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PREDICTION OF UNSTEADY SALINITY INTRUSION IN ESTUARIES: MATHEMATICAL MODEL AND USER'S MANUAL

by

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FOREWORD

This report is intended as a documentation of the computer program and as a user's manual for the implementation of the mathematical model for the prediction of unsteady salinity intrusion in estuaries. The details of the model development and verification are contained in the following report:

> "A Mathematical Model for the Prediction of Unsteady Salinity Intrusion in Estuaries" by M. Llewellyn Thatcher and Donald R. F. Harleman, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Technical Report No. 144, February 1972 [also published by M.I.T. Sea Grant Project Office as Report No. MITSG 72-7 (index No. 72-307-Ccb)].

The unsteady salinity intrusion model is one-dimensional, although varying degrees of stratification are accounted for in the assumed longitudinal dispersion relationship.

This model is a component in two additional studies, one of which is concerned with the two-dimensional aspects of salinity intrusion (i.e. vertical salinity and velocity distributions in estuaries):

> "Mathematical Simulation of Tidal Time-Averages of Salinity and Velocity Profiles in Estuaries" by John S. Fisher, John D. Ditmars and Arthur T. Ippen, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Technical Report No. 151, July 1972 [also published by M.I.T. Sea Grant Project Office as Report No. MITSG 72-11 (index No. 72-311-Ccb)]

The second study is concerned with the development of a model for predicting the transient longitudinal distribution of water quality parameters in estuaries:

> "Numerical Model for the Prediction of Transient Water Quality in Estuary Networks" by James E. Dailey and Donald R. F. Harleman, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Technical Report No. 158, October 1972 [also published by M.I.T. Sea Grant Project Office as Report No. MITSG 72-15 (index No. 72-315-Ccb)]

This user's manual therefore assists in the implementation of the analytical and numerical models listed above.

ACKNOWLEDGEMENT

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The authors wish to express their appreciation to Mr. David Najarian, Research Assistant, for his valuable assistance throughout the preparation of this manual.

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I. Introduction and Review

1.1 Introduction

This is a user's manual for the computer program implementing the transient salinity intrusion model developed by Thatcher and Harleman(1). The purpose of this manual is to enable researchers and engineers to use the computer program in an effective manner without requiring that they have other than a fundamental understanding of how digital computers accept input data, execute logical and numerical instructions, and present calculations in readable form. Although a knowledge of FORTRAN programming is helpful, it is not considered necessary for the prospective user of this program. However, to avoid unnecessary computing expense, it is recommended that a user not familiar with computer applications seek the assistance of someone who is experienced when it comes to the actual execution of the computer program.

1.2 Review of the Mathematical Model

Reference 1 describes the development of a predictive, one-dimensional mathematical model for longitudinal salinity distributions in estuaries under transient conditions of fresh water inflow and ocean tidal elevations. The governing equations for the tidal motion are:

the continuity equation,

$$b \frac{\partial h}{\partial t} + \frac{\partial Q}{\partial x} - q = 0 \qquad (1\text{-}1)$$

and the longitudinal momentum equation,

$$\frac{\partial Q}{\partial t} + u \frac{\partial Q}{\partial x} + Q \frac{\partial u}{\partial x} + g \frac{\partial h}{\partial x} A + g \frac{A d_c}{\rho} \frac{\partial \rho}{\partial x} + g \frac{Q|Q|}{AC^2 R_h} = 0 \qquad (1\text{-}2)$$

Determination of the salinity distribution requires the conservation of salt, or salt balance equation,

$$\frac{\partial (A_{Total} s)}{\partial t} + \frac{\partial (Qs)}{\partial x} = \frac{\partial}{\partial x} \left[EA_{Total} \frac{\partial s}{\partial x} \right] \qquad (1\text{-}3)$$

and an equation of state relating salinity and density,

$$\rho = 0.75\ s + 1000 \qquad (1\text{-}4)$$

where

b = the total width of the channel [b_{Total} in Reference 1]

h = the depth of water from surface to a horizontal datum

Q = cross-sectional discharge

q = lateral inflow per unit length

u = average cross-sectional velocity of the conveyance area

g = acceleration of gravity

A = cross-sectional area of conveyance area [A_{core} of Reference 1]

A_{Total} = total area of cross section, including storage

d_c = depth of the centroid of conveyance area

ρ = fluid density

C = Chezy coefficient

R_h = hydraulic radius

E = longitudinal dispersion coefficient

s = salinity representative of a cross-section (parts per thousand)

The boundary conditions required to solve these equations are:

(1) the specification of tidal elevation at the ocean entrance as a function of time

(2) the specification of fresh water inflow at the upstream boundary and of tributary inflows as functions of time

(3) the specification of zero salt flux across the upstream boundary and

(4) the specification of conditions on salinity at the downstream entrance of the estuary.

Information on water surface elevations at the ocean entrance is usually available from tide tables, and it is assumed that the user has fresh water inflow hydrographs. Conditions on salinity at the downstream boundary require

only a specification of ocean salinity, s_o or a maximum salinity. This salinity specification constitutes the boundary condition during the flood (incoming) flow. During ebb (outgoing) flow, the ocean boundary salinity is not specified, as the solution is continued in terms of a convective transport across the downstream boundary. When the ebb flow ceases and flood begins, the salinity at the downstream boundary will return to its maximum value s_o. When the downstream boundary coincides with the ocean entrance, the time of return of salinity to its maximum value will be relatively rapid due to longshore currents which sweep away much of the diluted water. It is assumed that this return is linear in time, and for the ocean entrance good results have been obtained using 5% of a tidal period as the time span over which the salinity returns to its maximum.

Figure 1.1 shows that this time span can be specified as considerably longer than 5% in order to account for the cases in which the downstream boundary is not at the ocean entrance.

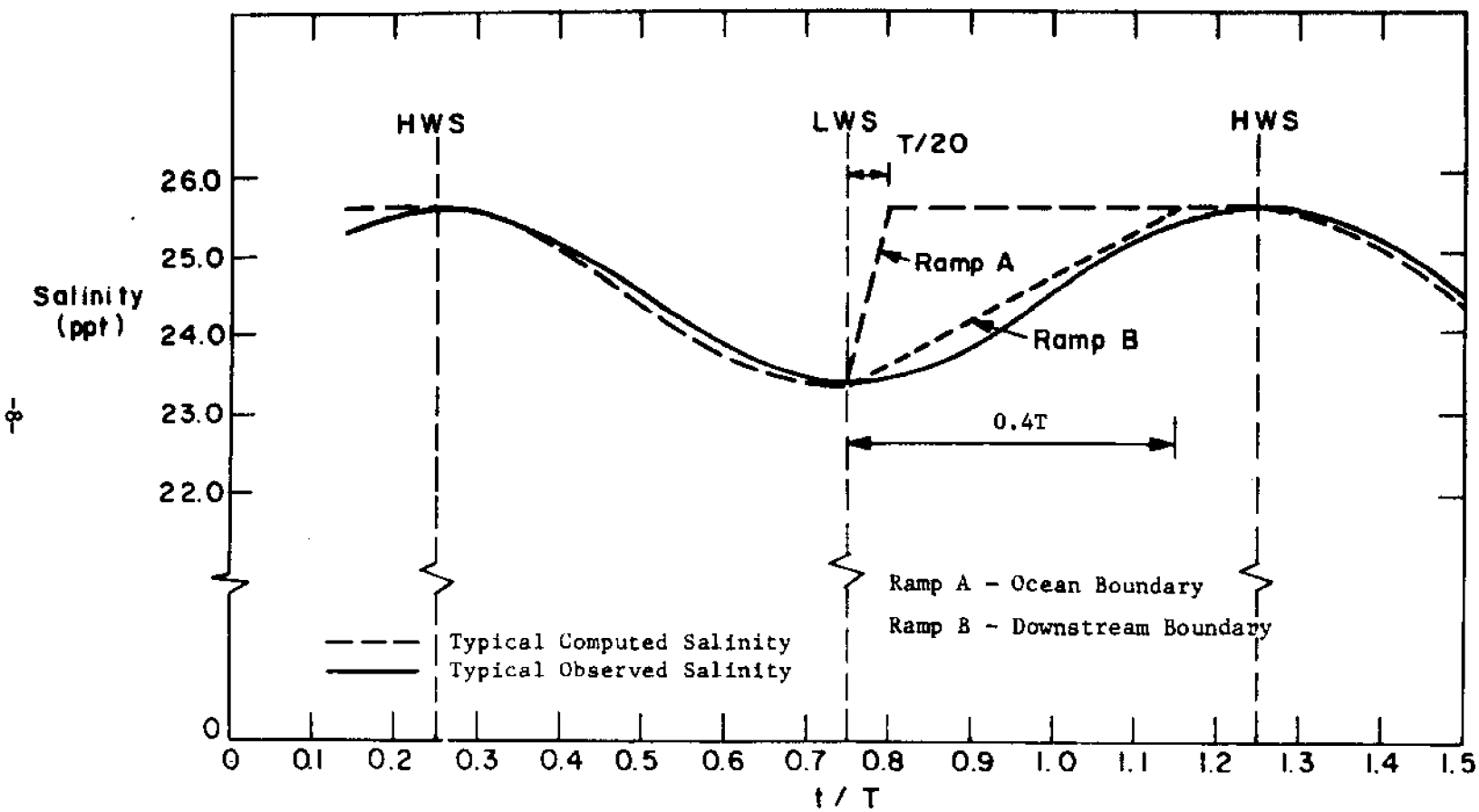
The longitudinal dispersion coefficient is related to the local non-dimensional salinity gradient, $\frac{\partial s/s_o}{\partial x/L}$, (where L = length of estuary) in the salinity intrusion region. The dispersion coefficient for the entire estuary is

$$E(x,t) = K\left|\frac{\partial s/s_o}{\partial x/L}\right| + 77\ n\ u\ R_h^{5/6} \qquad (1\text{-}5)$$

where K is a constant of proportionality related to the degree of stratification as measured by gross estuarine parameters. The second term represents the dispersion in the fresh water region where n is the Manning resistance coefficient, u is the cross-sectional average velocity and R_h is the hydraulic radius.

Reference 1 has shown that a correlation exists between K/u_oL and an estuary number $\mathbb{E}_D$. This permits the determination of a value for K for each tidal period based on the previous tidal period's calculated value of the tidal prism, P_T, the densimetric Froude number, $\mathbb{F}_D$, the fresh water inflow, Q_f, and the tidal period, T. These are the gross parameters which define the estuary number

$$\mathbb{E}_D = \frac{P_T \mathbb{F}_D^{\,2}}{Q_f T} \qquad (1\text{-}6)$$



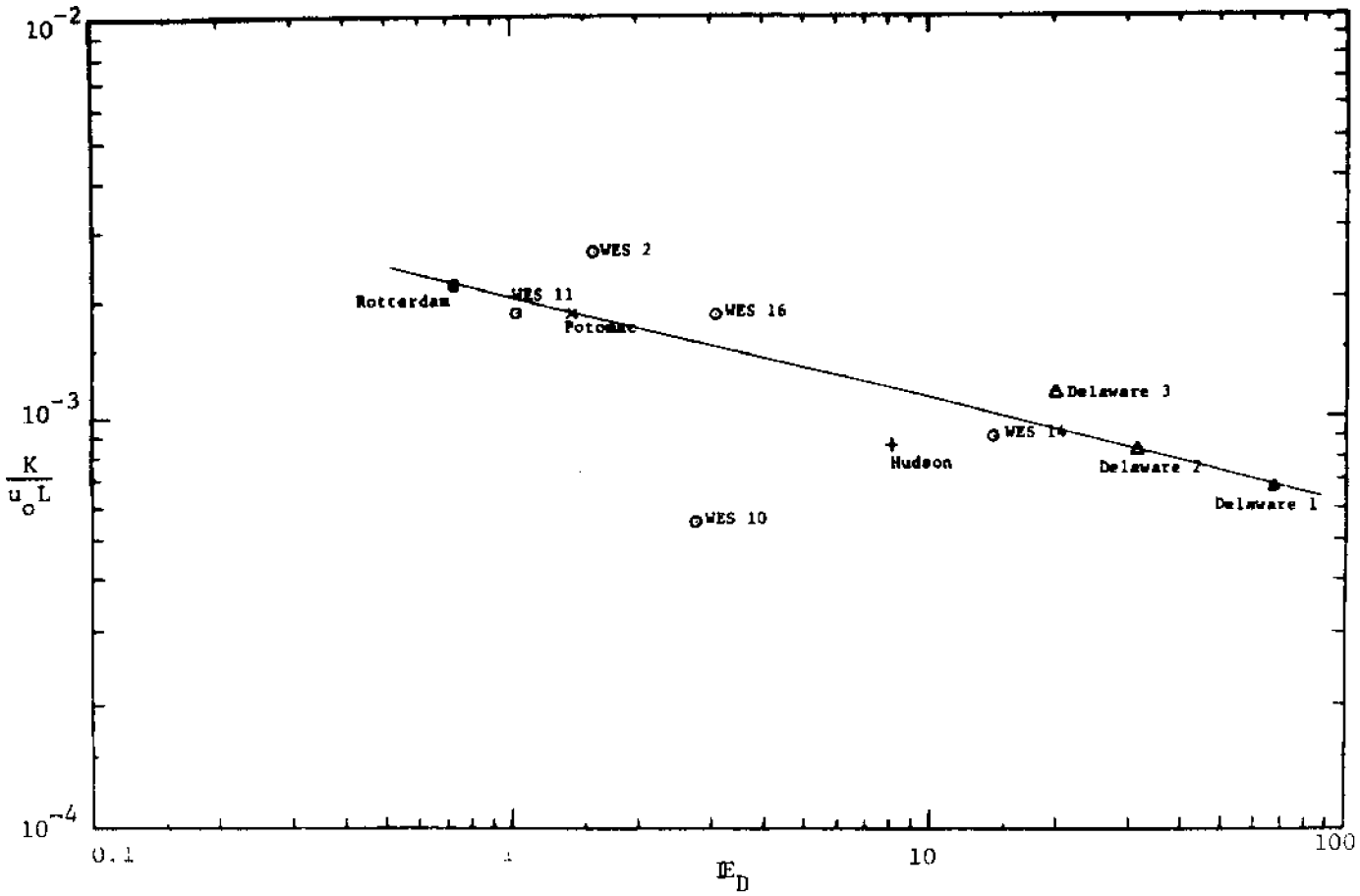
Representation of Entrance Boundary Condition
on Salinity for Estuary

Figure 1.1

The correlation between K/u_oL and $\mathbb{E}_D$, developed using steady-state salinity distribution data, covers a wide range of stratification conditions. This relationship is shown in Figure 1.2.

Calculations of salinity, water surface elevation and discharge are made by solving Equations 1-1, 1-2, 1-3 and 1-4 in finite difference form. The numerical model consists of two fundamental components of calculation. The first component solves for the water surface elevations and discharges and is a modification of the numerical model of Harleman and Lee(2). The second component is the finite difference solution of the salt balance Equation 1-3. Details of the finite-difference techniques used are described in Reference 1.

The solution requires initial conditions and advances in time in accordance with the values of the time-varying boundary conditions of tidal elevation at the entrance and fresh water inflows. The solution determines surface elevations, discharges and salinities as functions of longitudinal distance and time for any specified number of tidal periods. Details pertaining to the practical application of the transient salinity intrusion numerical model are presented in the following sections of this report.



Correlation of Dispersion Parameter to Degree of Stratification

Figure 1.2

II. Principal Steps in the Application of the Numerical Model

2.1 Initial Decisions in Reducing Estuary Geometry to One-Dimensional Parameters

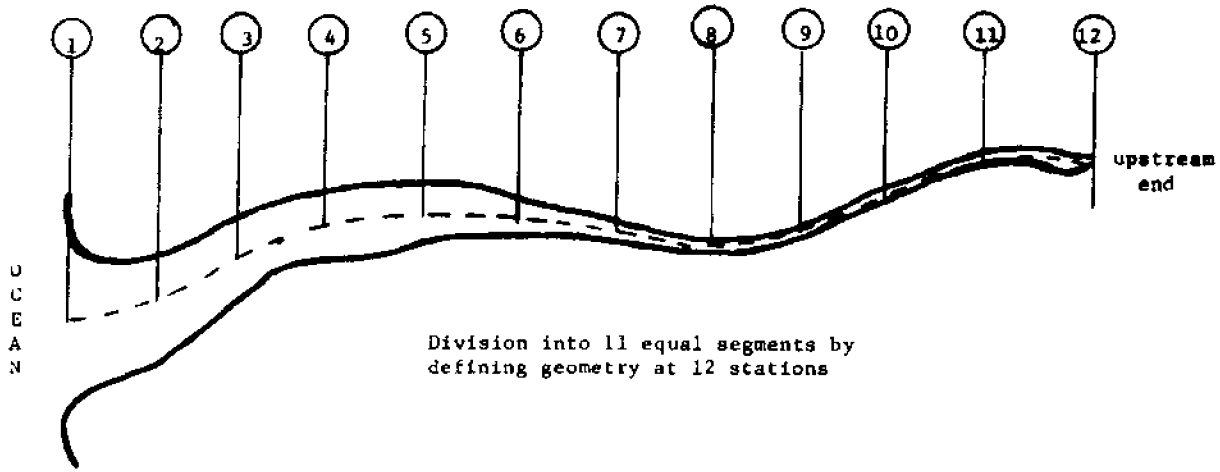
The geometric configuration of the estuary must be studied to determine the appropriate extent or domain of the estuary, and the degree of detail necessary in terms of discretization. The longitudinal extent of the estuary is the first determination to be made. The upstream boundary is usually taken at the head of tide. This can be a physical closed-end such as a dam, lock, waterfall or rapids. If no physical barrier exists, the estuary is of the open-end type, and the upstream boundary is set at a point far enough upstream so as to be unaffected by tidal action.

Ideally, the downstream boundary should coincide with the ocean entrance to the estuary. The case studies presented in Ref. (1) consider three different types of estuaries from the standpoint of downstream boundary location:

1. Delaware. The downstream boundary is at the ocean entrance (Cape Henlopen–Cape May).
2. Potomac. The downstream boundary is at the junction with Chesapeake Bay.
3. Hudson. The downstream boundary was chosen to be at the Battery. Below the Battery the estuary is no longer one-dimensional because of the connection to Long Island Sound through the East River.

The salinity boundary condition for the Delaware and Potomac were assumed to follow "ramp A" of Figure 1.1 with the value of s_o being determined by salinity conditions in the Atlantic and in Chesapeake Bay respectively. In the case of the Hudson the salinity variation at the Battery was assumed to be more nearly sinusoidal as shown by "ramp B" of Figure 1.1.

Once the limits of the estuary have been defined, the next decision is that of determining the segment length, Δx, for discretization of the physical characteristics. This interval of discretization, Δx, must be small enough to be representative of the principal variation in geometry. Case studies made in Ref. (1) have shown that segment lengths of 2 to 3 miles generally provide sufficient detail. The computer model requires that the total number of stations be an even number. This is the result of a staggered finite-difference scheme in which water surface elevations and salinities are calculated at odd numbered stations and discharges at even numbered stations. Figure 2.1 illustrates



Station Number

1	2	3	4	5	6	7	8	9	10	11	12
·	Q	·	Q	·	Q	·	Q	·	Q	·	Q
S		S		S		S		S		S	

· - water surface elevation and S - salinity; determined at odd numbered stations

Q - discharge; determined at even numbered stations

Segmentation of the Estuary

Figure 2.1

the division of a simplified estuary into 12 stations (11 segments).

After the identification of longitudinal stations has been accomplished the schematization of the natural geometry into basic parameters of depth and area is performed. Two basic types of schematization are available in this model and the user must choose that which best suits his particular study.

The first type, Figure 2.2a, is that of a trapezoidal cross-section. This type of schematization is especially useful in cases where it is important to represent the change in estuary width with change in depth. It assumes that the entire trapezoidal area participates in the longitudinal tidal flow and consequently it does not provide for portions of the estuary which act as storage. It is noted that schematization to a rectangular cross-section is a special case of the trapezoidal schematization.

The second type, Figure 2.2b, represents the area of the discrete interval by two rectangular areas; one for storage, the other for conveyance. This schematization simplifies the cross-section in terms of geometry, and allows the user to specially treat the cases of embayments and other portions of the estuaries which do not act directly or significantly in terms of the longitudinal tidal flow.

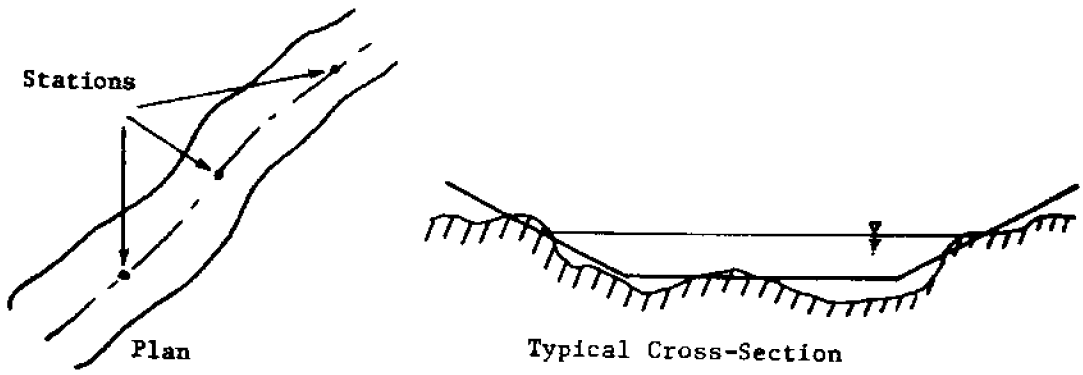
After the user has decided which of the types of schematization to use he can proceed to the schematization process itself. This process will depend on the particular case, the time available and sources of data. The following sections are intended to serve as an example of the schematization process.

2.2 General Principles of Schematization

The numerical model employs discrete quantities. At each station such as those indicated in Figure 2.2 the user must determine basic parameters which permit the calculation of a conveyance cross-sectional area, A_{core}, and, if so chosen, a storage area, $A_{storage}$. These areas are to be representative of the estuary in the region of the station being considered. More precisely, they represent an average for the segment centered on that station. The cross-section at the station itself may not be representative of the entire segment.

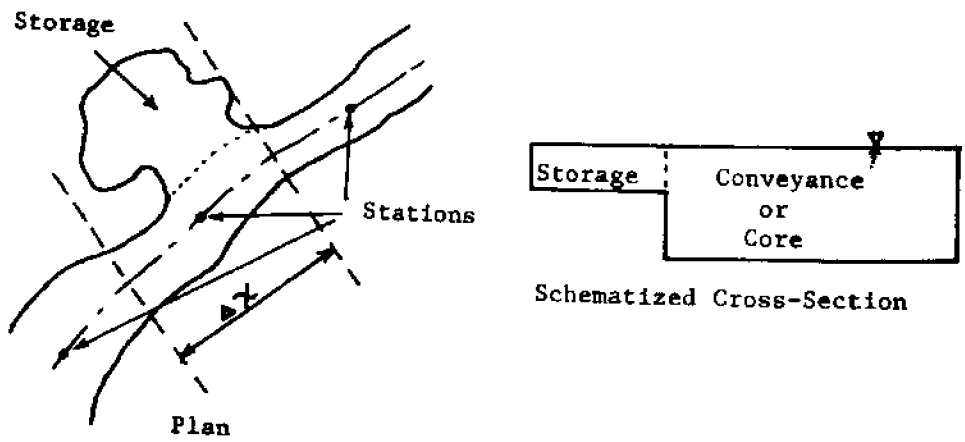
2.3 Establishing the Datum

In order to correctly represent the water surface the data defining each cross-section must be related to a common horizontal datum. Often this presents



Trapezoidal Schematization

Figure 2.2a



Storage and Conveyance (or Core) Area Schematization

Figure 2.2b

a problem because hydrographic charts are intended for navigation and not for numerical modeling. Chart depths are relative to some water surface such as local mean low water, local mean river level, or other local water surface which is not necessarily horizontal.

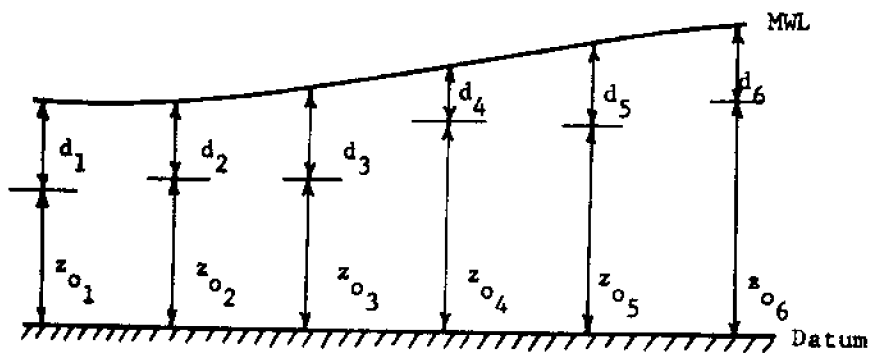
In order to accurately define the estuarine geometry the bottom elevations of the schematized cross-sections must be specified relative to a common horizontal datum. This entails obtaining information which defines the local datums. Such information is usually available from the organization that issued the charts. (For example, the National Ocean Survey of the U.S. Department of Commerce.)

Figure 2.3 shows how the common horizontal datum is used. Each station is schematized with reference to the mean water level (MWL). The depth from MWL to the bottom of the schematized cross-section is d_j. The location of the common horizontal datum is specified by the user, and the changes in local datums are included by defining z_{o_j} so that $d_j + z_{o_j}$ measures the distance from the common horizontal datum to the local MWL. The changes in local datums are illustrated in Figure 2.3 by the fact that the MWL varies with respect to the horizontal.

If no data is available on the local datums it is possible to assume that the local datums are all the same. This means that the MWL is assumed to be horizontal from one end of the estuary to the other. The effect of such an assumption is the introduction of an error in the depth of the schematized cross-sections equal to the difference between the assumed local MWL and the actual local MWL.

2.4 Schematization to a Trapezoidal Cross-Section Without Storage

The cross-section which typifies each reach is considered to be centered on the station. The trapezoid which most closely represents the cross-section of the reach should be found. This can be achieved by a variety of techniques



Sketch of Common Datum

Figure 2.3

ranging from estimation by visual inspection to mathematical fitting techniques employing chart soundings. In terms of required input data to the computer program, the trapezoid selected must be defined by the following four parameters as shown in Figure 2.4a:

1. bottom width, b_o
2. depth, d
3. horizontal distance per unit vertical distance, SS
4. distance from common datum to the bottom of the channel, z_o

The depth is measured to mean water level (MWL).

2.5 Schematization Including Storage and Conveyance (or Core) Areas

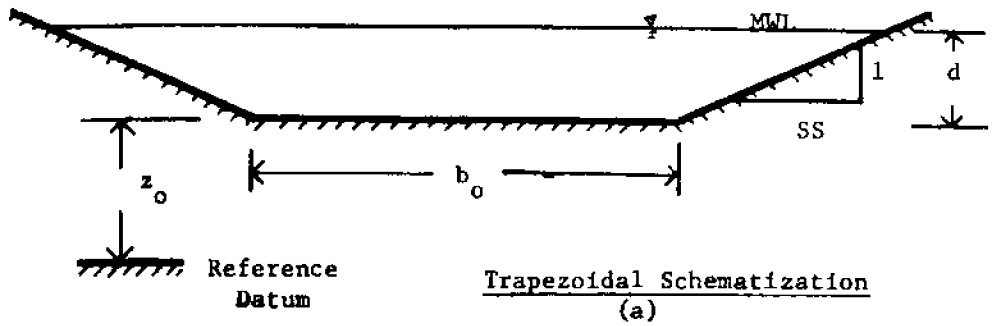
The plan view of Figure 2.2b shows a typical estuary reach containing an embayment. The water in the embayment does not participate in the longitudinal tidal transport, however it fills and empties with the change of water surface elevation. The embayment acts as storage, and in estuaries where the surface area of such embayments is a significant percentage of the total surface area, the schematization should represent the storage action.

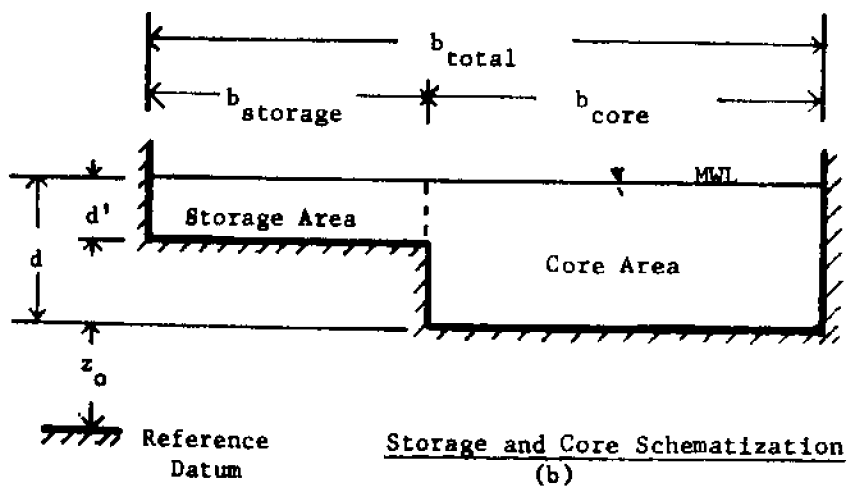
The schematization employed is based on the determination of a conveyance or core area which is defined in terms of a width b_{core} and a depth d. This requires that the user determine an average cross-sectional area and width for the segment. This area is then represented in rectangular form by dividing it by the average width to obtain the depth, d.

Figure 2.4b shows how this core area is joined to a storage area. To define the storage area it is necessary to define a depth of the storage area, d'. This depth, multiplied by the surface area of storage, $A^s_{storage}$, yields a volume of storage $V_{storage}$. To obtain an equivalent cross-sectional storage area $A_{storage}$, the volume of storage is divided by the segment length, Δx. Further division of this cross-sectional storage area by the storage depth, d' gives the equivalent width, $b_{storage}$, of the schematized rectangular cross-section. These relationships are:

$$V_{storage} = A^s_{storage}\, d'$$

$$A_{storage} = \frac{V_{storage}}{\Delta x}$$





Basic Schematized Cross-Sections

Figure 2.4

$$b_{storage} = \frac{A_{storage}}{d'} = \frac{A^s_{storage}}{\Delta x} \qquad (2\text{-}1)$$

The final relationship shows how the schematization process spreads out the surface area over the reach length Δx.

The data required by the computer program for each section are:

1. the core width, b_{core}
2. the core depth, d
3. the total width, $b_{total} = b_{core} + b_{storage}$
4. the storage depth, d'
5. the distance from the common datum to the bottom of the schematized section, z_o

Again, it must be remembered that the depth is with respect to mean water level.

2.6 Verification of Tidal Hydraulics

2.6.1 Choice of Δt, Based on Stability Requirements

The explicit finite-difference solution of the continuity and the momentum equations (1-1 and 1-2) imposes a limit on the size of time increment, Δt. This requirement can be approximated by

$$\Delta t \leq \frac{\Delta x}{u+c} \qquad (2\text{-}2)$$

where u is the average cross-sectional velocity and c is the wave speed $\sqrt{gh}$ at the same location. Equation 2-2 can be used to estimate the Δt corresponding to a particular Δx by estimating u and c. For example, if the maximum depth of an estuary is 40 ft. and the expected tidal velocity will not be greater than 2 feet per second, Equation 2-2 limits Δt to a maximum of about $\frac{\Delta x}{38}$ seconds. For Δx = 10,000 feet, $\Delta t \leq 263$ seconds, and for a tidal period of 12.4 hours, this would require 170 time intervals per tidal cycle.

2.6.2 Channel Roughness as the Variable Parameter in Tidal Hydraulics Verification

Tide table data on tidal range and phase is utilized to insure that the numerical model correctly represents the advective characteristics of the estuary. The tidal verification process is executed by varying the channel roughness (Manning's n) so as to achieve the best fit with available data. Often the data is presented in terms of local tidal range and phase lags for a particular tidal

range at the ocean, or downstream boundary. The tidal verification runs are made by assuming typical fresh water inflows and holding these constant for each tidal cycle of calculation. The time varying surface elevation at the ocean is repeated for each tidal cycle. Such a repetition of boundary conditions defines a quasi-steady state condition. Initial conditions of surface elevation and discharge can be approximated (or set equal to zero) and any reasonable approximation of the longitudinal salinity distribution can be used for an initial condition on salinity. The numerical model is then run and it has been found that about 5 to 8 tidal periods of calculation will result in tidal elevations and discharges which are essentially the same from one period to the next. This procedure can be applied for different variations in channel roughness until the resulting convergent surface elevations give a satisfactory verification of the tidal data. The unsteady salinity intrusion study can then be continued using this distribution of channel roughness. It is noted that the tidal hydraulics are not very sensitive to small changes in the salinity distribution and this is why the above procedure can be successfully executed using only an approximate salinity distribution.

Typical values of Manning's n found in Ref. (1) are:

Delaware $n = 0.017$ to 0.033 (ave. $= 0.024$)

Potomac $n = 0.018$

Hudson $n = 0.015$

2.7 Treatment of Entrance Salinity for Different Entrance Configurations

When the estuary being studied can be schematized as far downstream as the ocean, the boundary treatment requires the specification of the ocean salinity, s_o, and the portion of the tidal period during which the salinity returns from the value at low water slack (LWS) to the maximum value, s_o. For such cases it has been found that a time equal to 0.05T for the return portion gives reasonable results. A well defined ocean boundary permits the prediction of salinity distributions starting with initial conditions requiring only the specification of the ocean salinity, s_o.

In cases where the downstream boundary cannot be taken at the ocean, but must be located farther upstream, the assumption that longshore currents will sweep away most of the diluted ebb flow is not as valid as it was for the ocean

boundary. The user can predict longitudinal salinity distributions under such conditions by specifying the maximum salinity at the downstream boundary and also by specifying a reasonable return time during which the salinity will return from its low water slack value to the maximum value. This return time will be between 0.05T and 0.4T. Ref. (1) has shown that for the Hudson a satisfactory representation of the downstream boundary at the Battery was achieved using 0.4T. The observed depth averaged salinity variation at the Battery was approximately sinusoidal. Figure 1.1 illustrates how the different specifications of return time affect the representation of the temporal variation of salinity at the downstream boundary.

2.8 Initial Conditions

An initial longitudinal salinity distribution must be specified to begin the calculation. In addition initial values of surface elevations and discharges are required. As discussed in Section 2.6.2, the effect of arbitrary initial conditions of surface elevation and discharge is negligible after 5 to 8 tidal cycles of calculation, and this characteristic can be used to generate realistic initial conditions of surface elevations and discharges for the unsteady salinity intrusion study.

Coast and Geodetic Tide Tables can be used to specify the maximum and minimum tidal elevations at the downstream boundary. By assuming an approximate salinity distribution, the user can back-up eight tidal cycles from the beginning of the study period and initiate a calculation using initial values of elevation and discharges equal to zero. The tidal surface elevations and the discharges produced after eight cycles are appropriate initial conditions for the unsteady study. The user can combine the elevations and discharges at the end of the introductory eight cycles of calculation with the initial salinity distribution and thus obtain a complete set of initial conditions for the unsteady salinity intrusion study.

III. Objective and Scope of the Computer Program

The objective of the computer program is to calculate water surface elevations, salinities and discharges as functions of time and of longitudinal distance along the estuary. This calculation is an implementation of the finite difference mathematical model developed in Ref. 1.

The scope of the program is defined in terms of three areas of user control. These areas of control are (1) specification of estuarine geometry and roughness, (2) specification of time-varying boundary conditions and of initial conditions, and (3) selection of the frequency and content of the output from the computer.

In the specification of geometry the user describes the estuary cross-sections in terms of either a rectangular or trapezoidal channel, or in terms of a rectangular channel with a storage area (Sections 2.2, 2.3, 2.4 and 2.5). Simplified descriptions can be used for the special cases of a uniform rectangular section and for a rectangular section whose width varies in an exponential manner. The channel roughness is described in terms of Manning's n and wind shear effects can be specified.

The boundary conditions are: tidal surface elevations at the downstream boundary, fresh water inflows at the head and at other locations along the estuary, and the maximum salinity, s_o, at the downstream boundary. If the tidal surface elevations at the downstream boundary are repeating from tidal cycle to tidal cycle, then the specification of this boundary condition can be made in terms of harmonic components or in tabular form. For the situation in which tidal variations are expressed in terms of a series of high and low water elevations (as from data found in tide tables), the user can specify the time series and the program will fit a cosine curve to the specified values of high and low water elevations. The specification of fresh water inflows and the maximum entrance salinity s_o is made for each tidal period of calculation.

The initial conditions of surface elevation, discharge, and salinity can be specified in a convenient form; either from the result of a previous calculation stored as a "data set", or in punch card form.

The computer output can be printed or stored on a sequential data device such as a magnetic tape. The program provides the user with the ability

to specify the frequency of printing the surface elevations, salinities and discharges. It is also possible to print out high water slack salinities and to punch the final calculated values into cards so that these values can become the initial conditions of a subsequent calculation. The storing of calculated values of elevations, salinities and discharges on a sequential data device is convenient for subsequent plotting of these results by a plotting program such as that included in Appendix III. It is also possible to store the calculated values of the longitudinal dispersion coefficient, E, on a sequential data device.

IV. Structure of the Program

The program consists of two principal multipurpose routines and several single purpose routines.

The first principal multipurpose routine is the main-line program, hereafter referred to as MAIN. MAIN executes the input routines TIDIN and OSIN and proceeds, cycle by cycle, to read in the time varying boundary specifications and execute the basic calculation routine, MARCH. When the calculation is completed MAIN outputs the final values of surface elevation, discharge and salinity.

The second principal multipurpose routine is MARCH. MARCH performs the basic calculation in time steps of $2\Delta t$, solving first the continuity equation, then the momentum equation, and finally the salt balance equation. In the solution of the salt balance equation, three routines are executed: (1) TDISP, which calculates the dispersion coefficient; (2) TOCNB, which performs the entrance or ocean boundary calculation; and (3) TRIDG, which solves the resulting tri-diagonal simultaneous equations.

The output is produced by executing routine SPEW.

At the end of each tidal cycle MARCH calculates the total mass of salt in the estuary. If requested by the user, the time of high water slack is found and the corresponding high water slack salinities are printed. Finally, the value of the dispersion parameter K is determined by executing routine ESNOD which determines the estuary number $\frac{P_T \mathbb{F}_D^{\,2}}{Q_f T}$ and determines K in terms of the specified $K/u_o L$ correlation with the estuary number.

The single purpose routines executed ("called") by MAIN and by MARCH are:

TIDIN: An input routine for geometry, roughness, wind effects and entrance tidal variation.

OSIN: An input routine for specification of parameters related to the solution of the salt balance equation and for the specification of output frequencies and options.

TDISP: A calculation of the dispersion coefficient from the equation

$$E = K \left| \frac{\partial \overset{o}{s}}{\partial \overset{o}{x}} \right| + n\, E_T \qquad (4\text{-}1)$$

where n = 1, unless otherwise specified by the user.

TOCNB: This routine supplies the finite-difference equation for the downstream element of the estuary (entrance boundary treatment).

TRIDG: A solver of simultaneous equations in tri-diagonal form.

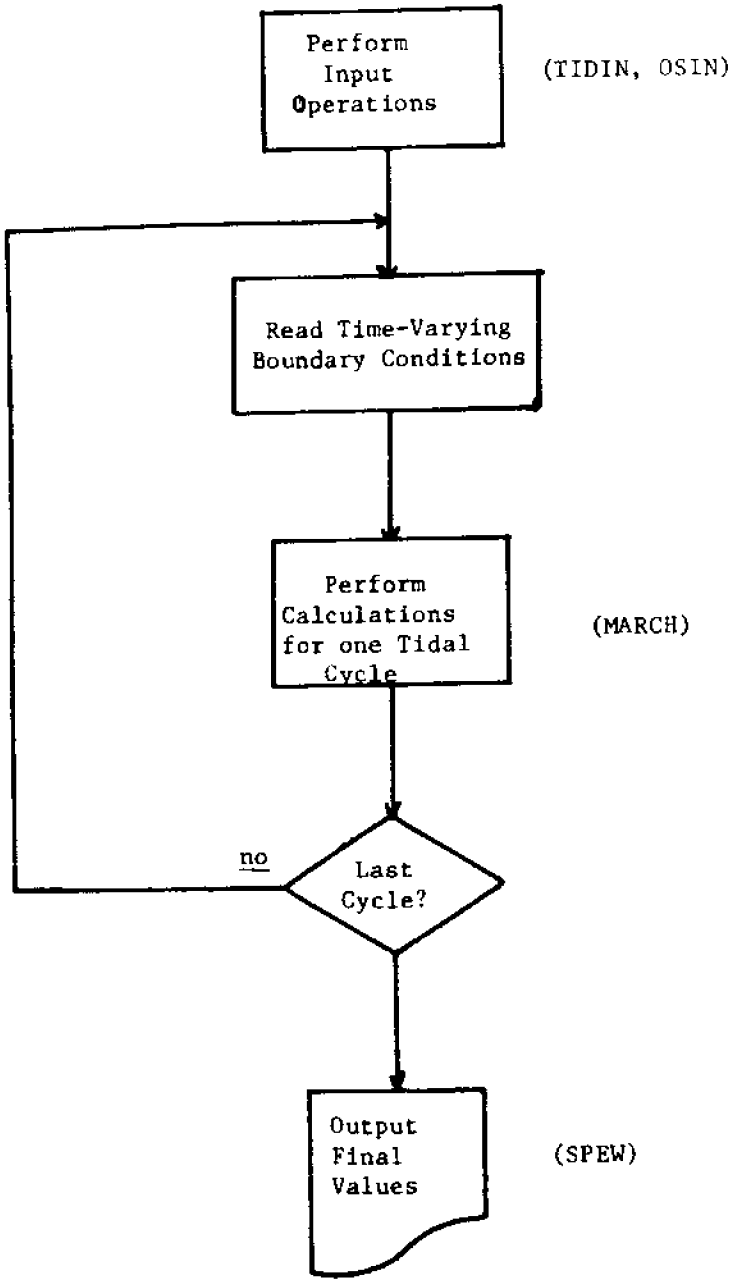
ESNOD: Calculates the tidal prism, P_T, the densimetric Froude number, the estuary number $\frac{P_T \mathbb{F}_D^{\,2}}{Q_f T}$ and then uses the correlation of $\frac{K}{u_o L}$ vs. $\frac{P_T \mathbb{F}_D^{\,2}}{Q_f T}$ to determine the value of dispersion parameter K to be used in the next tidal cycle of calculation.

SPEW: An output routine for the surface elevation, discharge, and salinities.

ERRL: An error handling routine to assist the user in preparing input decks and to understand what went wrong.

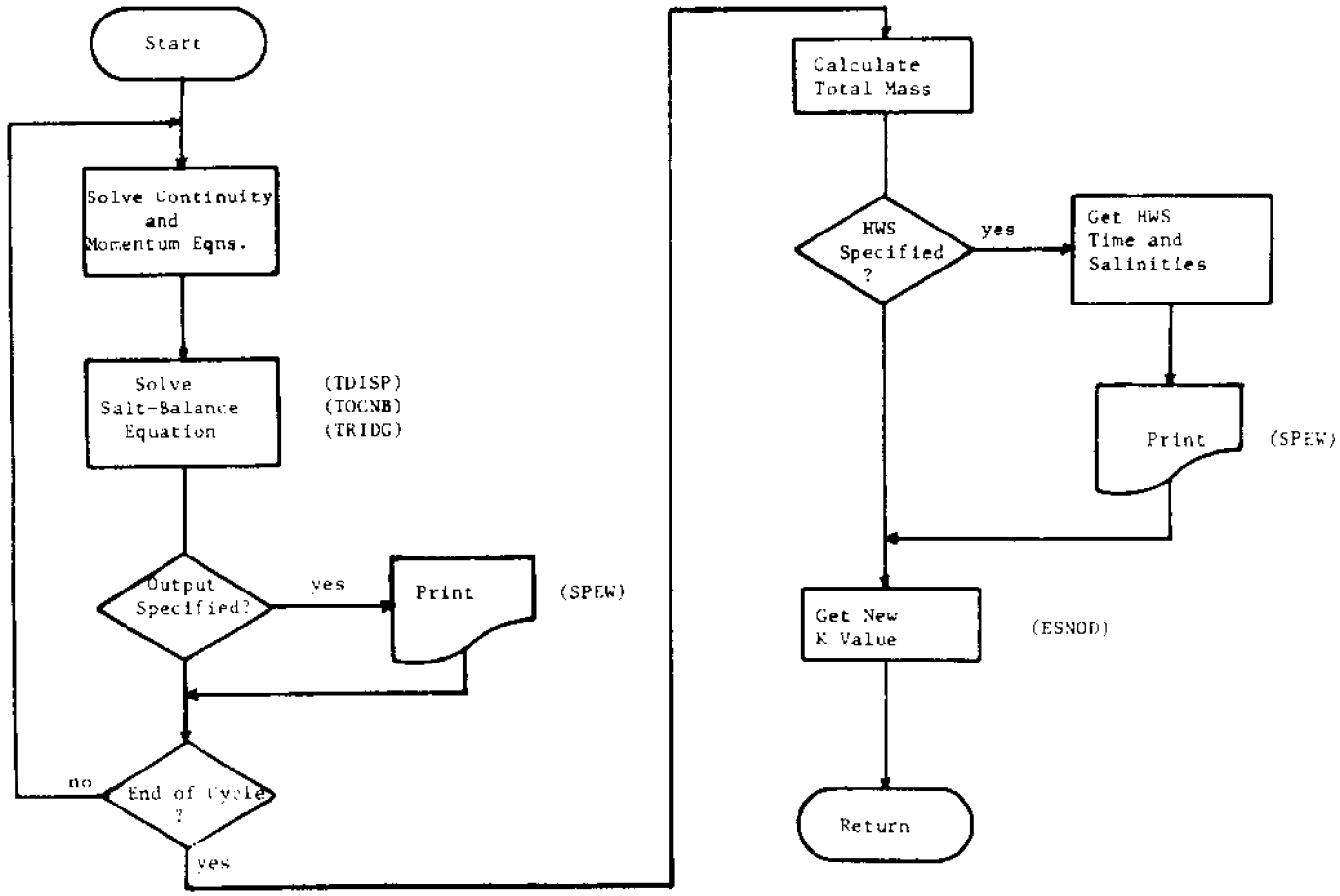
SEQTST: A sequence checking routine.

Figure 4.1 shows the basic structure of the program MAIN and Figure 4.2 shows the basic structure of subroutine MARCH. In both figures the single purpose routines used at the corresponding step are indicated in parenthesis.



Structural Diagram of Routine MAIN

Figure 4.1



Structural Diagram of Subroutine MARCH

Figure 4.2

V. User Control Through Input Data

5.1 Introduction

This section presents the requirements and format for control of the computer program. There are six subsections, each one defining input requirements. The input is in the form of eighty column unit record cards and the perforation of these cards is according to specified FORTRAN formats. The card is divided according to the format instructions which specify the columns that correspond to each piece of input data. These columns constitute the "field" in the card for each item of data. A detailed explanation of FORTRAN formats can be found in many texts, the specific reference for this program is the IBM System/360, "FORTRAN IV Language", manual Form C28-6515, obtainable from local IBM branch offices (Ref. 3).

For the user who has had little experience with FORTRAN programming, a brief description of the format codes used in this section is included with explanation in Appendix II.

5.2 Input Description and Format

(Note: Punch decimal point in all "F" format fields.)

Section 1. Description of Schematized Estuary

Card No.		Format
A1	Descriptive Information for a Heading	20A4
A2	Descriptive Information for a Heading	"
A3	Field 1 (right justified) Number of Sections (even)	I5
	Field 2 Total Length in Feet	F10.d
A4	Field 1 (right justified) Number of Time Intervals Per Cycle (even)	I5
	Field 2 Tidal Period (cycle) in Seconds	F10.d
A5	Field 1, Type of Schematization, Number 1,2,3,4 or 5 in Column 5 for:	I5
	1: Rectangular Cross-Section	
	2: Irregular Cross-Section (storage)	
	3: Trapezoidal Cross-Section	
	4: Exponentially Varying Width, Rectangular Cross-Section	
	5: Constant Rectangular Cross-Section	
	Field 2, for Closed End Estuary Blank or 0, for Open End Case = 1	I5

For each case:

Case 1, Rectangular Cross-Section

For each section a card:

Card No.		Format
A6(1)	1: Sequence Number[1] (right justified)	I5,5x
	2: Depth, d	F10.d
	3: Distance from Datum to Bottom of Section, z_o	F10.d
	4: Width at Section, $b = b_{core}$	F10.d

Case 2, Irregular Cross Section (storage)

For each section a card:

A6(2)	Field 1 Sequence Number[1] (right justified)	I5,5x
etc.	Field 2 Depth, d_{core}	F10.d
	Field 3 Distance from Datum to Bottom of Section, z_o	"
	Field 4 Total Width, b_{total}	"
	Field 5 Core Width, b_{core}	"
	Field 6 Storage Depth, d'	"

Case 3, Trapezoidal Cross-Section

For each section a card:

A6(3)	Field 1 Sequence Number[1] (right justified)	I5,5x
etc.	Field 2 Depth, d	F10.d
	Field 3 Distance from Datum to Bottom of Section, z_o	"
	Field 4 Side Slope, Horizontal Distance Corresponding to a Unit Vertical Distance	"
	Field 5 Bottom Width, b_o	"

Case 4, Exponentially Varying Width, Rectangular Cross-Section

Width is assumed to vary as

$$b(j) = b(1) \exp(-\delta x)$$

A6(4)	Field 1 Argument, δ	E10.d
	Field 2 Width at Entrance, b(1)	F10.d
	then for each station a card:	
A7(4)	Field 1 Sequence Number[1] (right justified)	I5,5x
etc.	Field 2 Depth, d	F10.d
	Field 3 Distance from Datum to Bottom of Section, z_o	F10.d

[1] Note: Sequencing need not start at the number 1, but must be ascending with an increment of unity (i.e. j, j + 1, j + 2, . . .)

Card No.		Format
	Case 5, Constant Rectangular Cross-Section	
A6(5)	Field 1 Blank	10x
	Field 2 Depth, d	F10.d
	Field 3 Distance from Datum to Bottom of Section, z_o	F10.d
	Field 4 Width, $b = b_{core}$	F10.d
	Section 2. Channel Roughness and Wind Effects	
B1	Case 1 (Enter "1" in Column 5)	
	Constant Roughness and Constant Wind Effect	
	Case 2 (Enter "2" in Column 5)	
	Variation in Roughness, Wind, or both	I5
	If Case 1 is specified only one card is necessary; for Case 2 a card for each section must be punched.	
B2	Field 1 Sequence Number	I5, 5x
etc.	Field 2 Manning's "n" in ft-sec. units	F10.d, 10
	Field 3 Wind Speed ft/sec, V_j	F10.d
	Field 4 Angle of Wind in Radians Relative to Axis of Channel (blowing upstream is 0 angle)	F10.d
	Section 3. Surface Elevation at Entrance	
C1	Type of Variation: Number 1, 2, or 3 in Column 5	
	Case 1 Cosine Fit to HW, LW Series	
	Case 2 Repeating, Harmonically Defined in Terms of Amplitudes and Periods of each Component	
	Case 3 Repeating, Defined by a Table of Values	I5
C2	Distance MWL above MSL at Entrance	F10.d
	Case 1 Cosine Fit to HW, LW Series	
C3(1)	Field 1 Initial HW with Respect to MWL at the Entrance	F10.d
	Case 2 Repeating, Harmonically Determined	
C3(2)	Field 1 Number of Harmonics	I5
C4(2)	Field 1 Amplitude in Feet, Field 2 Period in Seconds[1]	2F10.d
	Case 3 Repeating Tabular	
C3(3)	Card A4 specified the number of time intervals per cycle and the specification was an even number. A series of elevations of length equal to 1/2 the number of time intervals is required. Thus every other interval is defined. The tabular information will be in five fields per card.	5F10.d

[1] Note: If only one harmonic, the period is taken as that of card A4.

Card No.			Forma
	Section 4. Definitions Concerning the Salt Balance Equation		
D1	Field 1	Initial Value of the Dispersion Parameter, K	F10.
	Field 2	Multiplying Factor n in Equation 4-1, see below. If the field is set to zero or left blank n is automatically set to 1. Right justify to Column 15. $(E = K \left\lvert \frac{\partial \rho}{\partial x} \right\rvert + n\, E_T)$	I5
D2	Field 1	Intercept of $K/u_o L$ vs. $\mathbb{E}_D$ relation; if blank or zero, intercept set at 0.00215, (this corresponds to Figure 1.2)	F10.(
	Field 2	Maximum limit of intrusion length for the calculation. If left blank or set to zero the total estuary length is taken. (This can be used to save computing time in cases where the maximum intrusion is well known and is significantly less than the total estuary length.)	F10.(
	Field 3	Fraction (0-0.5) of the tidal period during which the entrance salinity returns linearly to s_o from its value at LWS. (Usually 0.05 if entrance is at the ocean but not more than 0.5.)	F10.d
	Field 4	Fraction (0-0.5) of the tidal period during which the entrance salinity remains at s_o after HWS (usually 0.0).	F10.d
D3	Source of Initial Conditions: Punch 1, 2 or 3 in Column 5 to define one of the following cases.		
	Case 1:	Sequential dataset containing a complete tidal period of elevations, η, salinities, s, and discharges Q.	
	Case 2:	Elevations, η, and discharges Q, from a sequential dataset as in Case 1, but salinities s from cards.	
	Case 3:	Elevations, η, salinities, s, and discharges, Q, all from cards.	I5
	For cases 1 and 2: The sequential dataset is assumed to have a FORTRAN dataset reference number of 3 unless the user wishes to override this by specifying another number in Columns 6-10, right justified. It is assumed that the dataset is organized in record lengths of "total number of sections /2" and that there are "total number of time intervals /2" sets of three		I5

Card No.		Format
	records, the records being in the sequence η, s, Q. (All elevations are assumed to be relative to MSL.) The last set of η, s, and Q will be taken as the initial conditions.	
	For Case 2:	
D4(2)	Initial salinities, s, at each odd section starting at the entrance, 5 per card	5F10.d
	For Case 3:	
D4(3)	Initial elevations, η at each odd station starting at entrance, 5 per card	5F10.d
	Initial salinities s, at each odd station starting at the entrance, 5 per card, the first value beginning a new card	5F10.d
	Initial discharges Q, at each even station, starting at the seaward-most station, 5 per card, the first value beginning a new card	5F10.d
	Section 5. Output Selection	
	Options	
E1	Four options are taken by punching keywords into any of the first four fields of 5 columns, always beginning on the first of the 5 columns.	
	Option 1: keyword = KEEP. This keyword will cause the program to store the calculated results of each time step on a sequential dataset, thereby enabling the user to keep the entire result for plotting or further processing. The unit number of this dataset, will be 15 unless the user specifies another number in Columns 26-30, right justified.	
	Option 2: keyword = HWS. This keyword will cause the calculation of High Water Slack salinities and these will be printed at the end of each tidal cycle.	
	Option 3: keyword = FC. This keyword will cause the program to punch out the final values of elevation, salinity and discharge in the format which permits these cards to be used as the initial conditions for a subsequent calculation. Elevations are relative to MSL.	

Card No.		Format
	Option 4: keyword = E. This keyword causes the program to output the dispersion coefficient calculated at each time step to a sequential dataset. The unit number of this dataset will be 11 unless the user specifies another number in Columns 31-35 right justified.	4(A4,1x),
	Frequency of Basic Output	2I5
	Frequency is measured in time increments between outputting a calculated variable, η, s, or Q. "0" would be not at all, "2" would be at the end of each calculation, "m" would be at the beginning of each tidal cycle and every m intervals thereafter. (Each calculation is of $2\Delta t$, therefore m must be even.)	
E2	Surface elevation specification: H is punched in Column 1 and the frequency is punched, right justified, in Columns 6-10.	(A1,4x,I5)
E3	Salinity specification: S is punched in Column 1 and the frequency is punched, right justified, in Columns 6-10	(A1,4x,I5)
E4	Discharge specification: Q is punched in Column 1 and the frequency is punched, right justified, in Columns 6-10. Note: Cards E2, E3 and E4 can be in any order relative to each other.	
	Section 6. Input of Time Varying Boundary Parameters at each Tidal Cycle	
F1	Specification of Transient Fresh Water Input Locations	
	Field 1: Number of Transient Fresh Water Inputs	
	Field 2: The number of these which will be summed to compute the Q_f used in calculating the estuary number.	
	Field 3,4,5,6, etc.: The section numbers of the inflows. These refer to an inflow between the section designated and the adjacent seaward section. The order given in fields 3,4,5,6 . . . is the order to be followed in the following specification cards for each tidal cycle. Those inflows to be summed into Q_f as specified in field 2 must be given first.	16I5
F2	Number of tidal cycles of calculation in Columns 1-5, right justified	I5

Card No.		Format
F3	Time varying boundary parameters for each cycle.	
etc.	Field 1 Number of the Tidal Cycle	I5,5x
	Field 2 If surface elevation at the entrance is time varying (case 1), the LW or minimum elevation.	F10.d
	Field 3 If surface elevation at the entrance is time varying (case 1), the HW or maximum elevation	F10.d
	Field 4 The maximum salinity at the entrance during the cycle, s_o	F10.d
	Fields 5,6,7,8,etc. These fields are for specification of the fresh water inflows. In the case of an open end estuary field 5 contains the end discharge and 6,7,8, etc. the lateral inflows. Lateral inflows must be given in the order specified in fields 3,4,5,6, etc. of card F1. If more than four values are specified a second card can be included with fields of F10.d There will be a card similar to this F3 for each tidal cycle of calculation	4F10.

End of Input to Program.

VI. Test Case and Example

6.1 Introduction

A test case is developed in order to further document the use of the computer program and to furnish the user with a basis of comparison. The user should be able to reproduce the results of the test case by using the input decks described.

The test case is a study of the Potomac Estuary (Figure 6.1) with the geometry described by Tables 6.1, 6.2 and 6.3. (Reference 1 also discusses this case.) A step-by-step development of the input deck will be followed in accordance with Section 5.2

6.2 Input Preparation and Results (see Table 6.5 for listing)

Section 1

Cards A1 and A2 contain descriptive information and are as shown.

Card A3: (Field 1) number of sections is taken as 40, (Field 2) the total length is 603,768 ft.

Card A4: (Field 1) number of time intervals per cycle taken as 120, (Field 2) the tidal period is 44,640 seconds.

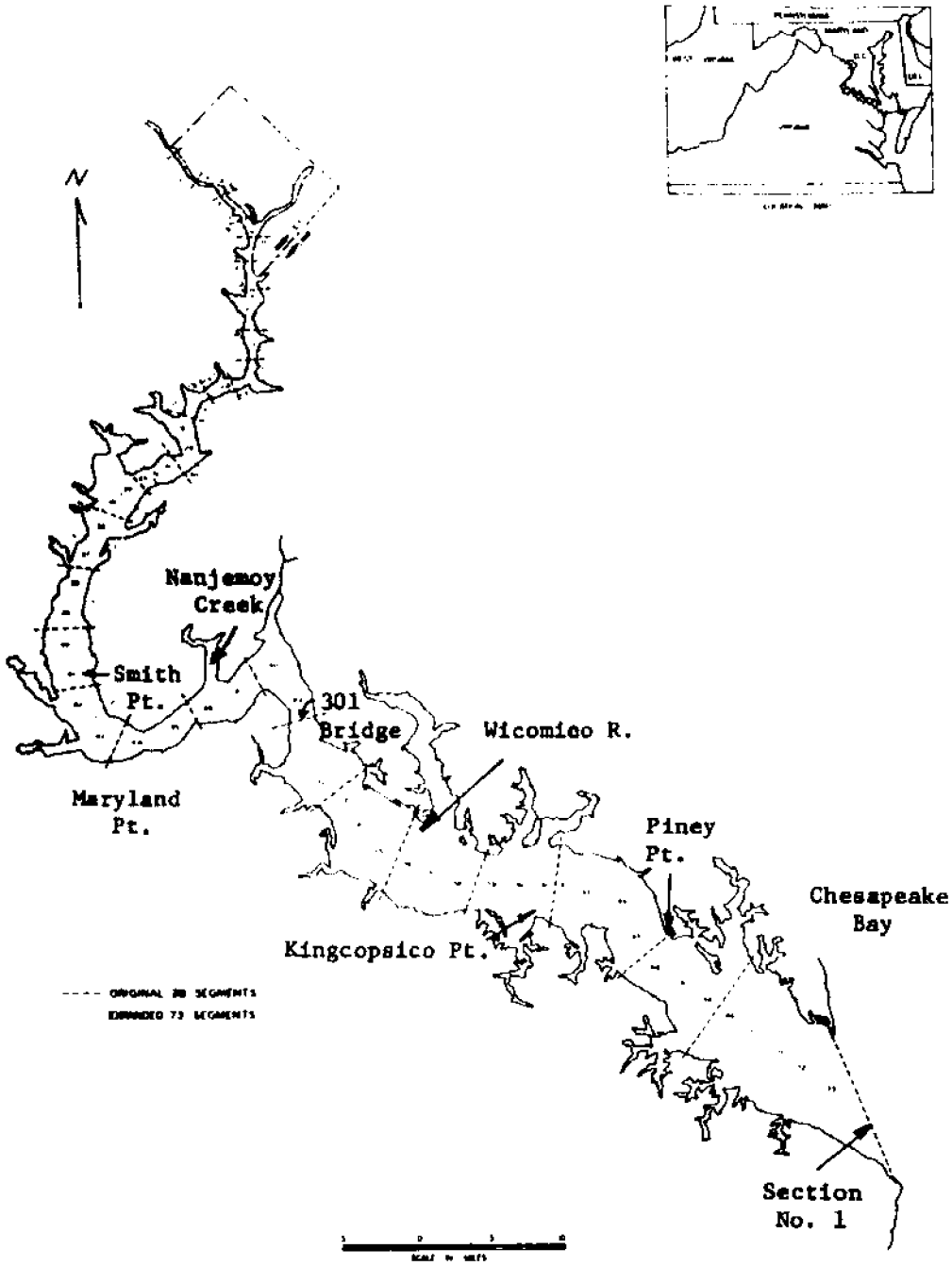
Card A5: The type of schematization for this case is that of the irregular cross-section with provisions for storage. This is type number 2. Field 2 is left blank for closed end case.

Cards A6(2), A7(2),,A45(2): These cards describe the forty cross-sections and are those shown in Table 6.3. (Note that the reference datum is 40 ft. below MWL at the entrance, and that as a horizontal water surface was assumed: $d + z_o = 40$ for all stations.)

Section 2

Card B1: As Manning's n is constant for the entire estuary and no wind effects are considered this is case number 1.

Card B2: (Field 1) no sequence number is necessary as only one card is required for case 1. (Field 2) Manning's n is taken at 0.018. (Field 3) wind speed is 0. (The field can be left blank.) (Field 4) no wind angle, leave blank.



POTOMAC ESTUARY

(from Data Source Reference 1)

Figure 6.1

Segment Geometry of Potomac Estuary
Excluding Embayments (Mean Water Data)
(from Jaworski and Clark, Data Source Reference 1)

Segment Number	Length in ft (from Chain Bridge)	Average Width in ft	Average Depth in ft
1	14,890	559	24.7
2	10,665	1,302	20.0
3	9,187	2,092	10.8
4	9,504	2,677	10.5
5	8,396	2,911	13.2
6	11,404	2,708	13.2
7	13,992	3,739	12.2
8	11,300	4,227	13.2
9	13,516	3,386	20.0
10	10,085	5,695	13.2
11	13,570	4,118	18.5
12	24,129	6,086	17.0
13	15,312	8,053	15.5
14	14,732	12,368	12.1
15	22,387	8,732	20.5
16	21,859	10,799	17.9
17	22,123	16,950	13.7
18	25,291	15,475	14.2
19	28,354	8,856	20.3
20	24,816	13,186	15.3
21	27,614	10,371	22.3
22	32,103	17,406	20.7
23	33,739	24,757	18.8
24	31,152	30,397	20.2
25	28,934	20,830	18.35
26	42,135	27,043	25.0
27	31,416	26,846	33.0
28	51,163	44,342	27.4

Table 6.1

Embayment Data for Potomac Estuary (Mean Water Data)
(from Jaworski and Clark, Data Source Reference 1)

Name	Average Depth ft	Volume $ft^3 \times 10^8$	Location (Miles below Chain Bridge)
Columbia Island Channel	6.40	0.16	4.65 - 5.76
Tidal Basin	10.40	0.46	5.81
Washington Channel	24.45	1.98	7.60 - 8.20
Anacostia River	15.45	5.56	7.60 - 8.20
Four Mile (Hunter Pt.)	12.45	0.79	8.79 - 9.70
Oxon Creek (Upper)	9.40	1.28	10.55 - 12.13
Oxon Creek (Lower)	9.35	1.71	12.13 - 13.57
Hunting Creek	3.35	0.71	12.13 - 13.50
Broad Creek	4.30	0.70	14.90 - 15.92
Piscataway Creek	4.20	1.53	18.11 - 18.63
Little Hunting Creek	3.10	0.14	19.90 - 20.33
Dogue Creek	4.05	0.72	21.85 - 22.80
Gunston Creek	5.00	3.27	24.02 - 25.42
Pomonkey Creek	3.95	0.35	26.73 - 27.10
Belmont Bay	4.80	3.33	31.45 - 34.09
Occoquan Bay	5.80	8.63	31.45 - 34.09
Powells Creek	2.80	0.54	34.79 - 35.92
Mattawoman Creek	8.80	6.56	34.13 - 35.60
Quantico Creek	2.70	0.79	38.10 - 38.55
Chicamuxen Creek	3.70	0.84	36.91 - 37.75
Chopawamsic Creek	2.67	0.36	40.75
Mallows Bay	4.65	0.21	41.64 - 42.44
Aquia Creek	4.60	4.65	46.89 - 48.40
Potomac Creek	3.58	2.76	49.20 - 49.70
Nanjemoy Creek	3.55	4.44	58.18 - 59.20
Port Tobacco River	6.75	11.06	62.00 - 63.80

Table 6.2
(to be continued)

Name	Average Depth ft	Volume $ft^3 \times 10^8$	Location (Miles below Chain Bridge)
Upper Machodoc Creek	5.80	4.16	69.45 - 71.32
Rosier Creek	3.80	0.55	72.60 - 73.27
Cuckold Creek	2.80	0.47	72.00 - 72.21
Monroe Creek	3.80	0.70	75.90
Mattox Creek	5.80	3.60	75.98 - 77.32
Popes Creek	1.85	0.23	79.15
Wicomico River	9.92	38.62	80.52 - 82.85
St. Clement Bay	9.90	15.25	86.05 - 88.35
Breton Bay	9.90	13.40	89.36 - 90.20
Nomini Bay	6.80	8.57	87.26 - 89.48
Lower Machodoc Creek	7.85	7.27	91.15 - 93.38
Herring Creek	4.80	0.88	96.10
St. Georges Creek	5.75	4.45	102.96 - 104.35
St. Mary's River	11.75	33.51	102.96 - 104.35
Yeocomico River	6.63	9.39	103.80 - 104.65
Smith Creek	7.75	3.77	105.15 - 106.65
Coan River	6.60	6.63	107.20 - 109.00
Hull Creek	6.60	1.34	113.00

Table 6.2
(continued)

	Section no.	d feet	z_0 feet	b_{total} feet	b_{core} feet	d' feet
Chesapeake Bay	1	30.00	10.00	58811.	57500.	6.60
	2	27.87	12.13	49325.	49325.	0.00
	3	27.65	12.35	48184.	41695.	6.60
	4	30.46	9.54	46673.	34032.	8.72
	5	32.97	7.03	48740.	28043.	10.63
	6	31.57	8.43	26016.	26016.	0.00
	7	27.63	12.37	28213.	27029.	4.80
	8	23.99	16.01	29123.	26386.	7.85
	9	20.49	19.50	33838.	22519.	8.37
	10	18.34	21.66	36988.	20844.	8.71
	11	19.10	20.90	27865.	25918.	9.90
	12	20.21	19.79	54428.	30468.	9.52
	13	19.49	20.51	30108.	28637.	9.02
	14	18.80	21.20	29914.	24840.	5.47
	15	19.45	20.55	23500.	21527.	3.34
	16	20.56	19.44	22586.	17953.	5.80
	17	21.96	18.04	13752.	13752.	0.00
	18	22.43	17.57	14927.	10458.	6.75
	19	18.15	21.35	18008.	11893.	6.75
	20	15.43	24.57	20975.	12896.	3.55
	21	19.31	20.69	9519.	9519.	0.00
	22	19.15	20.85	10146.	10146.	0.00
	23	14.79	25.21	19852.	14793.	3.60
	24	13.33	26.67	23450.	17007.	4.60
	25	14.18	25.82	16272.	16272.	0.00
	26	17.42	22.58	12503.	11418.	3.40
	27	20.45	19.55	12179.	8905.	3.22
	28	17.95	22.05	17187.	8924.	7.80
	29	12.23	27.77	23908.	11878.	5.52
	30	15.97	24.03	7456.	7456.	0.00
	31	16.94	23.06	8221.	6150.	4.76
	32	18.99	21.01	7849.	4183.	4.79
	33	13.19	26.81	6155.	5702.	3.51
	34	19.12	20.88	5751.	3398.	4.20
	35	12.20	27.80	5535.	4103.	5.92
	36	12.94	27.06	5311.	2909.	8.30
	37	12.71	27.29	6001.	2892.	17.30
	38	10.47	29.53	2577.	2150.	9.37
	39	23.03	16.97	1005.	1005.	0.00
Chain Bridge	40	20.00	20.00	110.	110.	0.00

Potomac Estuary
Schematized Geometry after Including Embayments

Table 6.3

Section 3

Card C1: The type of water surface variation at the entrance will be that typically defined by tide tables, a HW and LW series. This is case 1.

Card C2: The distance that MWL is above MSL at the entrance is assumed to be 0.0 ft.

Card C3(1): The initial HW value with respect to MWL at the entrance is 0.52 ft. (from Table 6.4).

Section 4

Card D1: (Field 1) The initial value of the dispersion parameter K is taken as 600 ft^2/sec. (Field 2) To use the dispersion relation $E = K\left|\frac{\partial \xi_o}{\partial x}\right| + 3E_T$ the multiplying factor n = 3 must be punched in column 15.

Card D2: (Field 1) The K/u_oL vs. $\mathbb{E}_D$ relations will be used with the standard intercept of 0.00215, therefore the field is left blank. (Field 2) It is assumed that reliable information exists which permits the specification of a limit for the salinity intrusion (and thus calculations) at a point 540,000 ft. above the entrance. (Without such justification the field would be left blank.)
(Field 3) The conditions at the entrance to the Potomac have been assumed to be those of a longshore current and thus the salinity is assumed to return to its maximum value in 0.05 of a tidal cycle after LWS. (Field 4) The salinity is not restricted to remain at its maximum value after HWS, therefore the field is either left blank or set to 0.

Card D3: Sequential datasets will not be used in this test case so as to accommodate those users without such facilities. Therefore the initial conditions will be all from cards - case 3.

Cards D4(3), D5(3), etc.: These are the initial conditions. Note that they are specified every other station due to the staggered mesh used in the finite difference calculations. Elevations and salinities are defined on the odd numbered sections starting at the entrance, whereas discharge is defined on the even numbered stations.

Maximum and Minimum Tidal Elevations
at the Entrance to the Potomac
(Relative to MWL at the Entrance)

Table 6.4

Tidal Period	LW	HW	Tidal Period	LW	HW
0		2.20	16	-2.00	2.80
1	-1.30	1.80	17	-2.60	1.90
2	-1.40	2.60	18	-1.80	2.60
3	-1.20	2.10	19	-2.30	2.00
4	-1.70	2.70	20	-1.70	2.60
5	-1.70	2.10	21	-2.20	2.10
6	-1.70	3.00	22	-1.50	2.60
7	-1.80	2.50	23	-2.20	2.30
8	-1.80	3.00	24	-1.60	2.50
9	-2.20	2.30	25	-2.10	2.50
10	-2.20	3.10	26	-1.80	2.30
11	-2.40	2.00	27	-2.40	2.70
12	-2.30	3.20	28	-2.20	2.10
13	-2.50	2.20	29	-2.50	3.00
14	-2.00	3.20	30	-2.20	2.30
15	-2.50	2.00	31	-2.60	2.10

For 40 stations this means 20 values, 5 per card for each variable or four cards per variable.

Section 5

Card E1: The output will not be put on a sequential data set so option 1 will not be taken. High water slack salinities will be requested, therefore the letters HWS will be punched in columns 1-3. As continuation after this run might be of interest, the third option of punching the final values will be taken. The letters FC are thus punched in columns 6-7. It is not desired to place the time and spatially varying dispersion coefficients on a sequential data set so option 4 will not be taken.

Card E2, E3, E4: For 120 time intervals per tidal cycle and a possible output every other interval due to the staggered finite difference mesh one could obtain 60 outputs per tidal cycle. 10 each cycle are to be specified which requires an output interval of 12. In this case all three variables will be assigned the same frequency. E2, E3 and E4 will contain the letters H, S, and Q in column one and 12 in columns 9 and 10.

Section 6

Card F1: (Field 1) Only one transient input is assumed. (Field 2) Again one input is involved. (Field 3) The input is at the head of the estuary and so it is identified as entering between section 39 and 40 by designating section 40.

Card F2: Only two tidal cycles are specified as this is a test case.

Cards F3, F4: (Field 1) cycle no. (Field 2,3) The LW, HW from Table 6.4. (Field 4) The maximum salinity at the entrance which is taken to be ~16.5 ppt for both cycles. (Field 5) The fresh water discharge for these cycles which are 2730 and 2626 cfs.

The resulting input listing for this test case is in Table 6.5 and the output for two tidal cycle's calculation is in Table 6.6.

Input Listing for Test Case

Table 6.5

```
* * * * *          TEST CASE          POTOMAC ESTUARY          * * * * *
      (DEMONSTRATION OF INPUT-OUTPUT RELATIONSHIPS)
 40 603768.
120 44640.
  2
  1          30.00     10.00   58811.4   57499.9    6.60        0.
  2          27.87     12.13   49324.7   49324.7    0.0     15481.
  3          27.65     12.35   48183.8   41694.9    6.60    30962.
  4          30.46      9.54   46672.8   34032.1    8.72    46444.
  5          32.97      7.03   48739.8   28042.9   10.63    61925.
  6          31.57      8.43   26015.6   26015.6    0.0     77406.
  7          27.63     12.37   28212.9   27028.7    4.80    92887.
  8          23.99     16.01   29122.6   26386.3    7.85   108369.
  9          20.49     19.50   33837.9   22518.9    9.37   123850.
 10          18.34     21.66   36988.4   20844.4    8.71   139331.
 11          19.10     20.90   27864.9   25918.1    9.90   154812.
 12          20.21     19.79   54428.1   30467.5    9.92   170293.
 13          19.49     20.51   30107.9   28636.8    9.02   185774.
 14          18.80     21.20   29913.9   24840.1    5.47   201256.
 15          19.45     20.55   23500.1   21527.0    3.34   216737.
 16          20.56     19.44   22585.8   17952.8    5.80   232218.
 17          21.96     18.04   13751.9   13751.9    0.0    247699.
 18          22.43     17.57   14926.6   10457.8    6.75   263180.
 19          18.15     21.85   18008.0   11892.8    6.75   278662.
 20          15.43     24.57   20975.3   12896.3    3.55   294143.
 21          19.31     20.69    9519.3    9519.3    0.0    309624.
 22          19.15     20.85   10146.0   10146.0    0.0    325105.
 23          14.79     25.21   19852.1   14792.5    3.60   340586.
 24          13.33     26.67   23450.0   17006.8    4.60   356068.
 25          14.18     25.82   16271.5   16271.5    0.0    371549.
 26          17.42     22.58   12502.5   11419.4    3.40   387030.
 27          20.45     19.55   12179.4    8904.8    3.22   402511.
 28          17.95     22.05   17187.3    9923.6    7.80   417992.
 29          12.23     27.77   23908.2   11877.5    5.52   433472.
 30          15.97     24.03    7455.8    7455.8    0.0    448955.
 31          16.94     23.06    8221.0    6160.3    4.76   464436.
```

Card No.

0001
0002
0003
0004
0005
0006
0007
0008
0009
0010
0011
0012
0013
0014
0015
0016
0017
0018
0019
0020
0021
0022
0023
0024
0025
0026
0027
0028
0029
0030
0031
0032
0033
0034
0035
0036

Table 6.5 (cont'd)

```
                                                                                Card No.
   32          18.99      21.01     7849.0     4182.7      4.79    479917.      0037
   33          13.19      26.81     6155.0     5702.0      3.51    495358.      0038
   34          19.12      20.88     5750.8     3397.7      4.20    510879.      0039
   35          12.20      27.90     5534.7     4103.4      5.92    526361.      0040
   36          12.94      27.06     5311.2     2908.8      8.30    541842.      0041
   37          12.71      27.29     6001.0     2891.6     17.30    557323.      0042
   38          10.47      29.53     2577.3     2149.8      9.37    572804.      0043
   39          23.03      16.97     1005.2     1005.2      0.0     588285.      0044
   40          20.00      20.00      110.1      110.1      0.0     603767.      0045
    1                                                                           0046
          1 0.018      0.                                                       0047
    1                                                                           0048
C.                                                                              0049
C.52                                                                            0050
600.          3                                                                 0051
          540000.    0.05       0.                                             0052
    3                                                                           0053
   0.52000   0.56230   0.59893   0.63069   0.65786                             0054
   0.62022   0.60293   0.55940   0.49907   0.38124                             0055
   0.20194  -0.00952  -0.18197  -0.32467  -0.44268                             0056
  -0.51065  -0.56445  -0.59675  -0.59867  -0.59297                             0057
16.89     16.46     16.23     15.25     13.50                                  0058
12.43     11.70     11.10     10.50     7.79                                   0059
5.36      3.38      1.52      0.25      0.0                                    0060
0.0       0.0       0.0       0.0       0.0                                    0061
   338446.   333211.   315704.   296609.   262419.                             0062
   223690.   174974.   133834.   109044.    82771.                             0063
    66325.    19291.   -12435.   -25034.   -27824.                             0064
   -24682.   -19499.   -12941.    -4572.        0.                             0065
HWS  FC                                                                         0066
F       12                                                                      0067
S       12                                                                      0068
Q       12                                                                      0069
    1    1   40                                                                 0070
    2                                                                           0071
    1          -0.47      0.88      16.57      2730.                            0072
    2          -0.52      0.52      16.56      2626.                            0073
```

Output Listing from Test Case

Table 6.6

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*   M.I.T. SALINITY INTRUSION PROGRAM, ONE-DIMENSIONAL SCHEMATIZATION *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

SECTION 1,  DESCRIPTION OF THE SCHEMATIZED ESTUARY

* * * *          TEST CASE          POTOMAC ESTUARY          * * * * *
      (DEMONSTRATION OF INPUT-OUTPUT RELATIONSHIPS)

GEOMETRIC DATA      *** CLOSED END ESTUARY ***

  NUMBER OF STATIONS =  40      ESTUARY LENGTH=   603768. FT.
  NUMBER OF TIME INCREMENTS PER PERIOD= 120      PERIOD= 44640.SECONDS

CASE 2,  IRREGULAR CROSS-SECTION (STORAGE)
```

MILES	C	Z0	B	BICORRI	D*	FEET	SECTION
0.0	30.00000	10.00000	58811.4	57499.5	6.6	0.	1
2.93205	27.87000	12.13000	49324.7	49324.7	0.0	19491.	2
5.86410	27.64999	12.35000	48183.8	41894.5	6.6	30967.	3
8.79615	30.45999	9.54000	46672.8	34032.1	8.7	40444.	4
11.72820	22.96999	7.03000	48739.8	28042.5	10.6	61929.	5
14.66025	31.56999	8.43000	26015.6	26015.6	0.0	77406.	6
17.59230	27.62999	12.37000	28212.9	27028.7	4.8	92887.	7
20.52434	23.58999	16.03999	29122.6	26388.3	7.8	108369.	8
23.45639	20.48999	19.50000	33837.9	22510.5	4.6	123850.	9
26.38846	18.34000	21.65999	36588.4	20844.4	8.7	139331.	10
29.32050	19.09999	20.89999	27864.9	25918.1	9.9	154812.	11
32.25255	20.20999	19.78999	54426.1	30467.5	9.9	170294.	12
35.18460	19.48999	20.50999	30107.9	28636.8	9.0	184775.	13
38.11665	18.79999	21.20000	29913.9	24840.1	5.5	201256.	14
41.04871	19.45000	20.54999	23500.1	21527.0	3.3	216737.	15
43.98076	20.86000	19.43999	22545.8	17952.8	5.8	232218.	16
46.91281	21.55999	18.03999	13751.9	13751.9	0.0	247700.	17
49.84485	22.42999	17.56999	14926.6	10457.8	6.8	263181.	18
52.77692	18.14999	21.64999	18008.0	11292.8	6.8	278662.	19
55.70897	15.43000	24.56999	20975.3	12996.3	3.5	294143.	20
58.64101	19.31000	20.68999	9519.3	9519.3	0.0	309625.	21
61.57306	19.14999	20.84999	10146.0	10146.0	0.0	325106.	22
64.50511	14.29000	25.20999	15852.1	14792.5	3.6	340587.	23
67.43716	13.33000	26.67000	23450.0	17006.8	4.6	356068.	24
70.36922	14.18000	25.81999	16271.5	16271.5	0.0	371550.	25
73.30127	17.42000	22.57999	12502.5	11419.4	3.4	387031.	26
76.23331	20.45000	19.54999	12179.4	8604.8	3.2	402512.	27
79.16537	17.55000	22.04999	17187.3	9923.6	7.8	417993.	28
82.09743	12.23000	27.76999	23908.2	11877.5	5.5	433474.	29
85.02946	15.57000	24.03000	7455.8	7455.8	0.0	448956.	30
87.96152	16.53999	23.06000	8221.0	6160.3	4.8	464437.	31
90.89357	18.58999	21.03999	7449.0	4102.7	4.8	479918.	32
93.82564	13.19000	26.81000	6155.0	5702.0	3.5	495399.	33
96.75768	19.12000	20.87999	5750.8	3367.7	4.2	510881.	34
99.68973	12.20000	27.79999	5534.7	4103.4	5.9	526362.	35
102.62178	12.54000	27.06000	5311.2	2908.8	8.3	541843.	36
105.55383	12.71000	27.28999	4001.0	2891.6	17.3	557324.	37
108.48589	10.47000	29.53000	2577.3	2149.8	9.4	572806.	38
111.41794	22.03000	16.56999	1005.2	1005.2	0.0	588287.	39
114.34998	20.00000	20.00000	110.1	110.1	0.0	603768.	40

NOTE, D* DEEPER THAN D FOR SECTION 37

Table 6.6 (cont'd)

SECTION 2 CHANNEL ROUGHNESS AND WIND EFFECTS

CASE 1 CONSTANT ROUGHNESS AND CONSTANT WIND

NO WIND

MILES	MANCC	FQ	V	PHI	FEET	SECTION
0.0	0.0180000	0.0	0.0	0.0	0.	1
2.93205	0.0180000	0.0	0.0	0.0	15481.	2
5.86410	0.0180000	0.0	0.0	0.0	30962.	3
8.79615	0.0180000	0.0	0.0	0.0	46444.	4
11.72820	0.0180000	0.0	0.0	0.0	61925.	5
14.66025	0.0180000	0.0	0.0	0.0	77406.	6
17.59230	0.0180000	0.0	0.0	0.0	92887.	7
20.52434	0.0180000	0.0	0.0	0.0	108369.	8
23.45639	0.0180000	0.0	0.0	0.0	123850.	9
26.38846	0.0180000	0.0	0.0	0.0	139331.	10
29.32050	0.0180000	0.0	0.0	0.0	154812.	11
32.25255	0.0180000	0.0	0.0	0.0	170294.	12
35.18460	0.0180000	0.0	0.0	0.0	185775.	13
38.11665	0.0180000	0.0	0.0	0.0	201256.	14
41.04871	0.0180000	0.0	0.0	0.0	216737.	15
43.98076	0.0180000	0.0	0.0	0.0	232218.	16
46.91281	0.0180000	0.0	0.0	0.0	247700.	17
49.84485	0.0180000	0.0	0.0	0.0	263181.	18
52.77692	0.0180000	0.0	0.0	0.0	278662.	19
55.70897	0.0180000	0.0	0.0	0.0	294143.	20
58.64101	0.0180000	0.0	0.0	0.0	309625.	21
61.57306	0.0180000	0.0	0.0	0.0	325106.	22
64.50511	0.0180000	0.0	0.0	0.0	340587.	23
67.43716	0.0180000	0.0	0.0	0.0	356068.	24
70.36922	0.0180000	0.0	0.0	0.0	371550.	25
73.30127	0.0180000	0.0	0.0	0.0	387031.	26
76.23331	0.0180000	0.0	0.0	0.0	402512.	27
79.16537	0.0180000	0.0	0.0	0.0	417993.	28
82.09743	0.0180000	0.0	0.0	0.0	433474.	29
85.02946	0.0180000	0.0	0.0	0.0	448956.	30
87.96152	0.0180000	0.0	0.0	0.0	464437.	31
90.89357	0.0180000	0.0	0.0	0.0	479918.	32
93.82564	0.0180000	0.0	0.0	0.0	495399.	33
96.75768	0.0180000	0.0	0.0	0.0	510881.	34
99.68973	0.0180000	0.0	0.0	0.0	526362.	35
102.62178	0.0180000	0.0	0.0	0.0	541843.	36
105.55383	0.0180000	0.0	0.0	0.0	557324.	37
108.48589	0.0180000	0.0	0.0	0.0	572806.	38
111.41794	0.0180000	0.0	0.0	0.0	588287.	39
114.34998	0.0180000	0.0	0.0	0.0	603768.	40

SECTION 3. SURFACE ELEVATION AT THE ENTRANCE

MWL 0.0 FT ABOVE MSL AT OCEAN
MSL 40.00 FT ABOVE THE HORIZONTAL DATUM

CASE 1, COSINE FIT TO HW-LW SERIES
FIRST HW VALUE RELATIVE TO MWL = 0.52

DT= 372.00 SEC. DX= 15481.2 FT.
DELTAX/DELTAT= 41.62 FT./SEC.

CELERITY WITH RESPECT TO DEPTH ONLY

SECTION	CELERITY (FT/SEC)	WAVE LENGTH (MILES)
1	31.08	262.77
2	29.96	253.27
3	29.84	252.27
4	31.32	264.78
5	32.58	275.47
6	31.88	269.56
7	29.83	252.18
8	27.79	234.98
9	25.69	217.16
10	24.30	205.46
11	24.80	209.67
12	25.51	215.68
13	25.05	211.80
14	24.60	208.02
15	25.03	211.58
16	25.73	217.54
17	26.59	224.82
18	26.87	227.21
19	24.17	204.39
20	22.29	188.45
21	24.94	210.82
22	24.83	209.94
23	21.82	184.50
24	20.72	175.16
25	21.37	180.66
26	23.68	200.24
27	25.66	216.95
28	24.04	203.26
29	19.84	167.78
30	22.68	191.72
31	23.36	197.46
32	24.73	209.06
33	20.61	174.24
34	24.81	209.78
35	19.82	167.57
36	20.41	172.58
37	20.23	171.04
38	18.36	155.24
39	27.23	230.23
40	25.38	214.55

Table 6.6 (cont'd)

```
SECTION 4,  DEFINITIONS RELATIVE TO THE SALT BALANCE EQUATION, AND TO INITIAL SALINITIES


E=K(DS/DX)+ 3*E(TAYLOR)      K FOR THE NEXT TIDAL CYCLE IS    600.00

K VS. ED GIVEN BY K/(UZ*L)= 0.215E-02ED**(-1/4)

SALINITY EXCURSION LIMIT = 540000.00 FT

SALINITY RETURNS TO SZERO AFTER LWS IN 0.05 OF A TIDAL PERIOD
EXTENTION OF SZERO AFTER HWS FOR 0.0  OF A TIDAL PERIOD                                                    1        0

CASE 3, INITIAL CONDITIONS ALL FROM CARDS

TIDAL CYCLE   1     0.0   HOURS      DAY   0     0.0   HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS     1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.      0.520   0.562   0.599   0.631   0.658   0.620   0.603   0.559   0.499   0.381   0.202  -0.013  -0.182  -0.325
STATIONS    29      31      33      35      37      39
ELEV.     -0.443  -0.511  -0.564  -0.597  -0.599  -0.593

TIDAL CYCLE   1     0.0   HOURS      DAY   0     0.0   HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS     1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY  16.890  16.460  16.230  15.250  13.500  12.430  11.700  11.100  10.900   7.780   5.360   3.380   1.520   0.250
STATIONS    29      31      33      35      37      39
SALINITY   0.0     0.0     0.0     0.0     0.0     0.0

TIDAL CYCLE   1     0.103 HOURS      DAY   0     0.103 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2       4       6       8      10      12      14      16      18      20
DISCHARGE   338446.  333211.  315704.  296609.  262419.  223690.  174974.  133834.  109044.   92771.
STATIONS     22      24      26      28      30      32      34      36      38      40
DISCHARGE    66325.   19291. -12435. -25034. -27824. -24682. -19499. -12941.  -4572.      0.


SECTION 5,   OUTPUT SELECTION

OPTION HWS  SPECIFIED

OPTION FC   SPECIFIED

 BASIC OUTPUT      FREQUENCY
      H              12
      S              12
      Q              12
```

CALCULATION BEGINS

TRANSIENT FRESH WATER INPUTS AT SEGMENTS 40
TRANSIENT MIN-MAX OCEAN ELEVATIONS WRT MSL

CALCULATION FOR 2 CYCLES

****

CYCLE 1 HMIN= -0.47 HMAX= 0.69 SZFRC= 16.57 QFS AND STATIONS ARE 2750.000 49
K= 600.00

TIDAL CYCLE 1 1.240 HOURS DAY 0 1.240 HOURS INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
ELEV.	0.425	0.482	0.541	0.608	0.679	0.719	0.791	0.702	0.695	0.557	0.481	0.293	0.195	-0.329
STATIONS	29	31	33	35	37	39								
ELEV.	-0.221	-0.390	-0.546	-0.653	-0.745	-0.750								

TIDAL CYCLE 1 1.240 HOURS DAY 0 1.240 HOURS INSTANTANEOUS SALINITIES IN PPT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
SALINITY	16.570	16.591	16.204	15.331	13.600	12.490	11.742	11.134	10.567	9.071	5.461	3.638	1.598	0.275
STATIONS	29	31	33	35	37									
SALINITY	-0.002	0.001	-0.000	0.000	-0.000									

TIDAL CYCLE 1 1.343 HOURS DAY 0 1.343 HOURS INSTANTANEOUS DISCHARGES IN CFS

STATIONS	2	4	6	8	10	12	14	16	18	20				
DISCHARGE	-1426.	63865.	133329.	167368.	200036.	214479.	230351.	227956.	221997.	202612.				
STATIONS	22	24	26	28	30	32	34	36	38	40				
DISCHARGE	152516.	164790.	144653.	119829.	38913.	14163.	2019.	-3219.	-3027.	0.				

TIDAL CYCLE 1 2.480 HOURS DAY 0 2.480 HOURS INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
ELEV.	0.178	0.229	0.281	0.346	0.426	0.524	0.575	0.616	0.634	0.632	0.517	0.417	0.322	0.266
STATIONS	29	31	33	35	37	39								
ELEV.	0.216	0.110	-0.062	-0.270	-0.531	-0.605								

TIDAL CYCLE 1 2.480 HOURS DAY 0 2.480 HOURS INSTANTANEOUS SALINITIES IN PPT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
SALINITY	16.577	16.603	16.179	15.349	13.610	12.562	11.759	11.177	10.693	8.441	5.904	3.792	1.930	0.375
STATIONS	29	31	33	35	37									
SALINITY	-0.002	0.001	-0.000	0.000	-0.000									

TIDAL CYCLE 1 2.583 HOURS DAY 0 2.583 HOURS INSTANTANEOUS DISCHARGES IN CFS

STATIONS	2	4	6	8	10	12	14	16	18	20				
DISCHARGE	-314786.	-200422.	-99904.	-27658.	53554.	109547.	168362.	203614.	220774.	229557.				
STATIONS	22	24	26	28	30	32	34	36	38	40				
DISCHARGE	228956.	208890.	180162.	152426.	99954.	77359.	53393.	26344.	1536.	0.				

TIDAL CYCLE 1 3.720 HOURS DAY 0 3.720 HOURS INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
ELEV.	-0.128	-0.104	-0.065	-0.012	0.076	0.180	0.236	0.307	0.366	0.459	0.493	0.540	0.530	0.421
STATIONS	29	31	33	35	37	39								
ELEV.	0.503	0.455	0.406	0.381	0.293	0.318								

TIDAL CYCLE 1 3.720 HOURS DAY 0 3.720 HOURS INSTANTANEOUS SALINITIES IN PPT

STATIONS	1	3	5	7	9	11	13	15	17	19	21	23	25	27
SALINITY	16.586	16.609	16.113	15.406	13.548	12.604	11.751	11.195	10.792	8.699	6.320	4.352	2.015	0.649
STATIONS	29	31	33	35	37									
SALINITY	0.004	-0.002	0.001	-0.000	0.000									

Table 6.6 (cont'd)

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TIDAL CYCLE   1    3.823 HOURS     DAY   0    3.823 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         20
DISCHARGE   -486704.  -385263.  -280823.  -212671.  -125047.   -52339.    31586.    98712.   131700.   163724.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE    170326.   167014.   156227.   140960.   101240.    82198.    63565.    43057.     6437.        0.

TIDAL CYCLE   1    4.960 HOURS     DAY   0    4.560 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
ELEV.      -0.375     -0.372     -0.356     -0.335     -0.280     -0.199     -0.151     -0.080      0.002      0.156      0.310      0.461      0.551      0.5[illegible]
STATIONS     29         31         33         35         37         39
ELEV.       0.704      0.785      0.833      0.935      1.038      1.060

TIDAL CYCLE   1    4.960 HOURS     DAY   0    4.560 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
SALINITY   16.594     16.607     16.054     15.370     13.428     12.612     11.715     11.190     10.853      8.772      6.631      4.205      2.133      1.5[illegible]
STATIONS     29         31         33         35         37
SALINITY    0.014     -0.006      0.002     -0.001      0.000

TIDAL CYCLE   1    5.063 HOURS     DAY   0    5.063 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         21
DISCHARGE   -518154.  -446900.  -356109.  -303169.  -229656.  -164031.   -99209.   -61096.   -11848.    34593.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE     53083.    78679.    89649.    87592.    67469.    53417.    36718.    18814.     1[illegible].        0.

TIDAL CYCLE   1    6.200 HOURS     DAY   0    6.200 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
ELEV.      -0.470     -0.507     -0.539     -0.569     -0.528     -0.455     -0.422     -0.370     -0.297     -0.147      0.036      0.[illegible]      0.[illegible]      0.[illegible]
STATIONS     29         31         33         35         37         39
ELEV.       0.743      0.908      1.073      1.194      1.304      1.337

TIDAL CYCLE   1    6.200 HOURS     DAY   0    6.200 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
SALINITY   16.557     16.599     16.002     15.299     13.303     12.592     11.665     11.178     10.827      8.661      6.636      4.181      2.2[illegible]      1.[illegible]
STATIONS     29         31         33         35         37
SALINITY    0.019     -0.009      0.003     -0.001      0.000

TIDAL CYCLE   1    6.303 HOURS     DAY   0    6.303 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         20
DISCHARGE   -327523.  -324867.  -311523.  -298468.  -268138.  -232762.  -190439.  -155744.  -118031.  -111620.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE    -98639.   -67317.   -41104.   -26861.   -8723.    -9076.    -2157.    -1514.    -2650.        0.

TIDAL CYCLE   1    7.440 HOURS     DAY   0    7.440 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
ELEV.      -0.341     -0.400     -0.463     -0.509     -0.560     -0.552     -0.546     -0.514     -0.480     -0.319     -0.174      0.[illegible]      0.[illegible]      0.5[illegible]
STATIONS     29         31         33         35         37         39
ELEV.       0.503      0.647      0.816      0.964      1.129      1.172

TIDAL CYCLE   1    7.440 HOURS     DAY   0    7.440 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
SALINITY   16.593     16.588     15.995     15.190     13.260     12.525     11.617     11.165     10.704      8.620      6.607      3.936      2.1[illegible]      1.[illegible]
STATIONS     29         31         33         35         37
SALINITY    0.012     -0.006      0.002     -0.000      0.000

TIDAL CYCLE   1    7.543 HOURS     DAY   0    7.543 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         20
DISCHARGE     19154.   -62791.  -147362.  -185055.  -220023.  -232519.  -233060.  -224278.  -216112.  -200944.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE   -193988.  -180091.  -164420.  -145672.   -85256.   -62698.   -43537.   -24511.    -5718.        0.

TIDAL CYCLE   1    8.680 HOURS     DAY   0    8.680 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
ELEV.      -0.004     -0.042     -0.127     -0.195     -0.266     -0.388     -0.436     -0.463     -0.458     -0.390     -0.209     -0.[illegible]      0.061      0.1[illegible]
STATIONS     29         31         33         35         37         39
ELEV.       0.172      0.237      0.327      0.408      0.558      0.583
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Table 6.6 (cont'd)

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TIDAL CYCLE   1    6.680 HOURS      DAY   0    6.680 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY   16.570  16.573  16.042  15.082  13.278  12.432  11.595  11.143  10.510   9.129   6.040   3.714   1.999   0.460
STATIONS     29      31      33      35      37
SALINITY    0.002  -0.001   0.000  -0.000  -0.000

TIDAL CYCLE   1    8.783 HOURS      DAY   0    8.783 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2       4       6       8      10      12      14      16      18      20
DISCHARGE   412949.  272904.  122896.   38516.  -58183. -124955. -180420. -213022. -228144. -229639.
STATIONS     22      24      26      28      30      32      34      36      38      40
DISCHARGE  -222642. -196606. -170161. -144994. -94905.  -77607.  -56890.  -36769.  -7587.       0.

TIDAL CYCLE   1    9.920 HOURS      DAY   0    9.920 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.       0.414   0.373   0.324   0.262   0.187   0.049  -0.028  -0.124  -0.212  -0.298  -0.364  -0.383  -0.333  -0.268
STATIONS     29      31      33      35      37      39
ELEV.      -0.115  -0.108  -0.104  -0.111  -0.096  -0.046

TIDAL CYCLE   1    9.920 HOURS      DAY   0    9.920 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY   16.570  16.555  16.129  15.036  13.467  12.372  11.617  11.124  10.297   7.867   4.468   3.645   1.747   0.369
STATIONS     29      31      33      35      37
SALINITY   -0.004   0.002  -0.001   0.000  -0.000

TIDAL CYCLE   1   10.023 HOURS      DAY   0   10.023 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2       4       6       8      10      12      14      16      18      20
DISCHARGE   688488.  548652.  402695.  309773.  157222.   96963.  -13977. -103639. -147659. -174995.
STATIONS     22      24      26      28      30      32      34      36      38      40
DISCHARGE  -178079. -168050. -144276. -123882. -76884.  -58689.  -43186.  -27748.  -4448.       0.

TIDAL CYCLE   1   11.160 HOURS      DAY   0   11.160 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.       0.751   0.746   0.730   0.712   0.467   0.552   0.499   0.423   0.321   0.153  -0.094  -0.225  -0.296  -0.369
STATIONS     29      31      33      35      37      39
ELEV.      -0.379  -0.401  -0.423  -0.450  -0.468  -0.648

TIDAL CYCLE   1   11.160 HOURS      DAY   0   11.160 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY   16.570  16.541  16.226  15.068  13.608  12.372  11.688  11.150  10.168   7.417   4.317   3.314   1.467   0.001
STATIONS     29      31      33      35      37
SALINITY   -0.007   0.004  -0.002   0.001  -0.000

TIDAL CYCLE   1   11.263 HOURS      DAY   0   11.263 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2       4       6       8      10      12      14      16      18      20
DISCHARGE   766371.  669640.  553001.  474564.  333670.  282921.  180847.  100477.   40342.  -26490.
STATIONS     22      24      26      28      30      32      34      36      38      40
DISCHARGE   -55093.  -27037.  -90490.  -42573.  -40925.  -37444.  -26358.  -15643.  -4414.       0.

TIDAL CYCLE   1   12.400 HOURS      DAY   0   12.400 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.       0.850   0.928   0.977   1.012   1.022   0.949   0.920   0.862   0.772   0.608   0.384   0.173  -0.047  -0.264
STATIONS     29      31      33      35      37      39
ELEV.      -0.453  -0.547  -0.617  -0.657  -0.674  -0.673

TIDAL CYCLE   1   12.400 HOURS      DAY   0   12.400 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY   16.570  16.533  16.306  15.148  13.815  12.441  11.727  11.205  10.197   7.037   4.328   3.381   1.583   0.274
STATIONS     29      31      33      35      37
SALINITY   -0.009   0.005  -0.003   0.001  -0.000

TIDAL CYCLE   1   12.503 HOURS      DAY   0   12.503 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2       4       6       8      10      12      14      16      18      20
DISCHARGE   520796.  518950.  492437.  670213.  424118.  971314.  304517.  242974.  225152.  183727.
STATIONS     22      24      26      28      30      32      34      36      38      40
DISCHARGE   144241.  108854.   51725.   16278.  -15152.  -15348.  -13120.   -9712.   -5604.       0.
                                                                                  AVE MASS =    0.3093719 15
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Table 6.6 (cont'd)

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TIDAL CYCLE   1    0.0   HOURS      DAY   0    0.0   HOURS        HIGH WATER SLACK SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
TIME HRS    1.240  1.653  2.067  2.480  2.893  3.307  4.133  4.753  4.960  5.373  5.540  5.787  5.993  6.044
SALINITY   16.570 16.593 16.189 15.389 13.596 12.593 11.743 11.141 10.853  9.748  6.654  4.213  2.254  0.641
STATIONS     29     31     33     35     37
TIME HRS    6.200  6.200  6.200  6.200  6.167
SALINITY    0.019 -0.009  0.003 -0.001  0.000

PRISM=   0.1037522E 11 CUFT                    VMAX=    0.5491 FT/SEC   AT  10.95 HRS FROM BEGINNING OF CYCLE
DENSIMETRIC FROUDE NO.=  0.164409              SUM OF DF'S=  2730.000 CU.FT/SEC
DENSIMETRIC ESTUARY NO.=     2.301             K FOR THE NEXT CYCLE IS     578.67 SQFT/SEC

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CYCLE   2      PMIN=  -0.52   HMAX=   0.52    SZERO=  16.56     DF'S AND STATIONS ARE  2674.000  AT
               K=     578.67

TIDAL CYCLE   2    1.240 HOURS      DAY   0   13.640 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.       0.746  0.820  0.903  0.986  1.064  1.099  1.101  1.075  1.025  0.907  0.692  0.494  0.394  0.149
STATIONS     29     31     33     35     37     39
ELEV.      -0.005 -0.221 -0.455 -0.618 -0.739 -0.757

TIDAL CYCLE   2    1.240 HOURS      DAY   0   13.640 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.560 16.541 16.327 15.255 13.647 12.569 11.775 11.280 10.336  8.474  5.692  3.425  1.735  0.341
STATIONS     29     31     33     35     37
SALINITY   -0.012  0.006 -0.003  0.001 -0.000

TIDAL CYCLE   2    1.343 HOURS      DAY   0   13.743 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE   66080.  156985.  242624.  285544.  326081.  360772.  342345.  329674.  314603.  243865.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE   287352.  232346.  205129.  170225.   79423.   39939.   19210.    1044.   -2320.      0.

TIDAL CYCLE   2    2.480 HOURS      DAY   0   14.880 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.       0.396  0.464  0.546  0.644  0.761  0.906  0.978  1.029  1.048  1.024  0.956  0.727  0.419  0.[illegible]
STATIONS     29     31     33     35     37     39
ELEV.       0.470  0.358  0.218  0.032 -0.327 -0.422

TIDAL CYCLE   2    2.480 HOURS      DAY   0   14.880 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.567 16.560 16.287 15.359 13.954 12.703 11.798 11.390 10.501  8.830  6.253  3.657  1.000  0.490
STATIONS     29     31     33     35     37
SALINITY   -0.006  0.003 -0.001  0.001 -0.000

TIDAL CYCLE   2    2.583 HOURS      DAY   0   14.983 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE  -356029.  -247051.  -99583.   -1595.  100699.  146510.  227877.  244774.  246194.  295194.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE   248826.  256256.  214197.  185274.  119537.   80043.   33572.   42287.   4248.      0.

TIDAL CYCLE   2    3.720 HOURS      DAY   0   16.120 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.      -0.036  0.016  0.086  0.178  0.283  0.499  0.591  0.649  0.744  0.856  0.874  0.908  0.980  0.841
STATIONS     29     31     33     35     37     39
ELEV.       0.832  0.779  0.731  0.709  0.709  0.787
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Table 6.6 (cont'd)

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TIDAL CYCLE   2    3.720 HOURS     DAY   0   16.120 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.576 16.578 16.201 15.407 13.893 12.769 11.784 11.580 10.652  9.078  6.776  4.289  2.236  0.444
STATIONS     29     31     33     35     37
SALINITY    0.000 -0.005  0.002 -0.000 -0.000

TIDAL CYCLE   2    3.823 HOURS     DAY   0   16.223 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE  -688261. -445261. -397919. -305717. -187198. -95460.  32140. 120029. 344668. 907564.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE   208786. 205555. 188180. 168784. 115341.  92012.  69379.  43635.   960.      0.

TIDAL CYCLE   2    4.960 HOURS     DAY   0   17.360 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.     -0.386 -0.373 -0.343 -0.299 -0.212 -0.052  0.022  0.111  0.223  0.418  0.674  0.933  0.934  1.027
STATIONS     29     31     33     35     37     39
ELEV.      1.103  1.163  1.242  1.364  1.435  1.445

TIDAL CYCLE   2    4.960 HOURS     DAY   0   17.360 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.587 16.584 16.108 15.382 13.669 12.733 11.734 11.367 10.746  9.105  7.159  4.641  2.634  0.792
STATIONS     29     31     33     35     37
SALINITY    0.079 -0.014  0.004 -0.001  0.000

TIDAL CYCLE   2    5.063 HOURS     DAY   0   17.463 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE  -774741. -673129. -541841. -455461. -348257. -258644. -160463. -83158. -34678.  34827.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE   81299.  94735. 136550. 104298.  35699.  56658.  34631.  19461.   1436.      0.

TIDAL CYCLE   2    6.200 HOURS     DAY   0   18.600 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.     -0.520 -0.572 -0.609 -0.633 -0.590 -0.452 -0.392 -0.310 -0.209 -0.008  0.240  0.483  0.903  0.964
STATIONS     29     31     33     35     37     39
ELEV.      1.165  1.332  1.492  1.623  1.743  1.739

TIDAL CYCLE   2    6.200 HOURS     DAY   0   18.600 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.589 16.474 16.030 15.293 13.470 12.729 11.661 11.343 10.778  8.945  7.194  4.441  2.412  0.839
STATIONS     29     31     33     35     37
SALINITY    0.040 -0.018  0.005 -0.001  0.000

TIDAL CYCLE   2    6.303 HOURS     DAY   0   18.703 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE  -503758. -458814. -471031. -483245. -402553. -344241. -276566. -223010. -194884. -159505.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE  -143636. -101436.  -63753.  -35892.  -13114.   -3644.     239.     362.   -2998.      0.

TIDAL CYCLE   2    7.440 HOURS     DAY   0   19.840 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
ELEV.     -0.421 -0.482 -0.562 -0.597 -0.637 -0.622 -0.606 -0.550 -0.458 -0.273  0.037  0.265  0.471  0.639
STATIONS     29     31     33     35     37     39
ELEV.      0.757  0.990  1.202  1.374  1.566  1.621

TIDAL CYCLE   2    7.440 HOURS     DAY   0   19.840 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1      3      5      7      9     11     13     15     17     19     21     23     25     27
SALINITY   16.587 16.558 16.012 15.156 13.362 12.671 11.995 11.310 10.583  8.647  6.858  4.189  2.570  0.232
STATIONS     29     31     33     35     37
SALINITY    0.027 -0.013  0.004 -0.001  0.000

TIDAL CYCLE   2    7.543 HOURS     DAY   0   19.943 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2      4      6      8     10     12     14     16     18     20
DISCHARGE  -105776. -177565. -247449. -289080. -328982. -336345. -327864. -307052. -284876. -261461.
STATIONS     22     24     26     28     30     32     34     36     38     40
DISCHARGE  -235591. -227783. -205893. -179911. -102113.  -71270.  -47887.  -28812.   -6818.      0.
```

Table 6.6 (cont'd)

```
TIDAL CYCLE   2    8.680 HOURS      DAY   0   21.080 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.     -0.161  -0.207  -0.257  -0.311  -0.370  -0.479  -0.525  -0.547  -0.527  -0.421  -0.147   0.047   0.209   0.310
STATIONS   29      31      33      35      37      39
ELEV.      0.356   0.482   0.599   0.713   0.910   0.961

TIDAL CYCLE   2    8.680 HOURS      DAY   0   21.080 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY  16.560  16.549  16.040  15.035  13.364  12.498  11.566  11.258  10.355   8.319   6.350   3.413   2.194   0.572
STATIONS   29      31      33      35      37
SALINITY   0.005  -0.005   0.002  -0.000  -0.000

TIDAL CYCLE   2    8.783 HOURS      DAY   0   21.183 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS    2       4       6       8      10      12      14      16      18      20
DISCHARGE  235361.  121931.    933.  -68930. -147839. -200811. -251696. -282804. -292995. -289321.
STATIONS   22      24      26      28      30      32      34      36      38      40
DISCHARGE -276200. -237407. -202419. -175041. -115655.  -92163.  -68168.  -40167.   -8114.      0.

TIDAL CYCLE   2    9.920 HOURS      DAY   0   22.320 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.      0.161   0.129   0.091   0.091  -0.006  -0.119  -0.196  -0.264  -0.325  -0.364  -0.244  -0.189  -0.087  -0.018
STATIONS   29      31      33      35      37      39
ELEV.      0.040   0.070   0.095   0.104   0.177   0.189

TIDAL CYCLE   2    9.920 HOURS      DAY   0   22.320 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY  16.560  16.433  16.098  14.973  13.438  12.422  11.576  11.218  10.112   8.011   5.834   3.490   1.044   0.441
STATIONS   29      31      33      35      37
SALINITY  -0.000  -0.001   0.000  -0.000  -0.000

TIDAL CYCLE   2   10.023 HOURS      DAY   0   22.423 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS    2       4       6       8      10      12      14      16      18      20
DISCHARGE  451061.  346200.  232855.  163888.   73635.  -10787. -109228. -168812. -200624. -224997.
STATIONS   22      24      26      28      30      32      34      36      38      40
DISCHARGE -227106. -206899. -178545. -152316.  -92158.  -69393.  -50788.  -32765.   -6932.      0.

TIDAL CYCLE   2   11.160 HOURS      DAY   0   23.560 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.      0.421   0.417   0.409   0.395   0.364   0.299   0.242   0.193   0.104  -0.034  -0.157  -0.249  -0.270  -0.287
STATIONS   29      31      33      35      37      39
ELEV.     -0.295  -0.299  -0.306  -0.324  -0.318  -0.317

TIDAL CYCLE   2   11.160 HOURS      DAY   0   23.560 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY  16.560  16.522  16.171  14.977  13.564  12.406  11.610  11.216   9.944   7.861   5.613   3.307   1.774   0.366
STATIONS   29      31      33      35      37
SALINITY  -0.004   0.001  -0.001   0.000  -0.000

TIDAL CYCLE   2   11.263 HOURS      DAY   0   23.663 HOURS       INSTANTANEOUS DISCHARGES IN CFS
STATIONS    2       4       6       8      10      12      14      16      18      20
DISCHARGE  531712.  458771.  369015.  308341.  226475.  134112.   71776.     448.  -44190. -103395.
STATIONS   22      24      26      28      30      32      34      36      38      40
DISCHARGE -121481. -133872. -125775. -110753.  -66436.  -47908.  -37840.  -18541.   -4304.      0.

TIDAL CYCLE   2   12.400 HOURS      DAY   1    0.800 HOURS       INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
ELEV.      0.570   0.557   0.595   0.631   0.650   0.623   0.604   0.555   0.489   0.377   0.189  -0.333  -0.236  -0.351
STATIONS   29      31      33      35      37      39
ELEV.     -0.472  -0.538  -0.595  -0.611  -0.607  -0.595

TIDAL CYCLE   2   12.400 HOURS      DAY   1    0.800 HOURS       INSTANTANEOUS SALINITIES IN PPT
STATIONS    1       3       5       7       9      11      13      15      17      19      21      23      25      27
SALINITY  16.560  16.517  16.230  15.078  13.701  12.444  11.652  11.241   9.918   7.424   5.244   3.243   1.568   0.300
STATIONS   29      31      33      35      37
SALINITY  -0.007   0.003  -0.001   0.001  -0.000
```

Table 6.6 (cont'd)

```
TIDAL CYCLE   2   12.503 HOURS      DAY   1    0.903 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         20
DISCHARGE   362601.    355858.    336673.    315037.    277675.    235973.    182830.    138204.    111027.     82664.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE    64635.     13949.    -19194.    -31512.    -31570.    -27338.    -21121.    -13598.     -4290.        0.
                                                                                                   AVE MASS =    0.304719E 13

TIDAL CYCLE   2    0.0   HOURS      DAY   0   12.400 HOURS      HIGH WATER SLACK SALINITIES IN PPT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
TIME HRS    1.447      1.860      2.273      2.480      3.100      3.307      3.927      4.547      4.753      5.167      5.373      5.787      5.993      5.993
SALINITY   16.560     16.550     16.294     15.359     13.915     12.756     11.777     11.372     10.737      9.085      7.194      4.493      2.515      0.839
STATIONS     29         31         33         35         37
TIME HRS    6.200      6.200      6.407      6.407      5.373
SALINITY    0.040     -0.018      0.005     -0.001      0.000

PRISM=   0.7327736E 10 CUFT                          VMAX=    0.5767 FT/SEC   AT   4.75 HRS FROM BEGINNING OF CYCLE
DENSIMETRIC FROUDE NO.=  0.173325                    SUM OF QF*S=  2626.000 CU.FT/SEC
DENSIMETRIC ESTUARY NO.=     1.878                   K FOR THE NEXT CYCLE IS    641.66 SQFT/SEC

*****************************************************************************************************************

TIDAL CYCLE   2    0.0   HOURS      DAY   0   12.400 HOURS      INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO MSL, FT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
ELEV.       0.520      0.557      0.595      0.631      0.650      0.623      0.604      0.555      0.489      0.377      0.189     -0.093     -0.206     -0.351
STATIONS     29         31         33         35         37         39
ELEV.      -0.472     -0.538     -0.585     -0.611     -0.607     -0.599

TIDAL CYCLE   2    0.0   HOURS      DAY   0   12.400 HOURS      INSTANTANEOUS SALINITIES IN PPT
STATIONS      1          3          5          7          9         11         13         15         17         19         21         23         25         27
SALINITY   16.560     16.517     16.230     15.028     13.703     12.444     11.652     11.241      9.918      7.926      5.244      3.269      1.669      0.300
STATIONS     29         31         33         35         37
SALINITY    -0.003      0.003     -0.001      0.001     -0.000

TIDAL CYCLE   2    0.103 HOURS      DAY   0   12.503 HOURS      INSTANTANEOUS DISCHARGES IN CFS
STATIONS      2          4          6          8         10         12         14         16         18         20
DISCHARGE   362601.    355858.    336673.    315037.    277675.    235973.    182830.    138204.    111027.     82664.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE    64635.     13949.    -19194.    -31512.    -31570.    -27338.    -21121.    -13598.     -4290.        0.

END OF ALL CALCULATIONS
```

VII. Possible Error Messages

There are a variety of error messages which may result from an inadvertent omission, a badly punched card or a misunderstanding in the preparation of input data. The program has built-in checks on certain logic conditions, and when these conditions occur a message is printed out to aid the user in correcting the condition. The following messages are produced by the computer program. All but the last are preceeded by

"* * * SALINITY INTRUSION PROGRAM ERROR * * *"

1) NUMBER OF SECTIONS MUST BE EVEN - This refers to card A3, field 1.
2) NUMBER OF TIME INTERVALS MUST BE EVEN - This refers to card A4, field 1
3) CASE NOT 1 THRU 5 - This refers to card A5.
4) NEGATIVE INTRUSION LENGTH IN INPUT - This refers to card D2, field 2.
5) COLUMN 1 DOES NOT CONTAIN H, Q, OR S - in cards E2, E3 or E4 the first column is not correctly punched.
6) SEQUENCING ERROR IN INPUT STREAM - In the input of geometry, Manning's n or wind data, the first sequence field shows that the cards are not sequentially identified. The sequence number of each card must be 1 greater than the preceding card.
7) INTERVAL FOR OUTPUT MUST BE EVEN - This refers to the interval for outputing η (H), S, or Q as specified in cards E2, E3 or E4.
8) WATER SURFACE BELOW THE BOTTOM WHICH INDICATES A PROBABLE NUMERICAL INSTABILIITY. THE REMEDY MAY WELL BE A SMALLER DELTA-T. This message speaks for itself and results from a probable instability. A check of the stability criteria and of the calculated wave speeds printed by the program may be of use to the user in specifying a smaller Δt.
9) THE WATER SURFACE IN THE STORAGE AREA HAS FALLEN BELOW THE BOTTOM. THIS IS NOT NECESSARILY AN INSTABILITY, BUT IS PROBABLY A PROBLEM IN SCHEMATIZATION - This message indicates that a deeper depth of storage area is necessary to continue the calculations. Often the depth of storage area is calculated by dividing a total volume by a planar or surface area. This may result in a depth which is less than the expected lowering of the water surface during tidal action. The program is not designed to account for schematizations which contain bottom sections which become dry. To correct for this

situation it is recommended that the volume of storage be maintained, but that a deeper depth of storage be taken with a correspondingly narrower storage width.

10) CARDS NOT IN SEQUENCE, EXIT TAKEN AFTER LAST CYCLE'S CALCULATION - The cards not in sequence are F3, F4, . . . etc. which specify the time varying boundary conditions from tidal cycle to tidal cycle. It should be possible to restart the calculation from the last cycle's calculation if the user so desires.

VIII. Implementation on Different Computer Systems

8.1 Memory Size

This program has been implemented on IBM 360/65 and 370/155 computers running in a MVT/OS environment. The G-level FORTRAN compiler has been used for compilation of the FORTRAN program. The memory requirements corresponding to the program as listed in this report are about 120 K bytes. This permits discretizations of up to 200 sections by 449 time intervals.

Should the user find it necessary to reduce the memory used by the program he may do so by two different procedures. First of all he can overlay the subroutines TIDIN and OSIN which are required for input operations only. Secondly he can reduce the dimensioned variables used in the program, if such a reduction is permitted by the size of his particular mesh of Δx and Δt.

8.2 FORTRAN IV Restrictions

Some FORTRAN IV compilers are not always compatible with others. Possible sources of incompatibility in this program's FORTRAN IV language are the use of mixed-mode expressions, T format codes and literals enclosed in apostrophes. If the user has available to him a computer whose FORTRAN IV language does not accept one or more of these conventions some minor reprogramming will be necessary.

8.3 Hints for Modifying the Program

It may be desirable for some users to modify or extend the program in accordance with their specific needs. This section will give some details of the program's construction which should prove helpful to those users.

The program's COMMON area is based on that contained in the program of Harleman and Lee, 1969 (Ref. 2). This was modified to form the Tidal Dynamics part of this model. The modification consists of including a density gradient term, and also eliminating the storage of the elevations and discharges at every time step of a tidal cycle. This eliminated a huge matrix which was always only one half full due to the use of subscripts which represented the full staggered Δx, Δt mesh. Harleman and Lee's input routines have been slightly modified and form the subroutine TIDIN. The use of subscripting which includes each cross-section, rather than every other one still exists, and most arrays such as H, S, and Q are only one half full as a result.

The computations proceed from time step to time step in the following manner. First the Tidal Dynamics section is executed which produces elevation,

η, and discharge, Q, distributions at time $t + \Delta t$ and $t + 2\Delta t$ respectively. Then the salinity, or Salt Balance Section, is executed using the η's, at $t + \Delta t$ and $t - \Delta t$ and the Q's at time t. The salinity distribution calculated is at time $t + \Delta t$. The new η, S, and Q distributions then become the old distributions for the next time step's calculation. The time subscripting is unfortunately a bit complicated in this calculation which is accomplished in subroutine MARCH. This subroutine uses subscripts I, IH, or IQ for the old time step and K, KH, or KQ for the new time step. These subscripts can be either 1 or 2. At the end of a time step when the new values of η, S, and Q become the old values for the next time step. This transposition is accomplished by simply setting the new value of subscripts I, IH or IQ equal to the old value of subscript K, KH or KQ.

References

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2. Harleman, D. R. F. and Lee, C. H., "The Computation of Tides and Currents in Estuaries and Canals", Technical Bulletin No. 16, Committee on Tidal Hydraulics, U.S. Army Corps of Engineers, September 1969.

3. "FORTRAN IV Language", IBM System/360, Manual Form C28-6515, International Business Machines.

4. "CALCOMP PLOTTER SUBROUTINES FOR THE IBM 360", Applications Program Series AP-59, Information Processing Service Center, M.I.T., January 31, 1972.

5. "Programming CALCOMP PEN PLOTTERS", California Computer Products, Inc., Anaheim, California 92801.

Data Source References

I. Jaworski, N.A. and Clark, L.J., "Physical Data Potomac River Tidal System Including Mathematical Model Segmentation", Technical Report No. 43, Chesapeake Technical Support Laboratory, EPA (former FWQA), about 1970.

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```
C        MAIN LINE FOR TRANSIENT SIMULATION                                MAIN   1
      INTEGER CASE                                                         MAIN   2
      REAL  FQ(200),  BB(200),  D(200),  SS(200),  B(200),MANCO(200)       MAIN   3
      REAL  ZZ(200),  R(200),  C(200),  D4(200),  W(200)                   MAIN   4
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                    MAIN   5
      REAL HDA(900),QDB(900)                                               MAIN   6
      DIMENSION DUM(100),ZO(200),ADUM(100)                                 MAIN   7
      DIMENSION MFQ(10),PFQ(10)                                            MAIN   8
      DIMENSION ETA(3),FW(4),LFW(4)                                        MAIN   9
      COMMON KO,KIN,KKK,JJJ                                                MAIN  10
      COMMON NDS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXO          MAIN  11
        COMMON D1,D2,D3,FH,FZ,FXL4,SZERO,FS                                MAIN  12
        COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7               MAIN  13
      COMMON H,Q,HDA,QDB,FQ,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E             MAIN  14
      COMMON /SW/ ISW10,ISW11                                              MAIN  15
      COMMON /T/ MMM,QF,IPF,IPE,NNN                                        MAIN  16
      COMMON /EXLI4/ JLIM,J2LIM,MOUT,LOUT                                  MAIN  17
      COMMON/SL/SLD,ZO                                                     MAIN  18
      COMMON /OUTP/ LFW,NO1,ADUM,NC                                        MAIN  19
      DATA DUM /100*0./                                                    MAIN  20
      DATA PI/3.141593/,KP/7/                                              MAIN  21
                                                                           MAIN  22
C
C        FILE 'MMM'  HOLDS THE SEQUENTIAL OUTPUT OF 'NC' CYCLES            MAIN  23
                                                                           MAIN  24
      KO=6                                                                 MAIN  25
      KIN=5                                                                MAIN  26
      LLL=3                                                                MAIN  27
      CALL TIDIN                                                           MAIN  28
      CALL OSIN                                                            MAIN  29
      CALL TDISP                                                           MAIN  30
      NMAXQ=NMAX+1                                                         MAIN  31
      NMD2=(NMAX-1)/2                                                      MAIN  32
      NF=JMAX/2                                                            MAIN  33
      ST=PI*2./(NMAX-1)                                                    MAIN  34
C                                                                          MAIN  35
C        NFW IS NO. OF VARYING FRESH WATER INPUTS.                         MAIN  36
C        NCQF IS THE NO. OF THESE WHICH ARE TO BE SUMMED INTO 'QF',
```

```
C         THE FRESH WATER FLOW USED TO CALCULATE THE ESTUARY NUMBER.
C         THESE VALUES WILL BE TAKEN IN SEQUENCE.
C         THE LFW(J),J=1,NFW   ARE THE STATION LOCATIONS.
      READ(KIN,1112) NFW,NCOF,(LFW(J),J=1,NFW)
1112  FORMAT(16I5)
      WRITE(KO,720) (LFW(J),J=1,NFW)
720   FORMAT(/,' TRANSIENT FRESH WATER INPUTS AT SEGMENTS',4I5)
      IF(ISWO .EQ. 1)    WRITE(KO,1428)
1428  FORMAT(' TRANSIENT MIN-MAX OCEAN ELEVATIONS WRT MWL')
      READ(KIN,1112) NC
      WRITE(KO,4285) NC
4285  FORMAT('0',T55,'CALCULATION FOR',I4,' CYCLES')
C
C         BEGIN  MASTER LOOP BY TIDAL CYCLE
C         ETA'S ARE WRT MWL AT THE OCEAN
      ETA(1)=HOA(1)
      DO 1111 LEW=1,NC
      IF(NOS .EQ. 0)    GOTO 5
      READ(KIN,721)KCK,ETA(2),ETA(3),SZERO,FEND,(FW(J),J=1,NFW)
721   FORMAT(I5,5X,7F10.0,(8F10.0))
C         SET RIVER END DISCHARGE FOR OPEN END CASE
      DO 7 J=2,NMAXQ,2
7     QOB(J)= -FEND
      GOTO 6
5     READ(KIN,721) KCK,ETA(2),ETA(3),SZERO,(FW(J),J=1,NFW)
6     WRITE(KO,2857)
2857  FORMAT(/,'0',120('*'))
      IF(ISWO .EQ. 2)    GOTO 722
      WRITE(KO,1113) KCK,ETA(2),ETA(3),SZERO,(FW(J),LFW(J),J=1,NFW)
1113  FORMAT(/,'0CYCLE',I4,5X,'HMIN=',F7.2,3X,'HMAX=',F7.2,4X,'SZERO=',
     1        F7.2,5X,'QF''S AND STATIONS ARE',4(F10.3,I4))
      GOTO 723
722                   WRITE(KO,1133) KCK,SZERO,(FW(J),LFW(J),J=1,NFW)
1133  FORMAT(/,'0CYCLE',I4,4X,'SZERO=',F7.2,5X,'QF''S AND STATIONS ARE',
     1        4(F10.3,I4))
C
```

```
723   WRITE(KO,1114) EZ                                                MAIN  73
1114  FORMAT(T16,'K=',F10.2)                                           MAIN  74
      IF(NOS .NE. 0) WRITE(KO,724) FEND                                MAIN  75
724   FORMAT('+',T31,'UPSTREAM BOUNDARY DISCHARGE=',F10.2)             MAIN  76
C        TEST SEQUENCE                                                 MAIN  77
      IF(KCK .EQ. LEW)     GOTO 1117                                   MAIN  78
      WRITE(KO,207)                                                    MAIN  79
207   FORMAT(' CARDS NOT IN SEQUENCE, EXIT TAKEN AFTER LAST CYCLE''S',  MAIN  80
     1        ' CALCULATION')                                          MAIN  81
      GOTO 1118                                                        MAIN  82
1117  DO 1115 J=1,NEW                                                  MAIN  83
      MYJO=LEW(J)                                                      MAIN  84
1115  FQ(MYJO)=FN(J)                                                   MAIN  85
C                                                                      MAIN  86
C        CALC. 'QF' FOR ESTUARY NUMBER.                                MAIN  87
      QF=0.                                                            MAIN  88
      DO 1116 J=1,NCQF                                                 MAIN  89
      MYJO=LEW(J)                                                      MAIN  90
1116  QF=QF+FQ(MYJO)                                                   MAIN  91
      IF(NOS .NE. 0)  QF=QF+FEND                                       MAIN  92
C                                                                      MAIN  93
C        ISWO TO CALCULATE TRANSIENT TIDAL ELEVATIONS                  MAIN  94
      GOTO(20,25),ISWO                                                 MAIN  95
20    RANG1=(ETA(1)-ETA(2))/2.                                         MAIN  96
      RANG2=(ETA(3)-ETA(2))/2.                                         MAIN  97
      IF((RANG1 .LT. 0) .OR. (RANG2 .LT. 0))  GOTO 22                  MAIN  98
      GOTO 23                                                          MAIN  99
22    WRITE(KO,221) LEW                                                MAIN 100
221   FORMAT(' WARNING EQUAL ELEVATIONS IN CYCLE',I5)                  MAIN 101
23    DO 30 II=1,NMAXH,2                                               MAIN 102
      ARG=ST*(II-1)                                                    MAIN 103
      IF(ARG .GT. PI)       GOTO 21                                    MAIN 104
C        GOING DOWN                                                    MAIN 105
      HOA(II)=ETA(1)-RANG1*(1.-COS(ARG))                               MAIN 106
      GOTO 30                                                          MAIN 107
C        GOING UP                                                      MAIN 108
```

```
21    HOA(II)=ETA(3)-RANG2*(1.-COS(ARG))                                MAIN 109
30    CONTINUE                                                          MAIN 110
      ETA(1)=ETA(3)                                                     MAIN 111
C                                                                       MAIN 112
25    CALL MARCH                                                        MAIN 113
1111  CONTINUE                                                          MAIN 114
1118  IF(ISW1 .EQ. 1)    GOTO 1119                                      MAIN 115
      END FILE MMM                                                      MAIN 116
      REWIND MMM                                                        MAIN 117
1119  IF(ISW4 .EQ. 1)     GOTO 1120                                     MAIN 118
      END FILE NNN                                                      MAIN 119
      REWIND NNN                                                        MAIN 120
1120  WRITE(KO,2857)                                                    MAIN 121
C                                                                       MAIN 122
C        OUTPUT FINAL TIME STEP'S H,S,&Q                                MAIN 123
C        REFER H TO MSL                                                 MAIN 124
      DO 182 J=1,JMAXH,2                                                MAIN 125
182   H(LOUT,J)=H(LOUT,J)-SLO+ZO(J)+D(J)                                MAIN 126
      CALL SPEW(1,1)                                                    MAIN 127
      CALL SPEW(2,1)                                                    MAIN 128
      CALL SPEW(3,1)                                                    MAIN 129
      GOTO (1200,1201),ISW3                                             MAIN 130
1201  WRITE(KP,1202) (H(LOUT,J),J=1,JMAXH,2)                            MAIN 131
1202  FORMAT(5F10.5)                                                    MAIN 132
      WRITE(KP,1203) (S(LOUT,J),J=1,JMAXH,2)                            MAIN 133
1203  FORMAT(5F10.4)                                                    MAIN 134
      WRITE(KP,1204) (Q(LOUT,J),J=2,JMAX,2)                             MAIN 135
1204  FORMAT(5F1).0)                                                    MAIN 136
1200  WRITE(KO,1205)                                                    MAIN 137
1205  FORMAT(/,'0END OF ALL CALCULATIONS',/,'1')                        MAIN 138
      CALL EXIT                                                         MAIN 139
      END                                                               MAIN 140
```

```
      SUBROUTINE TIDIN                                                  TIDI   1
C     ESTUARY CLOSED AT ONE END                                         TIDI   2
C     ALL TIDAL ELEVATIONS REFER TO PRINCIPLE DATUM DEFINED             TIDI   3
C     ALL WATER DEPTHS MEASURED FROM PRINCIPLE DATUM TO THE BOTTOM      TIDI   4
C     CASE=1, RECTANGULAR CROSS-SECTION                                 TIDI   5
C     CASE=2, IRREGULAR CROSS-SECTION (STORAGE)                         TIDI   6
C     CASE=3, TRAPEZOIDAL CROSS-SECTION                                 TIDI   7
C     CASE=4, FOR EXPONENTIALLY VARYING WIDTH, RECTANGULAR CROSS-SECTIONTIDI   8
C     CASE=5, CONSTANT RECTANGULAR CROSS-SECTION                        TIDI   9
C     ROUGH=1, CONSTANT ROUGHNESS AND CONSTANT WIND EFFECT              TIDI  10
C     ROUGH=2, EITHER ROUGHNESS OR WIND EFFECT VARIES                   TIDI  11
C     CLASA=1,  ENTRANCE SURFACE A FIT TO TRANSIENT HW AND LW DATA      TIDI  12
C     CLASA=2, FOR OCEAN TIDE INPUT OF HARMONIC TYPE                    TIDI  13
C     CLASA=3, FOR OCEAN TIDE INPUT FROM TIDE TABLE OR FIELD DATA       TIDI  14
C                                                                       TIDI  15
      INTEGER CLASA,CASE,ROUGH,SLOPE                                    TIDI  16
      INTEGER WEND                                                      TIDI  17
      REAL KB                                                           TIDI  18
      REAL  FQ(200),  BB(200),  D(200), SS(200),  B(200),MANCO(200)     TIDI  19
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)                 TIDI  20
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                 TIDI  21
      REAL HOA(900),QOB(900),DP(200),COREA(200)                         TIDI  22
      LOGICAL LDP                                                       TIDI  23
      DIMENSION AMP(4),T(4),OMEGA(4),THETA(4)                           TIDI  24
      DIMENSION SCEL(200),WALEN(200)                                    TIDI  25
      DIMENSION ZO(200),V(200),PHI(200),WDUM(20)                        TIDI  26
      COMMON KO,KIN,KKK,JJJ                                             TIDI  27
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ       TIDI  28
        COMMON D1,D2,D3,EH,EZ,EXLM,SZERO,ES                             TIDI  29
      COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7              TIDI  30
         COMMON H,Q,HOA,QOB,FQ,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E       TIDI  31
      COMMON /STOR/DP,COREA,LDP                                         TIDI  32
      COMMON/SL/SLD,ZO                                                  TIDI  33
      EQUIVALENCE (KO,KOUT)                                             TIDI  34
      DATA PI/3.14159/,G/32.2/,WAUWT,ARDEN,BETA/64.0,0.078,0.0026/      TIDI  35
C                                                                       TIDI  36
```

```
C                                                                       TIDI  37
C        SECTION 1, DESCRIPTION OF SCHEMATIZED ESTUARY                  TIDI  38
      WRITE(KO,200)                                                     TIDI  39
200   FORMAT('1',T16,37('* '),/,T16,'*',T88,'*',/,T16,'*',T20,'M.I.T. ',TIDI  40
     1        'SALINITY INTRUSION PROGRAM, ONE-DIMENSIONAL ',           TIDI  41
     2        'SCHEMATIZATION',T88,'*',/,T16,'*',T88,'*',/,T16,37('* '), TIDI  42
     3        ///,'0SECTION 1,  DESCRIPTION OF THE SCHEMATIZED ESTUARY', TIDI  43
     4        //)                                                       TIDI  44
      DO 1010 I=1,2                                                     TIDI  45
      READ(KIN,1020) WDUM                                               TIDI  46
1020  FORMAT(20A4)                                                      TIDI  47
1010  WRITE(KOUT,1021)WDUM                                              TIDI  48
1021  FORMAT(1X,20A4)                                                   TIDI  49
C                                                                       TIDI  50
      READ(KIN,1050) JMAX,CHLEN,NMAX,TCOM                               TIDI  51
1050  FORMAT(I5,F10.0)                                                  TIDI  52
C        NOS =0 FOR CLOSED END, = ANYTHING ELSE FOR OPEN END            TIDI  53
      READ(KIN,1055) CASE,NOS                                           TIDI  54
1055  FORMAT(2I5)                                                       TIDI  55
      IF(NOS .EQ. 0)   GOTO 300                                         TIDI  56
      WRITE(KO,3001)                                                    TIDI  57
3001  FORMAT('0GEOMETRIC DATA',5X,'*** OPEN END ESTUARY ***')           TIDI  58
      GOTO 302                                                          TIDI  59
300   WRITE(KO,3002)                                                    TIDI  60
3002  FORMAT('0GEOMETRIC DATA',5X,'*** CLOSED END ESTUARY ***')         TIDI  61
302   WRITE(KO,1090) JMAX,CHLEN,NMAX,TCOM                               TIDI  62
1090  FORMAT(/,'0   NUMBER OF STATIONS =',I4,5X,                        TIDI  63
     1        'ESTUARY LENGTH=',F10.0,' FT.',/,'   NUMBER OF TIME ',    TIDI  64
     2       'INCREMENTS PER PERIOD=',I4,5X,'PERIOD=',F7.0,'SECONDS')   TIDI  65
      IF(2*(JMAX/2) .NE. JMAX)     CALL ERRL(1)                         TIDI  66
      IF(2*(NMAX/2) .NE. NMAX)     CALL ERRL(2)                         TIDI  67
      NMAX=NMAX+1                                                       TIDI  68
      JMAXH=JMAX-1                                                      TIDI  69
      JMAXQ=JMAX                                                        TIDI  70
      NMAXH=NMAX                                                        TIDI  71
      NMAXQ=NMAX+1                                                      TIDI  72
```

```
      NEQ=NMAXQ-2                                                       TIDI  73
      JJTEM = JMAXQ-2                                                   TIDI  74
      DELT=TCOM/(NMAX-1)                                                TIDI  75
      DELX=CHLEN/(JMAX-1)                                               TIDI  76
C        SELECT SCHEMATIZATION CASE                                     TIDI  77
      IF((CASE .LT. 1) .OR. (CASE .GT. 5))        CALL ERRL(3)          TIDI  78
C        INPUT SCHEMATIZED GEOMETRY                                     TIDI  79
      GO TO (540,550,560,565,566),CASE                                  TIDI  80
C                                                                       TIDI  81
C        CASE 1   RECTANGULAR CROSS-SECTION                             TIDI  82
  540 WRITE(KOUT,1110)                                                  TIDI  83
      WRITE(KOUT,1120)                                                  TIDI  84
 1110 FORMAT('0 CASE 1,  RECTANGULAR CROSS-SECTION')                    TIDI  85
 1120 FORMAT('0  MILES',8X,'D',11X,'ZO',14X,'B',7X,'B(CORE)',6X,        TIDI  86
     1        'FEET',3X,'SECTION')                                      TIDI  87
      DO 1 J=1,JMAX                                                     TIDI  88
      READ(KIN,1130) ISEQ,D(J),ZO(J),B(J)                               TIDI  89
 1130 FORMAT(I5,5X,5F10.0)                                              TIDI  90
      DFEET=(J-1)*DELX                                                  TIDI  91
      DIST=DFEET/5280.                                                  TIDI  92
      BS(J)=B(J)                                                        TIDI  93
      WRITE(KOUT,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J               TIDI  94
 1140 FORMAT (F10.5,2(2X,F10.5),2(2X,F10.2),2X,F10.0,I8)                TIDI  95
      CALL SEQTST(J,ISEQ)                                               TIDI  96
    1 CONTINUE                                                          TIDI  97
      GO TO 570                                                         TIDI  98
C                                                                       TIDI  99
C        CASE 2    IRREGULAR CROSS-SECTION, (STORAGE)                   TIDI 100
  550 WRITE(KOUT,1150)                                                  TIDI 101
      WRITE(KOUT,1160)                                                  TIDI 102
 1150 FORMAT('0 CASE 2,  IRREGULAR CROSS-SECTION (STORAGE)')            TIDI 103
 1160 FORMAT ('0  MILES',8X,1HD,11X,2HZO,14X,1HB,7X,'B(CORE)',8X,       TIDI 104
     1        'D***',8X,'FEET',3X,'SECTION')                            TIDI 105
      DO 2 J=1,JMAX                                                     TIDI 106
      READ(KIN,1130) ISEQ,D(J),ZO(J),B(J),BS(J),DP(J)                   TIDI 107
      DFEET=(J-1)*DELX                                                  TIDI 108
```

```
      DIST=DFEET/5280.                                                  TIDI 109
      WRITE(KOUT,1180) DIST,D(J),ZO(J),B(J),BS(J),DP(J),DFEET,J         TIDI 110
 1180 FORMAT (F10.5,2(2X,F10.5),3(2X,F10.1),2X,F10.0,I8)                TIDI 111
      CALL SEQTST(J,ISEQ)                                               TIDI 112
    2 CONTINUE                                                          TIDI 113
C                                                                       TIDI 114
C        CALCULATE CORE AREA IF STORAGE TO BE CONSIDERED                TIDI 115
      DO 30 J=1,JMAX                                                    TIDI 116
      COREA(J)=BS(J)*(D(J)-DP(J))                                       TIDI 117
      IF ( COREA(J) .LT. 0)  WRITE(KO,31)J                              TIDI 118
31    FORMAT('0 NOTE, D'' DEEPER THAN D FOR SECTION',I5)                TIDI 119
30    CONTINUE                                                          TIDI 120
      GO TO 570                                                         TIDI 121
C                                                                       TIDI 122
C        CASE 3    TRAPEZOIDAL CROSS-SECTION                            TIDI 123
  560 WRITE(KOUT,1190)                                                  TIDI 124
1190  FORMAT('0 CASE 3,  TRAPEZOIDAL CROSS-SECTION')                    TIDI 125
      WRITE(KOUT,1200)                                                  TIDI 126
 1200 FORMAT ('0  MILES',8X,1HD,11X,2HZO,13X,2HBB,7X,2HSS,11X,2HZZ,     TIDI 127
     1        8X,'FEET',3X,'SECTION')                                   TIDI 128
      DO 3 J=1,JMAX                                                     TIDI 129
      READ(KIN,1130) ISEQ,D(J),ZO(J),SS(J),BB(J)                        TIDI 130
      ZZ(J)=1.+SS(J)**2                                                 TIDI 131
      ZZ(J)=SQRT(ZZ(J))                                                 TIDI 132
      DFEET=(J-1)*DELX                                                  TIDI 133
      DIST=DFEET/5280.                                                  TIDI 134
      WRITE(KOUT,1230) DIST,D(J),ZO(J),BB(J),SS(J),ZZ(J),DFEET,J        TIDI 135
 1230 FORMAT (F10.5,2(2X,F10.5),2X,F10.1,2(2X,F10.5),F10.0,I8)          TIDI 136
      CALL SEQTST(J,ISEQ)                                               TIDI 137
    3 CONTINUE                                                          TIDI 138
      GO TO 570                                                         TIDI 139
C                                                                       TIDI 140
C        CASE 4  EXPONENTIALLY VARYING WIDTH, RECTANGULAR CROSS-SECTION TIDI 141
  565 READ(KIN,1231) KB,BO                                              TIDI 142
1231  FORMAT(2F10.0)                                                    TIDI 143
      WRITE(KOUT,1232) KB                                               TIDI 144
```

```
1232  FORMAT('0 CASE 4,  EXPONENTIALLY VARYING WIDTH, RECTANGULAR',
     1        ' CROSS-SECTION   B= ',E12.4)
      WRITE(KOUT,1120)
      DO 9 J=1,JMAX
      READ(KIN,1130) ISEQ,D(J),ZO(J)
      X1=KB*(J-1)*DELX
      B(J)=BO*EXP(-X1)
      BS(J)=B(J)
      DFEET=(J-1)*DELX
      DIST=DFEET/5280.
      WRITE(KOUT,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J
      CALL SEQTST(J,ISEQ)
    9 CONTINUE
      GOTO 570
C
C        CASE 5, CONSTANT RECTANGULAR CROSS-SECTION
566   WRITE(KO,1112)
1112  FORMAT('0CASE 5, CONSTANT RECTANGULAR CROSS-SECTION')
      WRITE(KO,1120)
      READ(KIN,1130) ISEQ,D(1),ZO(1),B(1)
      DO 567 J=1,JMAX
      DFEET=(J-1)*DELX
      DIST=DFEET/5280.
      D(J)=D(1)
      ZO(J)=ZO(1)
      B(J)=B(1)
      BS(J)=B(1)
567   WRITE(KO,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J
C     END OF GEOMETRIC DATA INPUT
C
C        SECTION 2    CHANNEL ROUGHNESS AND WIND EFFECTS
570   WRITE(KO,1260)
1260  FORMAT(   '1',T10,'SECTION 2   CHANNEL ROUGHNESS AND WIND EFFECTS'
     1)
      READ(KIN,1050) ROUGH
      GOTO(1294,1292),ROUGH
```

```
C                                                                       TIDI 181
C         CONSTANT ROUGHNESS AND WIND                                   TIDI 182
C             NOTE THAT ALL LATERAL INFLOWS ARE SET TO ZERO AT THIS POINTTIDI 183
1294  READ(KIN,1300) ISEQ,MANCO(1),V(1),PHI(1)                          TIDI 184
      DO 1296 J=2,JMAX                                                  TIDI 185
      MANCO(J)=MANCO(1)                                                 TIDI 186
      FQ(J-1)=0.                                                        TIDI 187
      V(J)=V(1)                                                         TIDI 188
1296  PHI(J)=PHI(1)                                                     TIDI 189
      FQ(JMAX)=0.                                                       TIDI 190
      WRITE(KO,1310)                                                    TIDI 191
1310  FORMAT('0 CASE 1 CONSTANT ROUGHNESS AND CONSTANT WIND')           TIDI 192
      GOTO 630                                                          TIDI 193
C                                                                       TIDI 194
C         VARIABLE ROUGHNESS OR VARIABLE WIND                           TIDI 195
1292  DO 4 J=1,JMAX                                                     TIDI 196
      READ(KIN,1300) ISEQ,MANCO(J),V(J),PHI(J)                          TIDI 197
1300  FORMAT(I5,5X,F10.7,10X,2F10.7)                                    TIDI 198
      CALL SEQTST(J,ISEQ)                                               TIDI 199
4     FQ(J)=0.                                                          TIDI 200
      WRITE(KOUT,1320)                                                  TIDI 201
1320  FORMAT('0 CASE 2  EITHER ROUGHNESS OR WIND EFFECTS VARY')         TIDI 202
C                                                                       TIDI 203
C         TEST FOR NO WIND                                              TIDI 204
630   WEND=1                                                            TIDI 205
      DO 5 J=1,JMAX                                                     TIDI 206
      IF(V(J) .NE. 0)  WEND=2                                           TIDI 207
5     CONTINUE                                                          TIDI 208
      GOTO(640,650),WEND                                                TIDI 209
C         NO WIND EFFECT                                                TIDI 210
  640 WRITE(KOUT,1350)                                                  TIDI 211
1350  FORMAT('0   NO WIND')                                             TIDI 212
      DO 6  J=2,JMAXQ,2                                                 TIDI 213
      W(J)=0.                                                           TIDI 214
    6 CONTINUE                                                          TIDI 215
      GOTO 661                                                          TIDI 216
```

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C         WIND BEING CONSIDERED                                          TIDI 217
  650 WRITE(KOUT,1360)                                                   TIDI 218
1360  FORMAT('0    WIND EFFECT INCLUDED')                               TIDI 219
      DO 7 J=2,JMAXO,2                                                   TIDI 220
      VCOS = V(J)*COS(PHI(J))                                            TIDI 221
      VCOS = VCOS*ABS(VCOS)                                              TIDI 222
      W(J)=      BETA*ARDEN*VCOS/WAUWT                                   TIDI 223
    7 CONTINUE                                                           TIDI 224
      WRITE(KO,1380) WAUWT,BETA,ARDEN                                    TIDI 225
1380  FORMAT(' DENSITY OF WATER=',F6.2,'  BETA=',F8.4,'  AIR DENSITY=',  TIDI 226
     1        F10.4)                                                     TIDI 227
C         OUTPUT                                                         TIDI 228
661   WRITE(KOUT,1390)                                                   TIDI 229
 1390 FORMAT ('0  MILES',5X,5HMANCO,11X,2HEQ,7X,1HV,10X,3HPHI,            TIDI 230
     1        12X,'FEET   SECTION')                                      TIDI 231
      DO 8 J=1,JMAX                                                      TIDI 232
      DFEET=(J-1)*DELX                                                   TIDI 233
      DIST=DFEET/5280.                                                   TIDI 234
      WRITE(KOUT,1400) DIST,MANCO(J),EQ(J),V(J),PHI(J),DFEET,J           TIDI 235
 1400 FORMAT (F10.5,2X,F10.7,2X,F10.3,2(2X,F10.7),2X,F10.0,I5)           TIDI 236
    8 CONTINUE                                                           TIDI 237
C                                                                        TIDI 238
C         SECTION 3   SURFACE ELEVATION AT THE ENTRANCE                  TIDI 239
      ISWO=2                                                             TIDI 240
      WRITE(KOUT,1405)                                                   TIDI 241
1405  FORMAT(//,'0  SECTION 3,  SURFACE ELEVATION AT THE ENTRANCE'/)     TIDI 242
      READ(KIN,1410) CLASA,DSLO                                          TIDI 243
1410  FORMAT(I5/F10.0)                                                   TIDI 244
      SLO=ZO(1)+D(1)-DSLO                                                TIDI 245
      WRITE(KO,1406) DSLO,SLO                                            TIDI 246
1406  FORMAT('  MWL',F5.2,' FT ABOVE MSL AT OCEAN',/,                   TIDI 247
     1       '  MSL',F7.2,' FT ABOVE THE HORIZONTAL DATUM')              TIDI 248
      GOTO(665,680,670),CLASA                                            TIDI 249
C                                                                        TIDI 250
C         CASE 1,  COSINE FIT TO HW,LW SERIES                            TIDI 251
C            PUT FIRST HW IN VARIABLE HOA(1)                             TIDI 252
C
```

```
665   READ(KIN,1231) HOA(1)                                          TIDI 253
      WRITE(KO,1407) HOA(1)                                          TIDI 254
1407  FORMAT('0 CASE 1, COSINE FIT TO HW-LW SERIES',/,               TIDI 255
     1        '  FIRST HW VALUE RELATIVE TO MWL =',F10.2,/)          TIDI 256
      ISWO=1                                                         TIDI 257
      GOTO 745                                                       TIDI 258
C                                                                    TIDI 259
C        CASE 2,  ELEVATIONS REPEATING AND HARMONIC                  TIDI 260
680   READ(KIN,1050) LMAX                                            TIDI 261
      WRITE(KO,1450)                                                 TIDI 262
1450  FORMAT('0 CASE 2, ELEVATIONS AT ENTRANCE REPEAT AND ARE HARMONIC')TIDI 263
      DO 10 L=1,LMAX                                                 TIDI 264
      READ(KIN,1231) AMP(L),T(L)                                     TIDI 265
      IF(LMAX .EQ. 1)   T(L)=TCOM                                    TIDI 266
      WRITE(KO,1441) AMP(L),T(L)                                     TIDI 267
1441  FORMAT(5X,'A=',F10.4,5X,'T=',F10.2)                            TIDI 268
      OMEGA(L)=2.*PI/T(L)                                            TIDI 269
   10 CONTINUE                                                       TIDI 270
      DO 11 N=1,NMAXH,2                                              TIDI 271
      HOA(N)=0.                                                      TIDI 272
      DO 11 L=1,LMAX                                                 TIDI 273
      THETA(L)=OMEGA(L)*(N-1)*DELT                                   TIDI 274
      HOA(N)=HOA(N)+AMP(L)*COS(THETA(L))                             TIDI 275
   11 CONTINUE                                                       TIDI 276
      GO TO 745                                                      TIDI 277
C                                                                    TIDI 278
C        CASE 3,  REPEATING ELEVATIONS FROM TABLE                    TIDI 279
670   WRITE(KOUT,1430)                                               TIDI 280
1430  FORMAT('0 CASE3, REPEATING ELEVATIONS FROM TABLE')             TIDI 281
      NDUM=NMAXH-2                                                   TIDI 282
      READ(KIN,1420) (HOA(N), N=1,NDUM,2)                            TIDI 283
 1420 FORMAT (5F10.5)                                                TIDI 284
      WRITE(KO,1408) (HOA(N),N=1,NDUM,2)                             TIDI 285
1408  FORMAT(5X,5F10.5)                                              TIDI 286
      HOA(NMAXH)=HOA(1)                                              TIDI 287
C     BOUNDARY CONDITION AT OCEAN A DEFINED                          TIDI 288
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```
C                                                                       TIDI 289
C                                                                       TIDI 290
C     SET UP BOUNDARY CONDITIONS AT RIVER END                           TIDI 291
  745 DO 19 N=2,NMAXQ,2                                                 TIDI 292
      Q08(N)=0.                                                         TIDI 293
   19 CONTINUE                                                          TIDI 294
C     INITIAL CONDITIONS DEFINED                                        TIDI 295
      D1=DELT/DELX                                                      TIDI 296
      D2=.5/(DELT*G)                                                    TIDI 297
      D3=.5/DELX                                                        TIDI 298
      DTEM=1./D1                                                        TIDI 299
      TDH=DELT/3600.                                                    TIDI 300
      DO 21 J=2,JJTEM,2                                                 TIDI 301
      D4(J)=D3*(D(J-1)-D(J+1)+ZO(J-1)-ZO(J+1))                          TIDI 302
   21 CONTINUE                                                          TIDI 303
      WRITE(KOUT,1500) DELT,DELX                                        TIDI 304
 1500 FORMAT(//,' DT=',F10.2,' SEC.   DX=',F10.1,' FT.')                TIDI 305
      WRITE(KOUT,1510) DTEM                                             TIDI 306
 1510 FORMAT(15H DELTAX/DELTAT=,F8.2, 9H FT./SEC.)                      TIDI 307
C     COMPUTATION OF CELERITY WITH RESPECT TO MEAN DEPTH                TIDI 308
C     SCEL DENOTES THE CELERITY WITH RESPECT TO THE DEPTH ONLY          TIDI 309
      WRITE(KOUT,1520)                                                  TIDI 310
 1520 FORMAT (36H0CELERITY WITH RESPECT TO DEPTH ONLY)                  TIDI 311
      WRITE(KOUT,1530)                                                  TIDI 312
 1530 FORMAT(T11,'CELERITY  WAVE LENGTH',/,' SECTION  (FT/SEC)',        TIDI 313
     1        T23,'(MILES)')                                            TIDI 314
      IWARN=0                                                           TIDI 315
      DO 22 J=1,JMAX                                                    TIDI 316
      SCEL(J)=(G*D(J))**.5                                              TIDI 317
      WALEN(J)=SCEL(J)*TCOM/5280.                                       TIDI 318
      WRITE(KOUT,1540) J,SCEL(J),WALEN(J)                               TIDI 319
 1540 FORMAT(1X,I7,F10.2,2X,F10.2)                                      TIDI 320
      IF(SCEL(J) .GT. DTEM)  IWARN=1                                    TIDI 321
   22 CONTINUE                                                          TIDI 322
      IF(IWARN .EQ. 1)  WRITE(KOUT,1550)                                TIDI 323
 1550 FORMAT('0*** WARNING, CELERITY GREATER THAN DX/DT IN SOME',       TIDI 324
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1        ' SECTIONS.  INSTABILITY COULD RESULT'1                    TIDI 325
 RETURN                                                             TIDI 326
 END                                                                TIDI 327
```

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      SUBROUTINE OSIN                                                   CSIN   1
      INTEGER CASE,ODS1,ODS2                                            CSIN   2
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCO(200)      CSIN   3
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)                 OSIN   4
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                 OSIN   5
      REAL HOA(900),QCB(900)                                            CSIN   6
      DIMENSICN OPT(4),OKEY(4),KVAR(3)                                  CSIN   7
      DIMENSICN DUM(100),ZC(200)                                        OSIN   8
      COMMCN KO,KIN,KKK,JJJ                                             CSIN   9
      CCMMCN NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ       CSIN  10
      COMMON D1,D2,D3,EH,EZ,EXLP,SZERC,ES                               OSIN  11
       COMMCN MH,MS,ISWO,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7             CSIN  12
        CCMMCN H,Q,HOA,QCB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E        OSIN  13
      COMMCN /CEPT/ XNCPT                                               OSIN  14
      COMMCN /T/ MMM,QF,IPF,IPE,NNN,IETM                                OSIN  15
      COMMON /SL/ SLD,ZO                                                OSIN  16
      DATA OKEY/'KEEP','HWS','FC  ','E   '/,KVAR/'H','S','Q'/           OSIN  17
      DATA INCPT/0/                                                     OSIN  18
      ISW1=1                                                            OSIN  19
      ISW2=1                                                            OSIN  20
      ISW3=1                                                            CSIN  21
      ISW4=1                                                            CSIN  22
      ISW5=-1                                                           OSIN  23
      ISW6=-1                                                           CSIN  24
      ISW7=-1                                                           OSIN  25
      IETM=1                                                            CSIN  26
C                                                                       CSIN  27
C        SECTION 4, DEFINITICNS RELATIVE TC THE SALT BALANCE EQN.       OSIN  28
C        AND TO INITIAL SALINITIES                                      CSIN  29
C                                                                       OSIN  30
      WRITE(KC,200)                                                     OSIN  31
200   FORMAT(//,'1 SECTION 4,  DEFINITICNS RELATIVE TO THE SALT BALANCE CSIN  32
     1EQUATION, AND TO INITIAL SALINITIES',//)                          CSIN  33
      NMO2=(NMAX-1)/2                                                   OSIN  34
      NF=JMAX/2                                                         OSIN  35
      III=5                                                             OSIN  36
      MMM=15
```

```
      NNN=11                                                            OSIN  37
      LLL=3                                                             CSIN  38
C                                                                       CSIN  39
      READ(KIN,199) EZ, ODS2                                            OSIN  40
199   FORMAT(F10.0,I5)                                                  CSIN  41
      IF(ODS2 .NE. 0)   IETM=ODS2                                       OSIN  42
      READ(KIN,100) XNCPT,EXLM,PF,PE                                    OSIN  43
100   FORMAT(5F10.0)                                                    OSIN  44
      WRITE(KO,201) IETM,EZ                                             OSIN  45
201   FORMAT(//,' E=K(DS/DX)+',I2,'*E(TAYLOR)',5X,' K FOR THE NEXT ',   CSIN  46
     1       'TIDAL CYCLE IS',F10.2,/)                                  OSIN  47
      IF(XNCPT .EQ. 0.)   XNCPT=2.15E-3                                 OSIN  48
      WRITE(KO,205) XNCPT                                               OSIN  49
205   FORMAT('OK VS. ED GIVEN BY K/(UZ*L)=',E10.3,'ED**(-1/4)',/)       OSIN  50
      IF(EXLM) 51,1,2                                                   OSIN  51
51    CALL ERRL(4)                                                      OSIN  52
1     WRITE(KO,202)                                                     OSIN  53
202   FORMAT(/,' SALINITY EXCURSION NOT LIMITED',/)                     CSIN  54
      GOTO 3                                                            OSIN  55
2     WRITE(KO,203) EXLM                                                OSIN  56
203   FORMAT(/,' SALINITY EXCURSION LIMIT =',F10.2,' FT',/)             OSIN  57
3     IPF=PF*NMD2+0.5                                                   OSIN  58
      IPE=PE*NMD2+0.5                                                   OSIN  59
      WRITE(KO,204) PF,PE,IPF,IPE                                       OSIN  60
204   FORMAT(' SALINITY RETURNS TO SZERO AFTER LWS IN',F5.2,            OSIN  61
     1       ' OF A TIDAL PERIOD',/,' EXTENTION OF SZERO AFTER HWS FOR',OSIN  62
     2       F5.2,' OF A TIDAL PERIOD',TIOO,2I8)                        OSIN  63
C                                                                       OSIN  64
C        DEFINITION OF THE SOURCE OF INITIAL CONDITIONS                 CSIN  65
C        ALL ELEVATIONS IN INITIAL CONDITIONS ARE WITH RESPECT TO MSL   CSIN  66
      READ(KIN,101) ICASE,ODS1                                          OSIN  67
101   FORMAT(2I5)                                                       CSIN  68
      IF(ODS1 .NE. 0)     LLL=ODS1                                      OSIN  69
C                                                                       OSIN  70
C        DEFINE INITIAL CONDITIONS                                      CSIN  71
      GOTO(19,195,18),ICASE                                             CSIN  72
```

```
C                                                                       CSIN  73
C        CASE 3, INPUT ALL I.C. FROM CARDS                              CSIN  74
C        H INPUT WRT MSL, THEN REFERED TO MWL AT THE OCEAN              CSIN  75
C        ALL STARTING VALUES FROM UNIT III                              CSIN  76
18     WRITE(KO,217)                                                    CSIN  77
217    FORMAT('0CASE 3, INITIAL CONDITIONS ALL FROM CARDS')             CSIN  78
       READ(III,100) (H(1,J),J=1,JMAXH,2)                               CSIN  79
       CALL SPEW(1,4)                                                   CSIN  80
       DO 180 J=1,JMAXH,2                                               CSIN  81
180    H(1,J)=H(1,J)+SLD-ZC(J)-D(J)                                     CSIN  82
       READ(III,100) (S(1,J),J=1,JMAXH,2)                               CSIN  83
       READ(III,100) (Q(1,J),J=2,JMAXQ,2)                               CSIN  84
       GOTO 17                                                          CSIN  85
C                                                                       CSIN  86
C        CASE1, ALL I.C. FROM DATASET                                   CSIN  87
19     WRITE(KO,216)                                                    CSIN  88
216    FORMAT('0CASE 1, ALL INITIAL CONDITIONS FROM DATASET')           CSIN  89
       GOTO 20                                                          CSIN  90
C                                                                       CSIN  91
C        CASE 2, ELEVATIONS AND DISCHARGES FROM DATASET,                CSIN  92
C        SALINITY FROM CARDS                                            CSIN  93
195    WRITE(KO,218)                                                    CSIN  94
218    FORMAT('0CASE 2, INITIAL ELEVATIONS AND DISCHARGES FROM DATASET', CSIN  95
1            ', SALINITIES FROM CARDS')                                 CSIN  96
       READ(KIN,100) (S(1,J),J=1,JMAXH,2)                               CSIN  97
20     NTNL=NMD2-1                                                      CSIN  98
       DO 520 I=1,NTNL                                                  CSIN  99
       READ(LLL)      (DUM(J),J=1,NF)                                   CSIN 100
       READ(LLL)      (DUM(J),J=1,NF)                                   CSIN 101
       READ(LLL)      (DUM(J),J=1,NF)                                   CSIN 102
520    SET UP H,S AND Q  ON LST  READ                                   CSIN 103
C      READ(LLL)      (H(1,J),J=1,JMAXH,2)                              CSIN 104
       CALL SPEW(1,4)                                                   CSIN 105
       DO 181 J=1,JMAXH,2                                               CSIN 106
181    H(1,J)=H(1,J)+SLD-ZC(J)-D(J)                                     CSIN 107
C         DECIDE WHETHER OR NOT TO USE S(INIT) FROM CARDS               CSIN 108
```

```
      GOTO(4560,4550),ICASE                                             CSIN 109
 4550 READ(LLL)       (DUM(J),J=1,NF)                                  OSIN 110
      GOTO 4570                                                        CSIN 111
 4560 READ(LLL)       (S(1,J),J=1,JMAXH,2)                             OSIN 112
 4570 READ(LLL)       (Q(1,J),J=2,JMAXQ,2)                             CSIN 113
C                                                                      CSIN 114
C        PLACE INTO S(2,J) FOR RHO CALC EXCEEDING JLIM                 OSIN 115
17    DO 4580 J=1,JMAXH,2                                              OSIN 116
4580  S(2,J)=S(1,J)                                                    CSIN 117
      CALL SPEW(2,4)                                                   CSIN 118
      CALL SPEW(3,4)                                                   CSIN 119
C                                                                      OSIN 120
C        SECTION 5.   OUTPUT SELECTION                                 OSIN 121
C        OPTIONS                                                       CSIN 122
      WRITE(KO,210)                                                    OSIN 123
210   FORMAT('0',/,' SECTION 5,   OUTPUT SELECTION')                   CSIN 124
      READ(KIN,120)(OPT(I),I=1,4),ODS1,ODS2                            OSIN 125
120   FORMAT(4(A4,1X),2I5)                                             CSIN 126
      DO 3001 I=1,4                                                    CSIN 127
      DO 3001 II=1,4                                                   OSIN 128
      IF(OPT(I) .NE. OKEY(II))   GOTO 3001                             OSIN 129
      WRITE(KO,270) OKEY(II)                                           OSIN 130
270   FORMAT('0OPTION ',A4,' SPECIFIED')                               OSIN 131
      INOPT=INOPT+1                                                    CSIN 132
      IF(II .EQ. 1)  ISW1=2                                            CSIN 133
      IF(II .EQ. 2)  ISW2=2                                            CSIN 134
      IF(II .EQ. 3)   ISW3=2                                           CSIN 135
      IF(II .EQ. 4)  ISW4=2                                            CSIN 136
3001  CONTINUE                                                         CSIN 137
      IF(INOPT .EQ. 0)  WRITE(KO,271)                                  CSIN 138
271   FORMAT('0 NO OPTIONS SPECIFIED')                                 OSIN 139
C        GET DATASET NO.S FOR 'KEEP' AND 'E'  OPTIONS                  CSIN 140
      IF((ISW1 .EQ. 2) .AND. (ODS1.NE.0))    MMM=ODS1                  OSIN 141
      IF((ISW4 .EQ. 2) .AND. (ODS2 .NE. 3))  NNN=ODS2                  CSIN 142
C        GET FREQUENCY OF BASIC OUTPUT                                 CSIN 143
      WRITE(KO,272)                                                    OSIN 144
```

```
272   FORMAT('0 BASIC OUTPUT',T20,'FREQUENCY')                    OSIN 145
      DO 275 I=1,3                                                CSIN 146
      READ(KIN,121) KEY,NFREQ                                     OSIN 147
121   FORMAT(A1,4X,I5)                                            CSIN 148
      DO 276 II=1,3                                               OSIN 149
      IF(KEY .NE. KVAR(II))     GOTO 276                          OSIN 150
      IF(II .EQ. 1)  ISW5=NFREQ                                   CSIN 151
      IF(II .EQ. 2)  ISW6=NFREQ                                   CSIN 152
      IF(II .EQ. 3)  ISW7=NFREQ                                   CSIN 153
      GOTO 277                                                    CSIN 154
276   CONTINUE                                                    OSIN 155
      CALL ERRL(5)                                                OSIN 156
277   WRITE(KO,273) KEY,NFREQ                                     OSIN 157
273   FORMAT(7X,A1,T19,I5)                                        OSIN 158
      IF((NFREQ/2)*2 .NE. NFREQ)     CALL ERRL(7)                 OSIN 159
275   CONTINUE                                                    OSIN 160
C                                                                 OSIN 161
C        CHECK  FOR NON-FATAL ERROR ACCUMULATION                  OSIN 162
      CALL ERRL(8)                                                OSIN 163
      RETURN                                                      OSIN 164
      END                                                         OSIN 165
```

```
      SUBROUTINE MARCH                                                  MARC   1
      INTEGER CASE,IHWS(100)                                            MARC   2
      REAL  FG(200),  FB(200),  C(200),  SS(200),  B(200),MANCO(200)    MARC   3
      REAL  ZZ(200),  R(200),  C(200),  D4(200),  W(200)                MARC   4
      REAL  BS(200),  E(200),H(2,200),S(2,200),G(2,200)                 MARC   5
      REAL HOA(900),QOB(900),DP(200),COREA(200)                         MARC   6
      LOGICAL LV(100),KEY(100),LF,LDP                                   MARC   7
      DIMENSION HKH(200),Z(200),WP(200),ZD(200),RHO(200),ZO(200)        MARC   8
      DIMENSION CU(100),CS(100),CL(100),F(100)                          MARC   9
      DIMENSION A(2,200),HWS(100),HH(450),GG(450)                       MARC  10
      COMMON KO,KIN,KKK,JJJ                                             MARC  11
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ       MARC  12
      COMMON C1,D2,D3,EH,EZ,EXLM,SZERO,ES                               MARC  13
      COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7              MARC  14
      COMMON F,Q,HOA,QOB,FQ,BB,C,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E          MARC  15
      COMMON /SW/ ISW10,ISW11                                           MARC  16
      COMMON /T/ MMM,GF,IPF,IPE,NNN                                     MARC  17
      COMMON /EXLIM/ JL14,J2LIM,K,I                                     MARC  18
      COMMON /STOR/DP,COREA,LDP                                         MARC  19
      COMMON /AREAS/A                                                   MARC  20
      COMMON /OUTP/ LEW,NN,HWS,NDLMM,IHWS                               MARC  21
      COMMON /SL/ SLO,ZO                                                MARC  22
      EQUIVALENCE (I,IH,IQ),(K,KF,KQ),(NREC,JM2)                        MARC  23
      DATA THETA/0.333333/                                              MARC  24
      DATA INIT/1/                                                      MARC  25
      DATA RHOS/0.75/,P/0.166667/,G/32.2/                               MARC  26
C                                                                       MARC  27
C                                                                       MARC  28
C        INITIALIZATION                                                 MARC  29
      GOTO(1,2),INIT                                                    MARC  30
1     NSEG=JMAX                                                         MARC  31
      INIT=2                                                            MARC  32
      GG=1.-THETA                                                       MARC  33
      NREC=NSEG/2                                                       MARC  34
      JM2M1=JM2-1                                                       MARC  35
      NMO2=(NMAX-1)/2                                                   MARC  36
```

```
      DX2=DELX*2.                                                       MARC  37
      XL   =(JMAX-1)*DELX                                               MARC  38
      DT2=DELT*2.                                                       MARC  39
      DTX=DELT/DELX                                                     MARC  40
      F(JM2+1)=0.                                                       MARC  41
      CT2=2.*THETA*DELX/DELT                                            MARC  42
      CG4=4.*(1.-THETA)*DELX/DELT                                       MARC  43
      CC4=2.*(1.-THETA*0.5)/DTX                                         MARC  44
      CF4=2.*(THETA*0.5)/DTX                                            MARC  45
      JLMM1=JLIM-1                                                      MARC  46
      J2LIM=2*JLIM-1                                                    MARC  47
C                                                                       MARC  48
C        IH=I=IQ IS THE PREVIOUS TIME STEP                              MARC  49
C        KH=K=KQ IS THE NEXT TIME STEP                                  MARC  50
      IH=1                                                              MARC  51
      KH=2                                                              MARC  52
C      NORMAL ENTRY                                                     MARC  53
C        AVERAGE MASS BALANCE FOR ITERATION                             MARC  54
2     TSUM=0.                                                           MARC  55
C        FOR HIGH WATER SLACK CALCS                                     MARC  56
      DO 13 J=1,JLIM                                                    MARC  57
      IF(Q(IH,2*J)) 11,11,12                                            MARC  58
11    LV(J)=.FALSE.                                                     MARC  59
      GOTO 13                                                           MARC  60
12    LV(J)=.TRUE.                                                      MARC  61
13    KEY(J)=.FALSE.                                                    MARC  62
C                                                                       MARC  63
C        SET COUNTERS FOR SELECTIVE OUTPUT                              MARC  64
      KHCT=1+ISW5                                                       MARC  65
      KSCT=1+ISW5                                                       MARC  66
      KQCT=1+ISW7                                                       MARC  67
C                                                                       MARC  68
C        MASTER LOOP  TIME                                              MARC  69
      DO 23 NN=3,NMAXH,2                                                MARC  70
      H(IH,1)=HOA(NN-2)                                                 MARC  71
      H(KH,1)=HOA(NN)                                                   MARC  72
```

```
      Q(IQ,JMAXQ)=QJB(NN-1)                                             MARC   73
      Q(KQ,JMAXQ)=QJB(NN+1)                                             MARC   74
C                                                                       MARC   75
C   CONTINUITY EQUATION                                                 MARC   76
      DO 24 J=3,JMAXH,2                                                 MARC   77
      FRDIS = FQ(J)+FQ(J+1)                                             MARC   78
      GO TO (770,770,760,770,770),CASE                                  MARC   79
  760 B(J)= BB(J)+ 2.*(D(J)+H(IH,J))*SS(J)                              MARC   80
  770 H(KH,J)=H(IH,J)-(Q(IQ,J+1)-Q(IQ,J-1)-FRDIS)*D1/B(J)               MARC   81
   24 CONTINUE                                                          MARC   82
C        GET RHO                                                        MARC   83
      DO 8020 J=1,JMAXH,2                                               MARC   84
 8020 RHO(J)=RHOS*S(1,J)+1000.                                          MARC   85
C                                                                       MARC   86
C        MOMENTUM EQUATION                                              MARC   87
      DO 25 J=2,JJTEM,2                                                 MARC   88
C        JJTEM =JMAXQ-2=JMAX-2   IN THIS CASE                           MARC   89
      GO TO (790,790,780,790,790),CASE                                  MARC   90
  780 HTEM=D(J)+.5*(H(KH,J-1)+H(KH,J+1))                                MARC   91
      B(J)= BB(J)+2.*HTEM*SS(J)                                         MARC   92
      BS(J)= BB(J)+HTEM*SS(J)                                           MARC   93
C        CALC. DIST. SURFACE TO CENTROID                                MARC   94
      ZD(J)=HTEM*(2.*BS(J)+B(J))/6./BS(J)                               MARC   95
      Z(J)=BS(J)*HTEM                                                   MARC   96
      WP(J)= BB(J)+2.*HTEM*ZZ(J)                                        MARC   97
      GO TO 800                                                         MARC   98
  790 Z(J)=BS(J)*(D(J)+.5*(H(KH,J+1)+H(KH,J-1)))                        MARC   99
      WP(J)=2.*D(J)+BS(J)+H(KH,J+1)+H(KH,J-1)                           MARC  100
C        CALC. DIST. SURFACE TO CENTROID                                MARC  101
      ZD(J)=(Z(J)/BS(J))*0.5                                            MARC  102
  800 R(J)=Z(J)/WP(J)                                                   MARC  103
C        TEST FOR NEGATIVE DEPTH AS AN EVIDENCE OF INSTABILITY          MARC  104
      IF(Z(J) .LT.0)          CALL ERRL(9)                              MARC  105
      C(J)=1.486*(R(J)**P)/MANCC(J)                                     MARC  106
      E1=D2/Z(J)                                                        MARC  107
      E2=.5/((C(J)**2)*(Z(J)**2)*R(J))                                  MARC  108
```

```
      E3=2.*B(J)       /(G*(Z(J)**2))                                    MARC 109
      E4=.25*(H(KH,J+1) +H(KH,J-1)-H(IH,J+1)-H(IH,J-1))/DELT             MARC 110
      FRDIS=(FQ(J)+FQ(J+1))/DX2                                          MARC 111
      E5=FRDIS/(G*(Z(J)**2))                                             MARC 112
      D6= ZD(J)/DELX*(RHO(J-1)-RHO(J+1))/(RHO(J-1)+RHO(J+1))             MARC 113
      Q(KQ,J)=(Q(IQ,J)*(E1-ABS(Q(IQ,J))*E2+E3*E4-E5)+D3*(H(KH,J-1)-      MARC 114
     1H(KH,J+1))+W(J)/R(J)+D4(J)+D6)/(E1+E2*ABS(Q(IQ,J)))                MARC 115
   25 CONTINUE                                                           MARC 116
C                                                                        MARC 117
C        AREA CALCULATION                                                MARC 118
      DO 10 J=1,J2LIM,2                                                  MARC 119
      GOTO (3001,3,5,3001,3001),CASE                                     MARC 120
5     DO 6 IT=1,2                                                        MARC 121
      HTEM=D(J)+H(IT,J)                                                  MARC 122
6     A(IT,J)= (BB(J)+HTEM*SS(J))*HTEM                                   MARC 123
      GOTO 10                                                            MARC 124
3     IF(B(J) .EQ. BS(J))      GOTO 3001                                 MARC 125
      DO 4 IT=1,2                                                        MARC 126
      DPPN=DP(J)+H(IT,J)                                                 MARC 127
      IF(DPPN .LT. J)    CALL ERRL(10)                                   MARC 128
4     A(IT,J)=B(J)*DPPN+DAREA(J)                                         MARC 129
      GOTO 10                                                            MARC 130
3001  DO 3002 IT=1,2                                                     MARC 131
3002  A(IT,J)=BS(J)*(E(J)+H(IT,J))                                       MARC 132
10    CONTINUE                                                           MARC 133
C        CALCULATE DISPERSION COEFFICIENTS                               MARC 134
      CALL TDISP                                                         MARC 135
C        OCEAN BOUNDRY CONDITION                                         MARC 136
      CALL TOCNB(CD,CJ,F,(NN-1)/2,NMD2)                                  MARC 137
C                                                                        MARC 138
C        CALCULATE COEFFICIENTS                                          MARC 139
      DO 7 M=2,JLM1                                                      MARC 140
      M2=2*M-1                                                           MARC 141
      M2M2=M2-2                                                          MARC 142
      M2P2=M2+2                                                          MARC 143
      A2M=(A(2,M2)+A(1,M2))/2.                                           MARC 144
```

```
      A2MM2=(A(2,M2M2)+A(1,M2M2))/2.                                    MARC 145
      A2MP2= (A(2,M2P2)+A(1,M2P2))/2.                                   MARC 146
      A2MM1=0.5*(A2M+A2MM2)                                             MARC 147
      A2MP1=0.5*(A2M+A2MP2)                                             MARC 148
      EBM1=E(M2-1)*A2MM1/DELX                                           MARC 149
      EBP1=E(M2+1)*A2MP1/DELX                                           MARC 150
      CL(M-1)=CT2*A(K,M2M2)-Q(I,M2-1)-EBM1                              MARC 151
      CD(M)= CG4*A(K,M2)-Q(I,M2-1)+Q(I,M2+1)+EBM1+EBP1                  MARC 152
      CU(M)=CT2*A(K,M2P2)+Q(I,M2+1)-EBP1                                MARC 153
      F(M)=S(I,M2M2)*(CT2*A(I,M2M2)+Q(I,M2-1)+EBM1)+                    MARC 154
     1      S(I,M2)*(CG4*A(I,M2)+Q(I,M2-1)-Q(I,M2+1)-EBM1-EBP1)+        MARC 155
     2      S(I,M2P2)*(CT2*A(I,M2P2)-Q(I,M2+1)+EBP1)                    MARC 156
C                                                                       MARC 157
7     CONTINUE                                                          MARC 158
C        MASS BALANCE HEAD BOUNDARY CONDITION                           MARC 159
C                                                                       MARC 160
      M=JLIM                                                            MARC 161
      EB=E(M2+1)*A2MP1/DELX                                             MARC 162
      CD(M)=CC4*A(K,M2P2)-Q(I,M2P2-1)+EB                                MARC 163
      CL(M-1)=CF4*A(K,M2)-Q(I,M2P2-1)-EB                                MARC 164
      F(M)=S(I,M2)*(CF4*A(I,M2)+Q(I,M2P2-1)+EB)+                        MARC 165
     1      S(I,M2P2)*(CC4*A(I,M2P2)+Q(I,M2P2-1)-EB)                    MARC 166
C                                                                       MARC 167
C        CALL  EQUATION SOLVER AT THIS POINT                            MARC 168
      CALL TRIDG(M     ,CL,CD,CU,F)                                     MARC 169
C                                                                       MARC 170
      DO 22 M=1,JLIM                                                    MARC 171
      J=2*M-1                                                           MARC 172
22    S(K,J)=F(M)                                                       MARC 173
C                                                                       MARC 174
C        OUTPUT SELECTION                                               MARC 175
C        FREQUENCY OF OUTPUT CONTAINED IN ISW5,ISW6,ISW7 FOR H,S,&Q     MARC 176
      IF(ISW5 .EQ. 0)      GOTO 851                                     MARC 177
      IF( NN .NE. KHCT)    GOTO 851                                     MARC 178
      CALL SPEW(1,2)                                                    MARC 179
      KHCT=KHCT+ISW5                                                    MARC 180
```

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851   IF(ISW6 .EQ. J)   GOTO 852                                    MARC 181
      IF(NN .NE. KSCT)  GOTO 852                                    MARC 182
      CALL SPEW(2,2)                                                MARC 183
      KSCT=KSCT+ISW6                                                MARC 184
852   IF(ISW7 .EQ. J)  GOTO 86                                      MARC 185
      IF(NN .NE. KQCT)  GOTO 86                                     MARC 186
      CALL SPEW(3,2)                                                MARC 187
      KQCT=KQCT+ISW7                                                MARC 188
C                                                                   MARC 189
C        MASS BALANCE                                               MARC 190
86    SUM=0.                                                        MARC 191
      DO 31 J=3,J2LIM,2                                             MARC 192
31    SUM=SUM+S(K,J)*A(K,J )                                        MARC 193
      SUM=SUM+0.5*S(K,1)*A(K,1)                                     MARC 194
      TSUM=TSUM+SUM                                                 MARC 195
C                                                                   MARC 196
C        TEST TO SEE IF OUTPUT TO A SEQUENTIAL DATASET IS SPECIFIED MARC 197
      IF(ISW1 .EQ. 1)      GOTO 4000                                MARC 198
C        OUTPUT TIME STEP RESULTS TO FILE 'MMM'                     MARC 199
      DO 400 J=1,JMAXH,2                                            MARC 200
400   HKH(J)=H(K,J)-SLD+ZO(J)+D(J)                                  MARC 201
      WRITE(MMM) (HKH(J),J=1,JMAXH,2)                               MARC 202
      WRITE(MMM) (S(K,J),J=1,JMAXH,2)                               MARC 203
      WRITE(MMM) (Q(K,J),J=2,JMAX,2)                                MARC 204
C                                                                   MARC 205
C        TEST TO SEE IF HWS OUTPUT HAS BEEN SPECIFIED               MARC 206
4000  IF(ISW2 .EQ. 1)  GOTO 4001                                    MARC 207
C        HIGH WATER SLACK CALCULATIONS                              MARC 208
      DO 40 J=1,JLIM                                                MARC 209
      IF(KEY(J))   GOTO 40                                          MARC 210
C        SIGN OF NEW 'Q' TO LP                                      MARC 211
      IF(Q(KH,2*J))  41,41,42                                       MARC 212
41    LP=.FALSE.                                                    MARC 213
      GOTO 43                                                       MARC 214
42    LP=.TRUE.                                                     MARC 215
C        TEST FOR HIGH WATER SLACK BY ZERO CROSSING OF Q, + TO -    MARC 216
```

```
43    IF(LV(J) .AND. .NOT. LP)     GOTO 44
C        NOT HWS,  SET UP FOR NEXT TRY
      LV(J)=LP
      GOTO 40
C        FOUND THE HWS
44    IHWS(J)=NN
      KEY(J)=.TRUE.
      HWS(J)=S(KH,2*J-1)
40    CONTINUE
C
C        SAVE H AND Q VALUES AT THE OCEAN FOR PRISM CALCS
4001  ISUB=(NN-1)/2
      HH(ISUB)=0.5*(H(KH,1)+H(KH,3)) + D(2)
      QQ(ISUB)=Q(KH,2)
C         END OF MAIN LOOP
C   SWAP BEFORE AND AFTER INDICES.
      ITTP=IH
      IH=KH
      KH=ITTP
   23 CONTINUE
C
      TSUM=TSUM*DX2/NMD2
      WRITE(KC,503)       TSUM
503   FORMAT(T101,'AVE MASS =',E16.6)
C
      IF(ISW2 .EQ. 1)    GOTO 46
C        OUTPUT  HWS
      DO 405 J=1,JLIM
C        IF HWS UNDEFINED, FILL WITH 999
      IF(KEY(J))    GOTO 403
      IHWS(J)=999
      HWS(J)=999.
405   CONTINUE
      CALL SPEW(4,3)
C
C        CALL TO PRISM ROUTINE
```

```
46    CALL ESNOD(JT2,NMD2,IREC,D(2),B(2),MANCO(2),QF,EEZ,HH,CQ,SZERO,XL) MARC 253
      EZ=EEZ                                                            MARC 254
      RETURN                                                            MARC 255
      END                                                               MARC 256
```

```
      SUBROUTINE TDISP
      INTEGER CASE                                                      TDIS   1
      REAL  FC(200),  BB(200),  D(200),  SS(200),  B(200),MANCC(200)    TDIS   2
      REAL  ZZ(200),  R(200),  C(200),  D4(200),  W(200)                TDIS   3
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                 TDIS   4
      REAL HOA(900),QOB(900)                                            TDIS   5
      DIMENSICN DZERO(200),EXK(200),A(2,200)                            TDIS   6
      CCMMCN KO,KIN,KKK,JJJ                                             TDIS   7
      CCMMON NOS,CASE,CELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ       TDIS   8
      COMMON D1,D2,D3,EH,EZ,EXLM,SZERC,ES                               TDIS   9
      COMMCN MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7              TDIS  10
        CCMMON H,Q,HOA,QOB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E        TDIS  11
      CCMMON /AREAS/ A,Q1                                               TDIS  12
      CCMMON /EXLIM/ JLIM,J2LIM,K,M                                     TDIS  13
      CCMMCN /T/ MMM,QF,IPF,IPE,NNN,IETM                                TDIS  14
      DATA INIT/1/                                                      TDIS  15
C                                                                       TDIS  16
C        M IS THE PREVIOLS TIME STEP                                    TDIS  17
C        K IS THE NEXT TIME STEP                                        TDIS  18
      GOTO(1,2),INIT                                                    TDIS  19
1     JLIM=JMAX/2                                                       TDIS  20
      XKFAC=(JMAX-1)*0.5                                                TDIS  21
      ETM=IETM                                                          TDIS  22
      IF(EXLM)40,41,40                                                  TDIS  23
41    J2LIM=JMAXH                                                       TDIS  24
      GOTO 42                                                           TDIS  25
40    JLIM= IFIX(EXLM/DELX/2.)+2                                        TDIS  26
      J2LIM=2*JLIM-1                                                    TDIS  27
42    INIT=2                                                            TDIS  28
      E(JMAXH)=0.                                                       TDIS  29
      J2M2=J2LIM-2                                                      TDIS  30
      FAC4=DELX/DELT*0.25                                               TDIS  31
      RETURN                                                            TDIS  32
C                                                                       TDIS  33
C        GET DZERO ON THE ODD INTERVALS                                 TDIS  34
2     XK=EZ*XKFAC/SZERO                                                 TDIS  35
                                                                        TDIS  36
```

```
      DO 10 J=1,J2LIM,2                                                 TDIS  37
      IF(J-1) 16,16,17                                                  TDIS  38
C        Q1 BY CONTINUITY                                               TDIS  39
16    H2OLD=0.5*(H(M,1)+H(M,3))                                         TDIS  40
      H2NEW=0.5*(H(K,1)+H(K,3))                                         TDIS  41
      Q1=Q(M,2)+FAC4*(B(1)*(H(K,1)-H(M,1))+B(2)*(H2NEW-H2OLD))          TDIS  42
      QODD=ABS(Q1)                                                      TDIS  43
      GOTO 18                                                           TDIS  44
C        NORMAL ... INTERIOR POINTS                                     TDIS  45
17    QODD=0.5*ABS(Q(M,J-1)+Q(M,J+1))                                   TDIS  46
18    HTEM=D(J)+0.5*(H(1,J)+H(2,J))                                     TDIS  47
      GOTO(13,13,14,13,13),CASE                                         TDIS  48
C        TRAPEZOIDAL SECTION                                            TDIS  49
14    AR=0.5*(A(1,J)+A(2,J))                                            TDIS  50
      R(J)=AR/(BB(J)+2.*HTEM*ZZ(J))                                     TDIS  51
      GOTO 15                                                           TDIS  52
C        OTHER SECTIONS                                                 TDIS  53
13    AR= BS(J)*HTEM                                                    TDIS  54
      R(J)=AR/(BS(J)+HTEM+HTEM)                                         TDIS  55
15    V=QODD/AR                                                         TDIS  56
      DZERO(J)=77.*MANCO(J)*(R(J)**0.833333)*V*ETM                      TDIS  57
10    CONTINUE                                                          TDIS  58
C                                                                       TDIS  59
C        GET EXK ON THE EVEN INTERVALS                                  TDIS  60
      DO 11 J=1,J2M2,2                                                  TDIS  61
C        TEST FOR SEAWARD POINT NEG.                                    TDIS  62
      SD=S(M,J)                                                         TDIS  63
      IF(SD) 9,9,8                                                      TDIS  64
9     EXK(J)=0.                                                         TDIS  65
      GOTO 11                                                           TDIS  66
8     EXK(J)=XK*ABS(SD-S(M,J+2))                                        TDIS  67
11    CONTINUE                                                          TDIS  68
C                                                                       TDIS  69
C        INTERPOLATE TO EVEN INTERVALS                                  TDIS  70
      DO 12 J=1,J2M2,2                                                  TDIS  71
12    E(J+1)=EXK(J)+0.5*(DZERO(J)+DZERO(J+2))                           TDIS  72
```

```
      E(1)=EXK(1)+DZERO(1)                                              TDIS  73
      GOTO(30,20),ISW4                                                  TDIS  74
20    WRITE(NNN    ) E(1),(E(J-1),J=3,J2LIM,2)                          TDIS  75
30    RETURN                                                            TDIS  76
      END                                                               TDIS  77
```

```
      SUBROUTINE   TOCNB (CD,CU,F,L,NMD2)                                TOCN   1
      INTEGER CASE                                                       TOCN   2
      REAL  FC(200),  BB(200),  D(200),  SS(200),  B(200),MANCC(200)     TOCN   3
      REAL  ZZ(200),  R(200),  C(200),  D4(200),  W(200)                 TOCN   4
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                  TOCN   5
      REAL HOA(900),QOB(900)                                             TOCN   6
      DIMENSION CD(1),CU(1),F(1)                                         TOCN   7
      DIMENSION A(2,200)                                                 TOCN   8
      COMMON KO,KIN,KKK,JJJ                                              TOCN   9
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ        TOCN  10
      COMMON D1,D2,D3,EH,EZ,EXLM,SZERO,ES                                TOCN  11
      COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7               TOCN  12
      COMMON H,Q,HOA,QOB,FQ,BB,C,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E           TOCN  13
      COMMON /T/ MMM,CF,IPF,IPE                                          TOCN  14
      COMMON /AREAS/ A,Q1                                                TOCN  15
      COMMON /EXLIM/ JD1,JD2,K,M                                         TOCN  16
      DATA INIT/1/                                                       TOCN  17
      DATA THETA/0.333333/                                               TOCN  18
C                                                                        TOCN  19
C        INITIALIZE SIGN OF PREVIOUS DISCHARGE, SMIN, COUNTER OF         TOCN  20
C        INCREMENTS SINCE FLOOD BEGAN                                    TOCN  21
C                                                                        TOCN  22
      GOTO(1,2),INIT                                                     TOCN  23
C        IF THE FIRST CYCLE BEGINS ON FLOOD SMIN MUST BE                 TOCN  24
C        ARBITRARILY DEFINED.  IT IS SET TO SZERO FOR FIRST CYCLE ONLY   TOCN  25
1     QLST=1.                                                            TOCN  26
      SMIN=SZERO                                                         TOCN  27
      NMAXM=NMAX-1                                                       TOCN  28
      NFLD=NMD2/2                                                        TOCN  29
      NEBB=0                                                             TOCN  30
      DXDT=DELX/DELT                                                     TOCN  31
      CC4=2.*(1.-THETA*0.5)*DXDT                                         TOCN  32
      CF4=2.*(THETA*0.5)*DXDT                                            TOCN  33
      INIT=2                                                             TOCN  34
C                                                                        TOCN  35
C        NORMAL ENTRY                                                    TOCN  36
2     IF(QLST*Q(M,2)) 10,20,20
```

```
C          CHANGE OF SIGN
10      IF(Q(M,2)) 11,12,12
C          TO EBB
11      NEBB=0
        GOTO 21
C          TO FLOOD
12      NFLD=1
        SMIN =S(M,1)
        GOTO 22
C          NO SIGN CHANGE
20      IF(Q(M,2)) 21,22,22
C          FLOOD
22      IF(NFLD-IPF) 23,24,24
C          WITHIN RANGE
23      SX=SMIN+(SZERO-SMIN)*NFLD/FLOAT(IPF)
        NFLD=NFLD+1
        GOTO 77
C          OUT OF RANGE
24      SX=SZERO
        GOTO 77
C          EBB
21      IF(NEBB-IPE) 25,26,26
C          WITHIN RANGE
25      NEBB=NEBB+1
        SX=SZERO
        GOTO 77
C
C          OUT OF RANGE  *** SPECIAL ROUTINE ***
C
C          Q1 AND AREAS FROM COMMON
26      A1B=(A(2,1)+A(1,1))*0.5
        A3B=(A(2,3)+A(1,3))*0.5
        EB=0.5/DELX*(E(1)*A1B-E(2)*(A1B+A3B)*0.5)
        CD(1)=CC4*A(K,1)-Q1-Q1+Q(M,2)-EB
        CU(1)=CF4*A(K,3)+Q(M,2)+EB
        F(1)=S(M,1)*(CC4*A(M,1)+Q1+Q1-Q(M,2)+EB)+
```

```
     1      S(M,3)*(CF4*A(M,3)-Q(M,2)-EB)                                TOCN  73
      GOTO 80                                                           TOCN  74
C        CALCULATE COEFFICIENTS                                         TOCN  75
77    F(1)=SX                                                           TOCN  76
      CD(1)=1.0                                                         TOCN  77
      CU(1)=0.                                                          TOCN  78
C        HOUSEKEEP                                                      TOCN  79
80    QLST=Q(M,2)                                                       TOCN  80
      RETURN                                                            TOCN  81
      END                                                               TOCN  82
```

```
      SUBROUTINE TRIDG (N,A,B,C,D)                                      TRID   1
C        ALGORITHM 24 OF ACM... BY B. LEAVENWORTH                       TRID   2
C             TRANSLATED TO FORTRAN IV BY M.L. THATCHER                 TRID   3
      REAL W, A(100),B(100),C(100),D(100)                               TRID   4
      INTEGER J,N,NM1,I                                                 TRID   5
      D(1)=C(1)/B(1)                                                    TRID   6
      W=B(1)                                                            TRID   7
      NM1=N-1                                                           TRID   8
      DO 1 J=1,NM1                                                      TRID   9
      B(J)=C(J)/W                                                       TRID  10
      W= B(J+1)-A(J)*B(J)                                               TRID  11
1     D(J+1)=(D(J+1)-A(J)*D(J))/W                                       TRID  12
      DO 2 J=1,NM1                                                      TRID  13
      I=N-J                                                             TRID  14
2     D(I)=D(I)-B(I)*C(I+1)                                             TRID  15
      RETURN                                                            TRID  16
      END                                                               TRID  17
```

```
      SUBROUTINE ESNOC(DT,NT,NX,C,B,XN,FRESH,EEZ,H,Q,S,XL)
C
C        THIS IS A MODIFICATION OF SUBROUTINE 'PRISM'
C        WHICH CONVERTS THE ESTUARY NO. TO A DENSIMETRIC ONE AND
C        EVALUATES THE GROSS DISPERSION PARAMETER 'K' IN TERMS
C        OF (U*L)
C        CALCULATION OF TIDAL PRISM, MAX. VELOCITY, DENSIMETRIC FROUDE
C        Q(F)  AND THE ESTUARY NUMBER(DENSIMETRIC)
      REAL          Q(450),H(450),V(450)
      COMMON KO
      COMMON /CEPT/ XNCPT
C        CONST FOR CONVERTING SALINITY TO DENSITY DEFINED BELOW
      DATA TCONS/0.75/
      VOLB(Q1,Q2)=Q2*Q2*DT*0.5/(Q2-Q1)
      VOLN(Q1,Q2)=0.5*(Q1+Q2)*DT
      VOLL(Q1,Q2)= Q1*Q1*DT*0.5/(Q1-Q2)
C
      PT=0.
      DRO=TCONS*S/1000.
      I=1
      IF(Q(I)) 1,2,2
C        STARTS GOING NEGATIVE
1     I=I+1
      IF(Q(I) .LT. 0.)  GOTO 1
      PT=VOLB(Q(I-1),Q(I))
11    I=I+1
      IF(I .GT. NT)     GOTO 30
      IF(Q(I) .LT. 0.)   GOTO 12
      PT=PT+VOLN(Q(I-1),Q(I))
      GOTO 11
12    PT=PT+VOLL(Q(I-1),Q(I))
      GOTO 30
C        STARTS GOING POSITIVE
2     I=I+1
      IF(Q(I) .LT. 0.)   GOTO 20
      PT=PT+VOLN(Q(I-1),Q(I))
```

```
      GOTC 2                                                            ESNO  37
20    PT=PT+VOLL(Q(I-1),Q(I))                                           ESNO  38
21    I=I+1                                                             ESNO  39
      IF(I .GT. NT)      GOTO 30                                        ESNO  40
      IF(Q(I) .LT. 0.)  GOTO 21                                         ESNO  41
      PT=PT+VOLB(Q(I-1),Q(I))                                           ESNO  42
22    I=I+1                                                             ESNO  43
      PT=PT+VCLN(Q(I-1),Q(I))                                           ESNO  44
      IF(I .LT. NT)   GOTO 22                                           ESNO  45
C                                                                       ESNO  46
C        FIND VMAX                                                      ESNO  47
30    NTM1=NT-1                                                         ESNO  48
      DO 40 I=1,NTM1                                                    ESNO  49
40    V(I)=Q(I)/B/(H(I)+H(I+1))*2.                                      ESNO  50
      V(NT)=Q(NT)/B/(H(NT)+H(1))*2.                                     ESNO  51
      VMAX=0.                                                           ESNO  52
      DO 41 I=1,NT                                                      ESNO  53
      IF(ABS(V(I)) .LT. VMAX)  GCTO 41                                  ESNO  54
      IH=I                                                              ESNO  55
      VMAX=ABS(V(I))                                                    ESNO  56
41    CONTINUE                                                          ESNO  57
      TIME=IH*DT/3600.                                                  ESNO  58
      WRITE(KO,200) PT,VMAX,TIME                                        ESNO  59
200   FORMAT('OPRISM=',E16.7,' CUFT',16X,'VMAX=',F10.4,' FT/SEC',3X,    ESNO  60
     1       'AT',F7.2,' HRS FRCM BEGINNING OF CYCLE')                  ESNO  61
      IF(IH .EQ. NT)  H(NT+1)=H(1)                                      ESNO  62
      RH=B*(H(IH)+H(IH+1))*0.5/(B+H(IH)+H(IH+1))                        ESNO  63
      FR=VMAX/SQRT(32.2*D)                                              ESNO  64
      FRDS=FR/SQRT(DRC)                                                 ESNO  65
      WRITE(KC,202) FRDS,FRESH                                          ESNO  66
202   FORMAT(' DENSIMETRIC FROUDE NO.=',F1C.6,10X,                      ESNO  67
     1       'SUM OF QF''S=',F10.3,' CU.FT/SEC')                        ESNO  68
      T=NT*DT                                                           ESNO  69
      ESNC= PT*FR*FR/FRESH/T/DRO                                        ESNO  70
C        CORRELATICN FOR K/(UL)=F(ESNC)                                 ESNO  71
      EEZ=VMAX*XL*XNCPT  *(ESNC**(-.25))                                ESNO  72
```

```
      WRITE(KC,203) ESNO,EEZ                                            ESNO  73
203   FORMAT(' DENSIMETRIC ESTUARY NO.=',F9.3,10X,'K FOR THE NEXT',     ESNO  74
     1       ' CYCLE IS',F10.2,' SQFT/SEC')                             ESNO  75
      RETURN                                                            ESNO  76
      END                                                               ESNO  77
```

```
      SUBROUTINE SPEW(KEY,IL)                                           SPEW   1
C        ARGUMENT 'KEY' IS 1 FOR H, 2 FOR S, 3 FOR Q, AND 4 FOR HWS     SPEW   2
C        ARGUMENT 'IL' IS 1 FOR FINAL CONDITION OUTPUT                  SPEW   3
C                         2 FOR NORMAL OUTPUT                           SPEW   4
C                         3 FOR HWS                                     SPEW   5
C                         4 FOR I.C.                                    SPEW   6
      INTEGER CASE                                                      SPEW   7
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCO(200)      SPEW   8
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)                 SPEW   9
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)                 SPEW  10
      REAL HOA(900),QOB(900)                                            SPEW  11
      DIMENSION HWS(100),ZO(200),DUM(200),IHWS(100),KNO(200)            SPEW  12
      COMMON KO,KIN,KKK,JJJ                                             SPEW  13
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ       SPEW  14
        COMMON D1,D2,D3,EH,EZ,EXLM,SZERO,ES                             SPEW  15
        COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7            SPEW  16
      COMMON H,Q,HOA,QOB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E          SPEW  17
      COMMON /EXLIM/ JLIM,J2LIM,K,M                                     SPEW  18
      COMMON/SL/SLD,ZO                                                  SPEW  19
      COMMON /OUTP/ NC,NN,HWS,NTCT,IHWS                                 SPEW  20
      DATA INIT/1/                                                      SPEW  21
C                                                                       SPEW  22
C        NUMBER SEQUENTIAL ARRAY                                        SPEW  23
      GOTO(1000,2000),INIT                                              SPEW  24
1000  DO 1001 J=1,200                                                   SPEW  25
1001  KNO(J)=J                                                          SPEW  26
      INIT=2                                                            SPEW  27
      T=(NMAX-1)*DELT/3600.                                             SPEW  28
      TFAC=T/(NMAX-1)                                                   SPEW  29
C                                                                       SPEW  30
C        SET UP THE 'FROM WHENCE' CONDITIONS                            SPEW  31
2000  GOTO(2001,2002,2003,2004),IL                                      SPEW  32
C        FROM MAIN,  OUTPUT FINAL CONDITIONS                            SPEW  33
2001  NP=1                                                              SPEW  34
      IT=M                                                              SPEW  35
      NTC=NTCT                                                          SPEW  36
```

```
      GOTO 2005                                                         SPEW  37
C        FROM MARCH,  NORMAL OUTPUT                                     SPEW  38
2002  NP=NN                                                             SPEW  39
      IT=K                                                              SPEW  40
      NTC=NC                                                            SPEW  41
      GOTO 2005                                                         SPEW  42
C        FROM MARCH, HWS                                                SPEW  43
2003  NP=1                                                              SPEW  44
      NTC=NC                                                            SPEW  45
      GOTO 2005                                                         SPEW  46
C        FROM OSIN,  I.C. READ IN                                       SPEW  47
2004  NP=1                                                              SPEW  48
      NTC=1                                                             SPEW  49
      IT=1                                                              SPEW  50
      J2LIM=JMAXH                                                       SPEW  51
C                                                                       SPEW  52
C                                                                       SPEW  53
2005  ISTOP=1                                                           SPEW  54
C        TIME CALCULATION                                               SPEW  55
      IF(KEY .EQ. 3)   NP=NP+1                                          SPEW  56
      CYHR=(NP-1)*TFAC                                                  SPEW  57
      DAY=((NTC-1)*T+CYHR)/24.                                          SPEW  58
      IDAY=DAY                                                          SPEW  59
      DAYHR=(DAY-IDAY)*24.                                              SPEW  60
      WRITE(KC,200) NTC,CYHR,IDAY,DAYHR                                 SPEW  61
200   FORMAT('0TIDAL CYCLE',I4,2X,F7.3,' HOURS',5X,'DAY',I4,2X,         SPEW  62
     1       F7.3,' HOURS')                                             SPEW  63
      GOTO(1,2,3,4),KEY                                                 SPEW  64
C        H-  ELEVATION  WRT  MSL                                        SPEW  65
1     WRITE(KC,201)                                                     SPEW  66
201   FORMAT('+',T65,'INSTANTANEOUS SURFACE ELEVATION WITH RESPECT TO ',SPEW  67
     1       'MSL, FT')                                                 SPEW  68
      JM=JMAXH                                                          SPEW  69
      IF(IL .NE. 2)   GOTO 70                                           SPEW  70
      DO 10 J=1,JMAXH,2                                                 SPEW  71
10    DUM(J)=H(IT,J)-SLO+ZO(J)+C(J)                                     SPEW  72
```

```
      GOTO 70
12    WRITE(KO,202) (KNC(J),J=NS,NF,2)
202   FORMAT(' STATIONS',I5,13I8)
      IF(IL .EQ. 2)  GOTO 1212
      WRITE(KO,203) (H(IT,J),J=NS,NF,2)
203   FORMAT(' ELEV.    ',14F8.3)
      GOTO 80
1212  WRITE(KO,203) (DUM(J),J=NS,NF,2)
      GOTO 80
C        S-  SALINITY
2     WRITE(KO,220)
220   FORMAT('+',T65,'INSTANTANEOUS SALINITIES IN PPT')
      JM=J2LIM
      GOTO 70
21    WRITE(KO,202) (KNC(J),J=NS,NF,2)
      WRITE(KO,207) (S(IT,J),J=NS,NF,2)
207   FORMAT(' SALINITY',14F8.3)
      GOTO 80
C        Q-       DISCHARGE
3     WRITE(KO,230)
230   FORMAT('+',T65,'INSTANTANEOUS DISCHARGES IN CFS')
      NS=2
      NF=20
33    IF(NF .LT. JMAX)  GOTO 31
      ISTOP=2
      NF=JMAX
31    WRITE(KO,205) (KNC(J),J=NS,NF,2)
205   FORMAT(' STATIONS',2X,I5,9I10)
      WRITE(KO,204) (Q(IT,J),J=NS,NF,2)
204   FORMAT(' DISCHARGE ',10F10.0)
      IF(ISTOP .EQ. 2)  RETURN
      NS=NF+2
      NF=NS+18
      GOTO 33
C        S-  HWS
4     WRITE(KO,240)
```

```
240   FORMAT('+',T65,'HIGH WATER SLACK SALINITIES IN PPT')                SPEW 109
      JM=J2LIM                                                            SPEW 110
C        GET TIME OF HWS IN HOURS FROM BEGINNING OF CYCLE                 SPEW 111
C        AND SET THE CODE IN CASE SOME HWS NOT DEFINED                    SPEW 112
      ICODE=0                                                             SPEW 113
      DO 42 J=1,JLIM                                                      SPEW 114
      IF(IHWS(J) .NE. 999)   GOTO 45                                      SPEW 115
      DUM(J)=999.                                                         SPEW 116
      HWS(J)=999.                                                         SPEW 117
C        THIS WILL CAUSE 999. TO PRINT ON OUTPUT                          SPEW 118
C        SET THE CODE                                                     SPEW 119
      ICODE=1                                                             SPEW 120
      GOTO 42                                                             SPEW 121
45    DUM(J)=(IHWS(J)-1)*TFAC                                             SPEW 122
42    CONTINUE                                                            SPEW 123
      IF(ICODE .EQ. 1)  WRITE(KO,242)                                     SPEW 124
242   FORMAT(' 999. INDICATES     THAT NO HWS WAS FOUND FOR THAT STATIONSPEW 125
     1 ')                                                                 SPEW 126
      GOTO 70                                                             SPEW 127
41    WRITE(KO,202) (KNC(J),J=NS,NF,2)                                    SPEW 128
C        AS HWS IS STORED COMPACTLY,  REFORMULATE INICES                  SPEW 129
      NS1=(NS+1)/2                                                        SPEW 130
      NF1=(NF+1)/2                                                        SPEW 131
      WRITE(KO,243) (DUM(J),J=NS1,NF1)                                    SPEW 132
243   FORMAT(' TIME HRS',14F8.3)                                          SPEW 133
      WRITE(KO,207) (HWS(J),J=NS1,NF1)                                    SPEW 134
      GOTO 80                                                             SPEW 135
C                                                                         SPEW 136
C        GET INDICES                                                      SPEW 137
70    NS=1                                                                SPEW 138
      NF=27                                                               SPEW 139
75    IF(NF .LT. JM)   GOTO(12,21,55,41),KEY                              SPEW 140
      NF=JM                                                               SPEW 141
      ISTOP=2                                                             SPEW 142
      GOTO(12,21,55,41),KEY                                               SPEW 143
80    IF(ISTOP .EQ. 2) RETURN                                             SPEW 144
```

```
      NS=NF+2                                                           SPEW 145
      NF=NS+26                                                          SPEW 146
      GOTO 75                                                           SPEW 147
55    WRITE(KO,255)                                                     SPEW 148
255   FORMAT(' PROG. ERR. IN SPEW')                                     SPEW 149
      CALL EXIT                                                         SPEW 150
      END                                                               SPEW 151
```

```
      SUBROUTINE ERRL(KEY)                                              ERRL   1
      COMMON KO                                                         ERRL   2
C                                                                       ERRL   3
C        THIS IS AN ERROR HANDLING ROUTINE, IT ISSUES MESSAGES TO HELP  ERRL   4
C        THE USER IDENTIFY THE CAUSE OF INPUT AND OTHER ERRORS          ERRL   5
      DATA JINX/0/                                                      ERRL   6
      IF(KEY .EQ. 8)    GOTO 8                                          ERRL   7
      WRITE(KO,200)                                                     ERRL   8
200   FORMAT('0 *** SALINITY INTRUSION PROGRAM ERROR ***')              ERRL   9
      IF((KEY .LT. 1) .OR. (KEY .GT. 10))       GOTO 60                 ERRL  10
       GOTO(1,2,3,4,5,6,7,8,9,10),KEY                                   ERRL  11
1     WRITE(KO,201)                                                     ERRL  12
201   FORMAT(' NUMBER OF SECTIONS MUST BE EVEN')                        ERRL  13
      GOTO 500                                                          ERRL  14
2     WRITE(KO,202)                                                     ERRL  15
202   FORMAT(' NUMBER OF TIME INTERVALS MUST BE EVEN')                  ERRL  16
      GOTO 500                                                          ERRL  17
3     WRITE(KO,203)                                                     ERRL  18
203   FORMAT(' CASE IS NOT 1 THRU 5')                                   ERRL  19
      GOTO 555                                                          ERRL  20
4     WRITE(KO,204)                                                     ERRL  21
204   FORMAT(' NEGATIVE INTRUSION LENGTH IN INPUT')                     ERRL  22
      GOTO 555                                                          ERRL  23
5     WRITE(KO,205)                                                     ERRL  24
205   FORMAT(' COLUMN 1  DOES NOT CONTAIN H,Q OR S')                    ERRL  25
      GOTO 500                                                          ERRL  26
6     WRITE(KO,206)                                                     ERRL  27
206   FORMAT(' SEQUENCING ERROR IN INPUT STREAM')                       ERRL  28
      GOTO 555                                                          ERRL  29
7     WRITE(KO,207)                                                     ERRL  30
207   FORMAT(' INTERVAL FOR OUTPUT MUST BE EVEN',/)                     ERRL  31
C                                                                       ERRL  32
C        CHECK FOR INPUT ERRORS                                         ERRL  33
8     IF(JINX .NE. 0) GOTO 80                                           ERRL  34
      WRITE(KO,208)                                                     ERRL  35
208   FORMAT('1 CALCULATION BEGINS',/)                                  ERRL  36
```

```
      RETURN                                                            ERRL  37
8C    WRITE(KO,2C80) JIAX                                               ERRL  38
2C80   FORMAT('0',I3,' INPUT ERRCRS DETECTED, CALCULATION ABORTED',/)   ERRL  39
      CALL EXIT                                                         ERRL  40
9     WRITE(KO,209)                                                     ERRL  41
209   FORMAT(' WATER SURFACE BELCW THE BOTTOM WHICH INDICATES A ',      ERRL  42
     1        'PROBABLE NUMERICAL INSTABILITY.',/,' THE REMEDY MAY WELL',ERRL  43
     2        ' BE A SMALLER CELTA-T')                                  ERRL  44
      GOTO 555                                                          ERRL  45
10    WRITE(KC,210)                                                     ERRL  46
210   FORMAT(' THE WATER SURFACE IN THE STCRAGE AREA HAS FALLEN BELOW', ERRL  47
     1        ' THE BOTTOM.  THIS IS NOT NECESSARILY AN INSTABILITY,',/, ERRL  48
     2        ' BUT IS PROBABLY A PROBLEM IN SCHEMATIZATION')           ERRL  49
      GOTO 555                                                          ERRL  50
6C    WRITE(KC,298) KEY                                                 ERRL  51
298   FORMAT(' ERROR CODE UNRECOGIZED, IT IS',I10)                      ERRL  52
      GOTO 555                                                          ERRL  53
555   WRITE(KC,299)                                                     ERRL  54
299   FORMAT('0 FATAL ERROR, EXIT TAKEN',/)                             ERRL  55
      CALL EXIT                                                         ERRL  56
5C0   JINX=JINX+1                                                       ERRL  57
      RETURN                                                            ERRL  58
      END                                                               ERRL  59
```

```
      SUBROUTINE SEQTST(J,ISEQ)                                         SEQT    1
C        TEST SEQUENCING                                                SEQT    2
      ITST1=ISEQ-J                                                      SEQT    3
      IF(J .EQ. 1) ITEST=ITST1                                          SEQT    4
      IF(ITEST .NE. ITST1)   CALL ERRL(6)                               SEQT    5
      RETURN                                                            SEQT    6
      END                                                               SEQT    7
```

Appendix II

Brief Description of Formats Used in Input

Fields are of three types: characters, integers and numbers with decimal points. A field is always given a width. Field specifications can be repeated n times by placing n in front of the field specification. For example 20A4 repeats a character field (A) of field width 4 a total of 20 times. This means effectively that all 80 columns (20 x 4) of the card are available for character information. The formats used here are:

Aw - a character field of width "w"

Iw - an integer field of width "w"

Fw.d - a decimal number field of width "w" and with a decimal point and "d" digits after the decimal point

nX - a spacing between fields of "n" columns

(There is one Ew.d format, but it will not be discussed.)

The integer specification contains the restraint that the number punched must be located all the way to the right of the field. This is called "right justified". For example the number 7 in a field of I5 must be punched in the 5th column. (The machine takes blank columns as zeros.)

The decimal specification requires a decimal point, but the location of the number within the field is completely up to the user as long as the decimal point is included.

As a final example the format 2F10.d, I5,5X, F10.d would require the first two fields to be decimal numbers of 10 columns each, then a 5 column field for an integer number, then skip 5 columns and finally a last decimal field of 10 columns.

Appendix III

A Plotting Program Using a CALCOMP Plotter

III.1 Introduction

As the results produced by the computer program are essentially a time series of elevations, η, salinities, S, and discharges Q at each station the presentation of results in graphical form is an obvious advantage. The CALCOMP plotter is especially well suited for such an application because it is widely available and because it is a drum plotter permitting an abscissa of great length.

The plotting program is written in FORTRAN IV and utilizes the CALCOMP subroutines described fully in Ref. 4.

The subroutines used are modifications of those described in Ref. 5, however the modifications are minor. Most data processing installations with CALCOMP plotter facilities have made some modifications to the basic subroutines and the user is advised to consult the programming staff of his particular installation for assistance in rendering the plotting program compatible.

III.2 Instructions for Use of the Plotting Program

The user must have specified the KEEP option in card E1 of the Salinity Intrusion Program, thereby generating a sequential data set such as a magnetic tape file which will serve as the source of data for the plotting program.

The user can plot any number of frames, each frame will consist of up to 8 curves of one variable, η, S or Q and any number of individual points corresponding to each curve.

The input data and its formats are described as follows:

Card	Description	Format
1	The number of frames, right justified	I5
	For each frame:	
A1	Field 1: (right justified) Number of Sections (even)	I5
	Field 2: Total Length in Feet	F10.d
A2	Field 1: (right justified) Number of Time Intervals	I5
	per Cycle (even). Field 2: Tidal Period in Seconds	F10.d
A3	Field 1: Number of Tidal Cycles Being Plotted.	I5
	Field 2: Plot Length in Inches	F10.d
A4	Field 1: Maximum Ordinate (η, S or Q)	F10.d

Card	Description	Format
	Field 2: Plot height in inches which corresponds to the maximum ordinate	F10.d
A5	Field 1: The letter H, S, or Q which determines the variable to be plotted (Elevation = H, Salinity = S, and Discharge = Q.)	A1
	Field 2: Number of Stations to be Plotted	I4
	Field 3: Place a number in Column 10 if points are to be plotted from card input. If left blank just the curves are plotted.	I5
A6	Fields 1 through 8: In each field starting from the left, punch the location of the station(s) to be plotted (feet from estuary entrance).	8F10.d
	If points are to be plotted as well as the curves, then supply points corresponding to <u>each</u> curve as follows:	
B1	Field 1: Number of Points of a Particular Symbol	I5
	Field 2: Symbol Code Described in Figure III.1.	I5
	For each point a card:	
C1,2 etc.	Field 1: Time of observation in days, assuming that the 1.0 days means 1200 hrs. from the beginning of the first tidal cycle	F10.d
	Field 2: Value of the observation	F10.d

An example of such a plot is given by the following listing which is of the FORTRAN program and input deck. The resulting plot is shown in Figure III.2.

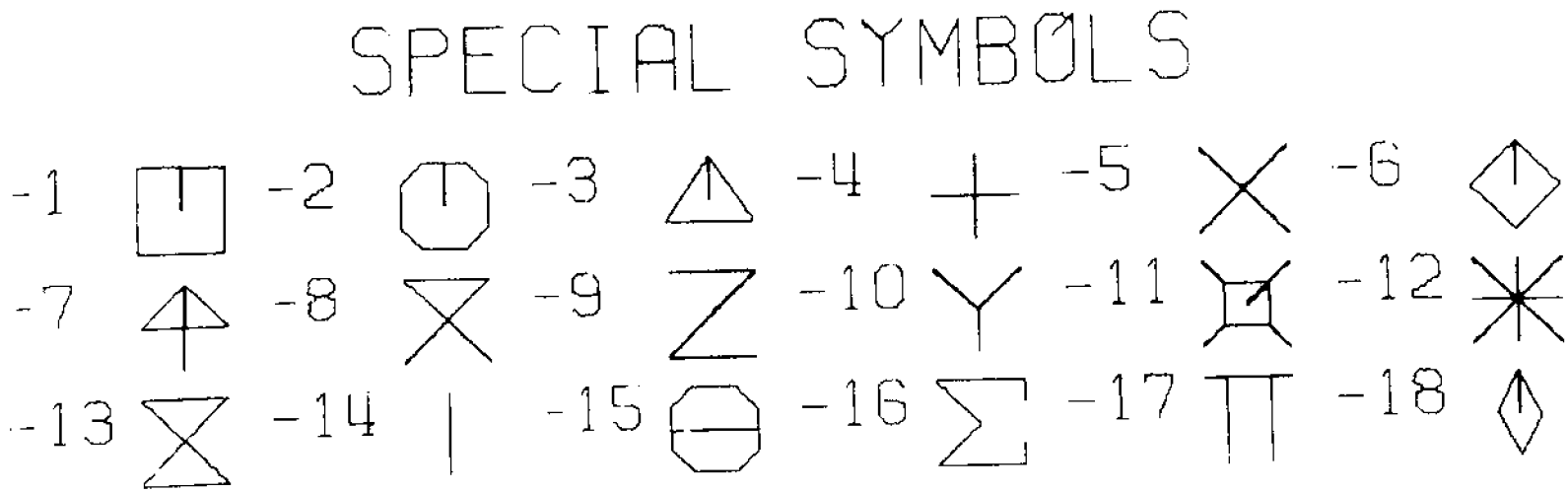

Figure III.1 Symbol Codes for M.I.T. Calcomp Subroutines

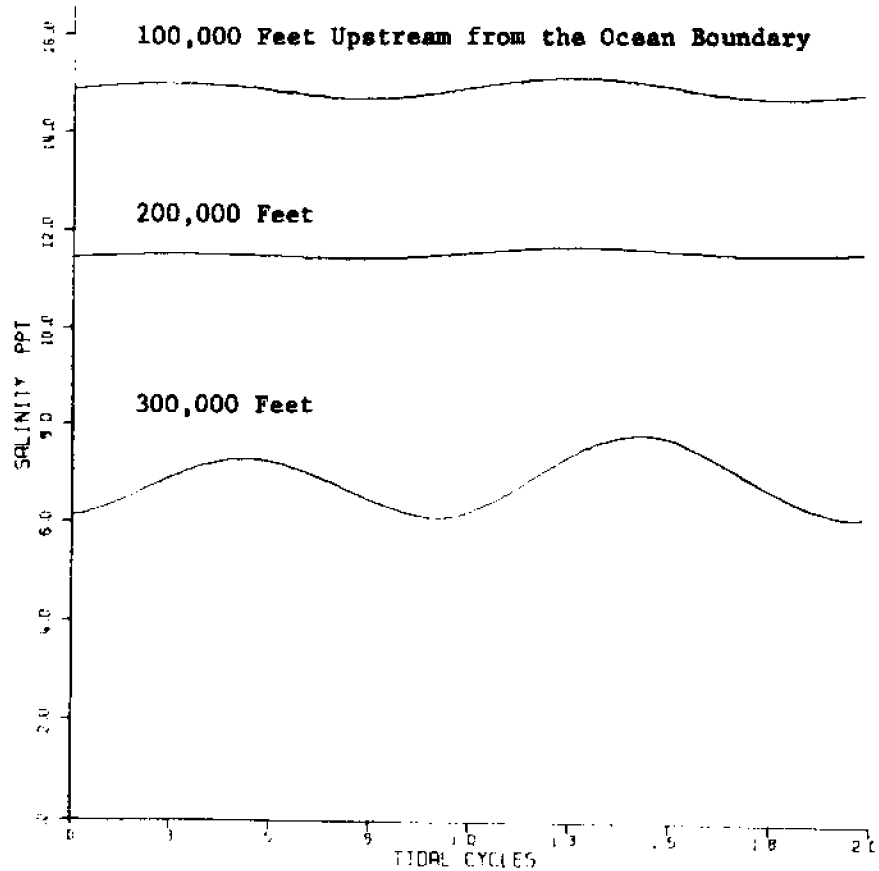

Figure III.2 Typical Plot

Table III.1

Listing of Plotting Program and Test Case

```
C                                                                       PLOT   1
C                                                                       PLOT   2
C        A PLOT LENGTH OF ABOUT 25 INCHES AT 50 PTS./INCH IS DIMENSIONEDPLOT   3
C        IN THE MATRIX 'SAVE'                                           PLOT   4
      REAL F(8),HSQ(100),Z(100),SAVE(8,1250),XO(1250)                   PLOT   5
      REAL ST(8),YLABEL(4),DLAB(3,4)                                    PLOT   6
      INTEGER KID(3),NS(8)                                              PLOT   7
      DIMENSION              UGDS(100),VGDS(100)                        PLOT   8
      DATA DLAB/'ELEV','SALI','DISC','ATIO','NITY','HARG',              PLOT   9
     1      'N  F','  PP','E  C','T   ','T   ','FS  '/                  PLOT  10
      DATA KID/'H','S','Q'/,KIN,KO,KU/5,6,1/                            PLOT  11
C        SET PLOT DENSITY IN DATA STATEMENT, IN POINTS PER INCH         PLOT  12
      DATA SDEN/50./                                                    PLOT  13
C        DEFINE VARIABLE KPROG =3, FOR H,S,Q, OR =2 FOR H AND Q ONLY    PLOT  14
      DATA KPROG/3/,IOOD/2/                                             PLOT  15
C                                                                       PLOT  16
C        READ THE NUMBER OF FRAMES                                      PLOT  17
      CALL NEWPLT('48238','C910','WHITE ','BLACK')                      PLOT  18
      READ(KIN,100) NOPLT                                               PLOT  19
      DO 55 IPLCT=1,NOPLT                                               PLOT  20
C                                                                       PLOT  21
      READ(KIN,100) NX2,XLT,NT2,T,NTC,PL                                PLOT  22
  100 FORMAT(I5,F10.0)                                                  PLOT  23
      NX=NX2/2                                                          PLOT  24
      XX=2.*XLT/(NX2-1)                                                 PLOT  25
      IF(2*NX .EQ. NX2)       GOTO 311                                  PLOT  26
C        CASE WITH ODD NUMBERED STATIONS AS UPSTREAM END BC BY ELEVATIONPLOT  27
      IOOD=1                                                            PLOT  28
      NX=NX+1                                                           PLOT  29
  311 NT=NT2/2                                                          PLOT  30
      IF(2*NT .NE. NT2)     GOTO 552                                    PLOT  31
      READ(KIN,102) SCL,YL                                              PLOT  32
      READ(KIN,101) ID,NSTA,IPCINT                                      PLOT  33
  101 FORMAT(A1,I4,I5)                                                  PLOT  34
      READ(KIN,102) (ST(I),I=1,NSTA)                                    PLOT  35
  102 FORMAT(8F10.0)                                                    PLOT  36
```

```
C                                                                       PLOT  47
C        PRINT BACK JA INPUT                                            PLOT  48
2      WRITE(KO,300) NTC,PL,YL                                          PLOT  49
300    FORMAT('1',T7,'CALCOMP  PLOTTING  FOR',I5,'  TIDAL CYCLES',/,    PLOT  50
     1        T3,'PLOT LENGTH =',F5.1,' INCHES  HEIGHT =',F5.2,' INCHES')PLOT  51
       WRITE(KO,301) NT2,NX2,SCL,XX                                     PLOT  52
301    FORMAT('0',I6,' TIME INCR. PER CYCLE',I6,' DISTANCE STATIONS',   PLOT  53
     1        /,T4,'MAX. ORDINATE =',F11.1,/,T4,                        PLOT  54
     2        'DISTANCE BETWEEN STATIONS =',F8.0,' FEET',//             PLOT  55
     3        ,T6,'LOCATION',T19,'DISTANCE',/,T7,'NUMBER',T20,'(FEET)') PLOT  56
       WRITE(KO,304) (DLAB(IN,J),J=1,4)                                 PLOT  57
304    FORMAT('0PLOT OF ',4A4)                                          PLOT  58
       DO 20 I=1,NSTA                                                   PLOT  59
       WRITE(KO,302) I,ST(I)                                            PLOT  60
302    FORMAT(T9,I3,T15,F3.0)                                           PLOT  61
C                                                                       PLOT  62
C        FOR 'C' SHIFT ALIGNMENT DELTA-X/2                              PLOT  63
       IF(IN .NE. KPROG)    GOTO 20                                     PLOT  64
       ST(I)=ST(I)-XX/2.                                                PLOT  65
20     CONTINUE                                                         PLOT  66
C                                                                       PLOT  67
C        CALCULATE SAMPLING INTERVAL 'IR'                               PLOT  68
       NOPTS=NTC*NT                                                     PLOT  69
       DEN=NOPTS/PL                                                     PLOT  70
       IR=1                                                             PLOT  71
       IF(DEN .GT. SDEN)      IR=DEN/SDEN                               PLOT  72
```

```
      WRITE(KC,303) IR
303   FORMAT('0 SAMPLING EVERY',I4,' POINTS')
C        FIND LAND SIDE OF INCR. FOR EACH STATION
      DO 6 I=1,NSTA
      DO 7 J=1,NX
      IF(ST(I) .EQ. 0.)  GOTO 8
      IF(XX*(J-1) .GE. ST(I))    GOTO 8
      GOTO 7
8     NS(I)=J
      IF(J .EQ. 1)    NS(I)=J+1
      JM2=NS(I)-2
      F(I)=(ST(I)-XX* JM2 )/XX
      GOTO 6
7     CONTINUE
      WRITE(KC,700)
700   FORMAT('0 STATION OUT OF RANGE')
      CALL EXIT
6     CONTINUE
C
C        SET YMIN AND Y-LABEL
      DO 3 I=1,4
3     YLABEL(I)=DLAB(IN,I)
      GOTO (4,5,4),IN
4     YMIN=-SCL
      DY=2.*SCL/YL
      GOTO 9
5     YMIN=0.
      DY=SCL/YL
C        THE INCREMENT IS IN TIDAL CYCLES
9     XINCR=1./NT*IR
      DX=NTC/PL
      XMAX=NTC
      NDX=1
      NDY=1
      KXY=0
C
```

```
C          ADJUST FILE LOCATION IF CASE IS FOR H QND Q ONLY
      IF((KPROG .EQ. 2) .AND. (IN .EQ. 3))       IN=2
C
C     BEGIN PLOTTING
      CALL AXIS(0.,0.,'TIDAL CYCLES',12,PL,0.,0.,DX,NDX,KXY,1.)
      CALL AXIS(0.,0.,YLABEL,16,YL,90.,YMIN,DY,NDY,KXY,1.)
      CALL PLOT(0.,0.,3)
C
      X=0.
      IOUT=0
      IC=1
C          LOOP BY TIDAL CYCLE
      DO 500 ITC=1,NTC
C          LOOP BY TIME INCREMENTS
      DO 100 I=1,NT
      DO 11 N=1,KPROG
      LRECL=NX
      IF(IDOS .EQ. 1 .AND. N .EQ. KPROG)    LRECL=NX-1
      READ(KU) (HSQ(J),J=1,LRECL)
      IF(N .NE. IN)      GOTO 11
      DO 110 J=1,NX
110   Z(J)=HSQ(J)
11    CONTINUE
      IF(IC .NE. 1)        GOTO 31
      IOUT=IOUT+1
      IF(IOUT .LE. 1250)    GOTO 24
      WRITE(KO,224)
224   FORMAT(' TO MANY POINTS. SEE PROGRAM TO CHANGE DIMENSION OF ',
     1        '''SAVE'', AND THIS TEST')
      GOTO 555
C          BY STATION
24    DO 25 M=1,NSTA
      MU=NS(M)
      ML=MU-1
      Y= Z(ML)+F(M)*(Z(MU)-Z(ML))
      IF( M .GT. 1)     GOTO 25
```

```
      XO(ICUT)=X                                                        PLOT 145
      IF( X .GT. XMAX)       GOTO 50                                    PLOT 146
      X=X+XINCR                                                         PLOT 147
25    SAVE(M,IOUT)=Y                                                    PLOT 148
      IF(ABS(Y) .GT. SCL)       GOTO 50                                 PLOT 149
30    IC=IC+1                                                           PLOT 150
      IF(IC .GT. IR)       IC=1                                         PLOT 151
1000  CONTINUE                                                          PLOT 152
500   CONTINUE                                                          PLOT 153
      DO 12 M=1,NSTA                                                    PLOT 154
      WRITE(KO,2001) M,ST(M)                                            PLOT 155
2001  FORMAT('1STATION NO.',I5,' AT',F10.0,' FEET',//)                  PLOT 156
      WRITE(KO,2002) (XO(J),SAVE(M,J),J=1,IOUT)                         PLOT 157
2002  FORMAT(F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,    PLOT 158
     1       F7.3,F12.3)                                                PLOT 159
      DO 23 I=1,IOUT                                                    PLOT 160
23    CALL PLOT1(XO(I)/DX,(SAVE(M,I)-YMIN)/DY,2)                        PLOT 161
      IF(IPOINT .EQ. 0)  GOTO 12                                        PLOT 162
C                                                                       PLOT 163
C        READ IN THE NO. OF POINTS AND PLOT CODE                        PLOT 164
C        IF CURVE HAS NO POINTS THEN ENTER ZERO (0)                     PLOT 165
      READ(KIN,103) NPT,NCODE                                           PLOT 166
103   FORMAT(2I5)                                                       PLOT 167
      WRITE(KO,221) T,NPT                                               PLOT 168
221   FORMAT(//,' PERIOD=',F8.0,' SEC',I5,' POINTS')                    PLOT 169
      IF( NPT .EQ. 0)     GOTO 12                                       PLOT 170
      IF( NCODE .EQ. 0)     NCODE =-12                                  PLOT 171
      DO 1002 J=1,NPT                                                   PLOT 172
      READ(KIN,102) XX,Y                                                PLOT 173
C                                                                       PLOT 174
C        CONVERT THE DAY NUMBER TO TIDAL CYCLES, CENTERING THE          PLOT 175
C        DAILY OBSERVATION AT 1200 HRS,  AND ASSUMING THAT T=0          PLOT 176
C        IS AT 0000 HRS OF THE FIRST DAY.                               PLOT 177
      X=((XX-1.)*86400.++3200.)/T                                       PLOT 178
      WRITE(KO,222) X,XX,Y                                              PLOT 179
222   FORMAT(5X,F7.1,2F7.2)                                             PLOT 180
```

```
      UGDS(J)=X/DX                                                      PLOT 181
1[illegible] 2  VGDS(J)=(Y-YMIN)/DY                                     PLOT 182
      CALL GRAPH(UGDS,VGDS,-NPT,0.14,NCODE)                             PLOT 183
12    CALL PLOT1(0.,0.,3)                                               PLOT 184
      REWIND KU                                                         PLOT 185
      CALL PLOT1(PL+3.,0.,-3)                                           PLOT 186
55    WRITE(KC,201)                                                     PLOT 187
201   FORMAT(' PLOTTED')                                                PLOT 188
      CALL ENDPLT                                                       PLOT 189
      GOTO 555                                                          PLOT 190
552   WRITE(KC,2552)                                                    PLOT 191
2552  FORMAT('UNU. TIME INTERVALS NOT EVEN')                            PLOT 192
      GOTO 555                                                          PLOT 193
50    WRITE(KO,501)M,I,Y,X                                              PLOT 194
501   FORMAT(' EDC',I3,' T INCR.',I1[illegible],' Y=',E16.6,' X=',E16.6,/,  PLOT 195
     1        ' X  OR  Y   OUT OF RANGE,  EXIT TAKEN')                  PLOT 196
555   CALL EXIT                                                         PLOT 197
      END                                                               PLOT 198
```

```
    1
   40 603768.
  120 44642.
    2  8.
 18.       9.
S   3
100000.   2[illegible]000.   3[illegible]000.
```