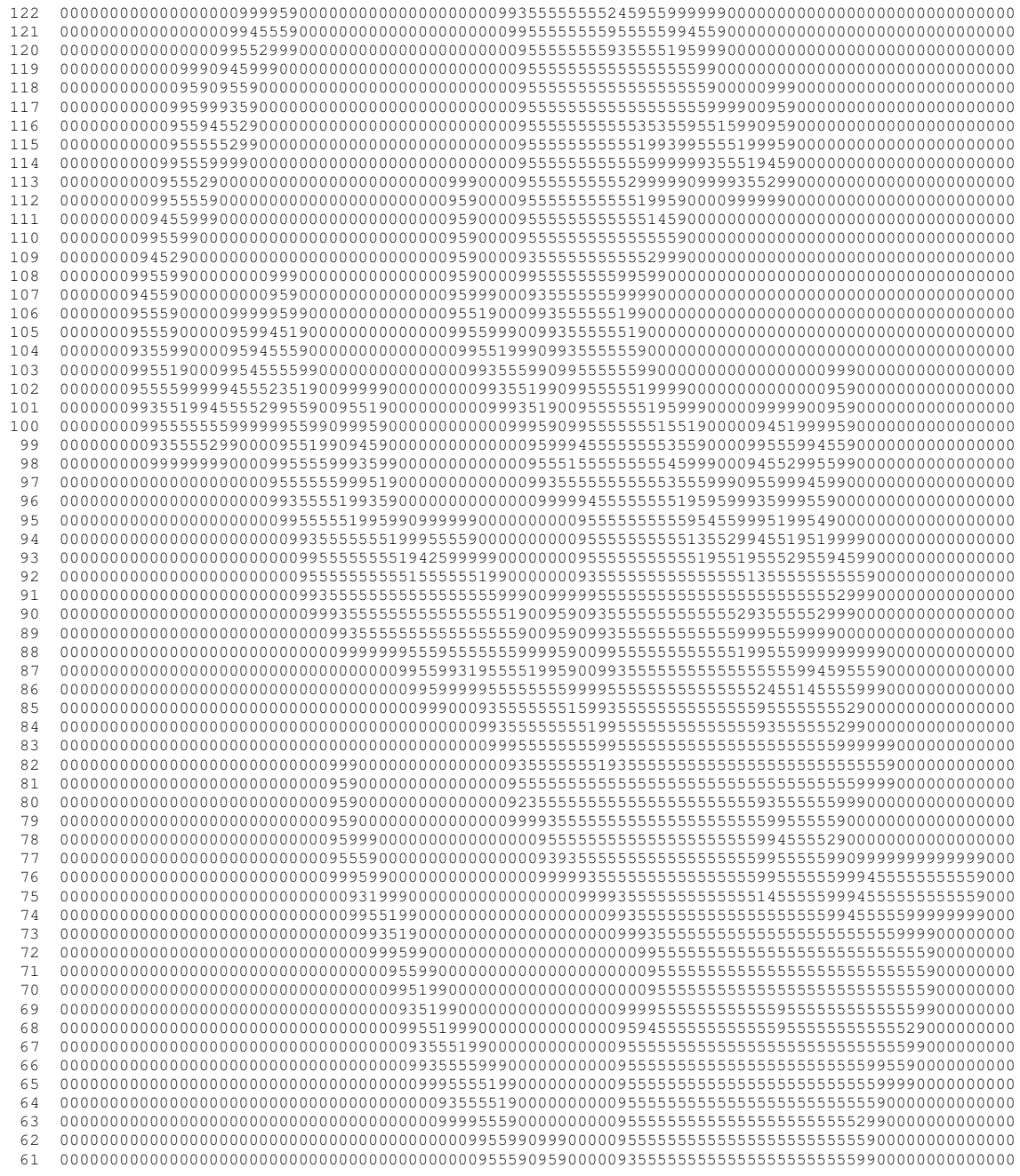

Figure B35b. Continuation of file cell.inp for Chesapeake Bay Grid Shown in Figure B34.

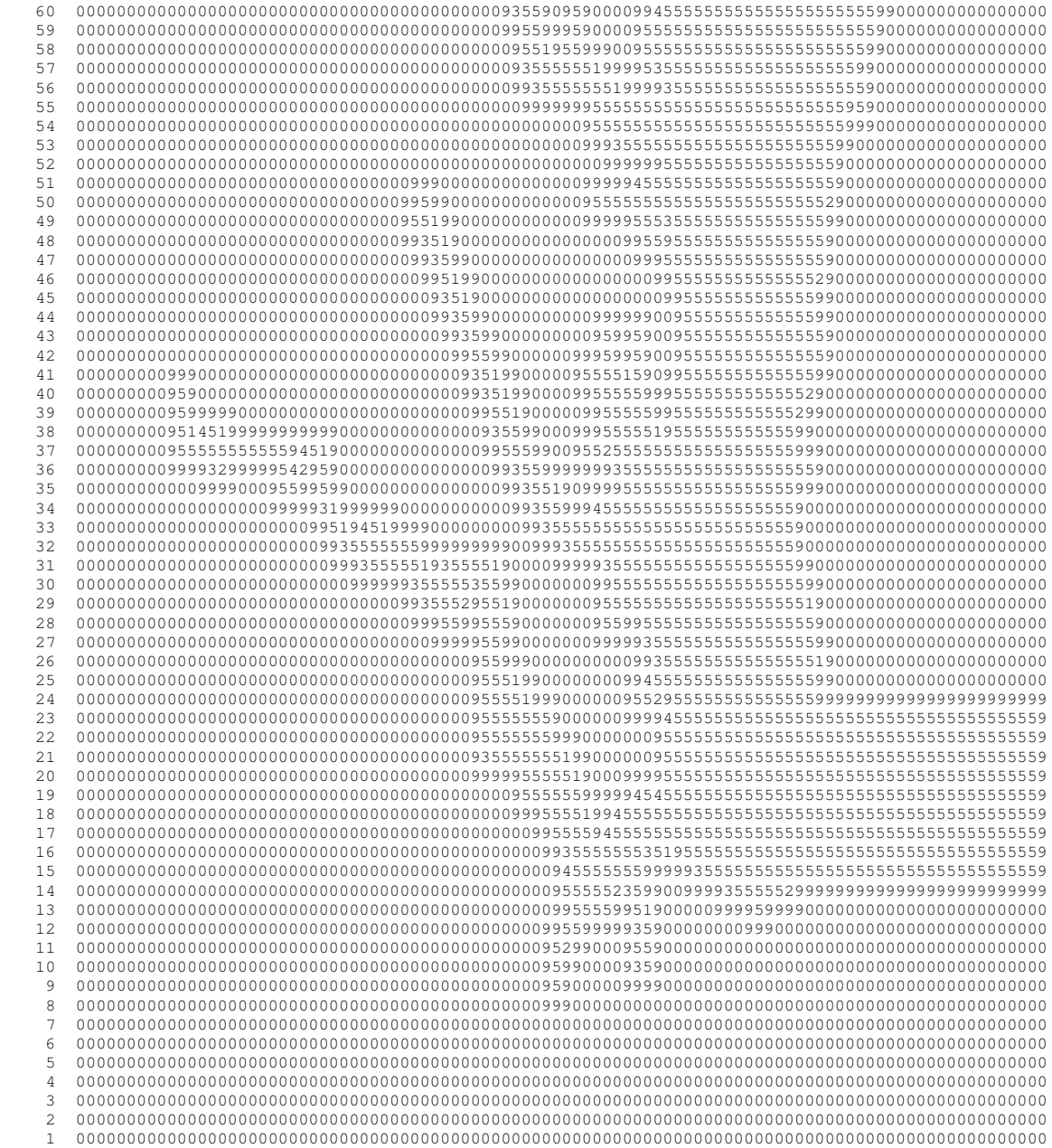

Figure B35c. Continuation of file cell.inp for Chesapeake Bay Grid Shown in Figure B34.

```
C1  TITLE
C1  (LIMITED TO 80 CHARACTERS)
    chesapeake bay cartesian, ll input, utm output
C2  INTEGER INPUT
C2  NTYPE  NBPP   IMIN  IMAX  JMIN  JMAX  IC   JC
     9      0      1     97    1     181   96   180
C3  GRAPHICS GRID INFORMATION
C3  ISGG  IGM  JGM  DXCG  DYCG nwtgg
     1     96   180  1850. 1850. 1
C4  CARTESIAN AND GRAPHICS GRID COORDINATE DATA
C4  CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2  CDLAT3
     -77.5   1.25    -0.625  36.7    1.0     -0.5
C5  INTEGER INPUT
C5  ITRXM  ITRHM  ITRKM  ITRGM
     100    100    100    100    4000  1.0
C6  REAL INPUT
C6  RPX  RPK  RPH  RSQXM  RSQKM  RSQKIM  RSQHM  RSQHIM  RSQHJM
     1.8  1.8  1.8  1.E-12 1.E-12 1.E-12  1.E-12 1.E-12  1.E-12
C7  COORDINATE SHIFT PARAMETERS
C7  XSHIFT    YSHIFT   HSCALE  RKJDKI  ANGORO
     0.        0.       1000.   1.      7.0
C8  INTERPOLATION SWITCHES
C8  ISIRKI  JSIRKI  ISIHIHJ  JSIHIHJ
     1       0       0        0
C9  NTYPE = 7 SPECIFIED INPUT
C9  IB    IE    JB    JE  NINITM N7RELAX ITN7MAX  SERRMAX
C10 NTYPE = 7 SPECIFIED INPUT
C10 X    Y   IN ORDER (IB,JB) (IE,JB) (IE,JE) (IB,JE)
C11 DEPTH INTERPOLATION SWITCHES
C11 ISIDEP  NDEPDAT   CDEP  RADM  isidptyp  surfelv
     0       79431       2.    1.  1         0.      0    0    0
C12 LAST BOUNDARY POINT INFORMATION
C12 ILT JLT X(ILT,JLT)  Y(ILT,JLT)
     1   1   1           1
C13 BOUNDARY POINT INFORMATION
C13 I   J   X(I,J)    Y(I,J)
```

Figure B36. File gefdc.inp for Chesapeake Bay Grid Shown in Figure B34.