SEA GRANT PROJECT OFFICE

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,

$$b \frac{\partial h}{\partial t} + \frac{\partial Q}{\partial x} - q = 0 \tag{1-1}$$

and the longitudinal momentum equation,

$$\frac{\partial Q}{\partial t} + u \frac{\partial Q}{\partial x} + Q \frac{\partial u}{\partial x} + g \frac{\partial h}{\partial x} A + g \frac{Ad_c}{\rho} \frac{\partial \rho}{\partial x} + g \frac{Q|Q|}{AC^2 R_h} = 0 \tag{1-2}$$

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

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

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.

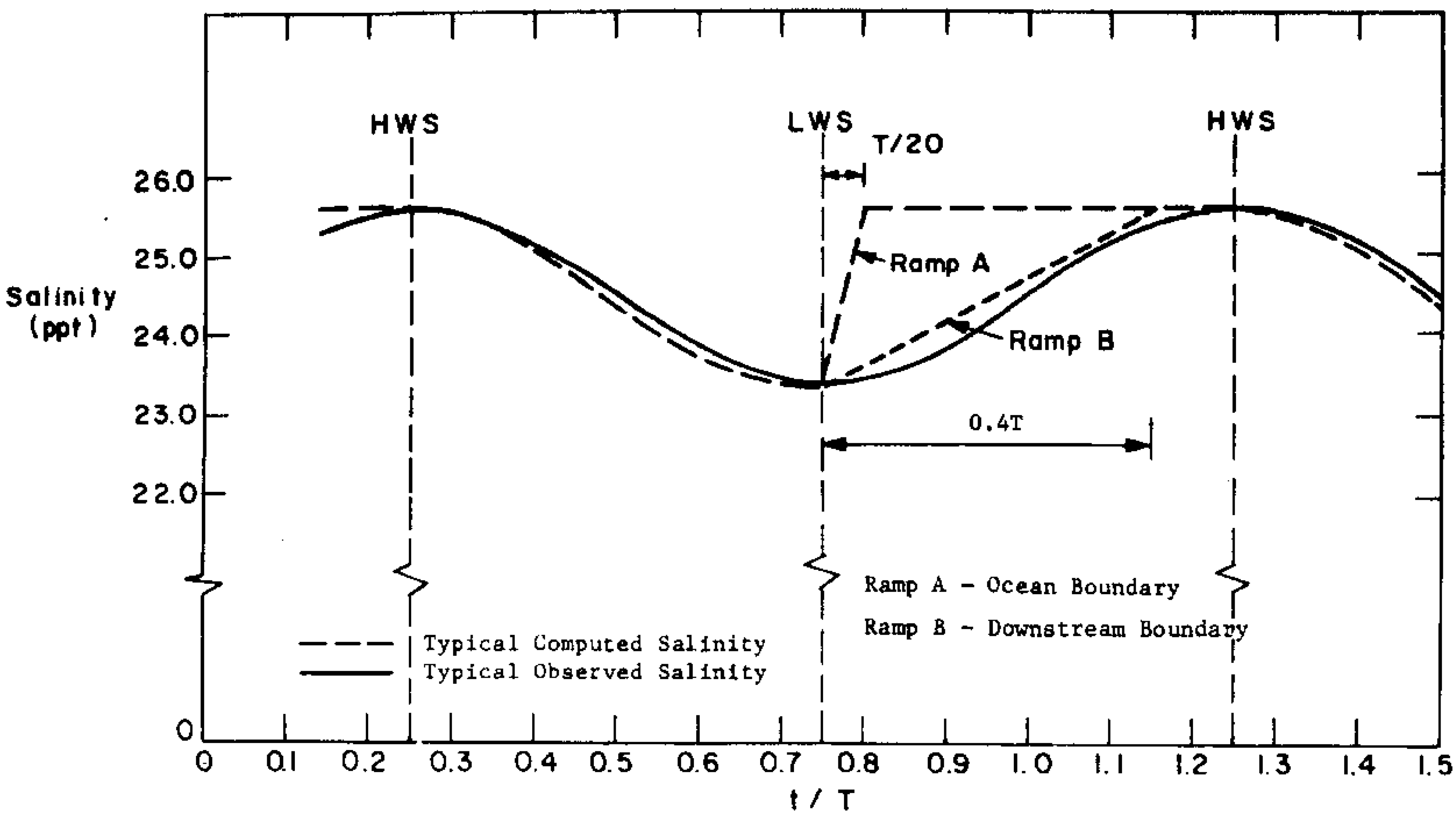
The longitudinal dispersion coefficient is related to the local non-dimensional salinity gradient, $\frac{\partial s/s_o}{\partial x/L}$, (where L = length of estuary) in the salinity intrusion region. The dispersion coefficient for the entire estuary is

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

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

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



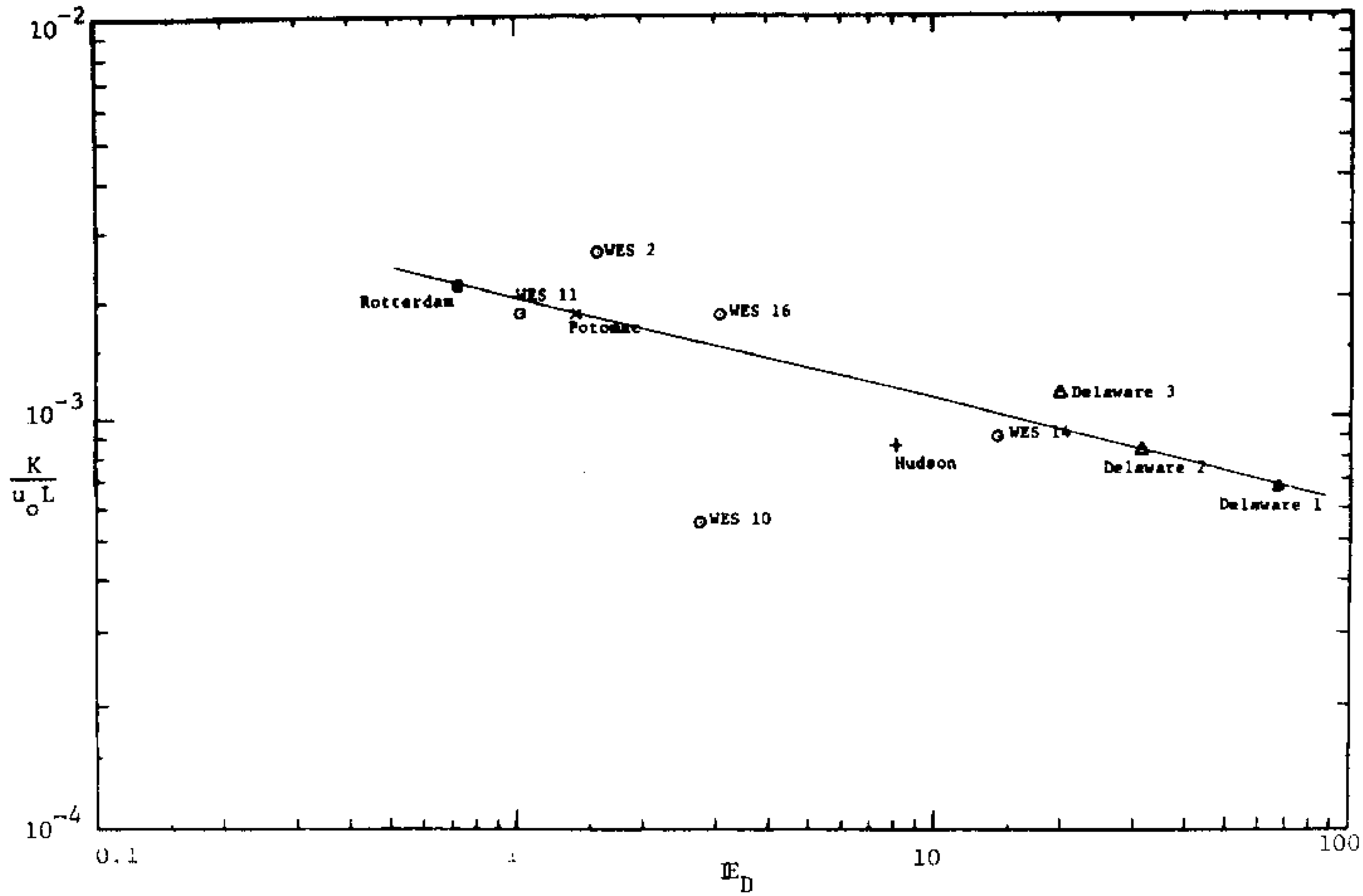
Representation of Entrance Boundary Condition
on Salinity for Estuary

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

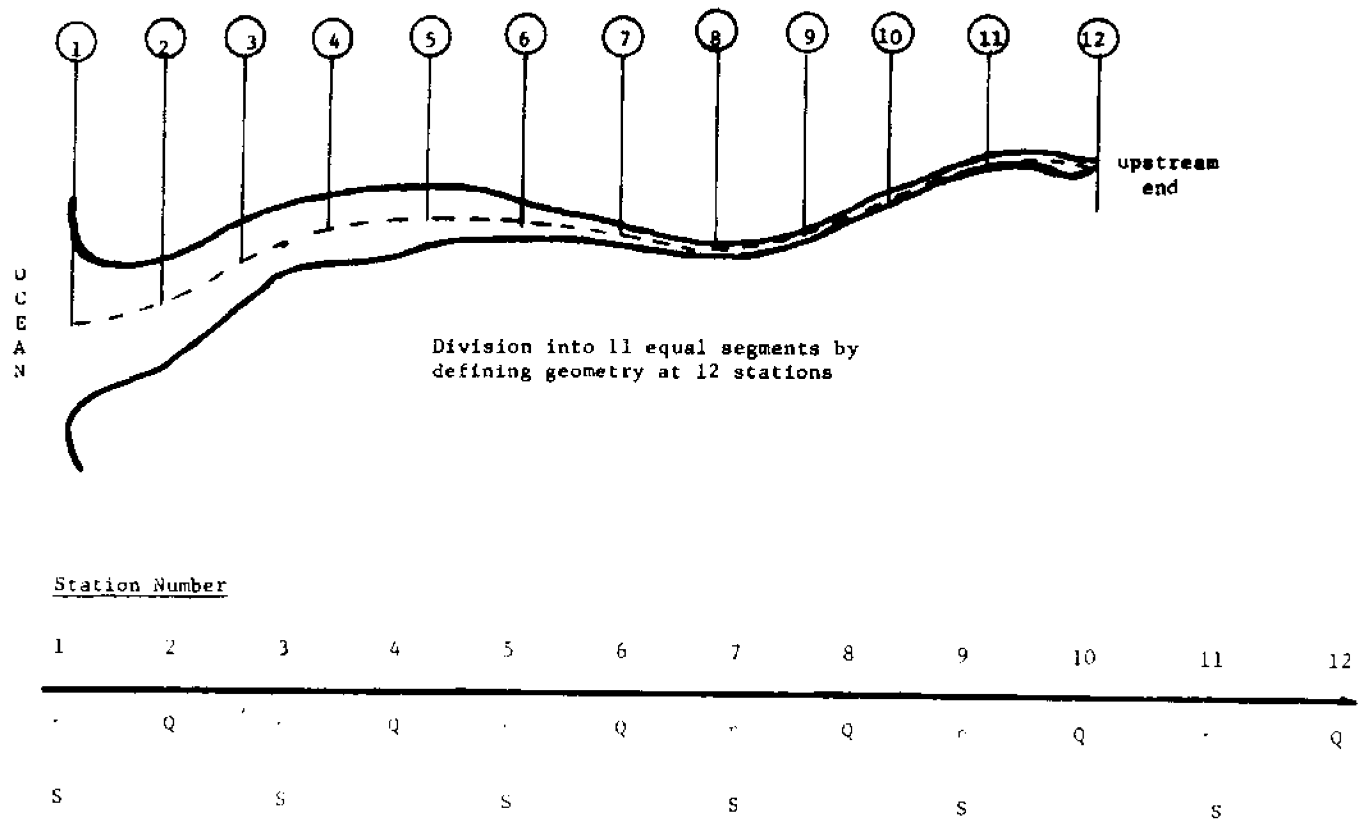
The geometric configuration of the estuary must be studied to determine the appropriate extent or domain of the estuary, and the degree of detail necessary in terms of discretization. The longitudinal extent of the estuary is the first determination to be made. The upstream boundary is usually taken 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



· - 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.

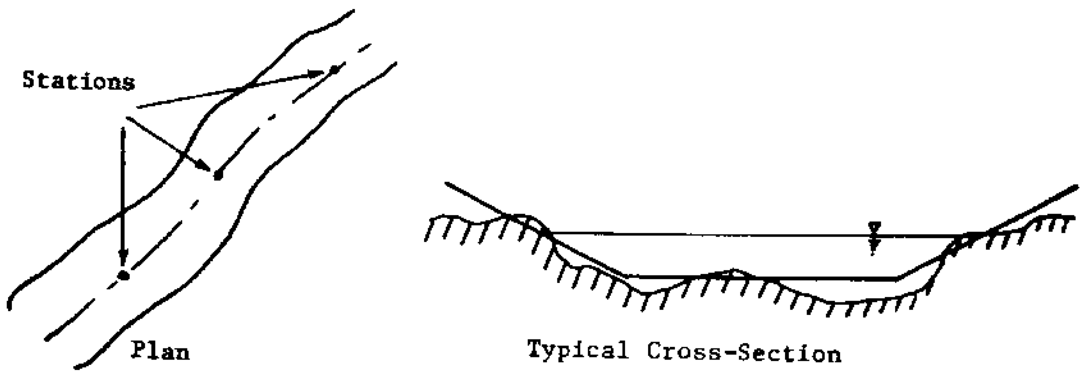
After the user has decided which of the types of schematization to use he can proceed to the schematization process itself. This process will depend on the particular case, the time available and sources of data. The following sections are intended to serve as an example of the schematization process.

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.

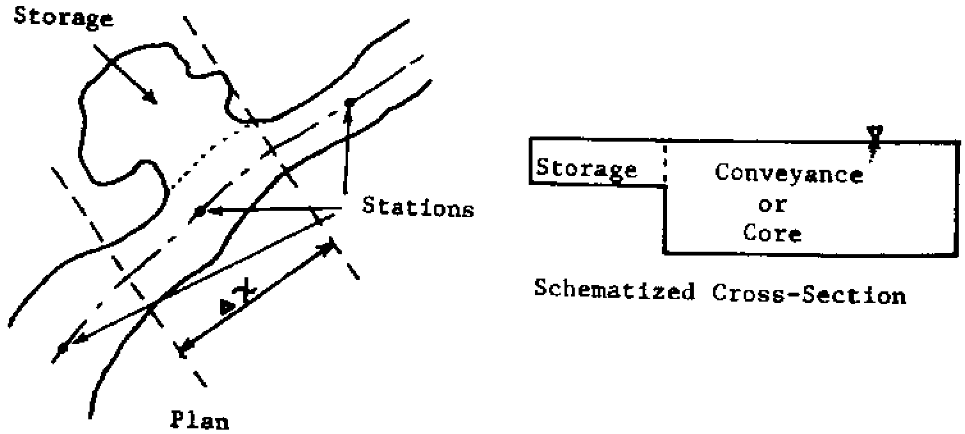
2.3 Establishing the Datum

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.

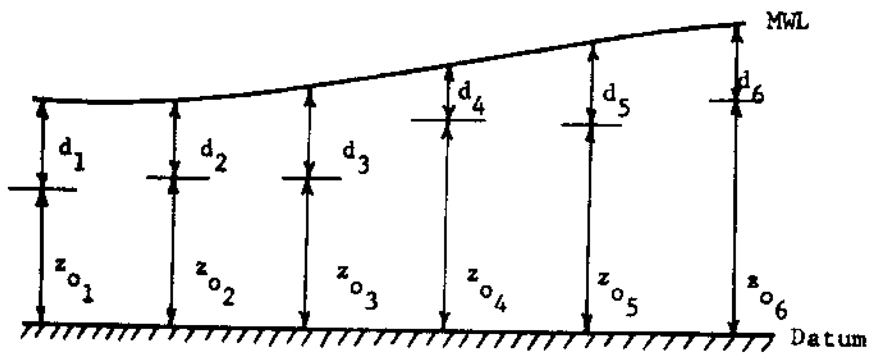
In order to accurately define the estuarine geometry the bottom elevations of the schematized cross-sections must be specified relative to a common horizontal datum. This entails obtaining information which defines the local datums. Such information is usually available from the organization that issued 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

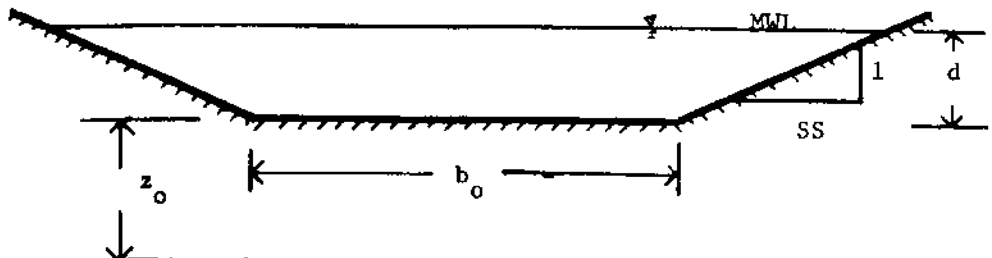
The plan view of Figure 2.2b shows a typical estuary reach containing an embayment. The water in the embayment does not participate in the longitudinal tidal transport, however it fills and empties with the change of water surface elevation. The embayment acts as storage, and in estuaries where the surface 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.

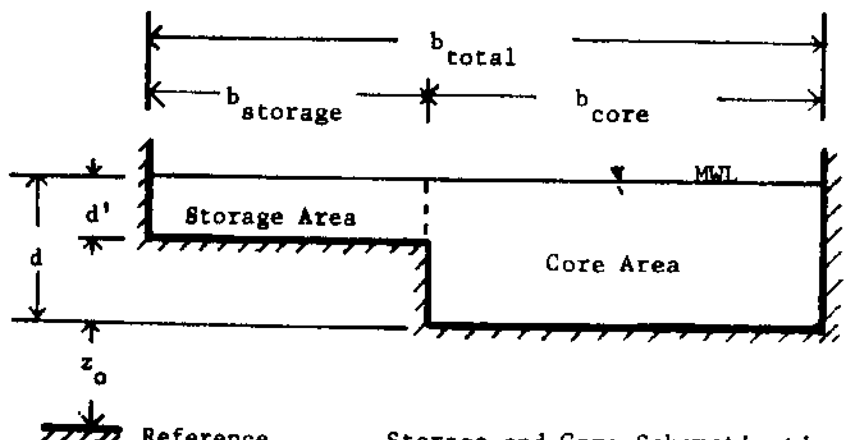
Figure 2.4b shows how this core area is joined to a storage area. To define the storage area it is necessary to define a depth of the storage area, d'. This depth, multiplied by the surface area of storage, $A^s_{storage}$, yields a volume of storage $V_{storage}$. To obtain an equivalent cross-sectional 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:

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

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



Trapezoidal Schematization
(a)



Storage and Core Schematization
(b)

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.

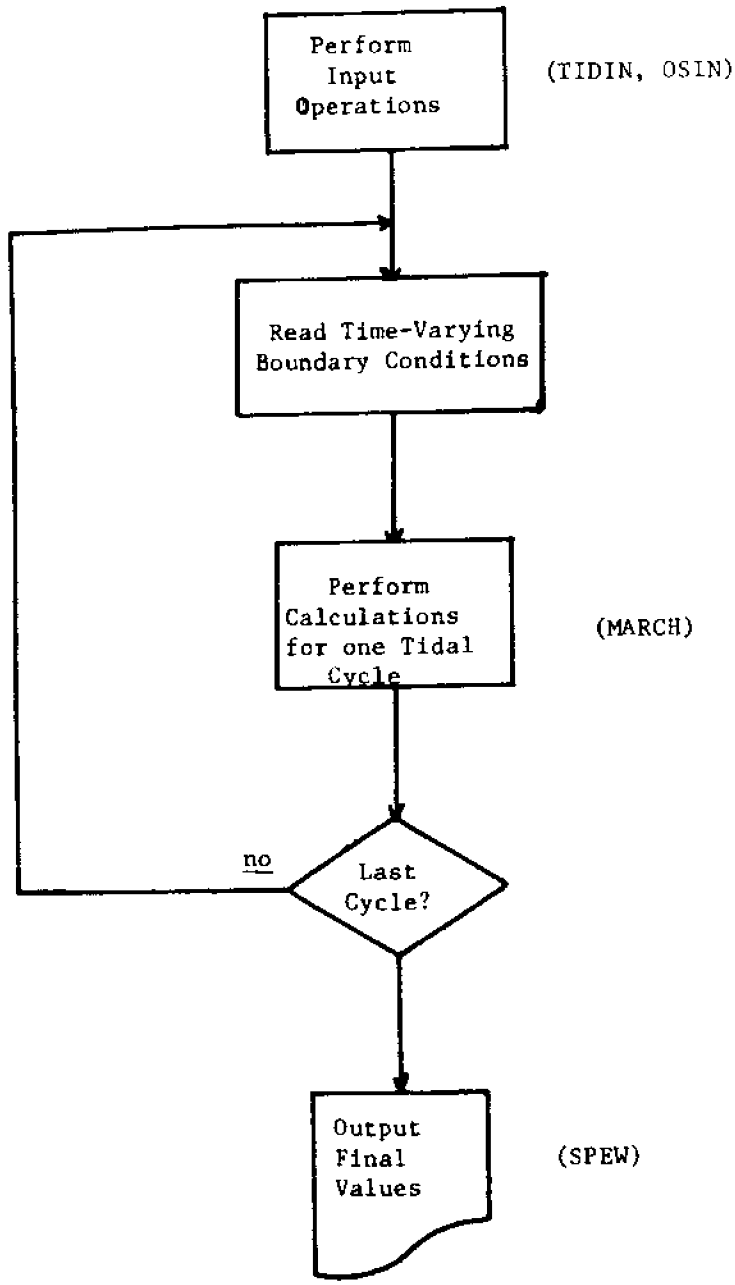
ESNOD: Calculates the tidal prism, P_T, the densimetric Froude number, the estuary number $\frac{P_T \mathbb{F}_D^2}{Q_f T}$ and then uses the correlation of $\frac{K}{u_o L}$ vs. $\frac{P_T \mathbb{F}_D^2}{Q_f T}$ to determine the value of dispersion parameter K to be used in the next tidal cycle of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

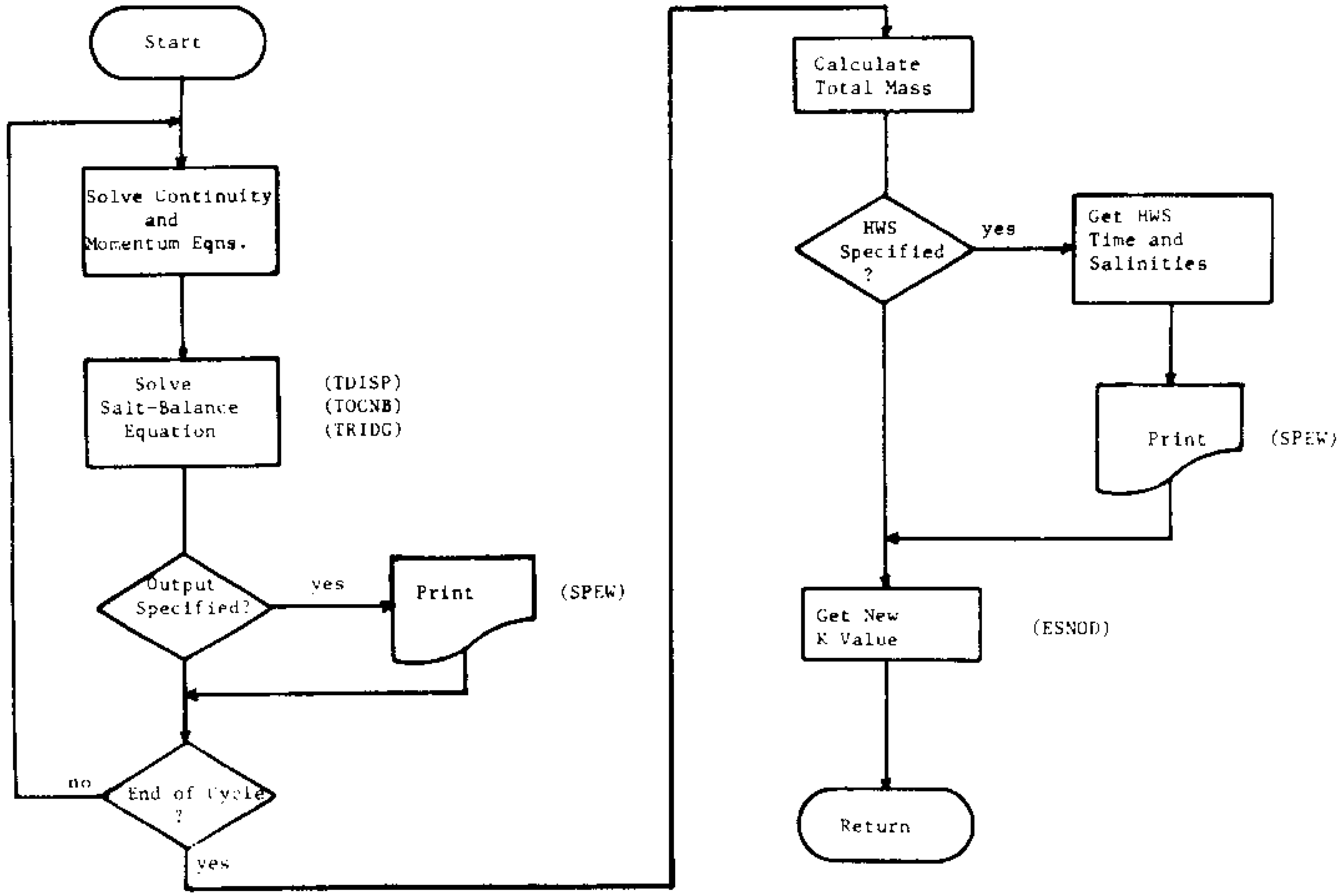
SEQTST: A sequence checking routine.

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.		Format
	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. $\left(E = K \left\lvert \frac{\partial \varrho}{\partial x} \right\rvert + n E_T\right)$	I5
D2	Field 1 Intercept of $K/u_o L$ vs. 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.d
	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.	I5
	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	

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.	
	<u>For Case 2</u>:	
D4(2)	Initial salinities, s, at each odd section starting at the entrance, 5 per card	5F10.d
	<u>For Case 3</u>:	
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
	<u>Section 5. Output Selection</u>	
	<u>Options</u>	
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.	
	<u>Option 1</u>: 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.	
	<u>Option 2</u>: 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.	
	<u>Option 3</u>: 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 2Δt, 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 etc.	Time varying boundary parameters for each cycle.	
	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.

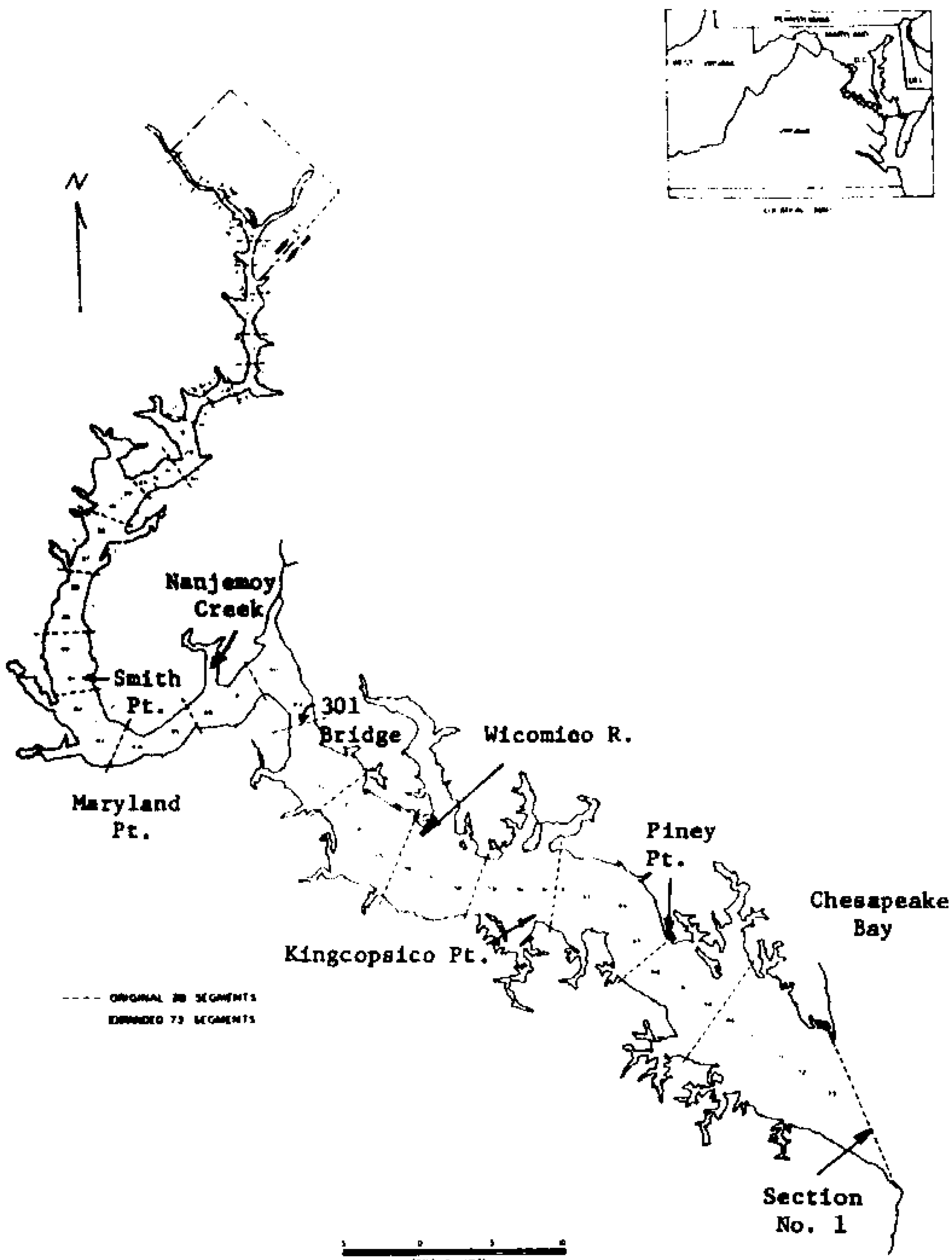
Card A5: The type of schematization for this case is that of the irregular cross-section with provisions for storage. This is type number 2. Field 2 is left blank for closed end case.

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.	9.37
	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.	11419.	3.40
	27	20.45	19.55	12179.	8905.	3.22
	28	17.95	22.05	17187.	9924.	7.90
	29	12.23	27.77	23908.	11878.	5.52
	30	15.97	24.03	7456.	7456.	0.00
	31	16.94	23.06	8221.	6160.	4.76
	32	18.99	21.01	7849.	4183.	4.79
	33	13.19	26.81	6155.	5702.	3.51
	34	19.11	20.89	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 $E = K\left|\frac{\partial s_o}{\partial x}\right| + 3E_T$ 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
0		2.20
1	-1.30	1.80
2	-1.40	2.60
3	-1.20	2.10
4	-1.70	2.70
5	-1.70	2.10
6	-1.70	3.00
7	-1.80	2.50
8	-1.80	3.00
9	-2.20	2.30
10	-2.20	3.10
11	-2.40	2.00
12	-2.20	3.20
13	-2.50	2.20
14	-2.00	3.20
15	-2.50	2.00
16	-2.00	2.80
17	-2.60	1.90
18	-1.80	2.60
19	-2.30	2.00
20	-1.70	2.60
21	-2.20	2.10
22	-1.50	2.60
23	-2.20	2.30
24	-1.60	2.50
25	-2.10	2.50
26	-1.80	2.30
27	-2.40	2.70
28	-2.20	2.10
29	-2.50	3.00
30	-2.20	2.30
31	-2.60	3.10

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

							Card No.
* * * * *	TEST CASE		POTOMAC ESTUARY			* * * * *	0001
	(DEMONSTRATION OF INPUT-OUTPUT RELATIONSHIPS)						0002
40	603768.						0003
120	44640.						0004
2							0005
1	30.00	10.00	58811.4	57499.9	6.60	0.	0006
2	27.87	12.13	49324.7	49324.7	0.0	15481.	0007
3	27.65	12.35	48183.8	41694.9	6.60	30962.	0008
4	30.46	9.54	46672.8	34032.1	8.72	46444.	0009
5	32.97	7.03	48739.8	29042.9	10.63	61925.	0010
6	31.57	8.43	26015.6	26015.6	0.0	77406.	0011
7	27.63	12.37	28212.9	27028.7	4.80	92887.	0012
8	23.99	16.01	29122.6	26386.3	7.85	108369.	0013
9	20.49	19.50	33837.9	22518.9	9.37	123850.	0014
10	18.34	21.66	36988.4	20844.4	8.71	139331.	0015
11	19.10	20.90	27864.9	25918.1	9.90	154812.	0016
12	20.21	19.79	54428.1	30467.5	9.92	170293.	0017
13	19.49	20.51	30107.9	28636.8	9.02	185774.	0018
14	18.80	21.20	29913.9	24840.1	5.47	201256.	0019
15	19.45	20.55	23500.1	21527.0	3.34	216737.	0020
16	20.56	19.44	22585.8	17952.8	5.80	232218.	0021
17	21.96	18.04	13751.9	13751.9	0.0	247699.	0022
18	22.43	17.57	14926.6	10457.8	6.75	263180.	0023
19	18.15	21.85	18008.0	11892.8	6.75	278662.	0024
20	15.43	24.57	20975.3	12896.3	3.55	294143.	0025
21	19.31	20.69	9519.3	9519.3	0.0	309624.	0026
22	19.15	20.85	10146.0	10146.0	0.0	325105.	0027
23	14.79	25.21	19852.1	14792.5	3.60	340586.	0028
24	13.33	26.67	23450.0	17006.8	4.60	356068.	0029
25	14.18	25.82	16271.5	16271.5	0.0	371549.	0030
26	17.42	22.58	12502.5	11419.4	3.40	387030.	0031
27	20.45	19.55	12179.4	8904.8	3.22	402511.	0032
28	17.95	22.05	17187.3	9923.6	7.80	417992.	0033
29	12.23	27.77	23908.2	11877.5	5.52	433473.	0034
30	15.97	24.03	7455.8	7455.8	0.0	448955.	0035
31	16.94	23.06	8221.0	6160.3	4.76	464436.	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
HHS  FC                                                                           0066
H         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

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*   M.I.T. SALINITY INTRUSION PROGRAM, ONE-DIMENSIONAL SCHEMATIZATION    *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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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	ZD	B	B(CORE)	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	15481.	2
5.86410	27.64999	12.35000	48183.8	41694.5	6.6	30967.	3
8.79615	30.45999	9.54000	46672.8	34032.1	8.7	46444.	4
11.72820	32.96999	7.03000	48739.8	28042.5	10.6	61925.	5
14.66025	31.56999	8.43000	26015.6	26015.6	0.0	77406.	6
17.59230	27.62999	12.37000	28212.9	27020.7	4.8	92887.	7
20.52434	23.58999	16.03999	29122.6	26388.3	7.8	108369.	8
23.45639	20.48999	19.50000	33817.9	22510.4	4.4	123850.	9
26.38846	18.34000	21.65999	36588.4	20844.4	8.7	139331.	10
29.32050	19.09999	20.89999	27864.9	25910.1	9.9	154812.	11
32.25255	20.20999	19.78999	54428.1	30467.5	9.9	170294.	12
35.18460	19.48999	20.50999	30107.9	28636.8	9.0	185775.	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	20.56000	19.43999	22585.8	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	14928.6	10457.8	6.8	263181.	18
52.77692	18.14999	21.84999	18008.0	11292.8	6.8	278662.	19
55.70897	15.43000	24.56999	20975.3	12998.3	3.5	294143.	20
58.64101	19.31000	20.68999	9515.3	9519.3	0.0	309625.	21
61.57306	19.14999	20.84999	10146.0	10146.0	0.0	325106.	22
64.50511	14.79000	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	15.54999	12179.4	8504.8	3.2	402512.	27
79.16537	17.55000	22.04999	17187.3	9923.4	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	7849.0	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	3397.7	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	6001.0	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 17

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 TICAL 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	0.292	-0.010	-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 MWL

                                        CALCULATION FOR   2 CYCLES

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

CYCLE    1      HMIN=  -0.47    HMAX=    0.83     SZFAC=  16.57     QF'S AND STATIONS ARE  2790.000  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   0.401   0.293   0.195  -0.029
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   8.071   5.941   3.938   1.998   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.   63869.  133329.  167368.  200034.  214479.  230351.  227956.  221097.  202417.
STATIONS    22      24      26      28      30      32      34      36      38      40
DISCHARGE 152516.  164790.  144653.  119829.   38913.   16163.    2015.   -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   0.312   0.269
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  16.170  15.349  13.610  12.562  11.759  11.177  10.683   8.441   5.904   3.797   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 -319766. -209822.  -99904.  -27658.   53554.  109547.  168362.  203614.  220774.  229557.
STATIONS    22      24      26      28      30      32      34      36      38      40
DISCHARGE 228956.  228890.  180162.  152426.   99594.   77559.   53393.   26344.    1596.      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   0.549   0.510   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  16.566  16.609  16.113  15.406  13.948  12.604  11.751  11.195  10.792   8.699   6.320   4.352   2.015   0.449
STATIONS    29      31      33      35      37
SALINITY   0.004  -0.002   0.001  -0.000   0.000
```

Table 6.6 (cont'd)

```
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.   140980.   101240.    82198.    63565.    43052.     6432.        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   0.003   0.156   0.310   0.461   0.551   0.518
STATIONS     29      31      33      35      37      39
ELEV.       0.704   0.755   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  [illegible]  [illegible]  [illegible]  [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         20
DISCHARGE   -518154.  -446900.  -356109.  -303169.  -229656.  -164031.   -99229.   -61906.  [illegible]  [illegible]
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE     53083.    78679.    89649.    87592.    67465.    53417.    36718.    18818.  [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  -0.549  -0.528  -0.455  -0.422  -0.370  -0.297  -0.192  [illegible]  [illegible]  [illegible]  [illegible]
STATIONS     29      31      33      35      37      39
ELEV.       0.743   0.908   1.073   1.196   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   4.191  [illegible]  [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.  -298408.  -268139.  -232752.  -190430.  -159744.  -138031.  -111420.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE    -98039.   -67317.   -41104.   -26861.    -8723.    -5076.    -2157.    -1516.    -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  -0.540  -0.552  -0.546  -0.514  -0.450  -0.319  -0.114  [illegible]  [illegible]  [illegible]
STATIONS     29      31      33      35      37      39
ELEV.       0.507   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  16.585  15.995  15.190  13.240  12.525  11.617  11.165  10.706  [illegible]  [illegible]  3.936   2.154  [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.  -147342.  -195055.  -220023.  -232515.  -233060.  -224278.  -216312.  -209944.
STATIONS     22         24         26         28         30         32         34         36         38         40
DISCHARGE   -153988.  -180091.  -164620.  -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  -0.047  -0.127  -0.195  -0.266  -0.388  -0.436  -0.463  -0.456  -0.390  -0.209  [illegible]   0.061   1.111
STATIONS     29      31      33      35      37      39
ELEV.       0.172   0.237   0.327   0.408   0.558   0.553
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Table 6.6 (cont'd)

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TIDAL CYCLE   1    8.680 HOURS      DAY   0    8.680 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    8.129    6.040    3.714    1.899    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.    38515.   -58183.  -124955.  -180620.  -219022.  -220144.  -229659.
STATIONS      22        24        26        28        30        32        34        36        38        40
DISCHARGE -222642.  -196606.  -170161.  -144994.   -99909.   -77607.   -56890.   -34769.    -7597.        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    0.177    0.049   -0.028   -0.124   -0.212   -0.290   -0.365   -0.943   -0.133   -0.168
STATIONS     29       31       33       35       37       39
ELEV.     -0.115   -0.108   -0.104   -0.111   -0.096   -0.044

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    6.461    3.643    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.   432955.   309773.   157222.    86963.   -13977.  -103699.  -147695.  -174995.
STATIONS      22        24        26        28        30        32        34        36        38        40
DISCHARGE -178079.  -166050.  -144276.  -123882.   -76884.   -58689.   -43186.   -27758.    -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    0.667    0.552    0.499    0.425    0.321    0.157   -0.054   -0.225   -0.296   -0.367
STATIONS     29       31       33       35       37       39
ELEV.     -0.379   -0.401   -0.423   -0.450   -0.466   -0.448

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   11.668   11.150   10.168    7.417    5.317    3.314    1.467    0.961
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.   474584.   373070.   282921.   180847.   100477.    40092.   -26490.
STATIONS      22        24        26        28        30        32        34        36        38        40
DISCHARGE  -55093.   -27057.   -90490.   -42573.   -40925.   -37486.   -26358.   -15043.    -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    0.969    0.920    0.862    0.772    0.608    0.388    0.173   -0.047   -0.768
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    8.037    6.128    3.381    1.583    0.279
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.   516950.   492431.   470213.   424118.   371316.   304517.   252974.   229192.   189927.
STATIONS      22        24        26        28        30        32        34        36        38        40
DISCHARGE  164241.   109854.    51925.    16278.   -13132.   -15548.   -13120.    -9712.    -5696.        0.
                                                                                          AVE MASS =    0.3093718 13
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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   5.580   5.787   5.993   5.993
SALINITY  16.570  16.593  16.189  15.389  13.596  12.593  11.743  11.191  10.853   8.746   6.654   4.712   2.254   0.641
STATIONS    29      31      33      35      37
TIME HRS   6.200   6.200   6.200   6.200   5.167
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 OF'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     HMIN=  -0.52   HMAX=   0.52    SZERO=  16.56     OF'S AND STATIONS ARE  2730.000  AT
              K=    578.67

TIDAL CYCLE   2    1.240 HOURS     DAY   0   13.440 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.      0.746   0.820   0.903   0.986   1.066   1.099   1.101   1.075   1.025   0.907   0.692   0.494   0.334   0.149
STATIONS    29      31      33      35      37      39
ELEV.     -0.005  -0.271  -0.455  -0.618  -0.739  -0.797

TIDAL CYCLE   2    1.240 HOURS     DAY   0   13.440 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  13.547  12.569  11.775  11.280  10.336   8.434   5.682   3.525   1.735   0.391
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  66089.  156965.  242624.  285544.  326081.  360772.  342345.  329674.  314407.  283865.
STATIONS    22      24      26      28      30      32      34      36      38      40
DISCHARGE 267352.  232346.  205129.  170225.   79423.   39925.   19210.    1855.   -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.      0.394   0.464   0.546   0.644   0.761   0.906   0.978   1.029   1.068   1.026   0.856   0.727   0.419   0.444
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  15.354  13.954  12.703  11.798  11.350  10.501   8.830   6.273   3.457   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. -247091.  -99983.   -1595.  120695.  166310.  227877.  266774.  344198.  395196.
STATIONS    22      24      26      28      30      32      34      36      38      40
DISCHARGE 248826.  254256.  214197.  185274.  119537.   96043.   73572.   42287.    6269.      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   0.176   0.293   0.459   0.591   0.669   0.746   0.856   0.874   0.909   0.989   0.941
STATIONS    29      31      33      35      37      39
ELEV.      0.832   0.779   0.751   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   16.578  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.  -545261.  -397919.  -305717.  -187198.   -85460.    32140.   120023.   149405.   909569.
STATIONS       22        24        26        28        30        32        34        36        38        40
DISCHARGE   208766.   205555.   188180.   168784.   115341.    92072.    69379.    43435.     9600.        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   0.419   0.674   0.893   0.925   1.077
STATIONS     29      31      33      35      37      39
ELEV.       1.103   1.163   1.242   1.364   1.415   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  15.392  13.669  12.711  11.734  11.367  10.746   9.108   7.139   6.441   4.494   2.797
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  -776741.  -670120.  -541841.  -455801.  -348257.  -258648.  -160893.   -83159.   -35678.    39827.
STATIONS       22        24        26        28        30        32        34        36        38        40
DISCHARGE    81295.    96735.   136550.   104298.    35659.    56658.    36471.    19661.     1636.        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  -0.625  -0.590  -0.452  -0.392  -0.310  -0.209  -0.008   0.240   0.483   0.703   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  16.575  16.030  15.293  13.470  12.729  11.661  11.343  10.776   8.965   7.194   4.441   2.512   0.939
STATIONS     29      31      33      35      37
SALINITY    0.040  -0.019   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.  -477031.  -457245.  -402553.  -345241.  -276566.  -223010.  -194884.  -159505.
STATIONS       22        24        26        28        30        32        34        36        38        40
DISCHARGE  -143636.  -101436.   -63753.   -35892.   -13114.    -3646.      239.      362.    -2991.        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  -0.275   0.027   0.265   0.471   0.638
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   8.667   6.858   4.189   2.570   0.732
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.  -177563.  -247449.  -289080.  -328982.  -336345.  -327864.  -307052.  -280878.  -261961.
STATIONS       22        24        26        28        30        32        34        36        38        40
DISCHARGE  -250591.  -227783.  -205853.  -179911.  -102113.   -71200.   -47887.   -26812.    -6818.        0.
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Table 6.6 (cont'd)

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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  11.259  10.355   8.319   6.350   3.411   2.154   0.577
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.   -282995.   -288321.
STATIONS      22         24         26         28         30         32         34         36         38         40
DISCHARGE  -276200.   -237407.   -202419.   -175041.   -115655.    -92143.    -68146.    -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   0.051  -0.006  -0.119  -0.196  -0.264  -0.325  -0.364  -0.288  -0.199  -0.087  -0.018
STATIONS    29      31      33      35      37      39
ELEV.      0.040   0.070   0.095   0.104   0.177   0.183

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   5.896   3.490   1.956   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.    252855.    163888.     73635.    -10787.   -109228.   -168812.   -200624.   -224987.
STATIONS      22         24         26         28         30         32         34         36         38         40
DISCHARGE  -227106.   -206899.   -178545.   -152216.    -92158.    -69393.    -50798.    -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   0.252   0.193   0.104  -0.034  -0.157  -0.249  -0.270  -0.257
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  11.236   9.944   7.861   5.619   3.307   1.776   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.    154112.     71076.       448.    -45190.   -103795.
STATIONS      22         24         26         28         30         32         34         36         38         40
DISCHARGE  -121481.   -133872.   -125775.   -110753.    -86436.    -47998.    -17860.    -18551.     -5906.        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  -0.113  -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  13.703  12.444  11.652  11.241   9.918   7.424   5.266   3.213   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.
STATICNS     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   0.372   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   5.266   3.269   1.668   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

1. Thatcher, M. L. and Harleman, D. R. F., "A Mathematical Model for the Prediction of Unsteady Salinity Intrusion in Estuaries", R. M. Parsons Laboratory for Water Resources and Hydrodynamics Technical Report No. 144, Department of Civil Engineering, M.I.T., February 1972.

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

1. 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.

List of Figures and Tables

```
C        MAIN LINE FOR TRANSIENT SIMULATION
      INTEGER CASE
      REAL  FQ(200),  BB(200),   D(200),  SS(200),   B(200),MANCO(200)
      REAL  ZZ(200),   R(200),   C(200),  D4(200),   W(200)
      REAL  BS(200),   E(200),H(2,200),S(2,200),Q(2,200)
      REAL HDA(900),QDB(900)
      DIMENSION DUM(100),ZO(200),ADUM(100)
      DIMENSION MFQ(10),PFQ(10)
      DIMENSION ETA(3),FW(4),LFW(4)
      COMMON KO,KIN,KKK,JJJ
      COMMON NDS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXO
        COMMON D1,D2,D3,FH,FZ,FXL4,SZERO,ES
        COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
      COMMON H,Q,HDA,QDB,FQ,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      COMMON /SW/ ISW10,ISW11
      COMMON /T/ MMM,QF,IPF,IPE,NNN
      COMMON /EXLIM/ JLIM,J2LIM,MOUT,LOUT
      COMMON/SL/SLD,ZO
      COMMON /OUTP/ LFW,ND1,ADUM,NC
      DATA DUM /100*0./
      DATA PI/3.141593/,KP/7/
C
C        FILE 'MMM'  HOLDS THE SEQUENTIAL OUTPUT OF 'NC' CYCLES
      KO=6
      KIN=5
      LLL=3
      CALL TIOIN
      CALL OSIN
      CALL TDISP
      NMAXQ=NMAX+1
      NMD2=(NMAX-1)/2
      NF=JMAX/2
      ST=PI*2./(NMAX-1)
C
C         NFW IS NO. OF VARYING FRESH WATER INPUTS.
C         NCOF 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
1114  FORMAT(T16,'K=',F10.2)
      IF(NOS .NE. 0) WRITE(KO,724) FEND
724   FORMAT('+',T31,'UPSTREAM BOUNDARY DISCHARGE=',F10.2)
C        TEST SEQUENCE
      IF(KCK .EQ. LEW)      GOTO 1117
      WRITE(KO,207)
207   FORMAT(' CARDS NOT IN SEQUENCE, EXIT TAKEN AFTER LAST CYCLE''S',
     1      ' CALCULATION')
      GOTO 1118
1117  DO 1115 J=1,NEW
      MYJO=LEW(J)
1115  FQ(MYJO)=FN(J)
C
C        CALC. 'QF' FOR ESTUARY NUMBER.
      QF=0.
      DO 1116 J=1,NCQF
      MYJO=LFW(J)
1116  QF=QF+FQ(MYJO)
      IF(NOS .NE. 0)    QF=QF+FEND
C
C        ISWO TO CALCULATE TRANSIENT TIDAL ELEVATIONS
      GOTO(20,25),ISWO
20    RANG1=(ETA(1)-ETA(2))/2.
      RANG2=(ETA(3)-ETA(2))/2.
      IF((RANG1 .LT. 0) .OR. (RANG2 .LT. 0))  GOTO 22
      GOTO 23
22    WRITE(KO,221) LEW
221   FORMAT(' WARNING EQUAL ELEVATIONS IN CYCLE',I5)
23    DO 30 II=1,NMAXH,2
      ARG=ST*(II-1)
      IF(ARG .GT. PI)        GOTO 21
C        GOING DOWN
      HOA(II)=ETA(1)-RANG1*(1.-COS(ARG))
      GOTO 30
C        GOING UP
```

```
 21    HOA(II)=ETA(3)-RANG2*(1.-COS(ARG))
 30    CONTINUE
       ETA(1)=ETA(3)
C
 25    CALL MARCH
1111   CONTINUE
1118   IF(ISW1 .EQ. 1)   GOTO 1119
       END FILE MMM
       REWIND MMM
1119   IF(ISW4 .EQ. 1)    GOTO 1120
       END FILE NNN
       REWIND NNN
1120   WRITE(KO,2857)
C
C         OUTPUT FINAL TIME STEP'S H,S,&Q
C         REFER H TO MSL
       DO 182 J=1,JMAXH,2
182    H(LOUT,J)=H(LOUT,J)-SLO+ZO(J)+D(J)
       CALL SPEW(1,1)
       CALL SPEW(2,1)
       CALL SPEW(3,1)
       GOTO (1200,1201),ISW3
1201   WRITE(KP,1202) (H(LOUT,J),J=1,JMAXH,2)
1202   FORMAT(5F10.5)
       WRITE(KP,1203) (S(LOUT,J),J=1,JMAXH,2)
1203   FORMAT(5F10.4)
       WRITE(KP,1204) (Q(LOUT,J),J=2,JMAX,2)
1204   FORMAT(5F10.0)
1200   WRITE(KO,1205)
1205   FORMAT(/,'0END OF ALL CALCULATIONS',/,'1')
       CALL EXIT
       END
```

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

```
C
C        SECTION 1, DESCRIPTION OF SCHEMATIZED ESTUARY
      WRITE(KO,200)
200   FORMAT('1',T16,37('* '),/,T16,'*',T88,'*',/,T16,'*',T20,'M.I.T. ',
     1        'SALINITY INTRUSION PROGRAM, ONE-DIMENSIONAL ',
     2        'SCHEMATIZATION',T88,'*',/,T16,'*',T88,'*',/,T16,37('* '),
     3        ///,'OSECTION 1,  DESCRIPTION OF THE SCHEMATIZED ESTUARY',
     4        //)
      DO 1010 I=1,2
      READ(KIN,1020) WDUM
1020  FORMAT(20A4)
1010  WRITE(KOUT,1021)WDUM
1021  FORMAT(1X,20A4)
C
      READ(KIN,1050) JMAX,CHLEN,NMAX,TCOM
1050  FORMAT(I5,F10.0)
C        NOS =0 FOR CLOSED END, = ANYTHING ELSE FOR OPEN END
      READ(KIN,1055) CASE,NOS
1055  FORMAT(2I5)
      IF(NOS .EQ. 0)    GOTO 300
      WRITE(KO,3001)
3001  FORMAT('OGEOMETRIC DATA',5X,'*** OPEN END ESTUARY ***')
      GOTO 302
300   WRITE(KO,3002)
3002  FORMAT('OGEOMETRIC DATA',5X,'*** CLOSED END ESTUARY ***')
302   WRITE(KO,1090) JMAX,CHLEN,NMAX,TCOM
1090  FORMAT(/,'0    NUMBER OF STATIONS =',I4,5X,
     1        'ESTUARY LENGTH=',F10.0,' FT.',/,'    NUMBER OF TIME ',
     2       'INCREMENTS PER PERIOD=',I4,5X,'PERIOD=',F7.0,'SECONDS')
      IF(2*(JMAX/2) .NE. JMAX)     CALL ERRL(1)
      IF(2*(NMAX/2) .NE. NMAX)     CALL ERRL(2)
      NMAX=NMAX+1
      JMAXH=JMAX-1
      JMAXQ=JMAX
      NMAXH=NMAX
      NMAXQ=NMAX+1
```

```
      NEQ=NMAXQ-2
      JJTEM = JMAXQ-2
      DELT=TCOM/(NMAX-1)
      DELX=CHLEN/(JMAX-1)
C        SELECT SCHEMATIZATION CASE
      IF((CASE .LT. 1) .OR. (CASE .GT. 5))        CALL ERRL(3)
C        INPUT SCHEMATIZED GEOMETRY
      GO TO (540,550,560,565,566),CASE
C
C        CASE 1   RECTANGULAR CROSS-SECTION
  540 WRITE(KOUT,1110)
      WRITE(KOUT,1120)
 1110 FORMAT('0 CASE 1,  RECTANGULAR CROSS-SECTION')
 1120 FORMAT('0  MILES',8X,'D',11X,'ZO',14X,'B',7X,'B(CORE)',6X,
     1        'FEET',3X,'SECTION')
      DO 1 J=1,JMAX
      READ(KIN,1130) ISEQ,D(J),ZO(J),B(J)
 1130 FORMAT(I5,5X,5F10.0)
      DFEET=(J-1)*DELX
      DIST=DFEET/5280.
      BS(J)=B(J)
      WRITE(KOUT,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J
 1140 FORMAT (F10.5,2(2X,F10.5),2(2X,F10.2),2X,F10.0,I8)
      CALL SEQTST(J,ISEQ)
    1 CONTINUE
      GO TO 570
C
C        CASE 2     IRREGULAR CROSS-SECTION, (STORAGE)
  550 WRITE(KOUT,1150)
      WRITE(KOUT,1160)
 1150 FORMAT('0 CASE 2,  IRREGULAR CROSS-SECTION (STORAGE)')
 1160 FORMAT ('0  MILES',8X,1HD,11X,2HZO,14X,1HB,7X,'B(CORE)',8X,
     1        'D''',8X,'FEET',3X,'SECTION')
      DO 2 J=1,JMAX
      READ(KIN,1130) ISEQ,D(J),ZO(J),B(J),BS(J),DP(J)
      DFEET=(J-1)*DELX
```

```
      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',       TIDI 145
     1        ' CROSS-SECTION   B= ',E12.4)                                   TIDI 146
      WRITE(KOUT,1120)                                                        TIDI 147
      DO 9 J=1,JMAX                                                           TIDI 148
      READ(KIN,1130) ISEQ,D(J),ZO(J)                                          TIDI 149
      X1=KB*(J-1)*DELX                                                        TIDI 150
      B(J)=BO*EXP(-X1)                                                        TIDI 151
      BS(J)=B(J)                                                              TIDI 152
      DFEET=(J-1)*DELX                                                        TIDI 153
      DIST=DFEET/5280.                                                        TIDI 154
      WRITE(KOUT,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J                     TIDI 155
      CALL SEQTST(J,ISEQ)                                                     TIDI 156
    9 CONTINUE                                                                TIDI 157
      GOTO 570                                                                TIDI 158
C                                                                             TIDI 159
C        CASE 5, CONSTANT RECTANGULAR CROSS-SECTION                           TIDI 160
566   WRITE(KO,1112)                                                          TIDI 161
1112  FORMAT('0CASE 5, CONSTANT RECTANGULAR CROSS-SECTION')                   TIDI 162
      WRITE(KO,1120)                                                          TIDI 163
      READ(KIN,1130) ISEQ,D(1),ZO(1),B(1)                                     TIDI 164
      DO 567 J=1,JMAX                                                         TIDI 165
      DFEET=(J-1)*DELX                                                        TIDI 166
      DIST=DFEET/5280.                                                        TIDI 167
      D(J)=D(1)                                                               TIDI 168
      ZO(J)=ZO(1)                                                             TIDI 169
      B(J)=B(1)                                                               TIDI 170
      BS(J)=B(1)                                                              TIDI 171
567   WRITE(KO,1140) DIST,D(J),ZO(J),B(J),BS(J),DFEET,J                       TIDI 172
C     END OF GEOMETRIC DATA INPUT                                             TIDI 173
C                                                                             TIDI 174
C        SECTION 2    CHANNEL ROUGHNESS AND WIND EFFECTS                      TIDI 175
570   WRITE(KO,1260)                                                          TIDI 176
1260  FORMAT(   '1',T10,'SECTION 2   CHANNEL ROUGHNESS AND WIND EFFECTS'TIDI 177
     1)                                                                       TIDI 178
      READ(KIN,1050) ROUGH                                                    TIDI 179
      GOTO(1294,1292),ROUGH                                                   TIDI 180
```

```
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
```

```
C         WIND BEING CONSIDERED
  650 WRITE(KOUT,1360)
 1360 FORMAT('0     WIND EFFECT INCLUDED')
      DO 7 J=2,JMAXQ,2
      VCOS = V(J)*COS(PHI(J))
      VCOS = VCOS*ABS(VCOS)
      W(J)=        BETA*ARDEN*VCOS/WAUWT
    7 CONTINUE
      WRITE(KO,1380) WAUWT,BETA,ARDEN
 1380 FORMAT(' DENSITY OF WATER=',F6.2,'   BETA=',F8.4,'   AIR DENSITY=',
     1         F10.4)
C         OUTPUT
 661  WRITE(KOUT,1390)
 1390 FORMAT ('0  MILES',5X,5HMANCO,11X,2HFQ,7X,1HV,10X,3HPHI,
     1          12X,'FEET    SECTION')
      DO 8 J=1,JMAX
      DFEET=(J-1)*DELX
      DIST=DFEET/5280.
      WRITE(KOUT,1400) DIST,MANCC(J),FQ(J),V(J),PHI(J),DFEET,J
 1400 FORMAT (F10.5,2X,F10.7,2X,F10.3,2(2X,F10.7),2X,F10.0,I5)
    8 CONTINUE
C
C         SECTION 3    SURFACE ELEVATION AT THE ENTRANCE
      ISWO=2
      WRITE(KOUT,1405)
 1405 FORMAT(//,'0  SECTION 3,   SURFACE ELEVATION AT THE ENTRANCE'/)
      READ(KIN,1410) CLASA,DSLD
 1410 FORMAT(I5/F10.0)
      SLD=ZO(1)+D(1)-DSLD
      WRITE(KO,1406) DSLD,SLD
 1406 FORMAT('  MWL',F5.2,' FT ABOVE MSL AT OCEAN',/,
     1         '  MSL',F7.2,' FT ABOVE THE HORIZONTAL DATUM')
      GOTO(665,680,670),CLASA
C
C         CASE 1,  COSINE FIT TO HW,LW SERIES
C            PUT FIRST HW IN VARIABLE HOA(1)
```

```
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
```

```
C
C
C     SET UP BOUNDARY CONDITIONS AT RIVER END
  745 DO 19 N=2,NMAXQ,2
      QOB(N)=0.
   19 CONTINUE
C     INITIAL CONDITIONS DEFINED
      D1=DELT/DELX
      D2=.5/(DELT*G)
      D3=.5/DELX
      DTEM=1./D1
      TDH=DELT/3600.
      DO 21 J=2,JJTEM,2
      D4(J)=D3*(D(J-1)-D(J+1)+ZO(J-1)-ZO(J+1))
   21 CONTINUE
      WRITE(KOUT,1500) DELT,DELX
 1500 FORMAT(//,' DT=',F10.2,' SEC.   DX=',F10.1,' FT.')
      WRITE(KOUT,1510) DTEM
 1510 FORMAT(15H DELTAX/DELTAT=,F8.2, 9H FT./SEC.)
C     COMPUTATION OF CELERITY WITH RESPECT TO MEAN DEPTH
C     SCEL DENOTES THE CELERITY WITH RESPECT TO THE DEPTH ONLY
      WRITE(KOUT,1520)
 1520 FORMAT (36HOCELERITY WITH RESPECT TO DEPTH ONLY)
      WRITE(KOUT,1530)
 1530 FORMAT(T11,'CELERITY  WAVE LENGTH',/,' SECTION  (FT/SEC)',
     1       T23,'(MILES)')
      IWARN=0
      DO 22 J=1,JMAX
      SCEL(J)=(G*D(J))**.5
      WALEN(J)=SCEL(J)*TCOM/5280.
      WRITE(KOUT,1540) J,SCEL(J),WALEN(J)
 1540 FORMAT(1X,I7,F10.2,2X,F10.2)
      IF(SCEL(J) .GT. DTEM)  IWARN=1
   22 CONTINUE
      IF(IWARN .EQ. 1)  WRITE(KOUT,1550)
 1550 FORMAT('0*** WARNING, CELERITY GREATER THAN DX/DT IN SOME',
```

```
     1     ' SECTIONS.  INSTABILITY COULD RESULT')                    TIDI 325
      RETURN                                                          TIDI 326
      END                                                             TIDI 327
```

```
      SUBROUTINE OSIN
      INTEGER CASE,ODS1,ODS2
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCO(200)
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)
      REAL HOA(900),QCB(900)
      DIMENSION OPT(4),OKEY(4),KVAR(3)
      DIMENSION DUM(100),ZC(200)
      COMMON KO,KIN,KKK,JJJ
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ
      COMMON D1,D2,D3,EH,EZ,EXLM,SZERO,ES
       COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
        COMMON H,Q,HOA,QCB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      COMMON /CEPT/ XNCPT
      COMMON /T/ MMM,QF,IPF,IPE,NNN,IETM
      COMMON /SL/ SLD,ZD
      DATA OKEY/'KEEP','HWS','FC  ','E   '/,KVAR/'H','S','Q'/
      DATA INCPT/0/
      ISW1=1
      ISW2=1
      ISW3=1
      ISW4=1
      ISW5=-1
      ISW6=-1
      ISW7=-1
      IETM=1
C
C        SECTION 4, DEFINITIONS RELATIVE TO THE SALT BALANCE EQN.
C        AND TO INITIAL SALINITIES
      WRITE(KO,200)
200   FORMAT(//,'1 SECTION 4,  DEFINITIONS RELATIVE TO THE SALT BALANCE
     1EQUATION, AND TO INITIAL SALINITIES',//)
      NMD2=(NMAX-1)/2
      NF=JMAX/2
      III=5
      MMM=15
```

```
      NNN=11                                                            OSIN
      LLL=3                                                             CSIN
C                                                                       CSIN
      READ(KIN,199) EZ, ODS2                                            OSIN
199   FORMAT(F10.0,I5)                                                  CSIN
      IF(ODS2 .NE. 0)    IETM=ODS2                                      OSIN
      READ(KIN,100) XNCPT,EXLM,PF,PE                                    OSIN
100   FORMAT(5F10.0)                                                    OSIN
      WRITE(KO,201) IETM,EZ                                             OSIN
201   FORMAT(//,' E=K(DS/DX)+',I2,'*E(TAYLOR)',5X,' K FOR THE NEXT ',   CSIN
     1       'TIDAL CYCLE IS',F10.2,/)                                  OSIN
      IF(XNCPT .EQ. 0.)    XNCPT=2.15E-3                                OSIN
      WRITE(KO,205) XNCPT                                               CSIN
205   FORMAT('OK VS. ED GIVEN BY K/(UZ*L)=',E10.3,'ED**(-1/4)',/)       OSIN
      IF(EXLM) 51,1,2                                                   OSIN
51    CALL ERRL(4)                                                      OSIN
1     WRITE(KO,202)                                                     OSIN
202   FORMAT(/,' SALINITY EXCURSION NOT LIMITED',/)                     CSIN
      GOTO 3                                                            OSIN
2     WRITE(KO,203) EXLM                                                OSIN
203   FORMAT(/,' SALINITY EXCURSION LIMIT =',F10.2,' FT',/)             OSIN
3     IPF=PF*NMO2+0.5                                                   OSIN
      IPE=PE*NMO2+0.5                                                   CSIN
      WRITE(KO,204) PF,PE,IPF,IPE                                       CSIN
204   FORMAT(' SALINITY RETURNS TO SZERO AFTER LWS IN',F5.2,            OSIN
     1       ' OF A TIDAL PERIOD',/,' EXTENTION OF SZERO AFTER HWS FOR',OSIN
     2       F5.2,' OF A TIDAL PERIOD',T100,2I8)                        CSIN
C                                                                       OSIN
C        DEFINITION OF THE SOURCE OF INITIAL CONDITIONS                 CSIN
C        ALL ELEVATIONS IN INITIAL CONDITIONS ARE WITH RESPECT TO MSL   CSIN
      READ(KIN,101) ICASE,ODS1                                          CSIN
101   FORMAT(2I5)                                                       CSIN
      IF(ODS1 .NE. 0)      LLL=ODS1                                     OSIN
C                                                                       OSIN
C        DEFINE INITIAL CONDITIONS                                      CSIN
      GOTO(19,195,18),ICASE                                             CSIN
```

```
C
C        CASE 3, INPUT ALL I.C. FROM CARDS
C        H INPUT WRT MSL, THEN REFERED TO MWL AT THE OCEAN
C        ALL STARTING VALUES FROM UNIT III
18    WRITE(KC,217)
217   FORMAT('OCASE 3, INITIAL CONDITIONS ALL FROM CARDS')
      READ(III,100) (H(1,J),J=1,JMAXH,2)
      CALL SPEW(1,4)
      DO 180 J=1,JMAXH,2
180   H(1,J)=H(1,J)+SLD-ZC(J)-D(J)
      READ(III,100) (S(1,J),J=1,JMAXH,2)
      READ(III,100) (Q(1,J),J=2,JMAXQ,2)
      GOTO 17
C
C        CASE1, ALL I.C. FROM DATASET
19    WRITE(KC,216)
216   FORMAT('OCASE 1, ALL INITIAL CONDITIONS FROM DATASET')
      GOTO 20
C
C        CASE 2, ELEVATIONS AND DISCHARGES FROM DATASET,
C        SALINITY FROM CARDS
195   WRITE(KC,218)
218   FORMAT('OCASE 2, INITIAL ELEVATIONS AND DISCHARGES FROM DATASET',
     1       ', SALINITIES FROM CARDS')
      READ(KIN,100) (S(1,J),J=1,JMAXH,2)
20    NTNL=NMD2-1
      DO 520 I=1,NTNL
      READ(LLL)      (DUM(J),J=1,NF)
      READ(LLL)      (DUM(J),J=1,NF)
520   READ(LLL)      (DUM(J),J=1,NF)
C        SET UP H,S AND Q  ON LST  READ
      READ(LLL)      (H(1,J),J=1,JMAXH,2)
      CALL SPEW(1,4)
      DO 181 J=1,JMAXH,2
181   H(1,J)=H(1,J)+SLD-ZC(J)-D(J)
C        DECIDE WHETHER OR NOT TO USE S(INIT) FROM CARDS
```

```
      GOTO(4560,4550),ICASE                                          CSIN 109
4550  READ(LLL)       (DUM(J),J=1,NF)                                CSIN 110
      GOTO 4570                                                      CSIN 111
4560  READ(LLL)       (S(1,J),J=1,JMAXH,2)                           CSIN 112
4570  READ(LLL)       (Q(1,J),J=2,JMAXQ,2)                           CSIN 113
C                                                                    CSIN 114
C        PLACE INTO S(2,J) FOR RFC CALC EXCEEDING JLIM               CSIN 115
17    DO 4580 J=1,JMAXH,2                                            CSIN 116
4580  S(2,J)=S(1,J)                                                  CSIN 117
      CALL SPEW(2,4)                                                 CSIN 118
      CALL SPEW(3,4)                                                 CSIN 119
C                                                                    CSIN 120
C        SECTION 5.   OUTPUT SELECTION                               CSIN 121
C        OPTIONS                                                     CSIN 122
      WRITE(KC,210)                                                  CSIN 123
210   FORMAT('0',/,' SECTION 5,   OUTPUT SELECTION')                 CSIN 124
      READ(KIN,120)(OPT(I),I=1,4),ODS1,ODS2                          CSIN 125
12C   FORMAT(4(A4,1X),2I5)                                           CSIN 126
      DO 3001 I=1,4                                                  CSIN 127
      DO 3001 II=1,4                                                 CSIN 128
      IF(OPT(I) .NE. CKEY(II))   GOTO 3001                           CSIN 129
      WRITE(KO,270) OKEY(II)                                         CSIN 130
270   FORMAT('0OPTION ',A4,' SPECIFIED')                             CSIN 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')                               CSIN 139
C        GET CATASET NO.S FOR 'KEEP' AND 'E'  OPTIONS                CSIN 140
      IF((ISW1 .EQ. 2) .AND. (CDS1.NE.0))    MMM=ODS1                CSIN 141
      IF((ISW4 .EQ. 2) .AND. (CDS2 .NE. 3))  NNN=ODS2                CSIN 142
C        GET FRQUENCY OF BASIC CUTPUT                                CSIN 143
      WRITE(KC,272)                                                  CSIN 144
```

```
  272 FORMAT('O 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))    GCTC 276                         OSIN 150
      IF(II .EQ. 1)  ISW5=NFREQ                                 CSIN 151
      IF(II .EQ. 2)  ISW6=NFREQ                                 CSIN 152
      IF(II .EQ. 3)  ISW7=NFREC                                 CSIN 153
      GOTC 277                                                  CSIN 154
  276 CCNTINUE                                                  OSIN 155
      CALL ERRL(5)                                              OSIN 156
  277 WRITE(KC,273) KEY,NFREC                                   OSIN 157
  273 FORMAT(7X,A1,T19,I5)                                      OSIN 158
      IF((NFREQ/2)*2 .NE. NFREQ)     CALL ERRL(7)               CSIN 159
  275 CONTINUE                                                  CSIN 160
C                                                               CSIN 161
C        CFECK  FOR NCN-FATAL ERRCR ACCUMULATICN                OSIN 162
      CALL ERRL(8)                                              OSIN 163
      RETURN                                                    OSIN 164
      END                                                       CSIN 165
```

```
      SUBROUTINE MARCH
      INTEGER CASE,IHWS(100)
      REAL  FG(200),  FB(200),   C(200),  SS(200),   B(200),MANCO(200)
      REAL  ZZ(200),   R(200),   C(200),  D4(200),   W(200)
      REAL  BS(200),   E(200),H(2,200),S(2,200),C(2,200)
      REAL HOA(900),QOB(900),DP(200),COREA(200)
      LOGICAL LV(100),KEY(100),LF,LOP
      DIMENSION HKH(200),Z(200),WP(200),ZD(200),RHO(200),ZO(200)
      DIMENSION CU(100),CD(100),CL(100),F(100)
      DIMENSION A(2,200),HAS(100),HH(450),GG(450)
      COMMON KO,KIN,KKK,JJJ
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ
      COMMON C1,D2,D3,EH,EZ,EXLM,SZERC,ES
      COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
      COMMON H,Q,HOA,QOB,FQ,BB,C,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      COMMON /SW/ ISW10,ISW11
      COMMON /T/ MMM,QF,IPF,IPE,NNN
      COMMON /EXLIM/ JLIM,J2LIM,K,I
      COMMON /STOR/DP,COREA,LOP
      COMMON /AREAS/A
      COMMON /OUTP/ LEN,NN,HWS,NDLMM,IHWS
      COMMON /SL/ SLO,ZO
      EQUIVALENCE (I,IH,II),(K,KF,KQ),(NREC,JM2)
      DATA THETA/0.333333/
      DATA INIT/1/
      DATA RHOS/0.75/,P/0.166667/,G/32.2/
C
C
C        INITIALIZATION
      GOTO(1,2),INIT
 1    NSEG=JMAX
      INIT=2
      GG=1.-THETA
      NREC=NSEG/2
      JM2M1=JM2-1
      NMD2=(NMAX-1)/2
```

```
      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)=QQB(NN-1)                                       MARC  73
      Q(KQ,JMAXQ)=QQB(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(I,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. 0)      CALL ERRL(10)                              MARC 128
4     A(IT,J)=B(J)*DPPN+CDREA(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,JLMM1                                                  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.
      A2MP2= (A(2,M2P2)+A(1,M2P2))/2.
      A2MM1=0.5*(A2M+A2MM2)
      A2MP1=0.5*(A2M+A2MP2)
      EBM1=E(M2-1)+A2MM1/DELX
      EBP1=E(M2+1)+A2MP1/DELX
      CL(M-1)=CT2*A(K,M2M2)-Q(I,M2-1)-EBM1
      CD(M)= CG4*A(K,M2)-Q(I,M2-1)+Q(I,M2+1)+EBM1+EBP1
      CU(M)=CT2*A(K,M2P2)+Q(I,M2+1)-EBP1
      F(M)=S(I,M2M2)*(CT2*A(I,M2M2)+Q(I,M2-1)+EBM1)+
     1     S(I,M2)*(LG4*A(I,M2)+Q(I,M2-1)-Q(I,M2+1)-EBM1-EBP1)+
     2     S(I,M2P2)*(CT2*A(I,M2P2)-Q(I,M2+1)+EBP1)
C
7     CONTINUE
C        MASS BALANCE HEAD BOUNDARY CONDITION
C
      M=JLIM
      EB=E(M2+1)*A2MP1/DELX
      CD(M)=CC4*A(K,M2P2)-Q(I,M2P2-1)+EB
      CL(M-1)=CF4*A(K,M2)-Q(I,M2P2-1)-EB
      F(M)=S(I,M2)*(CF4*A(I,M2)+Q(I,M2P2-1)+EB)+
     1     S(I,M2P2)*(CC4*A(I,M2P2)+Q(I,M2P2-1)-EB)
C
C        CALL  EQUATION SOLVER AT THIS POINT
      CALL TRIDG(M     ,CL,CD,CU,F)
C
      DO 20 M=1,JLIM
      J=2*M-1
20    S(K,J)=F(M)
C
C        OUTPUT SELECTION
C        FREQUENCY OF OUTPUT CONTAINED IN ISW5,ISW6,ISW7 FOR H,S,&Q
      IF(ISW5 .EQ. 0)      GOTO 851
      IF( NN .NE. KHCT)    GOTO 851
      CALL SPEW(1,2)
      KHCT=KHCT+ISW5
```

```
851   IF(ISW6 .EQ. 0)   GOTO 852
      IF(NN .NE. KSCT)  GOTO 852
      CALL SPEW(2,2)
      KSCT=KSCT+ISW6
852   IF(ISW7 .EQ. 0)  GOTO 86
      IF(NN .NE. KQCT)  GOTO 86
      CALL SPEW(3,2)
      KQCT=KQCT+ISW7
C
C        MASS BALANCE
86    SUM=0.
      DO 31 J=3,J2LIM,2
31    SUM=SUM+S(K,J)*A(K,J )
      SUM=SUM+0.5*S(K,1)*A(K,1)
      TSUM=TSUM+SUM
C
C        TEST TO SEE IF OUTPUT TO A SEQUENTIAL DATASET IS SPECIFIED
      IF(ISW1 .EQ. 1)      GOTO 4000
C        OUTPUT TIME STEP RESULTS TO FILE 'MMM'
      DO 400  J=1,JMAXH,2
400   HKH(J)=H(K,J)-SLD+ZO(J)+D(J)
      WRITE(MMM) (HKH(J),J=1,JMAXH,2)
      WRITE(  MMM) (S(K,J),J=1,JMAXH,2)
      WRITE(MMM) (Q(K,J),J=2,JMAX,2)
C
C        TEST TO SEE IF HWS OUTPUT HAS BEEN SPECIFIED
4000  IF(ISW2 .EQ. 1)  GOTO 4001
C        HIGH WATER SLACK CALCULATIONS
      DO 40 J=1,JLIM
      IF(KEY(J))   GO TO 40
C        SIGN OF NEW 'Q' TO LP
      IF(Q(KH,2*J))   41,41,42
41    LP=.FALSE.
      GOTO 43
42    LP=.TRUE.
C        TEST FOR HIGH WATER SLACK BY ZERO CROSSING OF Q, + TO -
```

```
43    IF(LV(J) .AND. .NOT. LP)     GOTC 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 405
      IHWS(J)=999
      HWS(J)=999.
405   CONTINUE
      CALL SPEW(4,3)
C
C        CALL TO PRISM ROUTINE
```

```
46    CALL ESNDD(JT2,NMDZ,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
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCC(200)
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)
      REAL HOA(900),QOB(900)
      DIMENSICN DZERO(200),EXK(200),A(2,200)
      CCMMCN KO,KIN,KKK,JJJ
      CCMMON NOS,CASE,CELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ
      COMMON D1,D2,D3,EH,EZ,EXLM,SZERC,ES
      COMMCN MH,MS,ISWO,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
        CCMMON H,Q,HOA,QOB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      CCMMCN /AREAS/ A,QI
      CCMMON /EXLIM/ JLIM,J2LIM,K,M
      CCMMCN /T/ MMM,QF,IPF,IPE,NNN,IETM
      DATA INIT/1/
C
C        M IS THE PREVIOUS TIME STEP
C        K IS THE NEXT TIME STEP
      GOTO(1,2),INIT
1     JLIM=JMAX/2
      XKFAC=(JMAX-1)*0.5
      ETM=IETM
      IF(EXLM)40,41,40
41    J2LIM=JMAXH
      GOTO 42
40    JLIM= IFIX(EXLM/DELX/2.)+2
      J2LIM=2*JLIM-1
42    INIT=2
      E(JMAXH)=0.
      J2M2=J2LIM-2
      FAC4=DELX/DELT*0.25
      RETURN
C
C        GET CZERO ON THE ODD INTERVALS
2     XK=EZ*XKFAC/SZERO
```

```
      DO 10 J=1,J2LIM,2
      IF(J-1) 16,16,17
C        Q1 BY CONTINUITY
16    H2OLD=0.5*(H(M,1)+H(M,3))
      H2NEW=0.5*(H(K,1)+H(K,3))
      Q1=Q(M,2)+FAC4*(B(1)*(H(K,1)-H(M,1))+B(2)*(H2NEW-H2OLD))
      CODD=ABS(Q1)
      GOTC 18
C        NORMAL ... INTERIOR POINTS
17    QODD=C.5*ABS(Q(M,J-1)+Q(M,J+1))
18    HTEM=D(J)+0.5*(H(1,J)+H(2,J))
      GOTO(13,13,14,13,13),CASE
C        TRAPEZOIDAL SECTION
14    AR=C.5*(A(1,J)+A(2,J))
      R(J)=AR/(BB(J)+2.*HTEM*ZZ(J))
      GOTO 15
C        OTHER SECTIONS
13    AR= BS(J)*HTEM
      R(J)=AR/(BS(J)+HTEM+HTEM)
15    V=QODD/AR
      DZERO(J)=77.*MANCO(J)*(R(J)**0.833333)*V*ETM
10    CONTINUE
C
C        GET EXK ON THE EVEN INTERVALS
      DO 11 J=1,J2M2,2
C        TEST FOR SEAWARD POINT NEG.
      SD=S(M,J)
      IF(SD) 9,9,8
9     EXK(J)=C.
      GOTO 11
8     EXK(J)=XK*ABS(SD-S(M,J+2))
11    CONTINUE
C
C        INTERPOLATE TO EVEN INTERVALS
      DO 12 J=1,J2M2,2
12    E(J+1)=EXK(J)+C.5*(DZERO(J)+DZERO(J+2))
```

```
      E(1)=EXK(1)+DZERO(1)                                              TDIS  73
      GOTC(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,NMO2)
      INTEGER CASE
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCC(200)
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)
      REAL HOA(900),QOB(900)
      DIMENSION CD(1),CU(1),F(1)
      DIMENSION A(2,200)
      COMMON KO,KIN,KKK,JJJ
      COMMON NOS,CASE,DELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ
      COMMON D1,D2,D3,EH,EZ,EXLM,SZERO,ES
      COMMON MH,MS,ISWO,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
      COMMON H,Q,HOA,QOB,FQ,BB,C,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      COMMON /T/ MMM,CF,IPF,IPE
      COMMON /AREAS/ A,Q1
      COMMON /EXLIM/ JD1,JD2,K,M
      DATA INIT/1/
      DATA THETA/0.333333/
C
C        INITIALIZE SIGN OF PREVIOUS DISCHARGE, SMIN, COUNTER OF
C        INCREMENTS SINCE FLOOD BEGAN
      GOTO(1,2),INIT
C        IF THE FIRST CYCLE BEGINS ON FLOOD SMIN MUST BE
C        ARBITRARILY DEFINED.  IT IS SET TO SZERO FOR FIRST CYCLE ONLY
1     QLST=1.
      SMIN=SZERO
      NMAXM=NMAX-1
      NFLD=NMD2/2
      NEBB=0
      DXCT=DELX/DELT
      CC4=2.*(1.-THETA*0.5)*DXCT
      CF4=2.*(THETA*0.5)*DXDT
      INIT=2
C
C        NORMAL ENTRY
2     IF(QLST*Q(M,2)) 10,20,20
```

```
C          CHANGE OF SIGN                                          TOCN  37
 1C     IF(Q(M,2)) 11,12,12                                        TOCN  38
C          TO EBB                                                  TOCN  39
 11     NEBB=0                                                     TOCN  40
        GOTO 21                                                    TOCN  41
C          TC FLOOD                                                TOCN  42
 12     NFLD=1                                                     TOCN  43
        SMIN =S(M,1)                                               TOCN  44
        GOTO 22                                                    TOCN  45
C          NO SIGN CHANGE                                          TOCN  46
 20     IF(Q(M,2)) 21,22,22                                        TOCN  47
C          FLOOD                                                   TOCN  48
 22     IF(NFLD-IPF) 23,24,24                                      TOCN  49
C          WITHIN RANGE                                            TOCN  50
 23     SX=SMIN+(SZERO-SMIN)*NFLD/FLOAT(IPF)                       TOCN  51
        NFLD=NFLD+1                                                TOCN  52
        GOTO 77                                                    TOCN  53
C          OUT CF RANGE                                            TOCN  54
 24     SX=SZERC                                                   TOCN  55
        GOTO 77                                                    TOCN  56
C          EBB                                                     TOCN  57
 21     IF(NEBB-IPE) 25,26,26                                      TOCN  58
C          WITHIN RANGE                                            TOCN  59
 25     NEBB=NEBB+1                                                TOCN  60
        SX=SZERC                                                   TOCN  61
        GOTO 77                                                    TOCN  62
C                                                                  TOCN  63
C          OUT OF RANGE  *** SPECIAL ROUTINE ***                   TOCN  64
C                                                                  TOCN  65
C          Q1 AND AREAS FRCM COMMCN                                TOCN  66
 26     A1B=(A(2,1)+A(1,1))*0.5                                    TOCN  67
        A3B=(A(2,3)+A(1,3))*0.5                                    TOCN  68
        EB=C.5/CELX*(E(1)*A1B-E(2)*(A1B+A3B)*0.5)                  TOCN  69
        CD(1)=CC4*A(K,1)-Q1-Q1+Q(M,2)-EB                           TOCN  70
        CU(1)=CF4*A(K,3)+Q(M,2)+EB                                 TOCN  71
        F(1)=S(M,1)*(CC4*A(M,1)+Q1+Q1-C(M,2)+EB)+                  TOCN  72
```

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

```
      SUBRCUTINE TRICG (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(10C),C(1CC),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
      DC 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 MODIFICATICN CF SUBROUTINE 'PRISM'
C        WHICH CCNVERTS THE ESTUARY NC. TC A DENSIMETRIC ONE AND
C        EVALUATES THE GROSS DISPERSICN PARAMETER 'K' IN TERMS
C        OF (U*L)
C        CALCULATION OF TIDAL PRISM, MAX. VELOCITY, DENSIMETRIC FROUDE N
C        Q(F)  AND THE ESTUARY NUMBER(DENSIMETRIC)
      REAL           Q(450),H(450),V(450)
      COMMCN KO
      COMMON /CEPT/ XNCPT
C        CONST FOR CCNVERTING SALINITY TO CENSITY DEFINED BELOW
      DATA TCCNS/0.75/
      VOLB(Q1,Q2)=Q2*Q2*DT*0.5/(Q2-Q1)
      VOLN(Q1,Q2)=0.5*(Q1+C2)*CT
      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),C(I))
11    I=I+1
      IF(I .GT. NT)      GOTO 30
      IF(C(I) .LT. 0.)   GOTC 12
      PT=PT+VOLN(Q(I-1),Q(I))
      GOTC 11
12    PT=PT+VCLL(Q(I-1),Q(I))
      GOTO 30
C        STARTS GCING POSITIVE
2     I=I+1
      IF(Q(I) .LT. 0.)   GOTO 2C
      PT=PT+VCLN(Q(I-1),Q(I))
```

```
      GOTC 2
20    PT=PT+VOLL(Q(I-1),Q(I))
21    I=I+1
      IF(I .GT. NT)      GOTO 30
      IF(Q(I) .LT. 0.)  GOTO 21
      PT=PT+VOLB(Q(I-1),Q(I))
22    I=I+1
      PT=PT+VCLN(Q(I-1),Q(I))
      IF(I .LT. NT)    GOTO 22
C
C        FIND VMAX
3C    NTM1=NT-1
      DO 40 I=1,NTM1
4C    V(I)=Q(I)/B/(H(I)+H(I+1))*2.
      V(NT)=Q(NT)/B/(H(NT)+H(1))*2.
      VMAX=0.
      DO 41 I=1,NT
      IF(ABS(V(I)) .LT. VMAX)  GCTO 41
      IH=I
      VMAX=ABS(V(I))
41    CCNTINUE
      TIME=IH*DT/3600.
      WRITE(KO,200) PT,VMAX,TIME
200   FORMAT('OPRISM=',E16.7,' CUFT',16X,'VMAX=',F10.4,' FT/SEC',3X,
     1       'AT',F7.2,' HRS FRCM BEGINNING OF CYCLE')
      IF(IH .EQ. NT)   H(NT+1)=H(1)
      RH=B*(H(IH)+H(IH+1))*0.5/(B+H(IH)+H(IH+1))
      FR=VMAX/SQRT(32.2*D)
      FRDS=FR/SQRT(DRC)
      WRITE(KC,202) FRDS,FRESH
2C2   FORMAT(' DENSIMETRIC FROUDE NO.=',F1C.6,10X,
     1       'SUM OF QF''S=',F10.3,' CU.FT/SEC')
      T=NT*DT
      ESNC= PT*FR*FR/FRESH/T/DRO
C        CORRELATICN FOR K/(UL)=F(ESNC)
      EEZ=VMAX*XL*XNCPT  *(ESNC**(-.25))
```

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

```
      SUBROUTINE SPEW(KEY,IL)
C        ARGUMENT 'KEY' IS 1 FOR H, 2 FOR S, 3 FOR Q, AND 4 FOR HWS
C        ARGUMENT 'IL' IS 1 FOR FINAL CCNDITION OUTPUT
C                         2 FOR NCRMAL OUTPUT
C                         3 FOR HWS
C                         4 FOR I.C.
      INTEGER CASE
      REAL  FC(200), BB(200),  D(200), SS(200),  B(200),MANCC(200)
      REAL  ZZ(200),  R(200),  C(200), D4(200),  W(200)
      REAL  BS(200),  E(200),H(2,200),S(2,200),Q(2,200)
      REAL HOA(900),QCB(900)
      DIMENSICN HWS(100),ZO(200),CUM(2C0),IHWS(100),KNO(200)
      COMMCN KO,KIN,KKK,JJJ
      CCMMCN NOS,CASE,CELT,DELX,NMAX,NMAXH,JMAX,JMAXH,JJTEM,JMAXQ
        CCMMCN D1,D2,D3,EH,EZ,EXLM,SZERO,ES
        COMMON MH,MS,ISW0,ISW1,ISW2,ISW3,ISW4,ISW5,ISW6,ISW7
      CCMMON H,Q,HOA,QCB,FC,BB,D,SS,B,ZZ,R,MANCO,C,D4,W,BS,S,E
      COMMCN /EXLIM/ JLIM,J2LIM,K,M
      COMMON/SL/SLD,ZO
      COMMCN /OUTP/ NC,NN,HWS,NTCT,IHWS
      DATA INIT/1/
C
C        NUMBER SEQUENTIAL ARRAY
      GOTO(10C0,2000),INIT
1C00  DO 10C1 J=1,200
1C01  KNO(J)=J
      INIT=2
      T=(NMAX-1)*DELT/3600.
      TFAC=T/(NMAX-1)
C
C        SET UP THE 'FROM WHENCE' CCNDITICNS
2C00  GOTO(20C1,2002,2003,20C4),IL
C        FRCM MAIN,  OUTPUT FINAL CCNDITICNS
2C01  NP=1
      IT=M
      NTC=NTCT
```

```
      GOTC 2005
C        FRCM MARCH,  NCRMAL CUTPLT
2002  NP=NN
      IT=K
      NTC=NC
      GOTC 2C05
C        FRCM MARCH, HWS
2C03  NP=1
      NTC=NC
      GOTC 2005
C        FRCM OSIN,  I.C. READ IN
2004  NP=1
      NTC=1
      IT=1
      J2LIM=JMAXH
C
C
2C05  ISTOP=1
C        TIME CALCULATICN
      IF(KEY .EQ. 3)   NP=NP+1
      CYHR=(NP-1)*TFAC
      DAY=((NTC-1)*T+CYHR)/24.
      ICAY=CAY
      DAYHR=(CAY-ICAY)*24.
      WRITE(KC,200) NTC,CYHR,ICAY,CAYHR
200   FORMAT('OTIDAL CYCLE',I4,2X,F7.3,' HOURS',5X,'DAY',I4,2X,
     1       F7.3,' HCURS')
      GOTC(1,2,3,4),KEY
C        H-  ELEVATION  WRT  MSL
1     WRITE(KC,201)
201   FORMAT('+',T65,'INSTANTANEOLS SLRFACE ELEVATION WITH RESPECT TO ',
     1       'MSL, FT')
      JM=JMAXH
      IF(IL .NE. 2)   GOTO 70
      DO 10 J=1,JMAXH,2
1C    DUM(J)=H(IT,J)-SLD+ZO(J)+C(J)
```

```
      GOTO 70
12    WRITE(KC,202) (KNC(J),J=NS,NF,2)
202   FORMAT(' STATICNS',I5,13I8)
      IF(IL .EQ. 2)  GOTO 1212
      WRITE(KC,203) (H(IT,J),J=NS,NF,2)
203   FORMAT(' ELEV.     ',14F8.3)
      GOTC 80
1212  WRITE(KC,203) (DUM(J),J=NS,NF,2)
      GOTO 80
C        S-  SALINITY
2     WRITE(KC,220)
220   FORMAT('+',T65,'INSTANTANEOLS SALINITIES IN PPT')
      JM=J2LIM
      GOTO 70
21    WRITE(KC,202) (KNC(J),J=NS,NF,2)
      WRITE(KC,207) (S(IT,J),J=NS,NF,2)
207   FORMAT(' SALINITY',14F8.3)
      GOTC 80
C        Q-      DISCHARGE
3     WRITE(KC,230)
230   FORMAT('+',T65,'INSTANTANEOLS DISCHARGES IN CFS')
      NS=2
      NF=20
33    IF(NF .LT. JMAX)  GOTO 31
      ISTCP=2
      NF=JMAX
31    WRITE(KC,205) (KNC(J),J=NS,NF,2)
205   FORMAT(' STATIONS',2X,I5,9I10)
      WRITE(KC,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(KC,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)   GOTC 45                                 SPEW 115
       DUM(J)=999.                                                    SPEW 116
       HWS(J)=999.                                                    SPEW 117
C         THIS WILL CAUSE 999. TO PRINT CN 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 CCMPACTLY,  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
       GOTC 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
       ISTCP=2                                                        SPEW 142
       GOTO(12,21,55,41),KEY                                          SPEW 143
 8C    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)
      CCMMCN KO
C
C        THIS IS AN ERROR HANDLING RCUTINE, IT ISSUES MESSAGES TO HELP
C        THE USER IDENTIFY THE CALSE CF INPUT AND OTHER ERRCRS
      DATA JINX/0/
      IF(KEY .EQ. 8)    GOTO 8
      WRITE(KO,200)
200   FORMAT('0 *** SALINITY INTRLSICN PRCGRAM ERROR ***')
      IF((KEY .LT. 1) .OR. (KEY .GT. 10))      GOTO 60
       GOTO(1,2,3,4,5,6,7,8,9,10),KEY
1     WRITE(KC,201)
201   FORMAT(' NUMBER OF SECTICNS MLST BE EVEN')
      GOTC 500
2     WRITE(KC,202)
202   FORMAT(' NUMBER OF TIME INTERVALS MLST BE EVEN')
      GOTC 500
3     WRITE(KC,203)
203   FORMAT(' CASE IS NOT 1 THRU 5')
      GOTC 555
4     WRITE(KC,204)
204   FORMAT(' NEGATIVE INTRUSICN LENGTH IN INPUT')
      GOTO 555
5     WRITE(KO,205)
205   FORMAT(' COLUMN 1  DOES NCT CCNTAIN H,Q OR S')
      GOTC 50C
6     WRITE(KO,206)
206   FORMAT(' SEQUENCING ERROR IN INPUT STREAM')
      GOTO 555
7     WRITE(KO,207)
207   FORMAT(' INTERVAL FOR CUTPUT MUST BE EVEN',/)
C
C        CHECK FOR INPUT ERRCRS
8     IF(JINX .NE. 0) GOTO 8C
      WRITE(KC,208)
208   FORMAT('1 CALCULATICN BEGINS',/)
```

```
      RETURN                                                            ERRL
80    WRITE(KO,2080) JIAX                                               ERRL
2080   FORMAT('0',I3,' INPUT ERRORS DETECTED, CALCULATION ABORTED',/)   ERRL
      CALL EXIT                                                         ERRL
9     WRITE(KO,209)                                                     ERRL
209   FORMAT(' WATER SURFACE BELOW THE BOTTOM WHICH INDICATES A ',      ERRL
     1        'PROBABLE NUMERICAL INSTABILITY.',/,' THE REMEDY MAY WELL',ERRL
     2        ' BE A SMALLER DELTA-T')                                  ERRL
      GOTO 555                                                          ERRL
10    WRITE(KC,210)                                                     ERRL
210   FORMAT(' THE WATER SURFACE IN THE STORAGE AREA HAS FALLEN BELOW', ERRL
     1        ' THE BOTTOM.  THIS IS NOT NECESSARILY AN INSTABILITY,',/, ERRL
     2        ' BUT IS PROBABLY A PROBLEM IN SCHEMATIZATION')           ERRL
      GOTO 555                                                          ERRL
60    WRITE(KC,298) KEY                                                 ERRL
298   FORMAT(' ERROR CODE UNRECOGIZED, IT IS',I10)                      ERRL
      GOTO 555                                                          ERRL
555   WRITE(KC,299)                                                     ERRL
299   FORMAT('0 FATAL ERROR, EXIT TAKEN',/)                             ERRL
      CALL EXIT                                                         ERRL
500   JINX=JINX+1                                                       ERRL
      RETURN                                                            ERRL
      END                                                               ERRL
```

```
      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 per Cycle (even).	I5
	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.

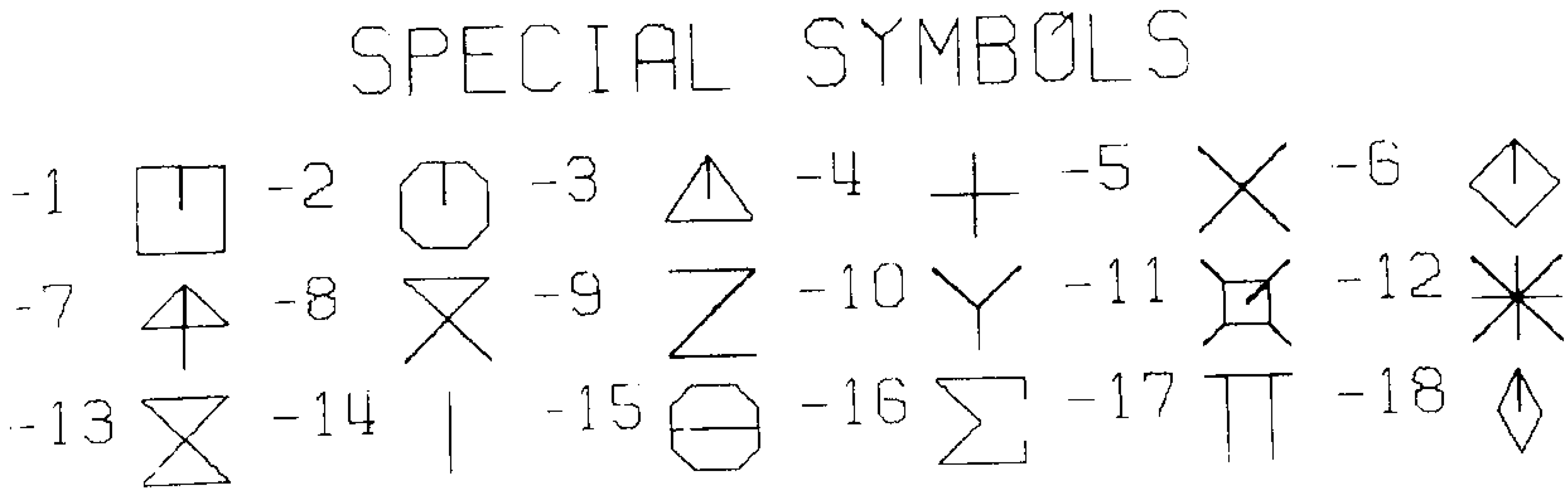

Figure III.1 Symbol Codes for M.I.T. Calcomp Subroutines

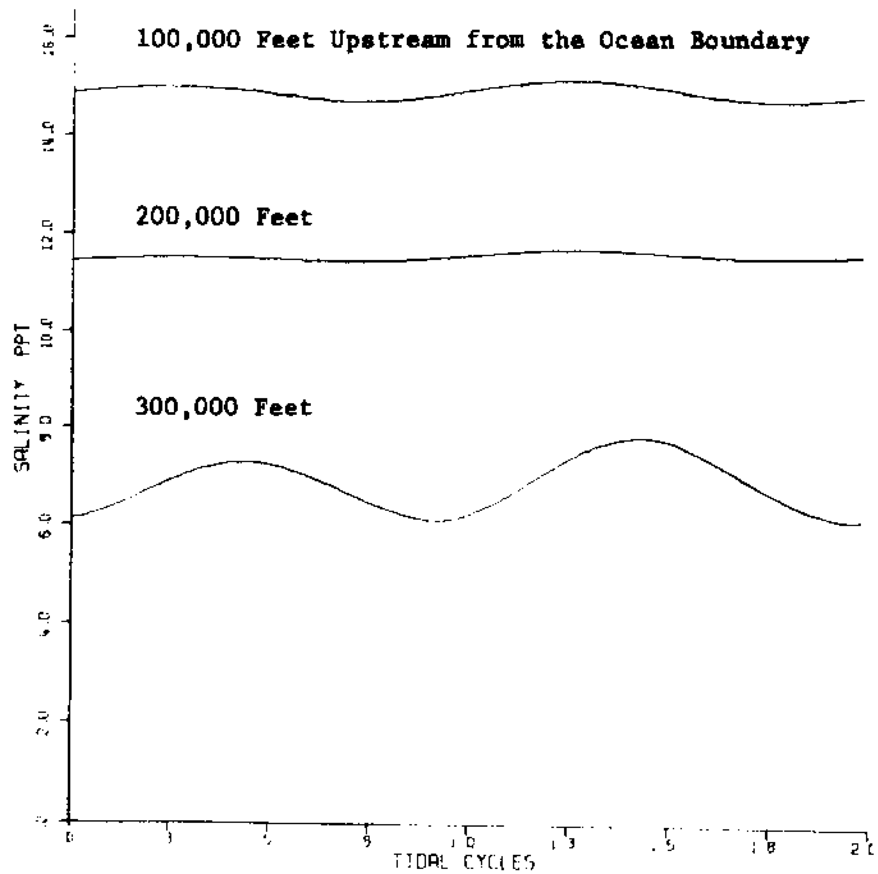

Figure III.2 Typical Plot

Table III.1

Listing of Plotting Program and Test Case

```
C
C
C     A PLOT LENGTH OF ABOUT 25 INCHES AT 50 PTS./INCH IS DIMENSIONED
C     IN THE MATRIX 'SAVE'
      REAL F(8),HSQ(100),Z(100),SAVE(8,1250),XO(1250)
      REAL ST(8),YLABEL(4),DLAB(3,4)
      INTEGER KID(3),NS(8)
      DIMENSION          UGDS(100),VGDS(100)
      DATA DLAB/'ELEV','SALI','DISC','ATIO','NITY','HARG',
     1     'N  F',' PP','E  C','T   ','T   ','FS  '/
      DATA KID/'H','S','Q'/,KIN,KO,KU/5,6,1/
C     SET PLOT DENSITY IN DATA STATEMENT, IN POINTS PER INCH
      DATA SDEN/50./
C     DEFINE VARIABLE KPROG =3, FOR H,S,Q, OR =2 FOR H AND Q ONLY
      DATA KPROG/3/,IODD/2/
C
C     READ THE NUMBER OF FRAMES
      CALL NEWPLT('M8238','C910','WHITE ','BLACK')
      READ(KIN,100) NOPLT
      DO 55 IPLOT=1,NOPLT
C
      READ(KIN,100) NX2,XLT,NT2,T,NTC,PL
100   FORMAT(I5,F10.0)
      NX=NX2/2
      XX=2.*XLT/(NX2-1)
      IF(2*NX .EQ. NX2)        GOTO 311
C     CASE WITH ODD NUMBERED STATIONS AS UPSTREAM END BC BY ELEVATION
      IODD=1
      NX=NX+1
311   NT=NT2/2
      IF(2*NT .NE. NT2)     GOTO 552
      READ(KIN,102) SCL,YL
      READ(KIN,101) ID,NSTA,IPCINT
101   FORMAT(A1,I4,I5)
      READ(KIN,102) (ST(I),I=1,NSTA)
102   FORMAT(8F10.0)
```

```
C
C         PRINT BACK ON INPUT
2     WRITE(KO,300) NTC,PL,YL
300   FORMAT('1',T7,'CALCOMP  PLOTTING  FOR',I5,'  TIDAL CYCLES',/,
     1        T3,'PLOT LENGTH =',F5.1,' INCHES  HEIGHT =',F5.2,' INCHES')
      WRITE(KC,301) NT2,NX2,SCL,XX
301   FORMAT('0',I6,' TIME INCR. PER CYCLE',I6,' DISTANCE STATIONS',
     1        /,T4,'MAX. ORDINATE =',F11.1,/,T4,
     2        'DISTANCE BETWEEN STATIONS =',F8.0,' FEET',//
     3        ,T6,'LOCATION',T19,'DISTANCE',/,T7,'NUMBER',T20,'(FEET)')
      WRITE(KC,304) (DLAB(IN,J),J=1,4)
304   FORMAT('0PLOT OF ',4A4)
      DO 20 I=1,NSTA
      WRITE(KC,302) I,ST(I)
302   FORMAT(T9,I3,T15,F8.0)
C
C        FOR 'C' SHIFT ALIGNMENT DELTA-X/2
      IF(IN .NE. KPROG)   GOTO 20
      ST(I)=ST(I)-XX/2.
20    CONTINUE
C
C         CALCULATE SAMPLING INTERVAL 'IR'
      NOPTS=NTC*NT
      DEN=NOPTS/PL
      IR=1
      IF(DEN .GT. SDEN)      IR=DEN/SDEN
```

```
      WRITE(KC,303) IR                                                  PLOT  73
303   FORMAT('0 SAMPLING EVERY',I4,' POINTS')                           PLOT  74
C        FIND LAND SIDE JF INCR. FOR EACH STATION                       PLOT  75
      DO 6 I=1,NSTA                                                     PLOT  76
      DO 7 J=1,NX                                                       PLOT  77
      IF(ST(I) .EQ. 0.)  GOTO 8                                         PLOT  78
      IF(XX*(J-1) .GE. ST(I))    GOTO 8                                 PLOT  79
      GOTO 7                                                            PLOT  80
8     NS(I)=J                                                           PLOT  81
      IF(J .EQ. 1)    NS(I)=J+1                                         PLOT  82
      JM2=NS(I)-2                                                       PLOT  83
      F(I)=(ST(I)-XX* JM2 )/XX                                          PLOT  84
      GOTO 6                                                            PLOT  85
7     CONTINUE                                                          PLOT  86
      WRITE(KC,700)                                                     PLOT  87
700   FORMAT('0 STATION OUT OF RANGE')                                  PLOT  88
      CALL EXIT                                                         PLOT  89
6     CONTINUE                                                          PLOT  90
C                                                                       PLOT  91
C        SET YMIN AND Y-LABEL                                           PLOT  92
      DO 3 I=1,4                                                        PLOT  93
3     YLABEL(I)=DLAB(IN,I)                                              PLOT  94
      GOTO (4,5,4),IN                                                   PLOT  95
4     YMIN=-SCL                                                         PLOT  96
      DY=2.*SCL/YL                                                      PLOT  97
      GOTO 9                                                            PLOT  98
5     YMIN=0.                                                           PLOT  99
      DY=SCL/YL                                                         PLOT 100
C        THE INCREMENT IS IN TIDAL CYCLES                               PLOT 101
9     XINCR=1./NT*IR                                                    PLOT 102
      DX=NTC/PL                                                         PLOT 103
      XMAX=NTC                                                          PLOT 104
      NDX=1                                                             PLOT 105
      NDY=1                                                             PLOT 106
      KXY=0                                                             PLOT 107
C                                                                       PLOT 108
```

```
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 AXIS1(0.,0.,'TIDAL CYCLES',12,PL,0.,0.,DX,NDX,KXY,1.)
      CALL AXIS1(0.,0.,YLABEL,16,YL,90.,YMIN,DY,NDY,KXY,1.)
      CALL PLOT1(0.,0.,3)
C
      X=0.
      IOUT=0
      IC=1
C        LOOP BY TIDAL CYCLE
      DO 5000 ITC=1,NTC
C        LOOP BY TIME INCREMENTS
      DO 1000 I=1,NT
      DO 11 N=1,KPROG
      LRECL=NX
      IF(IOOD .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,NK
110   Z(J)=HSQ(J)
11    CONTINUE
      IF(IC .NE. 1)        GOTO 3?
      IOUT=IOUT+1
      IF(IOUT .LE. 1250)    GOTO 24
      WRITE(KO,224)
224   FORMAT('0 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(IOUT)=X
      IF( X .GT. XMAX)        GOTO 50
      X=X+XINCR
25    SAVE(M,IOUT)=Y
      IF(ABS(Y) .GT. SCL)        GOTO 50
30    IC=IC+1
      IF(IC .GT. IR)        IC=1
1000  CONTINUE
5000  CONTINUE
      DO 12 M=1,NSTA
      WRITE(KO,2001) M,ST(M)
2001  FORMAT('1STATION NO.',I5,' AT',F10.0,' FEET',//)
      WRITE(KO,2002) (XO(J),SAVE(M,J),J=1,IOUT)
2002  FORMAT(F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,F7.3,F12.3,
     1         F7.3,F12.3)
      DO 23 I=1,IOUT
23    CALL PLOT1(XO(I)/DX,(SAVE(M,I)-YMIN)/DY,2)
      IF(IPOINT .EQ. 0)   GOTO 12
C
C        READ IN THE NO. OF POINTS AND PLOT CODE
C        IF CURVE HAS NO POINTS THEN ENTER ZERO (0)
      READ(KIN,103) NPT,NCODE
103   FORMAT(2I5)
      WRITE(KO,221) T,NPT
221   FORMAT(//,' PERIOD=',F8.0,' SEC',I5,' POINTS')
      IF( NPT .EQ. 0)      GOTO 12
      IF( NCODE .EQ. 0)      NCODE =-12
      DO 1002 J=1,NPT
      READ(KIN,102) XX,Y
C
C        CONVERT THE DAY NUMBER TO TIDAL CYCLES, CENTERING THE
C        DAILY OBSERVATION AT 1200 HRS,  AND ASSUMING THAT T=0
C        IS AT 0000 HRS OF THE FIRST DAY.
      X=((XX-1.)*86400.+43200.)/T
      WRITE(KO,222) X,XX,Y
222   FORMAT(5X,F7.1,2F7.2)
```

```
      UGDS(J)=X/DX                                                      PLOT 181
1002  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('0 PLOTTED')                                               PLOT 188
      CALL ENDPLT                                                       PLOT 189
      GOTO 555                                                          PLOT 190
552   WRITE(KC,2552)                                                    PLOT 191
2552  FORMAT('0NO. TIME INTERVALS NOT EVEN')                            PLOT 192
      GOTO 555                                                          PLOT 193
50    WRITE(KO,501)M,I,Y,X                                              PLOT 194
501   FORMAT(' LOC',I3,' T INCR.',I10,' 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 44640.
    2  8.
 18.       9.
9    3
10000.    20000.    30000.
```