A FINITE ELEMENT MODEL FOR
STRATIFIED FLOW AND COHESIVE SEDIMENT/SAND TRANSPORT
RMA-10S
USERS GUIDE
VERSION 3.4

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1. INTRODUCTION

This documentation describes the implementation of a revised version of RMA-10 designated RMA-10S designed to extend the capability of RMA-10 to simultaneous simulation of sand or cohesive sediment transport (including erosion and deposition and tracking of the bed). Version 3.0 is derived from version 7.2 of the basic RMA-10 model. An additional section documents the additional coding required to add the cohesive sediment and sand transport and bed evolution algorithms.

This user guide should also be* considered as an addendum to the original report and users guide that documents RMA-10 . It describes the FORTRAN implementation that has been tested on the IBM-PC under DOS and WINDOWSxx, and Dec Alpha computers under UNIX.

The following changes and additions have been added to Version 7.2D. The last set of changes implemented in RMA-10 is provided as a starting reference. The list below also indicates the extent of testing on each of these changes.

Version 3.3 of RMA-10S

- Revision of structure so that the cohesive sediment transport option now allows for definition of properties by element property number. There is some duplication of input variables. These have been left in that format for compatibility with earlier versions. In addition to basic properties, initial conditions and old bed structure may be input as element type dependent values.

Version 3.2 of RMA-10S

- Revision of storage structure so that nearly all files are dynamically allocated. For two-dimensional applications the number of nodes and elements and the number of equations are automatically assigned. Other variables such as front width, number of popints in a hydrograph data file etc., have default values that may be over-ridden in the "limits" section of the input R10 file.
- Additional options have been added to the file output to permit saving of wave data for cohesive sediment simulations in RMA-11 format and to output the results from triangulation of the surface stress data to an RM1 format file.

Version 3.1 of RMA-10S

- Addition of two-dimensional control structures compatible with those used in RMA-2
- An additional option for control structures that allows flows to be calculated from a tabular form expresses in terms of water surface elevation upstream or downstream (using INCSTR file input). Also see section 4.12 for file format
- An option that allows for time based switching of flow at weir or tabular form control structures. This option requires ITIMS file input (also see section 4.13 for file format).

Version 3.0 of RMA-10S

- Input of cohesive sediment parameters
- Overall calculation of resulting erosion/deposition rates
- Local calculation at Gauss points of net gain/loss of cohesive sediment
- Computation of net bed changes and updating of bed elevation
- Addition of two-dimensional elements that do not use the vertical transformation and addition of a switch that activates this option (see INOTR option on the C1 data line).

Version 1.0 of RMA-10S

Routines have been added to RMA-10 to permit:

- Input of sand parameters
- Overall computation of bed shears
- Overall calculation of sand transport potential
- Overall calculation of resulting erosion/deposition rates
- Local calculation at Gauss points of net gain/loss of sand
- Computation of net bed changes and updating of bed elevation

Version 7.2d

This revision updates the capabilities of RMA-10 to consistently treat inflows and outflows and single layers. A number of bugs have been corrected and the options for selection of specification of sal/temp/sed have been updated. The model now operated as follows for boundary conditions of type QC or HC. When a positive concentration is applied this value is applied regardless of the flow direction (into or out from the system). When a negative concentration is specified the absolute value of the concentration is applied only when flow is into the system.

A second change is that RMA-10 is now capable of reading comma delimited hydrograph tidalgraph and element inflow graphs, however in this case the user must define all columns and not leave blanks to be treated as zeros.

Version 7.2c

This revision updates the treatment of files in RMA-10. This version creates a message file based on the input name for the OUTFIL and creates uniquely named optional restart files. Additional functions have been added for the case when Manning "n" varies with depth. The MAH option applies (on an element by element basis) a function, the MAT option applies interpolation across four table entries.

Version 7.2b

This minor revision implements a change to RMA10 to make the use of the horizontal turbulence options more flexible. The changes permit different turbulence options for different element types and different parameters for different element types when the Smagorinsky option is selected. To achieve this, an additional option has been added to the IEDSW parameter on the C0 data line that allows input of element-type-dependent values of IEDSW, TBFACT and TBMIN on a new ED3 data line. In addition, values of TBFACT and/or TBMIN may be optionally be input on an ED3 line when the IEDSW on the C1 data line selects the Smagorinsky option.
A bug that occurs when negative concentrations are specified on tidal boundaries that caused incorrect vertical distributions for flow boundaries has been corrected. An option that allows element loads to be treated only as mass loads (for heat/salinity/sediment has been added. For this option see the EFE line of the data input.

Version 7.2a

This minor revision implements two changes to RMA10 associated with wind stresses. The first change causes the model to detect when the location is dry in a "marshing" sense and then set the wind and surface stresses to zero. The second change modifies the input structure of the 'Met" file to add wind direction and thus allow the model to develop wind surface tractions from this file. Options have been added to the "Met" file to enable this capability as needed and at the same time to disable the heat budget capability if the user wants to use the input format of the "Met" file purely for input of wind stress related data.

Version 7.2

This version of RMA-10 expands the input capabilities of RMA-10 to allow interpolation of surface tractions from files containing these stresses on a different external geometric grid. These files may be radiation stresses from wave activity or wind stresses or any other external surface traction Two files are required; one file contains weighting factors, in ASCII or binary format, for the interpolation from a separate grid to the finite element nodes. This file may be generated using the separate utility GENT. The second file that also may be binary or ASCII contains the time series of surface tractions from the external grid. A second expansion permits RMA-10 to use an input geometry an ASCII file in RM1 format

Version 7.1a

This version of RMA-10 implements a simplified surface heat budget algorithm. The equilibrium method is used in which the heat flux is computed as a linear function of the difference between surface temperature and an input equilibrium temperature. Additional data is input through the EQT data line. More complete details on the algorithms used are given in Appendix D of this document.

Version 7.1

This version of RMA-10 implements a surface ice heat budget algorithm. Additional data is entered on two new data lines ICE1 and ICE2 and snow depth data may be added as an additional column in meteorologic data file. Input of the ICE1 data line automatically implements this option. A additional binary results file may be used to save water temperature and ice thickness values. This file is in RMA-11 format. It stores water temperature as constituent 1 and ice thickness (in mm) as constituent 2. More complete details on the algorithms used are given in Appendix C of this document.

Version 7.0 of RMA-10

This revision has been designed to update the usability of RMA-10 to reflect the growing need for more digits in nodal coordinates and to allow for the potential development of over 32,768 equations. The limit of 32,768 nodes was originally created the use of a number of INTEGER*2 arrays (to save memory space at a time of much smaller computers) for storage of cross-reference information on nodal numbers. Version 7.0 changes the relevant INTEGER*2 arrays to INTEGER*4 arrays. The coordinate array is now stored in double precision thus permitting up to 16 digits in coordinate definition.
RMA-10 has been modified to allow input of geometry files either from old format GEO files or from a newly developed format output by version 7.0 of RMAGEN.

2. FINITE ELEMENT IMPLEMENTATION

This chapter briefly presents the finite element implementation used in this model.

2.1 Element Description

The finite element model RMA-10 has been developed using a plan form of linear, triangular and quadrilateral isoparametric elements. Three, six and eight node points define these elements respectively. In each case two/three/four of the nodes are placed at the vertices and one/three/four nodes on the sides. The exact position of the mid-side node determines the curved shape of the side. If the location is precisely at the middle then a true straight side is developed. At any other location a parametric quadratic curve defines the shape. Within an element, quadratic approximations are used to represent the velocities u and v and salinity-temperature-sediment. A linear approximation is used for the depth h.

2.2 Drying Node Implementation.

Beginning with version 6.4 of RMA-10 the marsh element approach is now available. The basic element dropout method is still implemented. The user may thus select from two options.

1. Any element that has a node with a depth less than the pre-specified constant is eliminated from the system and new parallel flow boundary conditions are established. The program is allowed to check for the condition at a pre-specified interval in the iteration process. Setting IDSWT on control line C5 along with appropriate data initiates this option
2. Use the marsh element method. Setting IDNOPT on control line C1 and inputting additional data as appropriate initiates this method. This option is only implemented for sections of the system that are approximated as depth or cross-section averaged. It is not recommended to use the marsh element method with element dropout. Issues associated with preservation of constituent and water mass are best served by allowing the elements to remain active in the system. Appendix A presents a description of the philosophy, mathematical approach and data requirements for the method.

3. USER INSTRUCTIONS

This chapter presents the program limitations, input instructions. An example problem for test purposes is included on the distribution disk. The initial section will describe the general philosophy of the model and discuss boundary conditions.

3.1 Finite Element Network Structure

The model is designed to execute from input specifications that define a one/two-dimensional horizontal network. The output file generated by an RMAGEN (graphics) or RMA-1 (network generator) runs or a conventional fixed format file may be used in the input stream. If the update frequency for drying nodes is set to zero the model operates directly as a conventional 2-D flow model without reference to the drying subroutines.

3.2 Boundary Conditions

Four alternate forms of nodal boundary conditions may be specified:
a) Regular flow boundaries in which the flow is specified by the product of velocity times depth for two-dimensional elements and total flow for one-dimensional elements.
b) Specified velocities at boundary nodes,
c) Head boundaries where the user inputs values for nodes that are to be specified at a given point
d) Salinity-temperature-sand concentration values at nodal points.
In this implementation of RMA-10 the previous requirement that slip boundary networks maintain perfect boundary slope continuity has been removed although model performance (particularly with respect to continuity checks) is probably superior when slope continuity is maintained as much as possible.

Four additional boundary condition types may also be specified based upon definition of boundary lines. These consist of:
a) Specified flow across a line, plus optional salinity-temperature-sand.
b) Specified elevation along a line, plus optional salinity-temperature-sand.
c) Specified elevation-flow along a line according to the formula
$Q = A + B * (Elev - C) ** D$, plus optional salinity-temperature-sand.
d) Specified salinity-temperature-sand along a line.

3.3 Program Limitations

The program is written in standard FORTRAN and has been executed on an IBM-PC under DOS and Windows 95 etc, and Dec Alpha workstations under UNIX each with virtual memory operating system. It is possible that in particular applications the size limitations listed below will have to be adjusted by recompilation with changed dimensions to reflect different size networks. All the limits listed below except fluid types are maintained in PARAMETER statements. The model is presently compiled to allow:

Max front width	1000	
Max buffer size	5,000,000	
Max number of layers	1	
Max number of sediment layers	5	
Max number of sand constituents	1	This is fixed
Max number of material types when using met data	20	

Max number of input boundary flows in hydrograph file	20
Max number of points in each hydrograph	2500
Max number of input tidal flows in tidal graph file	5
Max number of points in each hydrograph	3500
Max number of input element flows in graph file	40
Max number of points in each hydrograph	2600

The following file units are required in execution of the model. Other files may be needed according to input definition:

0/ or 1/ for console or log output. This file number is defined in the main program as ICFL and assumed to be open.

2/ Input data
3/ Output results
8/, 9/ Scratch units for data during equation solution.

3.4 Program Structure

The list below presents a brief description of the purpose of the main program, subroutines and function of the model.

RMA10MN** Main program that calls all the primary routines governs the overall flow and writes restart and save files. The ** indicates different version for various compilers

AGEN Subroutine to compute cross-sectional areas for inflow lines

AMF Subroutine to compute

ANGLEN Subroutine to compute parameters for eddy and diffusion coefficient scaling

ARAA Subroutine to compute length of one-dimensional elements

BCS Setup subroutine for boundary conditions

BED Subroutine to read BED data

BEDLBED Subroutine to compute bed changes when the bedload transport option is selected

BFORM The subroutine (called from INPUT) that installs the input boundary conditions into the appropriate arrays.

BLINE1 Subroutine to compute angles and parallel flow boundary conditions

BLOK Block data routine for variable definition

BROWNLIE Subroutine to compute equilibrium potential for sand using the Brownlie method

BLSOP Subroutine to compute bottom slope components, used to compute vertical velocity boundary conditions

CHECK Subroutine for computation of continuity checks at specified sections.

COEF11 Subroutine for generation of element coefficient matrices for one-dimensional elements (plan view)

COEF11NT Subroutine for generation of element coefficient matrices for one-dimensional elements (plan view) with no vertical transformation

COEF25 Subroutine for generation of element coefficient matrices for two-dimensional elements (plan view)

COEF25NT Subroutine for generation of element coefficient matrices for two-dimensional elements (plan view) with no vertical transformation

COEF2D Subroutine for generation of element coefficient matrices for two-dimensional elements (plan view) using the Smagorinsky closure

COEF2DNT Subroutine for generation of element coefficient matrices for two-dimensional elements (plan view) using the Smagorinsky closure with no vertical transformation

COEF37 Subroutine for generation of element coefficient matrices for three-dimensional elements

COEF3D Subroutine for generation of element coefficient matrices for three-dimensional elements using the Smagorinsky closure

COEFV Subroutine for generation of element coefficient matrices for two-dimensional elements (elevation)

CSTRC 1-D control structure subroutine

DEL Subroutine for establishment of network in the dry node configuration, generating nodes as required

DEPSN Subroutine for computation of suspended sediment deposition

DISFCT Subroutine to compute distribution factors when applying vertical distributions

DNX and DNY Functions for definition of shape function derivative in 2-D

DRPOUT Subroutine to set parameters for equation dropout when convergence has been achieved

DSFCT Subroutine to develop mean flow and momentum coefficients

ELFLOWS Subroutine for input of element inflows

EXSWAN Subroutine to execute call to SWAN (not currently active)

FILE** Subroutine that is called to interactively open required files

FRONT Subroutine for solution of simultaneous equations.

FUNS Functions for definition density based on salinity/temp/sand

GETBC	Subroutine for control of and input of boundary conditions
GETCON	Subroutine to get elements connected to nodes and allocate areas
GETDRSST	Subroutine to extract surface stress data from various files
GETEQ	Subroutine to input element inflows from a time series file
GETGEO**	Subroutine for input of principal elements of the geometry of the system
GETH	Subroutine to enter tidal graph data from a time series file
GETINIT	Subroutine to enter initial conditions from a file or from data
GETMET	Subroutine to enter meteorological data
GETQ	Subroutine to enter hydrograph data from a time series file
GETSST	Subroutine to enter surface stress data from a time series file
GETSTRESS	Subroutine to get stresses from general layout of data
GETWAVE	Subroutine to enter wave data from a time series file
GETWT	Subroutine to generate weighting factors for surface stress locations
GPT	Function to define Gauss point locations
GTIDE	Subroutine to enter tidal harmonic data from a time series file
GTMAXSLP	Subroutine to compute erosion due to slumping of sand
HEATEX	Subroutine to generate flux components from the meteorological data
HGEN	Subroutine that generates fixed elevation boundary conditions
HGENSPCL	Subroutine that generates fixed elevation boundary conditions for selected levels only
ICETHK	Subroutine to compute ice thickness
INITL	Subroutine used to set initial values for arrays.
INMET	Subroutine for initial input of met data from a time series file
INPUT	Principal subroutine used for control of inflow of data.
INPUTD	Subroutine for data input during each time step
INSAND	Subroutine to read sand parameters
LNFLO	Subroutine to compute individual element inflows as determined by ELFLOWS

LOAD3 Subroutine for generation of equivalence between node number and degree of freedom from equation number. Also establishes lists indicating compilation of equation formulation.

MARSH Subroutine to input marsh method parameters

MELLIIHS Subroutine to compute vertical eddy and diffusion parameters using the quadratic vertical distribution and the Henderson Sellers correction

MEROSN Subroutine to compute mass erosion

MKSAND Subroutine to compute Gauss point rate and source terms for sand based on the settling velocity and the computed effective erosion rate

MKTEMP Subroutine to generate flux input values for the coefficient generating routines.

NELLI Level 2 Mellor Yamada closure for vertical eddy and diffusion parameters

NEWBED Subroutine to compute cohesive bed changes

NUMBOPT Package of subroutines for computation of an optimum order for equation solution

OUTNRM Subroutine to establish the direction of the outward normal from the each boundary line

OUTPUT Subroutine used for printing of latest velocities and depths.

PAL Compaq Visual Fortran program required to hold DOS screen when model run is completed

PLANAR Subroutine for computation of slope and gradients needed as boundary conditions in vertical velocity evaluation.

PRESR Subroutine to compute pressure at each node

QGEN Subroutine for generation of boundary conditions for specified flow across a line.

QGENSPCL Subroutine for generation of boundary conditions for specified flow across a line at a layer level

RDBIN Subroutine to read binary SMS geometry files

RDRM1 Subroutine to read ASCII RM1 geometry files

REWET Subroutine for restoration of original grid with apparent negative depths, used at end of solution

RMA10 Major logic control subroutine

ROIN1 Subroutine for generation of horizontal density gradients for three-dimensional elements.

SA,SA2,SAN Subroutines for computation of level 1 shape functions in two and three dimensions at Gauss points and nodes

SANDBED Subroutine to compute evolution of sand bed from suspended sediment.

SB,SB2, Subroutines for computation of level 2 shape functions in two and three dimensions at Gauss points

SBGEN Subroutine that controls generation of boundary conditions from convenience input values.

SEC***Elapsed time subroutine

SEDIMENT Subroutines to compute erosion and deposition rates for sand and develop equilibrium potential

SETGT Subroutine to compute gate set settings as demanded by model input

SETUP Subroutine to set up equation structure when solving for vertical velocities.

SETVEL Subroutine to compute settling velocities

SGEN Subroutine to compute specified boundary values of salinity/temperature/sand

SHEAR Subroutine to compute bed shears based on local velocities

SLUMP Subroutine to compute erosion term from slope collapse

STGEN Subroutine used to generate a given stage-flow boundary condition.

SURCOF Subroutine for generation of element coefficient matrices for surface element associated with three-dimensional elements.

SWANDT Subroutine to initiate SWAN operation (not used at present)

TF Tangent function

THREED Subroutine for generation of a three-dimensional net from initial two-dimensional structure

TWODSW Subroutine to implement collapse to 2-D for 3-D nodes as they dry up

UPDATE Subroutine to develop update set of values for primary variables from the equation solution.

VANRIJN Subroutine to compute equilibrium potential for sand using the original Van Rijn method

VRTVEL Subroutine for computation of vertical velocities

VVELF Subroutine for establishment of vertical velocities from the latest solution

WAVECM Subroutine to compute equilibrium potential for sand using the revised Van Rijn method allowing for wave induced shear

WSHEAR Subroutine to compute addition shear stress due to waves

XRED,XWRT Subroutines for reading and writing of blocks of data at intermediate stages of the equation solution process.

ZVRS Entrance and exit routine controlling file cleanup

3.5 File Structure for RMA-10

The model operates interactively with the user requesting the file name for data input. All other files are named in the data input file depending on the functions desired by the user. The basic input data is entered on this interactively named file and is described in section 4.

The model may activate the following files:

a) Input file. Basic input data is entered on this file and is described in the section below.

b) Output file. This file, which should be given without a suffix, is used to develop filenames for tabulation of all simulation results. The following suffices are added:
.ech to echo the input data
.itr to list the convergence parameters for all iterations.
.out to output full results at the requested frequency.

c) Input two-dimensional geometry file (from RMA1 or RMAGEN)[1] *Not required*.

d) Output two-dimensional geometry file (contains layer data). *Not required*

e) Boundary condition file for appending to the end of the main input file *Not required*.

f) Output 3-d geometry file for saving a copy of the generated 3-dimensional element structure. This file is used in post-processing programs *Not required*.

g) Output 2-d geometry file for saving a copy of the generated 2-dimensional element structure. This file can be used as an update of the input geometry file. *Not required*.

h) Input 3-d geometry file for use in place of the 2-d geometric input structure. The use of this file is not recommended *Not required*.

i) Input restart file, for restarting from a previous run. *Not required*.

j) Output restart file for saving results with a view to restarting. *Not required*

[1]). Two or three file types may be used. Each binary file allows the type to be selected optionally by changing the ID line
(1) Standard UNFORMATTED or
(2) TRANSPARENT/BINARY for compatibility between different compilers. Version 7.0 of RMAGEN now has a 1000 character header for the geometry file.
(3) RMA format (used for results files only), these are pure binary without headers for compatibility between different compilers. There is however a 1000 character ASCII header on these file types.

k) Output results file for storing all velocities and depths computed during each solution step. *Not required*.

l) Input results file. Use as input device when velocities, heads or concentrations are to be used from a previous run to solve for other parameters *Not required*.

m) File containing element inflow hydrograph data for interpolation *Not required*.

m) File containing hydrograph data for interpolation *Not required*.

n) File containing tidal-graph data for interpolation *Not required*.

o) File containing tidal harmonic data for later computation *Not required*.

p) File containing atmospheric weather data for later computation *Not required*.

q) File containing wave data for later computation *Not required*.

r) File containing surface stress data for later computation *Not required*.

4. DATA INPUT

This chapter presents the data format instructions for assemblage of the input files required to execute RMA-10. The model is designed to operate in English and metric units, units are selected based on the value IGRV input on line type C1. In these instructions actual units are only given where they are needed for clarity and for the wind stress input where they must conform. The optional boundary condition input data file may start with any new time step of the boundary condition data.

The main ASCII input file is designed to control the main flow of the program, inputting filename, control information, geometry, initial conditions, and then boundary conditions for each time step. Each line of this file is entered with an identifier in cols 1-8 (left adjusted). This identifier is essential for successful execution of the model

4.1 Main Input file formats

FILES BLOCK

The initial set of data lists the files that will be used by the model. This list may be entered in any order, however it must be terminated with an **ENDFIL** data line.

Columns	*Format*	*Name*	*Description*

Line type OUTFIL: File Name Data 1 line

01-06	A	ID	"OUTFIL"
09-40	A	FNAME	Output file name, (do not use suffix.)

Line type METFIL: File Name Data 1 line

01-06	A	ID	"METFIL "
09-40	A	FNAME	Input meteorological data file name, *not required.* If named heat budget data will be read from this file. See section 4.6

Line type BCFIL: File Name Data 1 line

01-05	A	ID	"BCFIL "
09-40	A	FNAME	Boundary condition file name for appending to the end of the main input file, *not required*.

Line type INGEO: File Name Data 1 line

01-05	A	ID	"INGEO " for type 1 "INBNGEO " for type 2 (see earlier footnote)
09-40	A	FNAME	Input binary file name containing two-dimensional geometry (from RMA1 or RMAGEN) *Not required.*

Line type INRM1: File Name Data 1 line

01-08	A	ID	"INRM1 "
09-40	A	FNAME	Input ASCII file name containing two-dimensional geometry in RM1 format *Not required.*

Line type INSMSBIN: File Name Data 1 line

01-05	A	ID	"INSMSBIN"
09-40	A	FNAME	Input binary file name containing two-dimensional geometry in SMS format *Not required.*

Line type INRST: File Name Data 1 line

01-07	A	ID	"INRST " for type 1 "INBNRST " for type 2 (see earlier footnote)
09-40	A	FNAME	Input binary restart file name, for restarting from a previous run. *Not required.*

Line type OUTRST: File Name Data 1 line

01-08	A	ID	"OUTRST" for type 1 "OUTBNRST " for type 2 (see earlier footnote)
09-40	A	FNAME	Output binary file name, for creation of file to permit restarting in a subsequent run. *Not required.*

Line type OUTRES: File Name Data 1 line

01-06	A	ID	"OUTRES " for type 1 "OUTBNRES " for type 2 "OUTBNRMA" for type 3 (see earlier footnote)
09-40	A	FNAME	Output binary file name, for creation of saved results from this run. *Not required.*

Line type OUTBNBED: File Name Data 1 line

01-06	A	ID	"OUTBNBED "
09-40	A	FNAME	Output binary file name, for creation of saved results of bed data in an RMA-11 RMA results format, from this run. *Not required.*

Line type OUTSMS: File Name Data 1 line

01-06	A	ID	"OUTSMS "
09-40	A	FNAME	Output binary file name, for creation of saved results in SMS format for velocities, depths and water surface elevation from this run. *Not required*.

Line type OUTSMS1: File Name Data 1 line

01-06	A	ID	"OUTSMS1 "
09-40	A	FNAME	Output binary file name, for creation of saved results in SMS format for:

1. Temperature
2. Salinity
3. Sand or cohesive sediment water column concentrations
4. Sand water column potential (if sand active)
5. Current bed elevation
6. Change in bed elevation
7. Bed shear stress

Line type VELFIL: File Name Data 1 line

01-06	A	ID	"VELFIL " for type 1 "VELBNFIL" for type 2 (see earlier footnote)
09-40	A	FNAME	Input results binary file name. Use as input device when velocities, heads or concentrations are to be used from a previous run to solve for other parameters *Not required*.

Line type OUT2GE: File Name Data 1 line

01-06	A	ID	"OUT2GE " for type 1 "OUTBN2GE" for type 2 (see earlier footnote)
09-40	A	FNAME	Output binary file name that will contain an updated copy of the geometry used in this run, *Not required*.

Line type OUT3GE: File Name Data 1 line

01-06	A	ID	"OUT3GE " for type 1 "OUTBN3GE" for type 2 (see earlier footnote)
09-40	A	FNAME	Output 3-d geometry file name for saving a copy of the generated 3-dimensional element structure. This file is used in post-processing programs *Not required*.

Line type IN3DGE: File Name Data 1 line

01-06	A	ID	"IN3DGE " for type 1 "INBN3DGE " for type 2 (see earlier footnote)
09-40	A	FNAME	Input 3-d geometry file for use in place of the 2-d geometric input structure. The use of this file is not recommended *Not required*.

Line type INELTFL: File Name Data 1 line

01-07	A	ID	"INELTFL "
09-40	A	FNAME	File containing element inflow hydrograph data for interpolation *Not required*.

Line type INELEV: File Name Data 1 line

01-06	A	ID	"INELEV "
09-40	A	FNAME	File containing tidalgraph data for interpolation *Not required*.

Line type INHYD: File Name Data 1 line

01-05	A	ID	"INHYD "
09-40	A	FNAME	File containing hydrograph data for interpolation *Not required*.

Line type INHARM: File Name Data 1 line

01-06	A	ID	"INHARM "
09-40	A	FNAME	File containing tidal harmonic data for later computation *Not required*.

Line type OUTCON: File Name Data 1 line

01-06	A	ID	"OUTCON "
09-40	A	FNAME	Output file name that will contain a time series of flow across continuity lines *Not required*.

Line type INWAVE: File Name Data 1 line

01-06	A	ID	"IN3WAVE " for type 1 "INBNWAVE " for type 2 (see earlier footnote)

09-40	A	FNAME	File containing wave data for later computation *Not required*.

Line type INSSTR: File Name Data 1 line

01-06	A	ID	"INSSTR " for type 1 "INBNSSTR " for type 2 (see earlier footnote)
09-40	A	FNAME	File containing surface stress data for later computation *Not required*.

Line type INSRCORD: File Name Data 1 line

01-05	A	ID	"INSRCORD"
09-40	A	FNAME	Input file name of an ASCII file that will contain the x and y coordinates an external grid. For format see section 4.8 *Not required*.

Line type INWGT: File Name Data 1 line

01-05	A	ID	"INWGT "
09-40	A	FNAME	Input file name of an ASCII file that will contain the weighting factors to interpolation of values from an external grid. For format see section 4.9 *Not required*.

Line type INBNWGT: File Name Data 1 line

01-07	A	ID	"INBNWGT "
09-40	A	FNAME	Input file name of a binary file that will contain the weighting factors to interpolation of values from an external grid. For format see section 4.9a *Not required*.

Line type INSTRESS: File Name Data 1 line

01-05	A	ID	"INSTRESS"
09-40	A	FNAME	Input file name of an ASCII file that will contain the time series of surface tractions from an external grid. For format see section 4.10 *Not required*.

Line type INBNSTRS: File Name Data 1 line

01-07	A	ID	"INBNSTRS"

09-40	A	FNAME	Input file name of a binary file that will contain the time series of surface tractions from an external grid. For format see section 4.10a *Not required*.

Line type OUTBNICE: File Name Data 1 line

01-06	A	ID	"OUTBNICE"
09-40	A	FNAME	Output file name that will contain a water temperature and ice thickness in RMA-11 RMA format. It is recommended that RMA be used as a subscript. *Not required*.

Line type AWINDIN/BWINDIN: File Name Data 1 line

01-07	A	ID	"AWINDIN " ASCII format "BWINDIN " Binary format
09-40	A	FNAME	Input file for wind time series. For formats see section 4.11 for ASCII format and 4.11a for binary format. *Not required*

Line type INCSTR: File Name Data 1 line

01-06	A	ID	"INCSTR"
09-40	A	FNAME	Input file name for control structure data For formats see section 4.12. *Not required*.

Line type INTIMS: File Name Data 1 line

01-06	A	ID	"INTIMS"
09-40	A	FNAME	Input file name for times series governing on/off of control structure operation For formats see section 4.13. *Not required*.

Line type MESHOUT: File Name Data 1 line

01-07	A	ID	"MESHOUT"
09-40	A	FNAME	Output file name for RM1 file generated during triangulation process from surface stress data. *Not required*.

Line type ENDFIL: File Name Data Indicator of end of file name data *Required* at end of file names 1 line

01-06	A	ID	"ENDFIL "

ALLOCATION LIMITS DATA BLOCK

(Only required if values larger than the default are used)

Line type MAXFRONT Front limit data 1 line (optional)

01-08	A	ID	"MAXFRONT"
09-16	I	MFW	Maximum allowed front size in equation solver (if not defined defaults to 1000)

Line type BUFFSIZ Front limit data 1 line (optional) or see below

01-07	A	ID	"BUFFSIZ "
09-16	I	NBSS	Buffer size for equation solver (if not defined defaults to 5,000,000)

Line type BUFFSIZL Front limit data for large buffer sizes 1 line (optional)

01-08	A	ID	"BUFFSIZL"
09-24	I	NBSS	Buffer size for equation solver (if not defined defaults to 5,000,000)

Line type MAXQPTS Points per inflow hydrograph limit data 1 line (optional)

01-07	A	ID	"MAXQPTS"
09-16	I	NDPTS	Maximum number of points per inflow hydrograph (if not defined defaults to 2000)

Line type MAXQINPT Number of inflow hydrographs limit data 1 line (optional)

01-08	A	ID	"MAXQINPT"
09-16	I	NQLDS	Maximum number of inflow hydrographs (if not defined defaults to 30)

Line type MAXHPTS Points per inflow tidalgraph limit data 1 line (optional)

01-07	A	ID	"MAXHPTS"
09-16	I	NHDPTS	Maximum number of points per inflow tidalgraph (if not defined defaults to 2,000)

Line type MAXHINPT Number of inflow tidalgraphs limit data 1 line (optional)

01-08	A	ID	A "MAXHINPT"
09-16	I	NHDS	Maximum number of inflow tidalgraphs (if not defined defaults to 15)

Line type MAXELPTS Points per element inflow graph limit data 1 line (optional)

01-08	A	ID	"MAXELPTS"
09-16	I	NEDPTS	Maximum number of points per element inflow graph (if not defined defaults to 2,000)

Line type MAXEINPT Number of element inflow graphs limit data 1 line (optional)

01-08	A	ID	"MAXEINPT"
09-16	I	NELDS	Maximum number of element inflow graphs (if not defined defaults to 80)

Line type **ENDLIMIT END OF LIMIT SETTING BLOCK** 1 line (optional but required if any limit lines been used)

01-08	A	ID	ENDLIMIT"

CONTROL DATA BLOCK

Line type TI: Title Data 1 line

01-02	A	ID	"TI"
09-80	A	TITLE	Any heading comment

Line type C0 Control Data 1 line Required

01-02	A	ID	"C0"
09-16	I	IOPTZD	Option for turbulence closure method' 0 = use original RMA-10 method 1 = use quadratic distribution based on nodal values with Henderson-Sellers correction for startified flow 2 = use linear distribution for the form of option 1 3 = gaussian Mellor-Yamada
17-24	I	IDNOPT	Option for marsh elements 0 = do not used marsh elements -1 = use default values for marsh parameters -2 = use input values for marsh parameters.
25-32	I	IYRR	Year to start simulation
33-40	I	DAYOFY	Julian day of year to start simulation
41-48	R	TET	Hour to start simulation
49-56	I	IEDSW	Switch controlling horizontal eddy/turbulence option used in the model. -1 = use ED3 data line for input of element type dependent options 0 = use input values directly 1 = use absolute magnitude of input values as scalars applied to nominal element lengths in the computed fixed principal direction of the element. 2 = Use Smagorinsky closure. Note that when this closure is used values must still be supplied on the ED line for use in the first 2 iterations from initial startup as if the type 1 closure had been used. These values are not used when restarting. 3 = use option 1, but apply in the current direction of flow in the element 4 = apply scalar factors in the direction of flow as in option 3 but compute element length in the direction of flow and apply second multiplier as a multiplier of the longitudinal value. This applies for both eddy and diffusion coefficients. For further information see instructions for line type ED.
57-64	R	TBFACT	Alfa factor applied in Smagorinsky closure. Typical range 0.02 - 0.5 (Default =0.2)

65-72	R	TBMIN	Minimum kinematic eddy viscosity using the Smagorinsky closure. Units are m^2/s of ft^2/s depending on unit system in use.
73-80	I	IPROJ	Projection option: 0 = project based on time derivative of variable 1 = do not project, use previous time step value 2 = project based on current and previous value.

Line type C1 Control Data 1 line Required

01-02	A	ID	"C1"
09-16	I	NDP	Control for number of layers NDP = 0, No NDEP values read. from this file. NDP = 1, Read NDEP values for all surface nodes, type LD1 NDP = -1, Read NDEP values at corner nodes as required, type LD2, defining proportional spacing. NDP = +2, Read NDEP values at corner nodes as required, type LD3. defining absolute elevations. NDP = -N Set NDEP to ABS(NDP) -1, provided NDP < -1. Do not read cards type LD*
17-24	I	IGRV	Switch controlling units. IGRV = 0 Use English units. IGRV = 1 Use metric units.
25-32	I	IZB	Switch controlling bottom velocities IZB = 0 Use bottom friction i.e. Manning or Chezy resistance. IZB = 1 Use zero bottom velocity constraint for elements that permit variable velocity over depth. Manning or Chezy resistance for depth averaged elements.
33-40	I	IPASS1	IPASS1 = 1 Treat salinity as a passive conservative constituent. That is, no density coupling. IPASS1 = 0 Treat salinity as a density coupled constituent.
41-48	I	IPASS2	IPASS2 = 1 Treat temperature as a passive conservative constituent. That is, no density coupling. IPASS2 = 0 Treat temperature as a density coupled constituent.
49-56	I	IPASS3	IPASS3 = 1 Treat suspended sediment as a passive conservative constituent. That is, no density coupling. IPASS3 = 0 Treat suspended sediment as a density coupled constituent.

57-64	I	IZERS	IZERS = 1 model water surface as constrained by zero horizontal velocity. IZERS = 0 use Chezy or Manning coefficient to apply friction if desired. (see line ED2)
65-72	I	IDIFSW	IDIFSW = 0 use values defined by IEDSW for diffusion. IDIFSW = 1 use scale factor values defined by IEDSW =1 option for diffusion. IDIFSW = 2 use Smagorinsky values defined by IEDSW =2 option for diffusion. IDIFSW = 5 use Elder-like[2] equation with coefficient defined by 1st entry on ED2 data line transverse diffusion defined as a scale factor of longitudinal diffusion as the 2nd entry on the ED2 data line IDIFSW = 9 use constant values defined on line ED2
73-80	I	INOTR	INOTR = 1 do not apply vertical transformation (may only be used for depth averaged simulations. INOTR = 0 apply vertical transformation

Line type C2 Control Data 1 line Required

01-02	A	ID	"C2"
09-16	R	OMEGA	Local latitude average, (degrees)
17-24	R	ELEV	Average initial water surface elevation (feet/m). Elevation is also used for vertical coordinate transformation.
25-32	R	XSCALE	Scale factor for X coordinate nodal inputs (including nodal widths)
33-40	R	YSCALE	Scale factor for Y coordinate nodal inputs
41-48	R	ZSCALE	Scale factor for Z coordinate nodal inputs (including bottom elevation).
49-56	I	IDEBUG	Debug switch: 0 = No action 1 = Write input external coordinates and stress components to unit 234

[2] Elder equation $D_F = 5.93\, U^* d$ is replaced by $D_F = K\, U^* d$

Where
d is water depth
U^* is the shear velocity = $Ug^{0.5}/C$
G is the acceleration due to gravity
C is the Chezy coefficient or Manning equivalent.
K is the input coefficient on the ED2 data line for each element type

Line type C3 Control Data 1 line Required

01-02	A	ID	"C3"
09-16	R	CMIN	Coefficients used to describe salinity-temperature-sediment distribution at 2-D/3-D transition.
17-24	R	CPR	Expression is C=CAVE*(CMIN+(1-CMIN)*(Z/H) **CPR where Z (feet/m) is the elevation above the bottom, and H (feet/m) is the depth.
25-32	R	UNOM	Nominal velocity (fps or m/s), used as initial guess if not restarting. Default equals 0.00. This option is currently used only for 1-d nodes.
33-40	R	UDIR	Direction in degrees of the nominal velocity anti-clockwise direction for x axis.
41-48	R	HMIN	Minimum depth (feet/m) used at startup. Eliminates possible negative depth on sloping river systems. If HMIN equals zero it is not used in initial definition.
49-56	R	DSET	Depth (feet/m) at which nodes are considered dry during drying process
57-64	R	DSETD	Depth (feet/m) at which nodes are considered submerged during wetting process

Line type C4 Control Data 1 line Required

01-02	A	ID	"C4"
09-16	R	SALI	Initial value for salinity concentration.
16-24	R	TEMPI	Initial value for temperature in degrees.
25-32	R	SEDI	Initial value for suspended sediment/sand concentration.
33-40	R	UINP	Value for u bed velocity used in friction calculations for initial iteration(ft/s or m/s).
41-48	R	VINP	Value for v bed velocity used in friction calculations for initial iteration (ft/s or m/s).
49-56	R	PRCNT	Percent of salt concentration outflowing returning during ocean exchange. (default=0.)
57-64	R	DMIX	Surface mixing depth that can be used to model surface wind induced mixing. Mixing is accomplished by increasing Z-direction diffusion and eddy coefficients by a factor of 32 at the surface and is steadily decreased this multiplier down to the input mixing depth. This option is only applicable when IOPTZD=0

Line type C5 Control Data 1 line Required

01-02	A	ID	"C5"
09-16	I	NITI	Maximum number of iterations for initial steady state solution, set = 0 to skip steady state solution.
17-24	I	NITN	Maximum number of iterations for each dynamic solution step
25-32	R	TSTART	Not used.
33-40	I	NCYC	Number of time steps to be simulated
41-48	I	IPRT	Print option 0 = suppress node and element information 1 = print all input data and expanded form of results 2 = suppress node and element data and print short form of the results
49-56	I	NPRTI	Frequency during iterations for printing of full solution. If set = 0 solution printed only after last iteration subject to value in NPRTF.
57-64	I	NPRTF	Time step frequency for printing full solution
65-72	I	IRSAV	Time step at which to start saving solutions on binary results file.
73-80	I	IDSWT	Frequency of testing for dry node modification. Set = 0 to eliminate dry node operation.
81-88	I	NBSFRQ	Time step frequency for output to RMA and SMS format results files, (Zero defaults to 1).

Line type C6 Control Data 1 line Optional

01-02	A	ID	"C6"
09-16	I	IOUTFREQ	Frequency for saving binary results files (Zero defaults to 1)
17-24	I	IOUTRST	Frequency for saving binary results files (Zero defaults to 10)

Line type INIT Initial Water Surface Data 1 line Optional

01-04	A	ID	"INI"
09-16	R	ELEV1	Initial water surface elevation. This input is designed to optionally over-ride the initial water surface elevation

input on the C2 line but to leave the transformation elevation unchanged.

Line type SND Activate bed model for sand transport 1 line Optional

01-03	A	ID	"SND" Presence of this data line activates sand transport and bed modelling. The model then requires input of the sand transport parameters

Line type SED Activate bed model for cohesive sediment transport 1 line Optional

01-03	A	ID	"SED" Presence of this data line activates cohesive sediment transport and bed modelling. The model then requires input of the cohesive sediment parameters

Line type BED Activate equilibrium bedload model for sand transport 1 line Optional

01-03	A	ID	"BED" Presence of this data line activates bedload sand transport and bed modelling using the equilibrium method. The model then requires input of the sand transport parameters

Line type ZSTDEP Set minimum depth for application of activation of surface stresses 1 line Optional

01-06	A	ID	"ZSTDEP"
09-16	r	R	Minimum depth for active surface stresses. Used to shutdown surface stresses as depths go to dry

Line type CRS Critical slope for sand As many lines as required Optional

01-03	A	ID	"CRS"
09-16	I	NN	Element number.
17-24	R	CRSLOP	Maximum allowable slope before slope collapse occurs for sand

Line type DRP Cutout option for erosion/deposition 1 line Optional

01-03	A	ID	"DRP"
09-16	I	NN	Element type numbers that will not be subject to deposition/erosion. (Up to 9 values)

to
73-80

<u>**Line type CV** Convergence Data 1 line Optional</u>

01-02	A	ID	"CV"
09-16	R	CONV(1)	Maximum allowable change in x-velocity component during convergence test (f/s or m/s).
17-24	R	CONV(2)	Maximum allowable change in y-velocity component during convergence test (f/s or m/s).
25-32	R	CONV(3)	Maximum allowable change in depth component during convergence test (feet or m).
33-40	R	CONV(4)	Maximum allowable change in salinity component during convergence test (conc units).
41-48	R	CONV(5)	Maximum allowable change in temperature component during convergence test (conc units).
49-56	R	CONV(6)	Maximum allowable change in sediment component during convergence test (conc units).
57-64	I	IDRPT	Switch controlling activation of equation dropout: 0 = do not activate 1 = activate basic method. This option resets the system to run the full set of nodes whenever the active constituent set changes. 2 = activate advanced method. This option examines the past history of convergence when the constituent set changes. A node may be dropped out if no changes have occurred for the node that violates the convergence criteria since a previous converged solution was achieved for the now active constituent set. This option is new at version 6.8f and should be used with care.
65-72	R	DRFACT	Factor applied to convergence tolerance to decide whether to dropout equation during the next iteration.

<u>**Line type IOV TIME OVERLAY OPTION** (optional) When this line is entered the input time from any restart file is overlaid with the time from the control line C1</u>

01-03	A	ID	"IOV"

<u>**Line type IOP** Internal reordering 1 line Optional</u>

01-04	A	ID	"IOP"

This option initiates an internal reordering processor that over-rides the order entered on the “geo” file. It is experimental and does not always produce better ordering (lower run time) than the methods in RMAGEN. For large simulations it may be used as part of an evaluation of the fastest equation solving process.

Line Type ICE1. Ice data 1 line Optional, if not provided ice formation and influence will not be simulated.

01-08	A	ID	"ICE1 "
09-16	R	ROW	Density of water (kg/m^3)
17-24	R	CHEAT	Heat capacity of water
25-32	R	TMED	Temperature at the ice/water interface (deg C
33-40	R	HTR	Heat transfer coefficient between snow and air (W/m^2/deg C)
41-48	R	XLAT	Latent heat of fusion of ice (J/g). Default=333.4
49-56	R	ROSN	Density of snow (kg/m^3). Default=300
57-64	R	ROIC	Density of ice (kg/m^3) Default=917
65-72	R	TICE	Ice temperature, (deg C). If TICE is set positive, the ice temperature is calculated as the mean of the snow–ice interface temperature and TICE. If set negative the value of TICE is used directly as the ice temperature.
73-80	I	ICESW	If ICESW = 0 then “Option 0” is used for stratified flow cases. This option uses the Ashton formulation to compute heat loss from the water column. If ICESW = 1 then “Option 1” is used for stratified flow cases. This option uses the RMA-10 diffusion formulation to compute heat loss from the water column.

Line Type ICE2. Ice data part 2 1 line Calibration and correction coefficients, required, if line type ICE1 is entered See appendix describing ice formation equations for more details

01-08	A	ID	"ICE2 "
09-16	R	CAL1	Calibration coefficient for ice-water transfers below critical water velocity
17-24	R	CAL2	Calibration coefficient for ice-water transfers above critical water velocity.

25-32	R	CAL3	Calibration coefficient for net heat flux in the presence of ice.
33-40	R	CAL4	Correction factor for thickness of snow cover.
41-48	R	VTR	Water velocity for transition of heat transfer formulation for ice-water heat flux

Line type COL 3-D Collapse Switch 1 line Optional

01-02	A	ID	"COL"
09-16	R	TRA	Transition depth at which 3-dimensional elements become 2-dimensional depth integrated. If = 0.0 then the transition depth is set equal to the depth at which wet/dry option starts to take effect.

Line type TST Time step adjustment option 1 line Optional

01-03	A	ID	"TST"
09-16	I	NODETR	Reference node for time step adjustment
17-24	R	TRELEV	Reference elevation for time step adjustment
25-32	R	TRFACT	Adjustment applied to input time step when water surface elevation is above the reference elevation TRELEV at node NODETR

Line type PWR Power station recycling option as many lines as required Optional

01-03	A	ID	"PWR"
09-16	I	NINCC	Model inflow continuity line number = power station outlet.
17-24	I	NOUTCC	Model outflow continuity line number = power station inlet
25-32	R	ADDSAL	Salinity concentration factor
33-40	R	ADDTMP1	Power station thermal load (MW)
41-48	R	ADDTMP2	No longer used.
49-56	R	ADDTMP3	Power station throttling factor
57-64	R	ADDSED	Sediment concentration factor
65-72	R	ADDMAX	Maximum increment in temperature.

73-80	I	NADTYP	Switch controlling method of inflow temperature computation. 0 = Use the standard method to compute the temperature increment. 1 = Ignore the values of ADDTMP and ADDMAX and use the values from the inflow hydrograph file as an increment applied to temperature of the outflow. 2 = Ignore the values of ADDTMP and ADDMAX and use the values on the inflow hydrograph file directly as the temperature of the inflow.

PROPERTIES DATA BLOCK

Line type ED1 Element Properties Data 2 lines Repeat line types ED1 and ED2 as pairs as many times as necessary

01-03	A	ID	"ED1"
09-16	I	J	Identification number for a set of turbulent exchange coefficients.
17-24	R	ORT(J,1)	Turbulent exchange coefficient associated with X direction shear of the X direction flow (lb-sec/ft^2 or Pascal-sec) If IEDSW = 0, input value is applied. If IEDSW = 1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the principal direction of the element. The X direction is transformed to this principal direction. If IEDSW = 2 the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not presently implemented) If IEDSW = 3. The magnitude of this entry is treated as a scale factor applied to the notional element length above If IEDSW = 4. The magnitude of this entry is treated as a scale factor applied to the element length in then characteristic direction of flow
25-32	R	ORT(J,2)	Turbulent exchange coefficient associated with Y direction shear of the X direction flow (lb-sec/ft^2 or Pascal-sec) If IEDSW = 0.0 input value is applied. If IEDSW =1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the transverse principal direction of the element. If IEDSW = 2 the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not presently implemented) If IEDSW = 3. The magnitude of this entry is treated as a scale factor applied to the notional transverse element dimension . If IEDSW = 4. The magnitude of this entry is treated as a scale factor applied the X-direction coefficient.
33-40	R	ORT(J,3)	Turbulent exchange coefficient associated with X direction shear of the Y direction flow (lb-sec/ft^2 or Pascal-sec) If IEDSW = 0, input value is applied. If IEDSW = 1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the principal direction of the element.

			If IEDSW = 2, the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not presently implemented) If IEDSW = 3, the magnitude of this entry is treated as a scale factor applied to the notional element length . If IEDSW = 4. This value is not used. Values for this coefficient are computed as identical to that for ORT(J,2)
41-48	R	ORT(J,4)	Turbulent exchange coefficient associated with Y direction shear of the Y direction flow (lb-sec/ft^2 or Pascal-sec) If IEDSW = 0, input value is applied. If IEDSW = 1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the transverse principal direction of the element. If IEDSW = 2 the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not presently implemented) If IEDSW = 3, the magnitude of this entry is treated as a scale factor applied to the notional transverse element dimension. If IEDSW = 4. This value is not used. Values for this coefficient are computed as identical to that for ORT(J,2)
49-56	R	ORT(J,5)	Chezy coefficient for this element type if ORT(J,5) < 1.0 Manning coefficient is assumed.
57-64	R	ORT(J,6)	Turbulent exchange coefficient associated with Z direction shear of the X direction flow (lb-sec/ft^2 or Pascal-sec)
65-72	R	ORT(J,7)	Turbulent exchange coefficient associated with Z direction shear of the Y direction flow (lb-sec/ft^2 or Pascal-sec)

Line type ED2 Element Properties Data 2nd line 2 lines see above.

01-03	A	ID	"ED2"
09-16			Leave blank
17-24	R	ORT(J,8)	Turbulent diffusion coefficient associated with the X direction (ft^2/s or m^2/s). If IEDSW = 0. input value is applied. If IEDSW = 1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the principal direction of the element. The X direction is transformed to this principal direction. If IEDSW = 2 the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not

			presently implemented) If IEDSW = 3. The magnitude of this entry is treated as a scale factor applied to a notional element length. If IEDSW = 4. The magnitude of this entry is treated as a scale factor applied to the element length in the characteristic direction of flow
25-32	R	ORT(J,9)	Turbulent diffusion coefficient associated with the Y direction (ft^2/s or m^2/s). If IEDSW = 0. input value is applied. If IEDSW = 1, the magnitude of this entry is treated as a scale factor that is applied to a notional element length in the transverse direction of the element. If IEDSW = 2 the Smagorinsky closure is used this value is used only for startup as if IEDSW=1 (not presently implemented) If IEDSW = 3. The magnitude of this entry is treated as a scale factor applied to the X direction value If IEDSW = 4. The magnitude of this entry is treated as a scale factor applied to the X direction value
33-40	R	ORT(J,10)	Turbulent diffusion coefficient associated with the Z direction (ft^2/s or m^2/s).
41-48	R	ORT(J,11)	Chezy coefficient for shoreline if ORT(J,11) < 1.0 Manning coefficient is assumed. Ignored if equal to zero.
49-56	R	ORT(J,12)	Multiplying factor for friction coefficient for application to drying section. Ignored if equal to zero or IDNOPT =0.
57-64	R	ORT(J,13)	Chezy coefficient for water surface. If ORT(J,13) < 1.0 Manning coefficient is assumed. Ignored if equal to zero.

Line type ED3 Element Properties Data 3nd line (May be optional - see above.)

01-03	A	ID	"ED3"
09-16			Leave blank
17-24	I	IEDSW1	Switch controlling horizontal eddy/turbulence option used in the model for this element type. -1 = use ED3 data line for input of element type dependent options 0 = use input values directly 1 = use absolute magnitude of input values as scalars applied to nominal element lengths in the computed fixed principal direction of the element. 2 = Use Smagorinsky closure. Note that when this closure is used values must still be supplied on the ED

			line for use in the first 2 iterations from initial startup as if the type 1 closure had been used. These values are not used when restarting. 3 = use option 1, but apply in the current direction of flow in the element 4 = apply scalar factors in the direction of flow as in option 3 but compute element length in the direction of flow and apply second multiplier as a multiplier of the longitudinal value. This applies for both eddy and diffusion coefficients. For further information see instructions for line type ED.
25-32	R	TBFACT1	Alfa factor applied in Smagorinsky closure for this element type. Typical range 0.02 - 0.5 (Default =0.2)
33-40	R	TBMIN1	Minimum kinematic eddy viscosity using the Smagorinsky closure for this element type. Units are m^2/s of ft^2/s depending on unit system in use.

Line type MAN Data for Variable height Manning Coefficients by Element Type (optional, need only be entered for as many element types as required)

01-03	A	ID	"MAN"
09-16	I	J	Element type number
17-24	R	ELMMIN(J)	Maximum elevation of minimum Manning Coefficient[3]
25-32	R	MANMIN(J)	Minimum Manning Coefficient
33-40	R	ELMMAX(J)	Minimum elevation of minimum Manning Coefficient
41-48	R	MANMAX(J)	Maximum Manning Coefficient

Line type DRG Data for drag coefficients by Element Type (optional, need only be entered for as many element types as required)

01-03	A	ID	"DRG"

[3] The active Manning coefficient is computed from the following equations:
If Water Surface Elevation is less than ELMMIN then Manning coefficient = MANMIN
If Water Surface Elevation is greater than ELMMAX then Manning coefficient = MANMAX
If Water Surface Elevation lies in the range between ELMMIN and ELMMAX then it is linearly interpolated between the values MANMIN and MANMAX.
Note that values for Manning "n" must be set in the ED1 and ED2 data lines in order to activate this option. If a value of "n" is entered for wall friction then the distribution function will be applied.
For three dimensional layouts the bed shear is applied using the variable Manning coefficient defined in this option.

09-16	I	J	Element type number
17-24	R	DRAGX(J)	Drag coefficients for the x-direction C_{dx}[4]
25-32	R	DRAGY(J)	Drag coefficients for the y-direction C_{dy}.

Line type CC1: Continuity Node Data   Lines types CC1 and CC2 form groups of lines. Repeat sets as needed (These line types are not required)

01-03	I	ID(1:3)	"CC1"
05-08	I	ID(5:8)	Line identifying number J (not required)
09-80 (9 @ 8)	I	LINE(J,K)	Lists of node numbers which define line segments for line J across which total flow is to be computed for continuity checking. If J equals zero then the line number is assigned as one more than the maximum already entered. Please note that the continuity calculation assumes the sequence of the input is positive, and thus the sign of computed flow will depend on the sequence of input values. Up to 9 values may be specified . Only corner node numbers should be specified. These lines are also used for automatic generation of boundary conditions.

Line type CC2: Continuity Node Data (continued) Use this line type when more than 9 values are desired

01-03	I	ID	"CC2"
09-80	I	LINE(J,K)	Continuation of node numbers which define a given line .

Line type EL: Element Data   Use this line type to define element data not entered in the binary geometry file. (Not required)

01-02	A	ID	"EL"
09-14	I	J	Element number

[4] The drag force in the x and y directions Fx and Fy are computed from the following equations:

$$Fx = -\rho.g.C_{dx.}u.V$$
$$Fy = -\rho.g.C_{dx.}v.V$$

Where ρ is the density, g is the acceleration due to gravity, C_{dx} and C_{dy} are the drag coefficients, u and v are the x and y velocity components and V is the total velocity.

15-62 (8 @ 6)	I	NOP(J,K)	Up to eight node numbers for elements listed counter-clockwise around the element
63-68	I	IMAT(J)	Element type (the number entered here corresponds to the parameters specified in the ORT array, defined above)
69-76	R	ANG(J)	Principal direction of eddy and diffusion coefficient anti-clockwise +'ve (radians) from x-axis.

Line type ND: Nodal Data Use this line type to define nodal data not entered in the binary geometry file (Not Required)

01-02	A	ID	"ND"
09-16	I	N	Node number
17-24	R	CORD(N,1)	X coordinate input at node N
25-32	R	CORD(N,2)	Y coordinate input at node N
33-40	R	AO(N)	Bottom elevation at node N

NOTE: The coordinate values read from the above lines are multiplied by the appropriate scale factors, XSCALE and YSCALE, and should result in the proper X and Y coordinates after scaling.

Line type WD: Width Data Use this line type to define width data not entered in the binary geometry file (Not Required)

01-02	A	ID	"WD"
09-16	I	J	Node number
17-24	R	WIDTH(J)	Node J channel width at zero depth
25-32	R	SS1(J)	Left side slope at node J
33-40	R	SS2(J)	Right side slope at node J
41-48	R	WIDS(J)	Storage width associated with node J at zero depth

Line type **WDT WEIR DATA** Not required As many lines as needed to form a complete data set for nodes along the line of the weir Use when flow controller type 10 is used on the FC data line and INCSTR data file is not used..

01-03	A	ID	"WDT"

09-16	I	J	Node number, use the node numbers of the notional upstream side
17-24	R	WGHT(J)	Elevation of weir crest at node J.
25-32	R	WLEN(J)	Length of weir crest at node J.
33-40	R	TRANSEL(J)	Transition elevation between submerged weir flow and free flow

Line type **MP** **MARSH CONTROLS TYPE 1** 1 line skip if IDNOPT[+] equals -1 or 0

01-03	A	ID	"MP "
09-16	I	J	Unused
17-24	R	AC1	Bottom elevation shift for A0. Default value = 4.5. (= 1.5 metric units)
25-32	R	AC2	Depth range over which section reduces. Default value = 2.0. (= 0.67 metric units)
33-40	R	AC3	Kappa = Minimum active fraction over lower section Default value = 0.04
41-48	R	AC4	Absolute bottom elevation that overrides the bottom elevation shift defined with AC1 (optional)

Line type **MP1** **MARSH CONTROLS TYPE 2** As many lines as required to define individual nodal values for marsh parameters , 1 per line, skip if IDNOPT[+] equals 0 (optional otherwise)

01-03	A	ID	"MP1"
09-16	I	J	Corner node number
17-24	R	AC1	Bottom elevation shift for A0 at node J
25-32	R	AC2	Depth range at node J over which section reduces
33-40	R	AC3	Kappa = Minimum active fraction for node J over lower section
41-48	R	AC4	Absolute bottom elevation at node J that overrides the bottom elevation shift defined with AC1 (optional)

[+] Note that when IDNOPT > 0 or = -2 line type MP is required to define default values when individual nodal values are input. Lines type MP1 do not have to include all nodes.

[+] Note that when IDNOPT > 0 or = -2 line type MP is required to define default values when individual nodal values are input. Lines type MP1 do not have to include all nodes.

Line type VD: Vertical distribution (Required if NDP on line type C1 not equal to zero, i.e. the problem is three-dimensional)

01-02	A	ID	"VD"
09-16 17-24	R R	VMIN POWER	Coefficients used to describe velocity distribution at interface between 2 and 3 dimensions. Expression is V=VAVE*(VMIN + (1-VMIN) *Z/H**POWER), where VAVE (f/s or m/s) is average velocity, Z (feet or m) is the elevation above bottom, and H (feet or m) is the depth.
25-32 33-40	R R	UMIN PWERIN	Coefficients used to describe velocity distribution at externally specified flow boundaries. Expression is U=UAVE*(UMIN + (1 - UMIN) *Z/H**PWERIN), where UAVE (f/s or m/s) is the average velocity, Z (feet or m) is the elevation above bottom and H (feet or m) is the depth.

Line type TD: Vertical distribution of eddy viscosity One for each element type (Optional, if TD line is not input then EDD1, EDD2 and EDD3 default to values shown)

01-02	A	ID	"TD"
09-16	I	J	Element number
17-24	R	EDD1	Coefficients used to describe vertical distribution of eddy
25-32	R	EDD2	coefficients ε_{xz} and ε_{yz} for homogeneous flow, EZ=E*(EDD1+EDD2*(Z/H)+EDD3*(Z/H)**2)
33-40	R	EDD3	where E is the nominal coefficient, Z (feet or m) is the average depth and H (feet or m) is the elevation above the bottom.

Line type LD1 Layer Data (All Nodes) Read only if NDP=1 Repeat this line type until all 2-D nodes are entered.

01-03	A	ID	"LD1"
09-80 (9 @ 8)	I	NDEP(J)	Number of elements in vertical direction of each node in succession. 9 values per line. (note numbers are only used for corner nodes, all mid-sides may be set to zero).

Line type LD2 Layer Data Read only if NDP=-1 Use sets of LD2 and LD2A lines to define layers at all 2-D corner nodes that will become 3-D

01-03	A	ID	"LD2"

09-16	R	I	For node I number of elements in vertical
17-24	I	NDEP(I)	Number of elements in vertical direction at each node (values are only needed for corner nodes and for nodes with non-zero value.
25-80 (7 @ 8)	R	THLAY(I,J)	Scalar multiplier for non-uniform element spacing. Zero defaults to uniform spacing (NDEP(I)) values. Continue on L2A line if necessary.

Line type L2A Layer Data Read only if NDP=-1 and NDEP(I) on line type LD2 > 7 Repeat until all THLAY values are defined

01-03	A	ID	"L2A"
09-80 (9 @ 8)	R	THLAY(I,J)	Continuation of scalar multiplier for non-uniform element spacing. Zero defaults to uniform spacing (NDEP(I)) values.

Line type LD3 Layer Data for Specified Elevations Read only if NDP = 2 Use sets of LD3 and L3A lines to define layers at all 2-D corner nodes that will become 3-D

01-03	A	ID	"LD3"
09-16	I	I	Node number I
17-24	I	NDEP(I)	Number of elements in vertical direction at each node (values are only needed for corner nodes and for nodes with non-zero value.
25-80 (7 @ 8)	R	THLAY(I,J)	Elevation of each non-uniformly spaced corner nodes below the surface node I. Note that the surface node is defined to be at elevation ELEV previously input.

Line type L3A Layer Data for Specified Elevations Read only if NDP= 2 and NDEP(I) on line type LD3 > 7 Repeat until all THLAY values are defined

01-03	A	ID	"L3A"
09-80 (9 @ 8)	R	THLAY(I,J)	Elevation of each non-uniformly spaced corner nodes below the surface node I.

Line type RO Reordering sequence data Continue as necessary on line type RO1 (not required, use only if order not specified on geometric data file)

01-02	A	ID	"RO"
09-80 (9 @ 8)	I	NFIXH	A complete list of NEM element numbers which will be used to reorder the internal formation of the system equations. This feature can be used to achieve more

efficient core storage allocation without re-entering other existing system data (NEM is the maximum element number in the network)

Line type RO1: Reordering Sequence Data (continued) Use this line type when more than 9 values are desired for line type RO

01-03	A	ID	"RO1"
09-80	I	NFIXH	Continuation of element numbers as necessary.

Line type SL: Over-riding nodal boundary slope values Use to define specialized values for boundary slopes at nodes (not required)

01-02	A	ID	"SL"
09-16	I	N	Node number
17-24	R	ALFAK(N)	The angle at node N measure anti-clockwise from the x-axis (Rad).

Line type SA: Specified Concentration Values Use to define values of salinity-temperature-sediment that are to be held constant at internal nodes (not required)

01-02	A	ID	"SA"
09-16	R	SALBC(1)	Specified value of salinity to be applied to the nodes listed in SA1.
17-24	R	SALBC(2)	Specified value of temperature to be applied to the nodes listed in SA1.
25-32	R	SALBC(3)	Specified value of sediment to be applied to the nodes listed in line type SA1.

Line type SA1: Nodes for Specified Concentration Values Use to define internal nodes where values of salinity-temperature-sediment defined above are to be (required if line type SA used, continue on as many lines type SA1 as required if more than 9 values are to be entered)

01-03	A	ID	"SA1"
09-80 (9 @ 8)	I	IFXSAL	Node numbers where salinity-temperature-sediment are to be held constant.

Line type ST1: Linear Interpolation Nodes Use to define mid-side nodes where linear interpolation is to be used for sal/temp/sal. (not required continue on as many lines type ST2 as required if more than 9 values are to be entered))

01-03	A	ID	"ST1"
09-80 (9 @ 8)	I	IMIDD	Mid-side node numbers where salinity-temperature-sediment are to be linearly interpolated.

Line type ST2: Linear Interpolation Nodes (continued) see above.

01-03	A	ID	"ST2"
09-80 (9 @ 8)	I	IMIDD	Mid-side node numbers where salinity-temperature-sediment are to be linearly interpolated.

Line type CP: Specified Internal Interface Distribution Use to define values of salinity-temperature-sediment interface that will differ from the standard values entered on line type C3 (not required) If defined, read together with lines type CP1 and CP2 as sets to define nodes where this distribution applies

01-02	A	ID	"CP"
09-16	A	J	Distribution number
17-24	R	CINT(J)	Coefficients used to describe the Jth salinity-temperature-
25-32	R	CPOW(J)	sediment distribution. Expression is C = CAVE * (CINT + (1-CINT) * (Z/H)**CPOW) where Z is the elevation above the bottom, and H is the depth.

Line type CP1: Nodes for Specified Internal Interface DistributionUse to define nodes where distribution defined above is to be applied (continue on as many lines type CP2 as required if more than 9 values are to be entered))

01-03	A	ID	"CP1"
09-80 (9 @ 8)	I	J	Node numbers to apply the distribution function.

Line type CP2: Nodes for Specified Internal Interface Distribution (continue) see above

01-03	A	ID	"CP2"
09-80 (9 @ 8)	I	J	Node numbers to apply the distribution function.

Line type ENDGEO: End of geometry indicator line

01-06	A	ID	"ENDGEO"

SAND DATA BLOCK

The data lines that follow up to and including the "ENDSAND line should be entered when the sand or bedload option is activated.

Line type SND Sand Data 1 line

01-03			"SND"
09-16	R	SACLL	Minimum grain size (mm)
17-24	R	SACUL	Maximum grain size (mm).
25-32	R	ASACI	Number of grain size classes (presently only one size allowed)
33-40	R	SGSA	Specific gravity of sediment
41-48	R	GSF	Grain shape factor.
49-56	R	CLDE	Characteristic length factor for deposition (typically 1.0)[5]
57-64	R	CLER	Characteristic length factor for erosion (typically 10.0).
65-72	R	VSAND	Fall velocity for sediment (m/sec).[6]
73-80	R	AMANN	Manning coefficient **used to calculate U***

.

Line type DIA Sand Diameter Data 1 line

01-03			"DIA "
09-16	R	D35	D35 grain size (mm)
17-24	R	D50	D50 grain size (mm)
25-32	R	D90	D90 grain size (mm)

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[5] CLDE is a factor used in calculation of time to adjust the computed time for all suspended material to settle i.e. CST = CLDE * DEPTH / SETTLING VELOCITY

CLER is a factor used to calculate an equivalent time for re-suspension back to the equilibrium level. i.e. CST = CLER *DEPTH /WATER VELOCITY. Note that this is much more of a calibration constant.

For both constituents, CST is adjusted so that it cannot be less than the model time step. This means that when this limitation is applied results will change for shorter time steps.

[6] Note that if the fall velocity is set equal to 0.0 then the settling velocity is computed according to the following formula:

$$V_S = 10.*\nu/(0.8*d_{50}) * (1.+ [0.01*(sg_s - 1.)*g*(0.8*d_{50})^3 / \nu^2]^{0.5} - 1)$$

Where Vs = Settling velocity of non-cohesive sediment (m/s)
ν = Kinematic viscosity of water (m/s)
d_{50} = 50th percentile grain size (m)
sg_s = Specific gravity of sand

33-40	I	ISMODE	Switch controlling choice of transport method 1 = Ackers and White" 2 = Van Rijn" 3 = Brownlie 4 = Van Rijn (1989) 5 = Van Rijn (1993)
48-56	R	GPMAX	Maximum allowable computed value for sand transport potential in (gm/m^3) Defaults to $1.*10^6$ when set = 0.0

Line type RGH Sand Bed Roughness Data As many lines as required

01-03			“RGH“
09-16	I	M	Element type number
09-16	R	RCAE	Current related roughness for element type M (m). If M = 0 roughness is applied globally
17-24	R	RWAE	Wave related roughness for element type M (m). If M = 0 roughness is applied globally

Line type IS Sand Bed Initial Thickness Data As many lines as required

01-02			“IS “
09-16	I	MT	Node number
17-24	R	TSAND	Initial sand thickness at all nodes if MT = 0 Sand thickness at node MT if MT > 0

Line type ENDSAND Sand Data Terminator 1 line

01-07			“ENDSAND“

COHESIVE SEDIMENT DATA BLOCK

The data lines that follow up to and including the “ENDSED line should be entered when the suspended sediment option is activated.

Line type CSS1 (COHESIVE) SUSPENDED SEDIMENT DATA 1 line

01-04	A4	IDL	“CSS1”
09-16	I8	ISVL	Control type for settling velocity data 1 = Set all settling velocities for time step ITS to a VSST 2 = Calculate settling velocities using parameters of this data line.
17-24	R	VSST	Constant settling velocity used for all nodes, use when ISVL = 1 (m/s)
25-32	R	CRCON1	Settling velocity parameter #1 see below. Use when ISVL = 2 (gm/m^3)
33-40	R	VSS1	Settling velocity parameter #2 see below. Use when ISVL = 2 (m/sec)
41-48	R	CRCON2	Settling velocity parameter #3 see below. Use when ISVL = 2 (gm/m^3)
49-56	R	EXP2	Settling velocity parameter #4 see below. Use when ISVL = 2

Settling velocity computation:

V = VSS1	C < CRCON1
V = VSK*C^{EXP2}	CRCON1 < C < CRCON2
V = VSS2	C > CRCON2

where VSK and VSS2 are computed values computed to assure continuity

Line type CSS2 (COHESIVE) SUSPENDED SEDIMENT DATA 1 line

01-04	A4	IDL	“CSS2”
09-16	R	VK	Von Karman's Constant = 0.0 defaults to 0.4
17-24	R	RKS	Bed height roughness (m) for Rouse distribution calculation. = 0.0 implies smooth bed.
25-32	R	D90	D90 for use as a bed height roughness parameter for computation of wave related shear stress (m).

Lines type CSS3 and CSS4 may be input either as constant values for all element property types or by entering a CSMT line for a group of element property types.
If line type CSMT is omitted parameters are automatically assigned to all element property types.
If line type CSMT is entered blocks of lines type CSMT, CSS3 and CSS4 must be entered to

define parameters for all types. Note that CSMT lines may be used to assign one set of parameters to more than one element property type by listing multiple element property types on CSMT data lines

Line type CSMT MATERIAL TYPE IDENTIFIERS 1 line or more lines, as many lines as needed

01-04	A4	IDL	"CSMT"
09-16	I8	IMTREF(1)	Element property type 1
17-24	I8	IMTREF(2)	Element property type 2
Etc			Up to 9 entries per line

Line type CSS3 (COHESIVE) SUSPENDED SEDIMENT DATA 1 line

01-04	A4	IDL	"CSS3"
09-16	I8	NLAYT	Number of layers of new deposits formed
17-24	R	TAUCD	Critical shear stress for deposition of new layer (N/m^2)
25-32	R	GAW	Density of suspending water - (kg/m^3)
33-40	R	GAB	Bulk density of top layer - (kg/m^3)
41-48	R	TTLAY	Full thickness of top layer - (m)
49-56	R	GAC	Density of sediment material - (kg/m^3)
57-64	R	ERC	Erosion rate constant for bottom layer - $kg/(m^2$ sec). All other layers erode en masse in time t.
65-72	R	UN	Kinematic viscosity of suspending water -m /sec (=1.16x10 m /sec at 15 C)

Line type CSS4 (COHESIVE) SUSPENDED SEDIMENT DATA Read one data line for each layer defined above

01-04	A4	IDL	"CSS4"
09-16	I8	I	Layer number
17-24	R	SS(I)	Critical shear stress of layer I - (N/m^2)
25-32	R	GB(I)	Bulk density of layer I (kg/m^3)

Line type CB: Initial Cohesive Suspended Sediment Control Data 1 line

01-08	A	ID	"CB "
09-16	I	IBED	= 1 read bed data line type CBD for one node and expand to all nodes = 2 read bed data line type CBD for each node =.3 read bed data line type CBD for element property types
17-24	I	IELEV	= 0 read no bed elevation data = 1 read old bed data line type CBL.

If IBED equals 3, repeat lines type CBD, CBMT and CBL as required

Line type CBD: Initial Cohesive Suspended Sediment Bed Data Read only if IBED =1 or 2
Repeat sets of CBD and CBL for each node if IBED = 2

01-08	A	ID	"CBD "
09-16	I	N	If IBED = 1 Ignore (values on this line will expand to all nodes) If IBED = 2 Node number If IBED = 3 Ignore (values on this line are assigned based on the CBMT line that follows
17-24	I	NLA	Number of layers in old bed data. = 0 set old bed thickness to zero.
25-32	R	TEMP1	Initial mass in new bed (kg/m2)

Line type CBMT MATERIAL TYPE IDENTIFIERS FOR INITIAL CONDITIONS OR OLD BED 1 line or more lines, as many lines as needed

01-04	A4	IDL	“CBMT”
09-16	I8	IMTREF(1)	Element property type 1
17-24	I8	IMTREF(2)	Element property type 2
Etc			Up to 9 entries per line

Line type CBL: Cohesive Suspended Sediment Old Bed Data IBED =1 2 or 3 and NLA >0
1 data line for each layer (NLA)

01-08	A	ID	"CBL "
09-16	I	L	Layer number
17-24	R	SSTO	Critical shear stress for erosion for layer L (N/m2)
25-32	R	SMVAL	Erosion rate constant for layer L. (kg.m2/sec)

33-40	R	GBO	Bulk density for layer L kg/m3
41-48	R	THICKO	Thickness of this layer (m)

TIME STEP DATA BLOCK

The data lines that follow up to and including the “ENDSTEP line should be repeated for each solution step or group of solution steps of the solution. If an initial steady state simulation is to be made then a set of data for this step should be included with the time step set equal to zero. If a steady state solution is not required a data set must still be supplied.

Line type DT: Time Step Control (required)

01-02	A	ID	"DT"
09-16	R	DELTA	Time step in hours. (Set = 0. for steady state case)
17-24	I	IYRE	[7]Year to end use of this time step. Set =0. for steady state case.
25-32	I	IDYE	Julian day to end use of this time step. Set =0. for steady state case.
33-40	R	IHRE	Hour to end use of this time step. Set =0. for steady state case.

Line type BC: Iteration Control NITI values for initial steady state set and NITN values for transient steps. 9 values/line repeat as necessary (required)

01-02	A	ID	"BC"
09-16			For each iteration enter four digits in fields of 8.
17-24			(right justified)
etc	I	IURVL	1st digit degree of under relaxation
73-80			0 = under relaxation factor equals 1.0
			1 = under relaxation factor equals 0.9 etc.
			9 = under relaxation factor equals 0.1
	I	ITLVL	2nd digit Gaussian integration level
...			0 = normal
...			1 = reduced order
...	I	ITEQV	3rd digit active equations
			0 = velocities, depth and conc.
			1 = velocities and depth only.
			2 = conc. only.
			3 = velocities and conc. only.
			4 = velocities only.
			5 = forced reduction to plan view i.e. 2-D
	I	ITEQS	4th digit active quality constituent type
...			0 = salinity.
...			1 = temperature
			2 = sediment.

Line type BN: Nodal Boundary Condition Data As many as needed (Not Required)

[7] Omit IYDE, IDYE and IHRE for the steady state time step

01-02	A	ID	"BN"
09-16	I	J	Node number
17-24	I	NFIX(J)	Boundary condition specification for this node. Note that parallel slip boundaries are automatically generated for edges and need not be specified unless additional conditions such as specified flow, velocity or head are required at that node. To specify flow, enter 310ZZZ, except in the special case of zero x-component when 130ZZZ must be entered. To specify velocity, enter 010ZZZ for velocity at a slope ALFA (see above). Enter 100ZZZ when ALFA = . Enter 110ZZZ when both components are specified. To specify elevation, enter XX2ZZZ where XX is the appropriate velocity boundary condition or 00. Note that flow or velocity and elevation may not both be defined at a node except at corners in the network. In all of the above examples each of the Z's in ZZZ may be 0,1 or 2. When 0 is specified then no boundary condition is applied to the first (salinity), second (temperature) or third (sediment) component respectively. When 1 is specified then a boundary value will be applied for any direction of flow. When 2 is specified the boundary value is applied only for inlfow conditions. The actual values to be applied are contained in SPEC later in this line.
25-32	R	SPEC(J,1)	The specified X-direction flow or velocity as appropriate (ft3/sec/ft or ft/sec or in metric units m3/sec/m or m/sec)
33-40	R	SPEC(J,2)	The specified Y-direction flow or velocity as appropriate (ft3/sec/ft or ft/sec or in metric units m3/sec/m or m/sec)
41-48	R	SPEC(J,3)	The specified water surface elevation (ft or m).
49-56	R	SPEC(J,4)	The specified value of salinity (conc units).
57-64	R	SPEC(J,5)	The specified value of temperature (degrees).
65-72	R	SPEC(J,6)	The specified value of sediment (conc units).

Line type QC: Continuity Line Inflows As many lines as needed (Not Required)

01-02	A	ID	"QC"
09-16	I	J	Continuity line number
17-24	I	LN	Layer number for application of this flow = 0 means apply to all layers.
25-32	R	QTOT	Total flow crossing the continuity line
33-40	R	THETA	Direction of flow (radians measured anticlockwise). Note that the boundary directions are adjusted to maintain parallel flow.

41-48	R	QQAL(1)	Salinity of inflow, neglect if less than 0
49-56	R	QQAL(2)	Temperature of inflow, neglect if less than 0
57-64	R	QQAL(3)	Sediment concentration of inflow, neglect if less than 0
65-72	I	LABL	= 1 if during dynamic simulation the user wishes to interpolate values from the input hydrograph values on the hydrograph file. = 0 or leave blank if flow values will be read from this file

Line type HC: <u>Continuity Line Elevation Specification As many lines as needed each line paired with lines type HCN as appropriate (Not Required)</u>

01-02	A	ID	"HC
09-16	I	J	Continuity line number.
17-24	I	LN	Layer number for application of this flow = 0 means apply to all layers.
25-32	R	ELEVS	Specified elevation for all nodes on this line.
33-40	R	QQAL(1)	Salinity of inflow, neglect if less than 0
41-48	R	QQAL(2)	Temperature of inflow, neglect if less than 0
49-56	R	QQAL(3)	Sediment concentration of inflow, neglect if less than 0
57-64	I	LABL	= 1 if during dynamic simulation the user wishes to interpolate values from the input tidal-graph values on the tidal-graph file. = 2 if during dynamic simulation the user wishes to compute elevation values from the input harmonic values on the tidal harmonic file. = 0 or leave blank if flow values will be read from this file

Line type HCN: Specified Velocity Distributions for Elevation Boundary   If needed, repeat until all nodes in continuity line are accounted for (Not Required - Optional even when line type HC defined)

01-03	A	ID	"HCN"
09-80 (9 @ 8)	R	WTS	Scalar multipliers for velocity distribution applied to each node (including mid-sides) Note that an input value of 0.0 is equivalent to 1.0. This input slightly relaxes the elevation specification along the line but allows the user to force a distribution of velocity.

Line type HI: Continuity Line Elevation Specification with Slope   As many lines as needed (Not Required)

01-02	A	ID	"HI"
09-16	I	J	Continuity line number.
17-24	I	LN	Layer number for application of this flow = 0 means apply to all layers.
25-32	R	ELEVL	Specified elevation for starting node on this line.
33-40	R	QQAL(1)	Salinity of inflow, neglect if less than 0
41-48	R	QQAL(2)	Temperature of inflow, neglect if less than 0
49-56	R	QQAL(3)	Sediment concentration of inflow, neglect if less than 0
57-64	I	LABL	= 1 if during dynamic simulation the user wishes to interpolate values from the input tidal-graph values on the tidal-graph file. = 2 if during dynamic simulation the user wishes to compute elevation values from the input harmonic values on the tidal harmonic file. = 0 or leave blank if flow values will be read from this file
65-72	R	ELEVR	Specified elevation for ending node on this line.

Line type SQC: Specified Stage-Flow Boundaries   As many lines as needed (Not Required)

01-03	A	ID	"SQC"
09-16	I	J	Continuity line number
17-24	R	A1	Coefficients in the elevation flow
25-32	R	A2	Relationship for line J given by
33-40	R	E0	Q = A1 + A2 * (ELEV - E0) ** C
41-48	R	C	

49-56	R	THETA	Direction of flow (radians measured anti-clockwise). Note that the boundary directions are adjusted to maintain parallel flow.
57-64	R	QQAL(1)	Salinity of inflow, neglect if less than 0
65-72	R	QQAL(2)	Temperature of inflow, neglect if less than 0
73-80	R	QQAL(3)	Sediment concentration of inflow, neglect if less than 0

Line type CQ: Specified Concentration Values As many lines as needed (Not Required)

01-02	A	ID	"CQ"
09-16	J	I	Continuity line number
17-24	R	QQAL(1)	Salinity of inflow, neglect if less than 0
25-32	R	QQAL(2)	Temperature of inflow, neglect if less than 0
33-40	R	QQAL(3)	Sediment concentration of inflow, neglect if less than 0

Line type WVA: Specified Global Wind Velocities As many lines as needed (Not Required)

01-03	A	ID	"WVA"
09-16			Blank
17-24	R	SIGMA(J,1)	The wind velocity at all nodes (miles/hr or m/s)
25-32	R	SIGMA(J,2)	The angle between the wind velocity and the X-axis (degrees measured anti-clockwise) NOTE: The wind values read here are used only for the calculation of the wind effect on fluid motion.

Line type WVN: Specified Nodal Wind Velocities As many lines as needed (Not Required)

01-03	A	ID	"WVN"
09-16	I	J	Node number
17-24	R	SIGMA(J,1)	The wind velocity at node J (miles/hr or m/s)
25-32	R	SIGMA(J,2)	The angle between the wind velocity and the X-axis (degrees measured anti-clockwise) NOTE: The wind values read here are used only for the calculation of the wind effect on fluid motion.

Line type **FC FLOW CONTROLLER DATA** As many lines as needed

01-02	A	ID	"FC"
09-16	I	NJN	Flow controller identifier
17-24	I	NJT1	Flow controller type

= 1
Point source of flow, conditions are flow out equals flow in plus source (AJ1), and equal total head at each node of the control element. **Note that this option is not available for two-dimensional control structures.**

= 2
Flow is a reversible function of head loss across the structure. Conditions are flow out = flow in, and flow Q = AJ1 +BJ1*(HN1-HN2-CJ1)**GAM1 in the direction QD1, where HN1 and HN2 are water surface elevations at the nodes of the control structure element. Note that if HN1-HN2 is negative the sign of the flow direction is reversed.

= 3

Flow is a irreversible function of head loss across the structure. Conditions are flow out = flow in, and flow Q = AJ1 +BJ1*(HN1-HN2-CJ1)**GAM1 in the direction QD1, where HN1 and HN2 are water surface elevations at the nodes of the control structure element. Note that if HN1-HN2-CJ1 is negative then the Q = 0.

= 4
Flow is a function water surface elevation. Conditions are flow out = flow in, and flow Q = AJ1 + BJ1*(HN1-CJ1)**GAM1 in the direction QD1, where HN1 is the water surface elevation at the first node of control structure element

= 5
Head loss is a function of flow.
Conditions are flow out = flow in, and head loss
HN1 - HN2 = AJ1 + BJ1*(Q)**GAM1 in the direction QD1, where HN1 and HN2 are the water surface elevations at the nodes of the control structure element.

= 6
Flow is a function of water surface elevations.
Conditions are flow out = flow in.
When levels are below BJ1, flow = 0.
When one level is above BJ1, flow is in the appropriate direction and given by:
Q = AJ1*(HN1-BJ1)**GAM1 or
Q = AJ1*(HN2-BJ1)**GAM1
When both levels are greater than BJ1, flow is in the appropriate direction and given by
Q = AJ2*(HN1-HN2)**CJ1
HN1 and HN2 are the water surface elevations at the nodes of the control structure element and AJ2 is given by
AJ2 = AJ1*(HN1-HN2)**(GAM1-CJ1)

= 10
System is a weir or uses data table input (for data table input see section 4.9). AJ1, BJ1, CJ1,GAM1 are not used. Only the direction QD1 is used

25-32	R	AJ1	
33-40	R	BJ1	
41-48	R	CJ1	AJ1, BJ1, CJ1, GAM1 and QD1 are defined by the options defined above.
49-56	R	GAM1	
57-64	R	QD1	

Line type GT: Gate Data As many lines as needed for individual gate types (Not Required)[8]

[8] The following options are permitted:

(1) When NDUPJ and NDDNJ are specified. Then if the water surface elevation of the upstream end (NDUPJ) is below the downstream end (NDDNJ) and the water surface elevation at the upstream end (NDUPJ) is greater than the elevation BJ, then the gate is closed.

01-02	A	ID	"GT"
09-16	I	NJT	Gate type number (in the range 904-999) corresponds to the element type number.
17-24	I	NDUPJ	Upstream node number locating reference elevation for gate decision.
25-32	I	NDDNJ	Downstream node number locating reference elevation for gate decision.
33-40	R	AJ	Maximum flow rate allowed through the gate.
41-48	R	BJ	Mean tidal elevation for gate opening decision.
49-56	I	NDFLJ	Node where flow level determines gate opening.

Line type EFA: Element Inflow data 1 line if appropriate Element inflows applied to all elements (Not Required)

01-03	A	ID	"EFA"
09-16			Leave blank
17-24	I	LN	Layer number, zero means distribute to all layers
25-32	I	NEST	Switch to control allocation to elements 0 = Apply as load per unit vol/area/length as appropriate. In the case of 3-D elements apply to the surface later vol/area equivalent to rainfall or evaporation when LN = 0 1 = Apply as a total load to the elements
33-40	R	SIDF(J)	Element inflow per unit area (cfs/ft**2 or cms/m**2) or length (cfs/ft or cms/m) as appropriate to the element type. For three-dimensional elements total inflow is (cfs or cms). See note above about surface flow case
41-48	R	SIDQ(1)	Salinity of inflow.
49-56	R	SIDQ(2)	Temperature of inflow.
57-64	R	SIDQ(3)	Sediment concentration of inflow.
65-72	I	LABL	Switch to indicate that for dynamic time steps, element inflows will come from element inflow graph file.

---

(2) When only NDFLJ is specified. Then when the flow at node NDFLJ is less than the flow AJ the gate is closed.

(3) When NDUPJ and NDFLJ are specified. Then if the water surface elevation at the upstream end (NDUPJ) is less than the elevation BJ or the flow at NDFLJ is greater than the flow AJ, the gate is closed.

0 = use regular input file or alternate
1 = use input graph file.

Line type EFE: Element Inflow Data As many lines as needed for individual element inflows (Not Required)

01-03	A	ID	"EFE"
09-16	I	J	Element number
17-24	I	LN	Layer number, zero means distribute to all layers
25-32	I	NEST	Switch to control allocation to elements 0 = Apply as load per unit vol/area/length as appropriate. 1 = Apply as a total load to the elements
33-40	R	SIDF(J)	Element inflow per unit area (cfs/ft**2 or cms/m**2) or length as appropriate to the element type, for three dimensional sections inflow is (cfs or cms).
41-48	R	SIDQ(1)	Salinity of inflow.
49-56	R	SIDQ(2)	Temperature of inflow.
57-64	R	SIDQ(3)	Sediment concentration of inflow.
65-72	I	LABL	Switch to indicate that for dynamic time steps, element inflows will come from element inflow graph file. 0 = use regular input file or alternate 1 = use input graph file.

Line type SN and SD: Specified Distribution Boundary Conditions As many lines as needed (Not Required)

Enter lines identical in format to lines type BN. The first line is the surface node value identified as **SN**. Subsequent lines identified as **SD** define values for the points that lie below the node after 3-D generation. Note that there will be (2 * the number of elements + 1) nodes for surface corner nodes and (1 * the number of elements +1 nodes) for mid-side nodes. It isn't necessary to specify node numbers for the lower points, leave that field blank. Repeat the process for each surface node as required.

Line type ENDSTEP: (Required)

01-07	A	ID	"ENDSTEP"

Line type ENDDATA: Required

01-07	A	ID	"ENDDATA"

4.2 File Format for the Element Inflow Hydrograph File

Line type **TE Element Hydrograph Title Line** 1 line

01-02	A	ID	"TE"
09-80	A	TITLE	Any heading comment

Repeat lines type **QEI** and **QE** for each element inflow using hydrograph data.

Line type **QEI Element Identifier** 1 line

01-03	A	ID	"QEI"
09-16	I	NCL	Element number for inflow. To trigger assignment of inflow to all elements set NCL = 0
17-24	I	NEST	Switch defining units of inflow 0 = Units are flow per unit length or area 1 = Units are total flow over the element.
25-32	I	IYDAT	Starting year for the data set

Line type **QE Hydrograph Data** As many lines as required

01-02	A	ID	"QE"
06-08	I	IDY	Julian day
09-16	R	TSS	Time (hours)
17-24	I	ILAY	Layer number for element inflow 0 = Apply to all layers ILAY = Apply to layer ILAY
25-32	R	QSS	Flow rate in units defined by NEST above.
33-40	R	QQAL(1)	Salinity concentration of inflow.
41-48	R	QQAL(2)	Temperature of inflow (or temperature of the increment when using PWR data and NADTYP =1.
49-56	R	QQAL(3)	Sediment concentration of inflow.

Line type **ENDDATA End Element Hydrograph Data File** 1 line (Required)

01-07	A	ID	"ENDDATA"

4.3 *File Format for the Boundary Hydrograph File*

<u>Line type **TH Hydrograph Title Line** 1 line</u>

01-02	A	ID	"TH"
09-80	A	TITLE	Any heading comment

<u>Repeat lines type **CLQ** and **QD** for each continuity line using hydrograph data.</u>

<u>Line type **CLQ Continuity Line Identifier** 1 line</u>

01-03	A	ID	"CLQ"
09-16	I	NCL	Continuity line number
16-24	I	IYDAT	Starting year for the data set

<u>Line type **QD Hydrograph Data** As many lines as required</u>

01-02	A	ID	"QD"
06-08	I	IDY	Julian day
09-16	R	TSS	Time (hours)
17-24	I	ILAY	Layer number for element inflow 0 = Apply to all layers ILAY = Apply to layer ILAY
25-32	R	QSS	Flow rate
33-40	R	QQAL(1)	Salinity concentration of inflow.
41-48	R	QQAL(2)	Temperature of inflow.
49-56	R	QQAL(3)	Sediment concentration of inflow.

<u>Line type **ENDDATA End Hydrograph Data File** 1 line (Required)</u>

01-07	A	ID	"ENDDATA"

4.4 File Format for the Tidal Graph File

<u>Line type **TT Tidal graph Title Line** 1 line</u>

01-02	A	ID	"TT"
09-80	A	TITLE	Any heading comment

<u>Repeat lines type **CLH** and **HD** for each continuity line using tidal-graph data.</u>

<u>Line type **CLH Continuity Line Identifier** 1 line</u>

01-03	A	ID	"CLH"
09-16	I	NCL	Continuity line number
16-24	I	IYDAT	Starting year for the data set

<u>Line type **HD Tidal graph Data** As many lines as required</u>

01-02	A	ID	"HD"
06-08	I	IDY	Julian day
09-16	R	TSS	Time (hours)
17-24	R	ILAYRH	Layer number for elevation specification 0 = all layers
25-32	R	HDL	Elevation for first node of continuity line.
33-40	R	HD(1)	Salinity concentration of inflow.
41-48	R	HD(2)	Temperature of inflow.
49-56	R	HD(3)	Sediment concentration of inflow.
57-64	R	HDR	Elevation for last node of continuity line.(optional, only required when a line type HI is used.

<u>Line type **ENDDATA End Tidal-graph Data File** 1 line (Required)</u>

01-07	A	ID	"ENDDATA"

4.5 File Format for the Tidal Harmonic File

Line type A 2 lines

01-80	A	TITLE	Heading or comments

Line type B 1 line

01-03	I	IYR	Year as defined for the harmonics
03-06	I	IMO	Month as defined for the harmonics
06-09	I	IDA	Day as defined for the harmonics
10-14	I	IHR	Starting hour for the harmonics
15-24	I	TDUM	Blank
25-34	R	UTILT	Adjustment to computed tidal stage

Line type C 1 line

01-05	I	NHM	Number of harmonics in file.

Line type D 1 line

Blank line that may be used as a header for data that follows

Line type E NHM lines

01-10	R	RH	Amplitude of harmonic
11-20	R	SP	Speed of harmonic (radians/hr)
21-30	R	EQ	Equilibrium phase advance degrees (date dependent)
31-40	R	ZP	Phase lag for this location degrees.
41-50	R	FCT	Dividing factor for amplitude of this constituent (date dependent)

The formula for the tidal elevation is the sum for each component of

RH/FCT*cos(SP*time+(EQ-ZP)/57.296) + UTILT

Line type F 1 line

01-10	R	QQAL(1)	Salinity concentration of inflow.
11-20	R	QQAL(2)	Temperature of inflow.
21-30	R	QQAL(3)	Sediment concentration of inflow.

4.6 File Format for the Meteorological Data

Line type **TI Atmospheric data title Line** 1 line

01-08	A	ID	"TI "
09-80	A	TITLE	Title for file

Line type **SYSTEM System data** 1line

01-08	A	ID	"SYSTEM '
09-16	R	ELEVAT	Elevation of site (m)
17-24	R	LAT	Latitude of site (m)
25-32	I	LONG	Longitude of site (m)
33-40	I	STANM	Standard time at site (deg)
41-48	I	IYT	Starting year for data
49-56	I		Leave blank
57-64	R	METRIC	Switch for atmospheric data 0=English units 1=Metric units
65-72	R	EXTINC	Solar extinction coefficient (1/m)

Repeat lines type **METID**, **ET**, **EV** and **MET** for each data group.

Line type **METITL Identifier for data set** 1 line

01-08	A	ID	"METITL"
09-80	A	METITL	Title for this data group

Line type **ET Element type listing** 1 line

01-08	A	ID	"ET "
09-80	I	METID	List of element types that this data group applies to. Up to 9 values in fields of 8

Line type **EV A and B evaporation data** 1 line

01-08	A	ID	"EV "
09-16	I	AETEMP	Coefficient "a" in evaporation computation (m/hr-mbar or ft/hr – in Hg)

17-24	R	BETEMP	Coefficient “b” in evaporation computation ((m/hr-mbar-m/s or ft/hr – in Hg - mph)
25-32	I	ISOL	Switch controlling source of Short wave data 0 = Compute from input data values of cloudiness etc. 1 = use input values directly.
25-32	I	IDPT	Switch controlling choice between wetbulb and dewpoint data 0 = use wetbulb data (see col 41-48) 1 = use dewpoint data.

<u>Line type MET: Atmospheric data</u> <u>As many lines as needed</u>

01-04	A	ID	“MET “
05-08	R	DAY	Julian day of data.
09-16	R	HR	Hour of data
17-24	R	DAT	Atmospheric dust attenuation. Range typically 0 - 0.13
25-32	R	CL	Cloudiness.
33-40	R	TA	Dry bulb temperature (deg C)
41-48	R	TWB	If IDPT = 0 Wet bulb temperature (deg C). If IDPT = 1 Dew point temperature (deg C)
49-56	R	EA	Atmospheric pressure (millibars or in Hg)
57-64	R	WIND	Wind speed (m/s or mph)
65-72	R	SOLR	Solar radiation (Watts/m^2) required only when ISOL = 1 on line type EV.

<u>Line type ENDDATA:</u> <u>Terminal data Required to end data file.</u>

01-08	I	ID	"ENDDATA "

4.7 File Structure for the Wave Data File

The wave data file is a binary file that may be constructed with or without headers. It consists of:

1 A 1000 character ASCII header with the following information

01-08	"WAVEDATA"	
101-105	MBND	where MBND = 1 for the case where a single data set is supplied and these values are interpreted as constant throughout the simulation MBND = 0 for the case of multiple data sets

2 A binary data set read in the following FORTRAN statement

```
READ(IWVIN) TTT,NV,IYDD,(K,WAVEHT(K),PEAKPRD(K),WAVEDR(K),L=1,NV)
```

In this statement:

TTT = the time in hours measured from Jan 1,
NV = the number of values to be read in
IYDD = the current year
K = the node number
WAVEHT = the wave height for node K (metres)
PEAKPRD = the peak period fro node K (sec)
WAVEDR = the wave direction measured in degrees counter-clockwise from the x-axis for node K (radians)

3 Repeated data sets in the format of 2 above should be applied for subsequent times.

Note

1 RMA-10S interpolates linearly between time steps if the values in the binary data file do not match time steps used in RMA-10

2 If values are not entered for a particular node RMA-10S assigns zero values.

4.8 File Format for the ASCII External Coordinate File

Line type **NVT Line** 1 line

01-03	ID	A	"NVT"
09-16	NVERT	I	Number of external coordinates
17-40	FMT	A	**Optional.** FORTRAN format that may be used to over-ride the column structure for CRD lines below If this entry is blank then the structure below is used.

Repeat lines type **CRD** for each external coordinate = NVERT lines.

Line type **CRD External Coordinates** 1 line per external point

01-03	ID	A	"CRD"
09-16	M	I	External coordinate number
17-32	XUSR(M)	R	X coordinate
33-48	YUSR(M)	R	Y coordinate

Line types OUT or COUT may be entered to define a polygon that surrounds the external coordinates. If not entered RMA-10S will assume that connecting the outermost locations to form a convex polygon defines the outline boundary. Lines type OUT use integer cross references to the external coordinate numbers. Lines type COUT use entered x and y coordinates to form the outline.

Repeat lines type **OUT** 9 values per line for each external coordinate forming the outline Note that these lines are optional

Line type **OUT Outline list** 9 values per line

01-03	ID	A	"OUT"
09-16	IPOLY(1)	I	External coordinate number forming the outline
17-24	IPOLY(2)	I	ditto

73-80	IPOLY(9)	I	ditto

Line type **COUT Outline list** 1 value per line

01-04	ID	A	"COUT"
17-32	XOUT(M)	R	X coordinate of outline polygon
33-48	YOUT(M)	R	Y coordinate of outline polygon

Line type **ENDDATA End ASCII External Coordinate File** 1 line (Required)

01-07	ID	A	"ENDDATA"

4.9 File Format for the ASCII External Weighting Factor File

Line type **Header Line** 1 line

01-1000	HEADWT	A	1000 character header

Repeat lines type **WT** for each finite element node = NP lines.

Line type **WT Node factor Identifier** 1 line per node

01-02	ID	A	"WT"
03-08			Blank
09-16	M	I	Node number
17-24	NODWT(M,1)	I	First external coordinate number
25-32	NODWT(M,2)	I	Second external coordinate number
33-40	NODWT(M,3)	I	Third external coordinate number
41-48	WAT(M,1)	R	Weighting factor for first external coordinate
49-56	WAT(M,2)	R	Weighting factor for second external coordinate
57-64	WAT(M,3)	R	Weighting factor for third external coordinate

Line type **ENDDATA End External Weighting Factor File** 1 line (Required)

01-07	ID	A	"ENDDATA"

4.9a File Format for the Binary External Weighting Factor File

The file must be in plain binary format with no headers or trailers

Record 1

```
READ(IBNWGT)   HEADWT
```

HEADWT is a 1000 character header

Record 2

```
READ(IBNWGT)    ((NODWT(M,J),J=1,3),(WAT(M,J),J=1,3),M=1,NP)
```

NODWT is an integer array containing the external coordinate number for the 3 weighting factors for application at node M.

WAT is a real array containing the weighting factors for the three external coordinates that are interpolated to obtain the values at node M

4.10 File Format for the ASCII Time Series Surface Traction File

Line type **Header Line** 1 line

01-100	HEADWT	A	100 character header with cols 1-8 = STRESS-D for time transient data cols 1-8 = STRESS-S for a single set of data to be treated as constant over time

Repeat lines type **DY** and **ST** for each time step.

Line type **DY Time Series Identifier** 1 line per time series set

01-02	ID	A	"DY"
03-08			Blank
09-16	IDYY	I	Julian day of year
17-24	TTT	R	Hour of day
25-32	NV	I	Number of external stress values
33-40	IYDD	I	Year

Repeat line type **ST** for each external coordinate.

Line type **ST Time Series Identifier** 1 line per external coordinate

01-02	A	ID	"ST"
03-08			Blank
09-16	M	I	Coordinate number
17-32	STR11	R	Surface traction in x-direction (Pascals).
33-48	STR21	R	Surface traction in y-direction (Pascals).
49-56	SPWP	R	Spectral peak wave period (secs)
57-64	AWL	R	Average wave length (m)
65-72	SWH	R	Significant wave height (m)
73-80	WVDR	R	Wave direction measure counter clockwise from the x –axis. This is the direction the waves are blowing to (deg)

Line type **ENDDATA End External Traction Data File** 1 line (Required)

01-07	A	ID	"ENDDATA"

4.10a File Structure for the Surface Stress Data File

The surface stress data file is a binary file that may be constructed with or without headers. It consists of:

1 A 1000 character ASCII header with the following information

01-08	"SSTRDATA"	
101-105	MBND	where MBND = 1 for the case where a single data set is supplied and these values are interpreted as constant throughout the simulation MBND = 0 for the case of multiple data sets

2 A binary data set read in the following FORTRAN statement:

```
READ(IWVFC)  IDYY,TTT, NV,IYDD,(K,(STRESS(K,J),J=1,2),SPWP(K),AWL(K),SWH(K),
                                                    ,WVDR(K),L=1,NV)
```

In this statement:

IDYY	=	Julian date (day measured from Jan 1)
TTT	=	Hour of day
NV	=	The number of values to be read in
IYDD	=	The current year
K	=	The coordinate number
STRESS(K,1)	=	The surface stress in the x-direction for node K (Pascals)
STRESS(K,2)	=	The surface stress in the y-direction for node K (Pascals)
SPWP(K)	=	Spectral peak wave period (hours)
AWL(K)	=	Average wave length (m)
SWH(K)	=	Significant wave height (m)
WVDR(K)	=	Wave direction measure counter clockwise from the x –axis. This is the direction the waves are blowing to (deg)

3 Repeated data sets in the format of 2 above should be supplied for subsequent times.

Note

1 RMA-10S interpolates linearly between time steps if the values in the binary data file do not match time steps used in RMA-10

2 If values are not entered for a particular node RMA-10S assigns zero values.

4.11 File Structure for the Wind Data File

The wind data file is an ASCII file that may be used to define wind speed and direction for a series of nodes in the system. Note that file is in a non standard format and is not interpolated over the time steps.

The file consists of repeated sets of lines for each time step to be modelled.

Line type **1** **Control Data** 1line

01-07	I	NXX	Number of lines of nodal wind data for this time step.
09-14	I	IYFL	Year
15-21	I	DYOFY	Julian day.
22-35	R	TFL	Hour.

Line type **2** **Wind Data** NXX lines as defined above

01-07	R	NXX	Wind speed (m/s) for metric formulation.
09-14	R	IYFL	Wind direction (in degrees) measured counter-clockwise from the x-axis. Note that this is the direction that the wind is blowing to.

4.11a File Structure for the Binary Wind Data File

The wind data file is a binary file that may be constructed without headers. It consists of data set read in the following FORTRAN statement:

```
READ(IWINDIN) NXX,IYFL,DYOFY,TFL,(WNDSP(J),WNDDR(J),J=1,NXX)
```

In this statement:

NXX	=	Number of lines of nodal wind data for this time step,
IYFL	=	The current year.
DYOFY	=	The time in Julian days measured from Jan 1
TFL	=	The hour on the given Julian day.
WNDSP(J)	=	The wind speed (m/s) for metric formulation
WNDDR(J)	=	The wind direction (in degrees) measured counter-clockwise from the x-axis. Note that this is the direction that the wind is blowing to.

Repeated data sets in the format above should be supplied for all time steps.

Note

1 RMA-10S doe not interpolate between time steps, values in the binary data file must match time steps used in RMA-10S

2 If values are not entered for a particular node RMA-10S assigns zero values.

4.12 File Structure for the Control Structure Data File

The control structure data file is an ASCII file that may be used to define flow across a structure based on upstream and downstream elevation as a matrix that will be interpolated. Multiple matrices may be defined for different flow controller element types.

The file consists of:

Line type **TI Control structure data title Line** 1 line

01-08	A	ID	"TI "
09-80	A	TITLE	Title for file

Repeat lines type **IDC, HRW, HCL** and **FLW** for each for each element type that is to be defined.

Line type **IDC** **Control Structure Definition data** 1line

01-03	A	ID	"IDC '
09-16	I	ID1,	Element type number
17-24	I	NROWCS	Number of rows of flow entries for this element type.
25-32	I	NCOLCS	Number of columns of flow entries for this element type.

Line type **HRW** **Upstream Water Surface Elevations** As many lines as required

01-03	A	ID	"HRW"
09-80	R	HRW	Upstream water surface elevations (@ 9 per line)

Line type **HCL** **Downstream Water Surface Elevations** As many lines as required

01-03	A	ID	"HCL"
09-80	R	HCL	Downstream water surface elevations (@ 9 per line)

Line type **FLW** **Control Structure flows** Enter row wise. One entry for each column NCOLCS (using as many lines as required) and repeated as a set for each row NROWCS

01-03	A	ID	"FLW"
09-80	R	HCL	Flow for each row and column elevation defined earlier. Note that values are in m^3/s per unit width or ft^3/s per unit width (@ 9 per line)

Line type **ENDDATA** **End Control Structure Data File** 1 line (Required)

01-07	A	ID	"ENDDATA"

4.13 File Structure for the Control Structure Time Series On/Off Data

The time series data file is an ASCII file that may be used to define when flow across a weir type structure - type 10 either computed or from the flow matrix file described above - is on or off. This control will over-ride any computed flows from the weir function

The file consists of:

Line type **TI Control structure data title Line** 1 line

01-08	A	ID	"TI "
09-80	A	TITLE	Title for file

Repeat lines type **IDC**, **NTV,** for each for each control structure element type that is to be defined.

Line type **IDC Control Structure Definition data** 1line

01-03	A	ID	"IDT '
09-16	I	ID1,	Element type number for the control structure
17-24	I	ITIM	Year for data set

Line type **NTV** **Control Structure on/off Times** One entry for each on/off sequence (use as many lines as required)

01-03	A	ID	"NTV"
09-16	I	DAYON	Julian day that control structure will be turned **on**
17-24	R	HRON	Hour of above Julian day that control structure will be turned **on**
25-32	R	DAYOF	Julian day that control structure will be turned **off**
33-40	R	HROF	Hour of above Julian day that control structure will be turned **off.**

Line type **ENDDATA End Control Structure Time Series Data File** 1 line (Required)

01-07	A	ID	"ENDDATA"

APPENDIX A

MARSH ELEMENTS / FLOODING AND DRYING

The marsh element or equivalent porosity formulation has been added to RMA-2 to improve performance when simulating areas the flood and dry during the tidal cycle or flood event.

Historically the first approach used for simulation of these types of system was to automatically drop from the system any element where any **one** corner water depth dropped below a nominal minimum value (an input parameter). This technically works. The problems found were:

- Inconsistent performance when irregular boundaries resulted.
- Element dropped out too soon just because one corner was notionally dry.
- Poor convergence at some times when elements cycled in and out the system.
- When an element was dropped or added the total water stored in this element was removed or added.

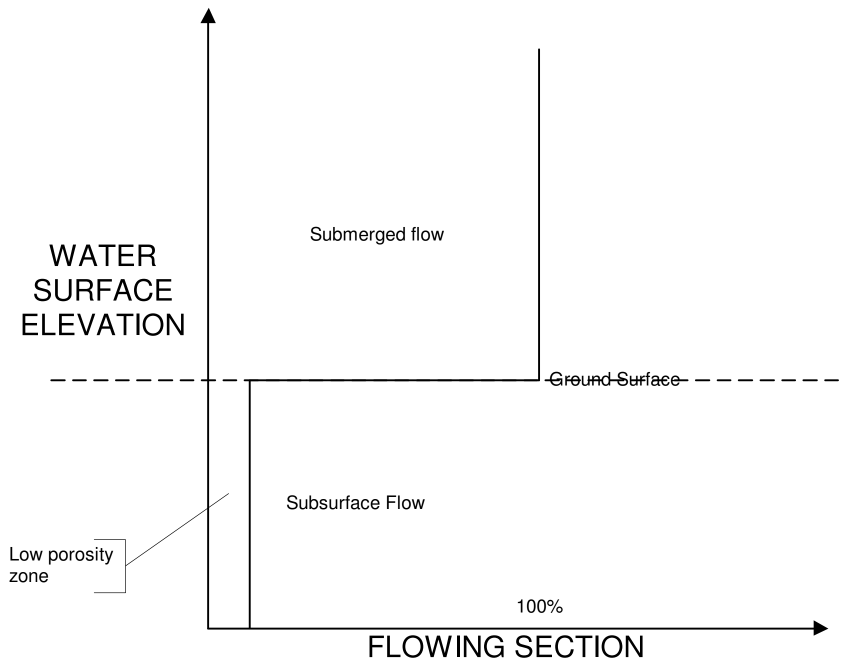
For these reasons an improved method was sought. Preferable a method where elements dropped out steadily (in a sense faded away) and would only be removed when **all** nodes were below the minimum.

The equivalent porosity/marsh method is the result. Conceptually the system was considered as an integration of both surface waters and subsurface groundwater. When the water surface elevation is below the ground surface flow is presumed to occur in the low porosity groundwater zone. However the governing equations are still the shallow water equations. The figure illustrates this concept. As a practical consideration the transition in porosity at the ground surface could no occur with a the infinite gradient shown. Instead an approximate system was conceptualised where porosity changed over a finite range as shown. This range has some physical basis. For example in sandy beach areas and overbank flood plains there are frequently uneven sections, in marshes there are small channels that are below the level of discretisation.

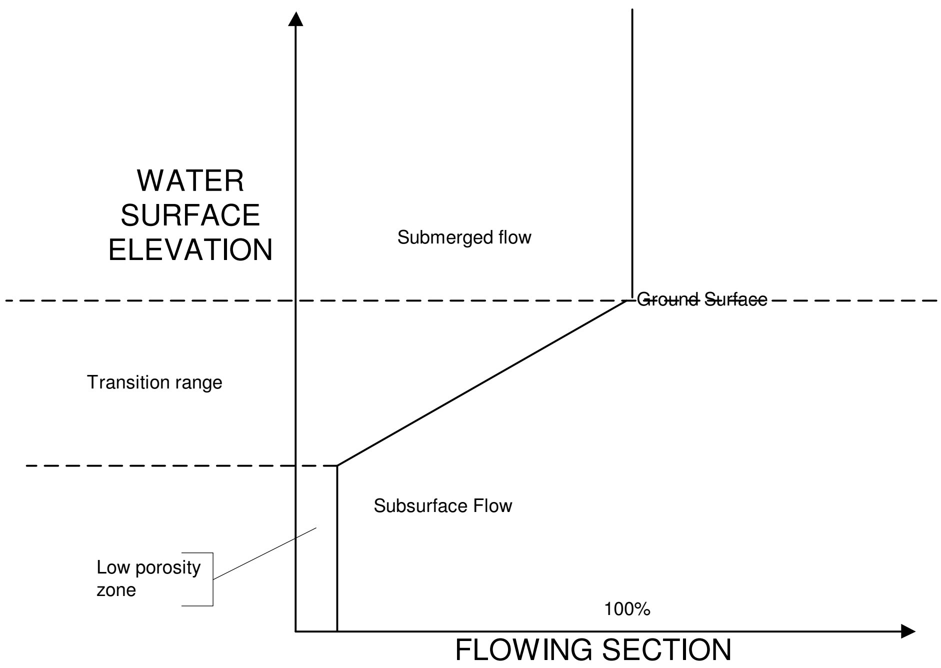
In order to assure mathematical consistency and not create water at any time the actual level of the transition must be slightly adjusted and the bottom elevation of the groundwater section had to be kept finite. The elevation of the groundwater section is thus best set to be just above the anticipated low water level.

The data requirements for the equivalent porosity formulation thus include:

- The range in feet or metres over which the element transitions from a fully flowing system to the fractional effective flowing section defined by the minimum porosity.
- The value of this minimum porosity.
- The depth below the transition over which the equivalent porosity is allowed to exist.



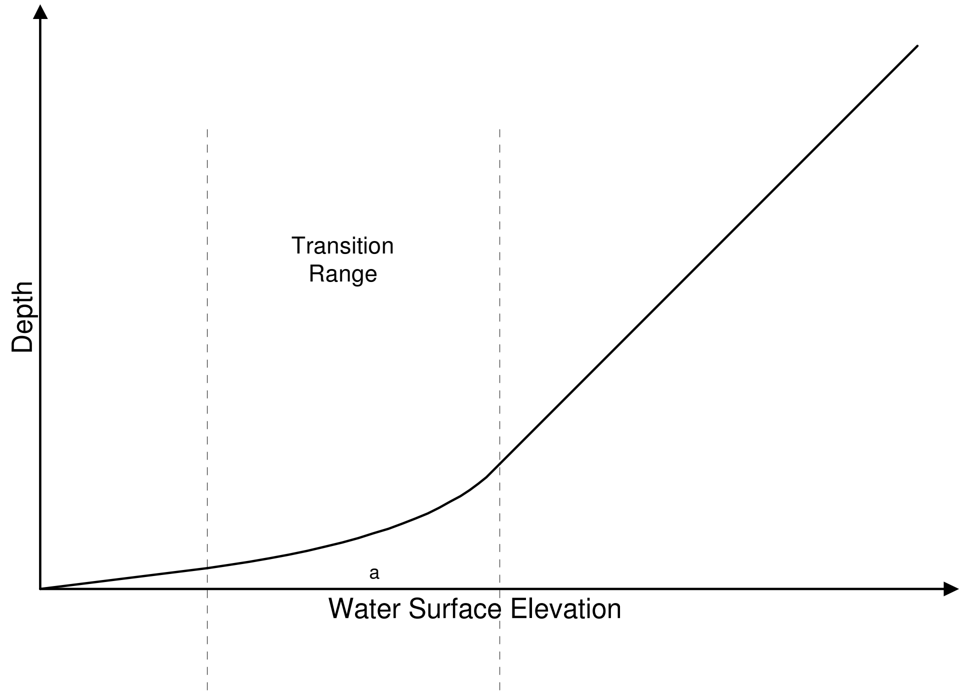
Idealized Representation



Approximate Representation

Modelling Consequences

The model incorporates this process by formal integration into the differential equations. Without going into full details, the result is that the model operates with a transformed equivalent depth. When the water surface is above the transition level this equivalent depth is identical to the conventional depth and the water surface elevation is equal to the bottom elevation plus the depth. Below the start of the transition this relationship no longer holds. The depth decreases at a smaller rate than the water surface, or in other words the effective bottom moves down as the depths falls The figure below illustrates this concept. Note that the curve below is a mathematical result and there are no consequences from the perspective of overall flow conservation.



WATER SURFACE VS DEPTH FOR THE MARSH APPROXIMATION

From a numerical perspective the greatest difficulty and cause of instability for this method is the sharp break in gradient as the depth decreases through the transition. This may be demonstrated by observing that the Newton Raphson correction to depth when a point in the system is fully submerged or low in the porous zone will not mathematically expect the transition and over-correction can result. The model has been modified to automatically switch to under-relaxation for these cases. Model convergence can be significantly slowed by these conditions.

RMA-2 has an option, input controls that allow elements that have water depths entirely in the porous zone, to be dropped from the system. This option should be used with caution because the resulting irregular boundaries can cause local instabilities.

Data Input

The data requirements for the model are nodal distributions of:

- Depth below the transition to groundwater flow.
- The transition range.
- The porosity of the groundwater flow.

In practical input terms the model allows the data to be input either as the default values, a revised global terms, or as distributed individual nodal values.

Actual values to use for the model are sensitive to the conditions and scale of the prototype system.

APPENDIX B

POWER STATION RECYCLING

RMA-10 is capable of modeling recycling of water through a Power station that can lead to dynamically varying input concentrations of salinity and sediment and temperature. The PWR data line where associated inlet and outlet continuity lines are identified and coefficients input to enable computation of the outlet parameters activates this feature.
The paragraphs below indicate how each of the constituent adjustments is made when the NADTYP option is set equal to zero.

Salinity and sediment concentration

CF = concentration factor (input by user, a fraction 0-1)

$$\frac{Co - Ci}{Ci} = CF$$

Co = outlet salinity/sediment concentration (mg/L)
Ci = inlet salinity/sediment concentration (mg/L)

Temperature calculations

H = thermal loading on cooling water (input by user in MW)
Q = volume flow rate input by user as the inflow to the model at the continuity line (m^3/s).
TF = throttling factor (input by user as a fraction of 0-1) (ie 20% reduction in flow would produce a TF = 0.8)

$$To = \frac{1000H}{TF\rho QCp} + Ti$$

$$\rho = 1000 - 0.0178\left|To - 4°C\right|^{1.7}$$

To = outlet temperature (°C)
Ti = inlet temperature (°C)
Cp = specific heat capacity (4.19 kJ/kg °K)
ρ = density of water (kg/m^3)

APPENDIX C

SAND TRANSPORT SIMULATION

RMA-10 provides two options for sand transport simulation.

Option 1 treats all sand transported as a suspended load computing erosion and effective settling rates from the equilibrium concentration and input correction factors.

Option 2 separates transported sand into a bedload component and a suspended component.

- The suspended component is simulated as in option 1 except that the equilibrium concentration is computed from the suspended load.
- The bed load component is analyzed with the assumption that the concentration remains at the equilibrium level and any excess or underage is made up for by deposition or erosion of the bed.

The reader is referred to the RMA-11 Users Manual for more details on the computational methods used to establish the transport rates. The section below will focus on how the transport rate is converted to equilibrium values for the two options.

Option 1

Computation of equilibrium concentration

Each of the sand transport algorithms computes a sand transport rate

Let T_a = the total computed transport rate in units of kg/sec/m width.
U = the water velocity in units of m/sec.
H = the water depth in units of m.

The equilibrium concentration C_a is given by:

$$C_a = \frac{T_a}{U\,H.}$$ and the units are kg/m^3 or mg/l.

Option 2

Computation of equilibrium concentration for suspended sand

In this case the computed total transport rate T_a is replaced by the suspended sand transport rate T_s. Then the equilibrium concentration for suspended sand C_s is given by:

$$C_s = \frac{T_s}{U\,H.}$$ and the units are kg/m^3 or mg/l.

Computation of equilibrium concentration for bedload sand

For this case the total water the effective depth of the bedload transport H_b replaces the depth and the velocity is replaced by near bed velocity U_b. Then the equilibrium concentration for the bedload C_b for a transport rate T_b is given by

$$C_b = \frac{T_b}{U_b\, H_b.}$$ and the units are kg/m^3 or mg/l.

Computation of deposition/erosion of bedload

In order to compute deposition/erosion due to changes in the equilibrium bedload concentration the advection-diffusion equation used in the finite element model for other transport computation is restated so that the source/sink term is the dependent variable. As an example, this revised finite element formulation for one-dimensional transport will be presented.

The finite element integral for the one-dimensional advection-diffusion is given by:

$$\mathbf{f_S} = \int_L (\mathbf{M^T}\left[(b-a)A(\frac{\partial C_b}{\partial t} + U_b\frac{\partial C_b}{\partial x}) - D_X A\frac{\partial a}{\partial x}\frac{\partial C_b}{\partial x} - (b-a)A\theta_S\right] + \mathbf{M_X^T}\, D_X \frac{\partial C_b}{\partial x} A(b-a)\, dL$$

In this equation:

A = The cross-sectional area
b = The reference elevation for the vertical transformation used in RMA-10S
a = The bed elevation
x and t = The space and time coordinate system
U_b = The bed velocity
Dx = The diffusion coefficient
θs The source/sink term due to erosion/deposition (Note that this the dependent variable
$\mathbf{M^T}$ and $\mathbf{Mx^T}$ = The linear finite element basis functions.
L = The element length.

The finite element coefficient contribution is then given by a differentiation with respect to θs to obtain

$$\frac{\partial \mathbf{f_S}}{\partial \theta s} = -\int_L (\mathbf{M^T}\left[(b-a)A\right] \mathbf{M}\, dL$$

When the finite element solution is completed the nodal values of θs represent the gain rates for the bed-load. In other words θs is the erosion rate from the bed. The units are $kg/m^2/sec$.

RMA-10S has been structured to adjust bed depths at the corner nodes based on the integral over time of θs and the density of the sand.

APPENDIX D

COHESIVE SEDIMENT TRANSPORT SIMULATION

RMA-11 is constructed to permit transport of fine cohesive sediment or mud as an option of the model. Several processes are modelled:

- Deposition through settling
- Erosion either as surface process or a mass process
- The development history of the bed layer.

Erosion and/or deposition are dependent on the bed shear stress developed by flowing water, and the shear strength of surface layer of the bed. The strength of lower layers of the bed are increase through consolidation. This process is approximately modelled. The methodology on which this is based is that of Ariathurai and Krone (1976)[9].

Cohesive Sediment Bed Shear Stress

RMA-11 provides two options for computation of bed shear stress, one based on a law of the wall with the wall assumed smooth. In this case bed shear stress is given by

$$\tau_b = \rho_w u_*^2$$

where

u_* = shear velocity, (m/sec).
ρ_w = water density, (kg/m^3).

then

$$u_m = u_* \log_e\left(\frac{\{3.32u_*d\}}{\upsilon}\right) / V_k$$

where:

u_m = mean flow velocity, (m/sec).
d = water depth, (m).
υ = kinematic viscosity of water, (m^2/sec).
V_k = Von Karman's Constant

For the case of a rough bed:

$$u_* = \frac{V_k\, u_m}{\log_e \{12.27\, d/r\}}$$

where

r = roughness height in metres.

Cohesive Sediment Settling Rate

In an effort to model effective flocculation and its influence on settling rates the particle settling rate is optionally defined as a function of the suspended sediment concentration. The governing equation for settling velocity V_s is thus:

$$V_s = V_1 \text{ for concentration } S < S_1$$
$$V_s = V_{sk}\, S^{p_c} \text{ for } S_1 < S < S_2$$

[9] Ariathurai R. and R. B. Krone, "Finite Element Model for Cohesive Sediment Transport," Journal of the Hydraulics Division, ASCE Vol. 102 No. HY3, 1976

$$V_s = V_{sk} S_2^{\,p_c} \quad \text{for} \quad S_2 < S$$

where:

V_1, S_1, S_2 and p_c are all input parameters and V_{sk} is derived as matching condition.

Cohesive Sediment Settling

When the shear stress on the bed is not sufficient to re-suspend particles that contact and bond with the bed, deposition occurs. The likelihood for settling to occur increases as the shear stress decreases relative to the critical shear stress. Thus the rate of settling V_b at the bed may be written as:

$$V_b = V_s \frac{\{\tau_d - \tau_b\}}{\tau_d} \qquad \text{when } \tau_b < \tau_d$$

where:

V_b = effective bed settling velocity, (m/sec)
V_s = particle settling velocity, (m/sec).
τ_b = bed shear stress for settling, (N/m^2).
τ_d^* = critical shear stress for settling, (N/m^2).

Cohesive Sediment Erosion

Above a critical level of shear stress erosion of the bed will occur. Resistance of a cohesive bed to erosion by flowing water depends on a number of factors:
(a) The type of clay minerals that constitute the bed.
(b) The structure of the bed, which in turn depends on the environment in which the aggregates that formed the bed were deposited, the elapsed time, the temperature and the rate of gel formation.
(c) The chemical composition of the pore and eroding fluids.
(d) The stress history, i. e., the maximum overburden pressure the bed has experienced and the elapsed time at various stress levels.
(e) The presence of organic matter and its state of oxidation.

At bed shear stresses just above the critical value, erosion occurs particle by particle. This process is called surface erosion. At higher levels of stress the bulk shear stress of the bed may be exceeded and a portion of the bed may be liable to exhibit mass erosion. That is, when the shear stress exceed the critical shear stress for that portion of the bed, it fails completely and is instantly suspended.

Thus a model for the bed must include data defining the critical shear strength of each stratum of the bed and an erosion rate for surface erosion.

The erosion rate for surface erosion may be written as:

$$E_s = M \frac{\{\tau_b - \tau_{ce}\}}{\tau_{ce}} \qquad \text{when } \tau_b > \tau_{ce}$$

where

τ_{ce}^* = critical shear stress for erosion, (N/m^2).
M = erodibility constant

The erosion rate for mass erosion can be defined assuming that all mass is eroded over a time step. The form may be written as:

$$E_m = \frac{\Delta m}{\Delta t} \qquad \text{when } \tau_b > \tau_{cl}$$

where

Δm	=	Mass eroded per unit bed area (gm/m^2)
Δt	=	time step, (s).
τ_l^*	=	critical shear stress for mass erosion for layer l, (N/m^2).