A Spatially Integrated Numerical Model for Inlet Hydraulics

Table of Contents

A Spatially Integrated Numerical Model for Inlet Hydraulics

Description

This application is a numerical model that estimates coastal inlet velocities, discharges, and bay levels as functions of time for a given time-dependent sea level fluctuation. Inlet hydraulics are predicted in this model by simultaneously solving the time-dependent momentum equation for flow in the inlet and the continuity equation relating the bay and sea levels to inlet discharge. The model is designed for cases where the bay water level fluctuates uniformly throughout the bay and the volume of water stored in the inlet between high and low water is negligible compared with the tidal prism of water that moves through the inlet and is stored in the bay. The model has been previously described by Seelig (1977) and Seelig, Harris, and Herchenroder (1977). Because of the complexity of this methodology and the input requirements, familiarization with the above references is strongly recommended.

An inlet-bay system typically consists of a *sea* (ocean or lake) connected to a *bay* by one or more *inlets*. Possible system configurations that this ACES application will run include:

- 1-Sea - 1-Inlet - 1-Bay System
- 1-Sea - 2-Inlet - 1-Bay System
- 2-Sea Boundary Condition - 2-Inlet - 1-Bay System (see Figure 7-1-1)

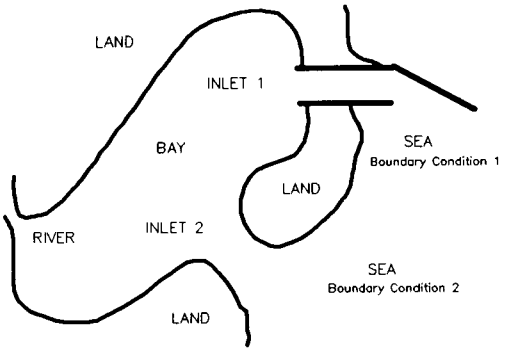

Figure 7-1-1. Conceptual 2-Sea, 2-Inlet, and 1-Bay System

CAUTION: Only the 1-Sea, 1-Inlet, 1-Bay System has been tested with this version of the model. Use the other system configurations with caution!

LIMITATION: The bay and inlet must contain water throughout the water level cycle. This application cannot treat shallow inlet areas that may be exposed (dry up) during any portion of the tidal cycle.

INPUT

The input requirements of this application consist of five general types of information:

- General data describing system configuration and temporal data.
- Inlet geometries characterized with cross-section tables and locations.
- Seaward boundary conditions (tabulated records or predicted tides using harmonic constituents).
- Bayside boundary conditions (bay area and shape factor, and other freshwater inflows distinct from inlet contributions).
- Locations where velocity hydrographs are to be reported from the simulation.

Data input to this application is accomplished through numerous input screens or through data saved in an external file. Detailed lists of the screens and input parameters are presented in the *Procedure* section of this document. Also, a review of the referenced documents is strongly recommended.

OUTPUT

Results from this application are written to the plot output files (1-3). The contents and organization of output data in the plot output files are summarized below. In addition, this application generates numerous screen plots (see section titled **Plot Output Data**).

Plot Output File 1

This file contains tabular summaries of grid characteristics for equal channel discharge (based upon an assumed representative velocity for the minimal cross section). The contents of the file are for general information only and are relative to assumptions made in constructing the flow net. The data are not results of the simulation using the time-dependent sea and bay hydrographs.

Summarized by channel for each cross section (for each inlet) are common geometric properties such as area, width, depth, and a weighting factor describing the flow distribution among the channels.

Also provided for each cross section is a table of discharge distribution and water depths for the entire cross section, tabulated at 100 equally spaced segments across the section. Finally, a table of friction loss (per foot of channel) is tabulated by cross section.

Plot Output File 2

This file contains a table of velocity hydrographs produced by the simulation at selected flow net cell locations. The velocities (feet per second) are reported at the *Tabular Output Time Interval* and represent the velocity condition at the centers of the selected flow net cells.

Plot Output File 3

This file contains elevation and discharge hydrographs for the sea boundary conditions (BC), bay, and inlet(s). Results are tabulated at the *Tabular Output Time Interval* and represent summary conditions at the indicated times for the entire system. Included are sea and bay elevations, riverine inflows, average velocity at the controlling cross section, and inlet discharge.

A final table is provided that summarizes flood and ebb regimes and volumes identified during the simulation.

PROCEDURE

This application provides only a Single Case Mode. The Multiple Case Mode is not available. The Single Case Mode requires interaction with the application and provides two options of interactive participation. The first option allows entering new data sets, and the second option allows the editing of existing data files.

Single Case Mode

- Press F1 on the Main Menu to select Single Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press F1 when all data on this screen are correct.
- Press F7 on the Functional Area Menu to select Inlet Processes.
- Press F1 on the Inlet Processes Menu to select A Spatially Integrated Numerical Model for Inlet Hydraulics.

Data Entry Options Menu
This menu provides two options of interactive participation with the application.

F1 Initial Case Data Entry
Use this option to enter an initial (new) set of data. These data will be written to the *Trace Output* file (default name **TRACE.OUT**) and become available for subsequent editing and use.

Alt F1 Edit Case in External File: INLET.IN
Use this option to access and modify data saved in an external file. This external data file is created by saving (or copying) a *trace file* from a previous execution of this application. The format and contents of the *trace file* for this application match exactly the requirements of this input file. The default input file name is **INLET.IN**, but other file names (including path name) are acceptable. After entering the file name, press ENTER to accept this file. *For more information on files, see the section of this manual entitled, "General Instructions and Information."*

Activity Menu
The Activity Menu is a point from which all options for Single Case data entry, modification, and execution are accessible. The options are:

- F1 Begin Computations.
- F2 General Time and Inlet Data Entry.
- F3 Inlet(s) Cross-Section Data Entry.
- F4 Sea(s) Boundary Condition Data Entry.
- F5 Bay Boundary Condition Data Entry.
- F6 Specify Velocity Output Locations.
- F7 Plot Output Data.
- F10 Exit Menu.

Each option and the required data are described below.

F1 Begin Computations
Use this option only after all data have been entered.

(F2) General Time and Inlet Data Entry

This screen provides for input of general parameters required to run the application. Values for all parameters listed are required.

Item	Units	Data Range
Profile point units	ft,m	
Simulation start time:		
Year		1900 to 2050
Month		1 to 12
Day		1 to 31
Hour		0 to 24
Time step	sec	60 to 300
Length of simulation	hr	0 to 48
Tabular output time interval	min	2 to 360

NOTE: The tabular output time interval must be a multiple of the time step, and, at a minimum, it must be at least twice the time step.

Number of inlets	1 or 2
Number of bays	1
Number of seaward boundary condition locations	1 or 2

The following data are required for each inlet:			
Number of channels	1	to	7
Number of cross sections	1	to	16
Flood loss coefficient	0.0	to	10.0
Ebb loss coefficient	0.1	to	10.0
Coefficient C_1 to evaluate Manning's n	0.001	to	3.0
Coefficient C_2 to evaluate Manning's n	0.00001	to	1.0

NOTE: After completing data entry on this screen, press (F10) to return to the Activity Menu.

(F3) Inlet(s) Cross-Section Data Entry

This series of screens provides for input of data that will be used to construct a flow net (or grid) for the inlet(s). The flow net is used to characterize hydraulic properties and bottom friction throughout the inlet (see Seelig, Harris, and Herchenroder, 1977, Appendix B). This application will accept 1 or 2 inlets with a maximum of 16 cross sections per inlet. Each cross section can be defined by a maximum of 54 elevations spaced at a constant distance (ΔX). Cross sections should be indexed in ascending order from sea to bay through the inlet. Channels are indexed in ascending order from left to right (from a seaward perspective). In Figure 7-1-2 a flow net with six channels and eight cross sections is depicted. Figure 7-1-3 shows a simple cross section consisting of nine equally spaced elevation points.

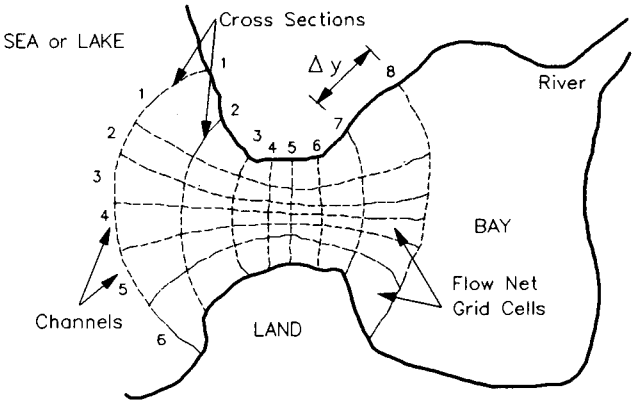

Figure 7-1-2. Typical Inlet Flow Net

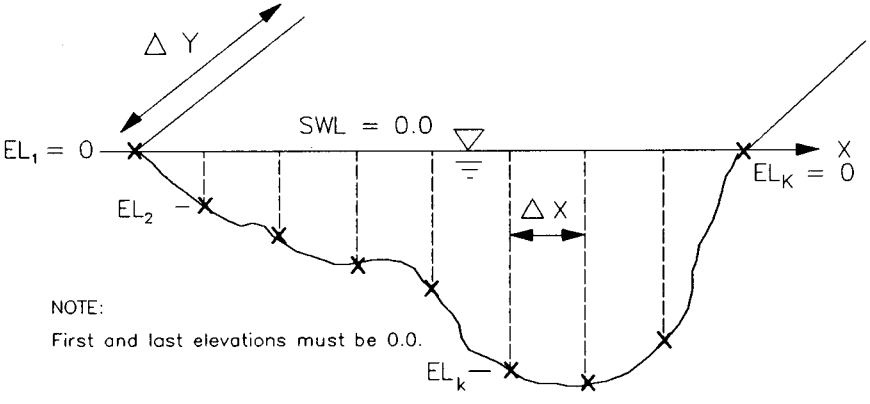

Figure 7-1-3. Typical Inlet Cross Section

Item/Description	Units	Data Range
$Inlet_i$ - (index)		1 or 2
Cross $section_j$ - (index)		1 to 16

Press [F1] to access the screen for input of specific cross-section data.

ΔX - horizontal spacing of cross-section points — ft,m — 1.0 to 5,000.0

NOTE: This distance should be small enough so that linear interpolation between elevation readings will adequately describe the bottom topography for each cross section.

ΔY - distance to the next cross section — ft,m — 5.0 to 10,000.0

NOTE: For the last cross section, the ΔY must be 0.0.

EL_k - cross-section elevations relative to still-water level ($k = 1 \ldots K$, $K \leq 54$) — -999.999 to 0.0

CAUTION: The first and last elevation on each cross section *must* be 0.0. Because the inlet must contain water throughout the water level cycle, cross-section elevations throughout the inlet should exceed the lowest point in the water cycle.

NOTE: If there are more than 27 elevation points for the selected cross section, press [F1] to access another screen for entering remaining (27 through 54) elevation values. After completing elevation data entry for one cross section, press [F10] to return to the Activity Menu. Then press [F3] to continue entering elevation data for the next cross section.

F4 Sea(s) Boundary Condition (BC) Data Entry

This series of screens provides for the input of the seaward-side forcing boundary conditions for the model. Water levels may be described by *tabulated* entries (120 maximum) collected at a constant sampling interval. Alternately, tides can be expressed as a *constituent* tide record with an amplitude and epoch for any of 37 constituents (see Table A-5, Appendix A).

Item/Description	Units	Data Range
Sea BC_1 - (index)		1 or 2
Sea BC type - (constituent or tabulated)		Tab or Con
Sea BC Δt - time interval for tabulated or generated BC hydrograph record	min	0.0 to 720.0

Press F1 to continue input.

Tabulated Data

Item/Description	Units	Data Range
Sea BC elevation units	ft, m	

Press F1 to continue *tabulated data* input.

Sea BC EL_m ($m = 1..M$, $M \leq 120$)	ft,m	-999.99 to 9,999.99

NOTE: Each screen will accept a maximum of 30 values. Press F1 to continue *tabulated* input (maximum 120 values). When finished entering all elevation data, press F10 to return to the Activity Menu.

CAUTION: The simulation begins with a sea level of zero and zero current, which means the sea boundary condition should reflect these conditions. This can be achieved by ensuring that tabulated entries begin with a gradual change (slope of the forcing boundary condition time series is near zero at the beginning of the simulation).

NOTE: The total time span for tabulated water levels must equal or exceed the *Length of Simulation*. For example, if the time interval between tabulated water level entries is 30 minutes and there are 77 entries, then the *Length of Simulation* must be less than or equal to 38 hours.

$$\frac{(77-1)*30 minutes}{60 minutes} = 38 hours$$

Constituent Tide Data

Item/Description	Units	Data Range
Sea BC longitude	deg WEST	-180.0 to 180.0
Sea BC amplitude units	ft,m	

Press [F1] to continue *constituent tide data* input.

$Amplitude_n$ of individual $constituent_n$	ft,m	0.0 to 999.99
$Epoch_n$ of individual $constituent_n$	deg	0.0 to 360.0

NOTE: The names of 37 common harmonic constituents (see Table A-5, Appendix A) are displayed on a series of screens. Place the values of amplitude and epoch by the appropriate desired constituent name. Press [F1] to continue additional *constituent* input on subsequent screens. When finished entering all data, press [F10] to return to the Activity Menu.

(F5) Bay Boundary Condition Data Entry

This series of screens provides for the input of bay characteristics and inflows from a source (river) other than the inlet. Bay surface area is the only required input.

Item/Description	Units	Data Range
Area - bay surface area	ft^2, m^2	$9x10^4$ to $1x10^{10}$
Bay α - bay area variation parameter		0.0 to 3.3
Press (F1) to continue input.		
Inflow Δt - time interval for river discharge inflow hydrograph	min	0.0 to 720.0
Inflow Q units - river discharge units	cfs,cms	
Press (F1) to access the screen for entering tabulated river discharge data.		
Inflow Q_{ii} $(ii = 1 \ldots II,\ II, \leq 120)$ - tabulated values of river inflow discharges	cfs,cms	0.0 to 9,999.99

NOTE: If there are more than 30 discharge values to be entered, press (F1) to access subsequent screens for entering the remaining values (each screen will allow input of 30 values). After completing discharge data entry, press (F10) to return to the Activity Menu.

CAUTION: Because the simulation begins with zero current in the inlet, it is advisable to begin any river discharge with zero inflow and gradually build up to the desired hydrograph for the simulation.

NOTE: The total time span for tabulated river discharge inflow must equal or exceed the *Length of Simulation*. For example, if the time interval between river discharge inflow entries is 240 minutes and there are nine entries, then the *Length of Simulation* must be less than or equal to 32 hours.

$$\frac{(9-1)*240 minutes}{60 minutes} = 32 hours$$

F6 Specify Velocity Output Locations

This series of screens provides for input of specific cell locations in the flow net grid where inlet velocities are desired (see Figure 7-1-4). Inlet velocities are computed at the specified *Time Step* at all grid cells, but only values at the *Tabular Output Time Interval* and at the specified cell locations are saved for output. The computed velocities are at the center of the flow net cells (see figure below). These velocity values are written to plot output file 2. A maximum of 20 locations can be identified, and a minimum of 1 location is required.

Item/Description	Units	Data Range
$Inlet_{ii}$ - (index)		1 or 2
Cross $Section_{jj}$ - (index)		1 to 15
$Channel_{kk}$ - (index)		1 to 6

NOTE: If there are more than 10 grid cells to be specified, press F1 to access another screen for inputting the remaining (11-20) cell locations. After completing grid cell location data entry, press F10 to return to the Activity Menu.

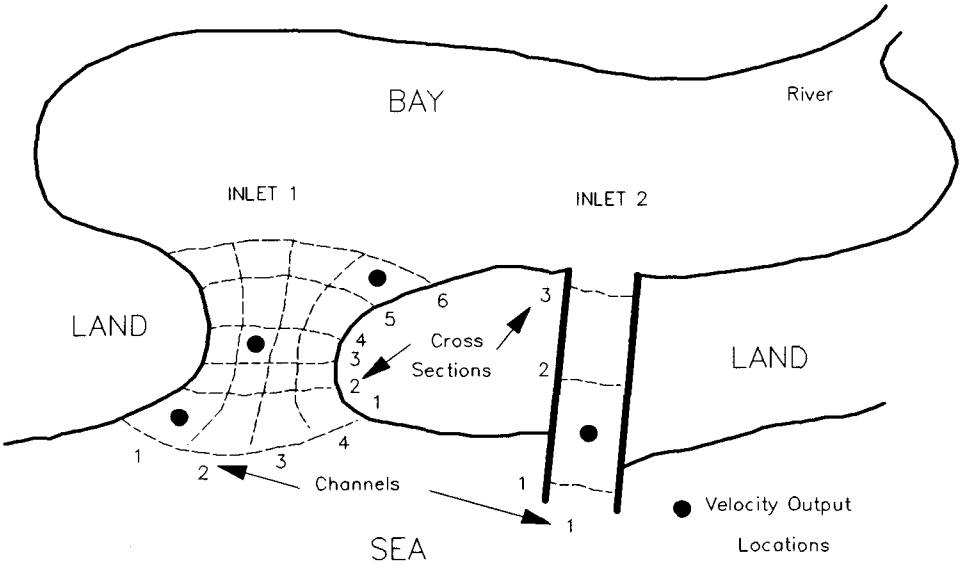

Figure 7-1-4. Typical Velocity Output Locations

For example, in Figure 7-1-4, four cell locations for a 1-sea, 2-inlet, 1-bay system are shown. A cell is referenced by Inlet, Cross Section, and Channel numbers.

Inlet - 1; Cross Section - 1; Channel - 1
Inlet - 1; Cross Section - 3; Channel - 2
Inlet - 1; Cross Section - 5; Channel - 4
Inlet - 2; Cross Section - 1; Channel - 1

F7 Plot Output Data

This application generates numerous plots. The plots may be accessed from the **INLET PLOT SELECTION MENU**, which appears when the **Plot Output Data** option is requested. To access a plot, move the cursor (using the arrow keys) to the desired plot and press F1. (Appendix C describes options to customize plots.) Available plots are:

- Predicted Water Velocities at Specified Cells (see Figure 7-1-5 of Example Problem 1)

  NOTE: This option displays a menu for selecting specific cells for which predicted water velocities are to be plotted. Use the arrow keys to move the cursor to the desired cells and enter an x. When finished selecting the cells, press F1 to begin plotting. If more than one cell was selected, use the **NEXT** option of the graphics package (Appendix C) to view each plot successively.

- Sea & Bay Elevations at Each Inlet (see Figure 7-1-6 of Example Problem 1)
- Riverine Inflow (see Figure 7-1-7 of Example Problem 1)
- Predicted Velocity at the Controlling Cross Section (Figure 7-1-8 of Example Problem 1)
- Discharge at Each Inlet (see Figure 7-1-9 of Example Problem 1)
- ALL PLOTS

  NOTE: This option will make all the plots available for viewing. Use the **NEXT** option of the graphics package (Appendix C) to view each plot successively.

- EXIT MENU

EXAMPLE PROBLEMS

Example 1 - One-Inlet, One-Bay, and One-Sea System with Constituent Tide and River Discharge Data

Example 1 Input

All input is accomplished through screens accessible from the **Activity Menu**.

(F2) General Time and Inlet Data Entry

Simulation start time:	
Year	1988
Month	7
Day	6
Hour	0.00
Time step	60 sec
Length of simulation	30 hr
Tabular output time interval	15 min
Number of inlets	1
Number of bays	1
Number of seaward boundary condition locations	1
Inlet 1	
Number of channels	4
Number of cross sections	5
Flood loss coefficient	4.00
Ebb loss coefficient	1.00
Coefficient C_1 to evaluate Manning's n	0.05
Coefficient C_2 to evaluate Manning's n	0.0007

(Example 1 Input Continued)

F3 Inlet(s) Cross-Section Data Entry

Data for five cross sections will be used in this first example.

Inlet 1 Cross Section 1

ΔX = 104.00 ft

ΔY = 1750.00 ft

Elevations (ft)

1	0.0	16	-13.0	31	-32.0
2	-27.0	17	-13.0	32	-24.0
3	-27.0	18	-13.0	33	-24.0
4	-27.0	19	-13.0	34	-24.0
5	-27.0	20	-18.0	35	-24.0
6	-27.0	21	-24.0	36	-25.0
7	-27.0	22	-30.0	37	-25.0
8	-27.0	23	-32.0	38	-18.0
9	-27.0	24	-34.0	39	-18.0
10	-27.0	25	-34.0	40	-18.0
11	-27.0	26	-34.0	41	-18.0
12	-18.0	27	-34.0	42	0.0
13	-13.0	28	-32.0		
14	-13.0	29	-32.0		
15	-13.0	30	-32.0		

Inlet 1 Cross Section 2

ΔX = 104.00 ft

ΔY = 1625.00 ft

Elevations (ft)

1	0.0	6	-34.0	11	-30.0
2	-30.0	7	-34.0	12	-30.0
3	-33.0	8	-34.0	13	-20.0
4	-33.0	9	-34.0	14	-10.0
5	-33.0	10	-34.0	15	0.0

(Example 1 Input Continued)

Inlet 1 Cross Section 3

ΔX = 104.00 ft

ΔY = 1917.00 ft

Elevations (ft)

1	0.0	9	-34.0	17	-8.0
2	-12.0	10	-34.0	18	-8.0
3	-18.0	11	-34.0	19	-8.0
4	-20.0	12	-34.0	20	-6.0
5	-25.0	13	-34.0	21	-6.0
6	-30.0	14	-30.0	22	-6.0
7	-33.0	15	-18.0	23	-6.0
8	-34.0	16	-12.0	24	0.0

Inlet 1 Cross Section 4

ΔX = 104.00 ft

ΔY = 1250.00 ft

Elevations (ft)

1	0.0	6	-50.0	11	-34.0
2	-18.0	7	-50.0	12	-24.0
3	-37.0	8	-34.0	13	-18.0
4	-37.0	9	-34.0	14	0.0
5	-50.0	10	-34.0		

Inlet 1 Cross Section 5

ΔX = 104.00 ft

ΔY = 0.00 ft

Elevations (ft)

1	0.0	13	-18.0	25	-10.0
2	-11.0	14	-25.0	26	-10.0
3	-11.0	15	-25.0	27	-10.0
4	-11.0	16	-20.0	28	-10.0
5	-12.0	17	-20.0	29	-10.0
6	-12.0	18	-20.0	30	-10.0
7	-17.0	19	-34.0	31	-10.0
8	-17.0	20	-34.0	32	-10.0
9	-17.0	21	-34.0	33	-10.0
10	-15.0	22	-34.0	34	-10.0
11	-15.0	23	-23.0	35	-10.0
12	-15.0	24	-18.0	36	-10.0
				37	0.0

(Example 1 Input Continued)

F4 Sea(s) Boundary Condition Data Entry

Sea BC	1
Sea BC type	Con
Sea BC Δt	15.00 min
Sea BC longitude	75.00 deg WEST
Sea BC amplitude units	ft
Length of simulation	30 hr
Tabular output time interval	15 min

Constituent tide data

Harmonic Constituent	Amplitude (ft)	Epoch (deg)
M2	2.0	90.0

NOTE: *All other harmonic constituents are zero for this example problem.*

F5 Bay Boundary Condition Data Entry

Bay	1
Bay surface area	1.80E+9 ft^2
Bay area variation parameter α	0.00
Inflow Δt	260.00 min
Inflow Q units	cfs

River Discharge (cfs)

1	4000.0	4	3200.0	7	4200.0
2	3800.0	5	3500.0	8	4300.0
3	3600.0	6	3800.0	9	4500.0

F6 Specify Velocity Output Locations

Inlet	Cross Section	Channel
1	2	2
1	2	1
1	2	3
1	2	4

Example 1 Output

Results from this application are written to three plot output files. In addition, this application generates numerous screen plots.

Plot Output File 1
This file contains tabular summaries of various grid characteristics for equal channel discharge. Summarized by channel for each cross section (for each inlet) are common geometric properties such as area, width, depth, and a weighting factor describing the flow distribution among all the channels. Also provided for each cross section is a table of discharge distribution and water depths for the entire cross section, tabulated at 100 equally spaced segments across the section. Finally, a table of friction loss (per foot of channel) is tabulated by cross section. Table 7-1-1 is a partial list of the data in the output file 1 (default name **PLOTDAT1.OUT**) for cross sections 1 and 5 only.

Table 7-1-1
Partial Listing of Plot Output File 1 for Example Problem 1

Inlet 1 Cross Section 1

Total area (ft^2)	100360.00
Total width (ft)	4264.00

Channel ->,	1	2	3	4
Area (ft^2)	23245.7	36558.4	9483.8	31071.7
Width (ft)	912.9	1708.6	288.0	1354.5
Depth (ft)	25.5	21.4	32.9	22.9
Weight	0.2521	0.2458	0.2513	0.2508

X	Discharge (cfs)	Depths (ft)
42.661	0.015	5.541
85.323	0.209	16.622
127.984	0.894	25.949
170.645	1.029	27.014
213.307	1.029	27.014
255.968	1.029	27.014
298.629	1.029	27.014
341.291	1.029	27.014
383.952	1.029	27.014
⇓	⇓	⇓
4095.491	0.235	18.009
4138.152	0.235	18.009
4180.813	0.204	17.128
4223.474	0.055	10.712
4266.135	0.004	3.334

(Table 7-1-1 Continued on the Next Page)

(Example 1 Output Continued)

(Table 7-1-1 Concluded)

Inlet 1 Cross Section 5

Total area (ft^2)	60112.00
Total width (ft)	3744.00

Channel ->	1	2	3	4
Area (ft^2)	22912.5	6873.2	5186.1	25139.6
Width (ft)	1507.7	325.9	155.5	1754.9
Depth (ft)	15.3	24.3	34.0	14.7
Weight	0.2850	0.3649	0.0600	0.2901

X	Discharge (cfs)	Depths (ft)
37.459	0.002	1.982
74.917	0.024	5.946
112.376	0.087	9.810
149.835	0.117	11.006
187.294	0.117	11.006
224.752	0.117	11.006
262.211	0.117	11.006
299.670	0.117	11.006
337.129	0.119	11.087
374.587	0.130	11.427
⇓	⇓	⇓
3633.498	0.090	10.005
3670.956	0.064	8.773
3708.415	0.017	5.225
3745.874	0.020	1.626

Summary of Friction Losses

Section	Friction Loss/ft of Channel Length (dimensionless)
1	43.992
2	2.460
3	14.245
4	3.332
5	35.970

(Example 1 Output Continued)

Plot Output File 2

This file (Table 7-1-2, default name **PLOTDAT2.OUT**) contains a table of velocity hydrographs produced by the simulation at selected flow net cell locations. The velocities (feet per second) are reported at the *Tabular Output Time Interval* and represent the velocity condition at the centers of the selected flow net cells. Figure 7-1-5 is a velocity hydrograph at cell (1,2,2) of the inlet.

Table 7-1-2
Listing of Plot Output File 2 for Example Problem 1

Hour	(1,2,2)	(1,2,1)	(1,2,3)	(1,2,4)
0.27	-6.42	-2.53	-6.56	-1.56
0.50	-9.02	-3.55	-9.21	-2.18
0.77	-10.12	-3.97	-10.33	-2.44
1.00	-10.63	-4.16	-10.85	-2.55
1.27	-11.00	-4.30	-11.23	-2.62
1.50	-11.19	-4.36	-11.43	-2.66
1.77	-11.26	-4.38	-11.50	-2.67
2.00	-11.19	-4.35	-11.43	-2.64
⇓	⇓	⇓	⇓	⇓
28.00	-10.50	-4.08	-10.73	-2.48
28.27	-9.55	-3.71	-9.76	-2.25
28.50	-8.55	-3.32	-8.73	-2.02
28.77	-7.16	-2.79	-7.32	-1.70
29.00	-5.67	-2.21	-5.79	-1.35
29.27	-3.49	-1.36	-3.56	-0.83
29.50	-0.81	-0.32	-0.83	-0.19
29.77	3.45	1.35	3.52	0.83
30.00	5.48	2.16	5.60	1.33

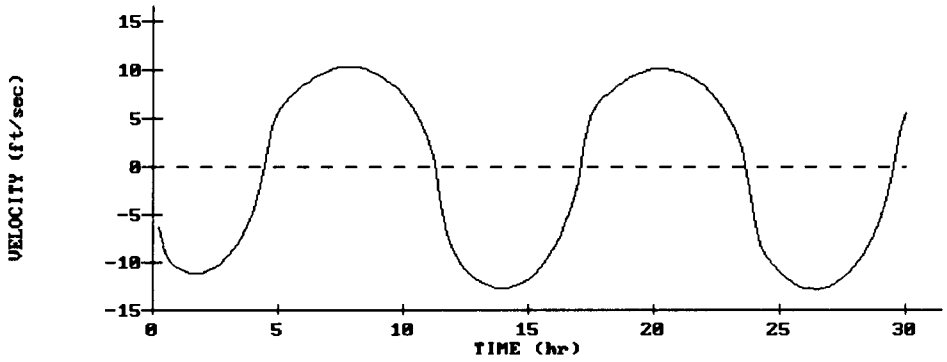

Figure 7-1-5. Velocity Hydrograph at Cell (1,2,2)

(Example 1 Output Continued)

Plot Output File 3

This file contains elevation and discharge hydrographs for the sea boundary conditions, bay, and inlet(s). Results are tabulated at the *Tabular Output Time Interval* and represent summary conditions at the indicated times for the entire system. Included in the file are sea and bay elevations, riverine inflows, average velocity at the controlling cross section, and inlet discharge. Also included in the file is a summary of flood and ebb regimes and volumes identified during the simulation. Table 7-1-3 is a partial listing of data contained in plot output file 3 (default name **PLOTDAT3.OUT**). Figures 7-1-6 through 7-1-9 are hydrograph plots of these parameters.

Table 7-1-3
Partial Listing of Plot Output File 3 for Example Problem 1

Time (hr)	Sea El (ft)	Bay El (ft)	Riverine Inflow (cfs)	Controlling Section Vel (cfs)	Inlet Q (cfs)
0.27	-0.80	-0.03	3993.10	-2.90	-123469.20
0.50	-1.00	-0.10	3985.94	-4.07	-172096.80
0.77	-1.21	-0.20	3976.59	-4.56	-191325.90
1.00	-1.38	-0.29	3967.49	-4.78	-199430.30
1.27	-1.55	-0.39	3956.17	-4.94	-204821.00
1.50	-1.67	-0.49	3945.55	-5.02	-207072.10
1.63	-1.73	-0.54	3939.24	-5.04	-207424.60
1.73	-1.77	-0.58	3934.39	-5.05	-207260.20
1.77	-1.79	-0.60	3932.75	-5.05	-207125.00
⇓	⇓	⇓	⇓	⇓	⇓
28.77	-1.47	-1.10	4269.00	-3.21	-131937.30
29.00	-1.31	-1.15	4271.69	-2.55	-104957.00
29.27	-1.11	-1.20	4275.25	-1.57	-64973.95
29.50	-0.92	-1.21	4278.98	-0.36	-15196.69
29.53	-0.89	-1.22	4279.58	0.15	-6093.05
29.77	-0.68	-1.20	4284.22	0.55	65138.12
30.00	-0.46	-1.16	4289.85	2.47	104461.80

Inlet #1	Start Time	End Time	Volume (ft^3x1000)
Ebb	0.03	4.47	-2551027.00
Flood	4.50	11.30	3883867.00
Ebb	1.33	17.10	-3765760.00
Flood	17.13	23.67	3693283.00
Ebb	23.70	29.53	-3843678.00
Flood	29.57	30.00	99142.08

(Example 1 Output Continued)

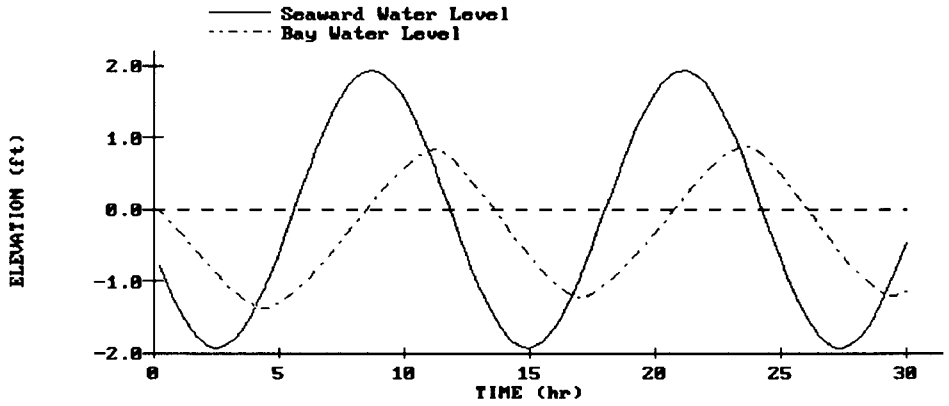

Figure 7-1-6. Sea and Bay Water Elevations at Inlet 1

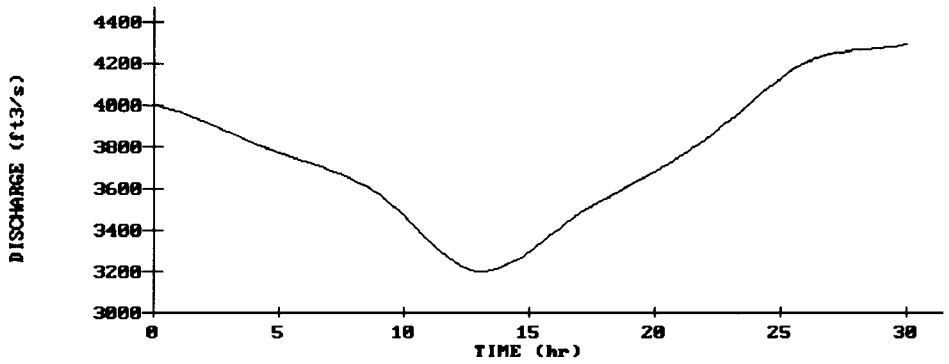

Figure 7-1-7. Riverine Inflow

(Example 1 Output Continued)

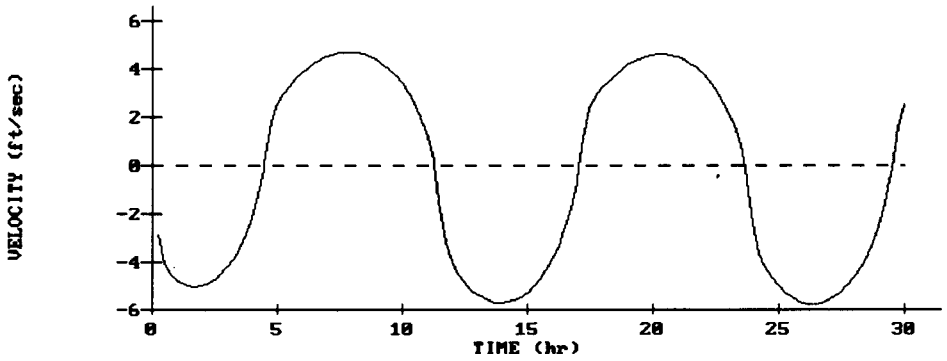

Figure 7-1-8. Average Velocity at Controlling Cross Section

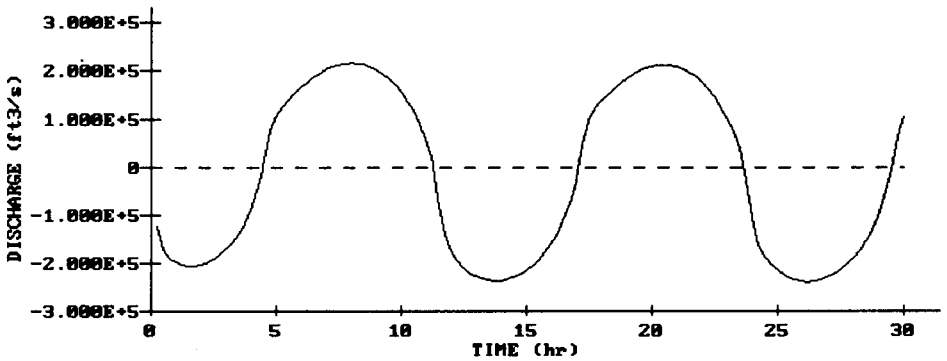

Figure 7-1-9. Inlet Discharge

Example 2 - One-Inlet, One-Bay, and One-Sea System with Tabulated Data

Example 2 Input

All input is accomplished through screens accessible from the **Activity Menu**.

(F2) General Time and Inlet Data Entry

Simulation start time:	
Year	1988
Month	8
Day	23
Hour	12.00
Time step	60 sec
Length of simulation	38 hr
Tabular output time interval	30 min
Number of inlets	1
Number of bays	1
Number of seaward boundary condition locations	1
Inlet 1	
Number of channels	4
Number of cross sections	5
Flood loss coefficient	4.00
Ebb loss coefficient	1.00
Coefficient C_1 to evaluate Manning's n	0.05
Coefficient C_2 to evaluate Manning's n	0.0007

(Example 2 Input Continued)

[F3] Inlet(s) Cross-Section Data Entry

Data for five cross sections will be used in this second example.

Inlet 1 Cross Section 1

ΔX = 104.00 ft

ΔY = 1750.00 ft

Elevations (ft)

1	0.0	16	-13.0	31	-32.0
2	-27.0	17	-13.0	32	-24.0
3	-27.0	18	-13.0	33	-24.0
4	-27.0	19	-13.0	34	-24.0
5	-27.0	20	-18.0	35	-24.0
6	-27.0	21	-24.0	36	-25.0
7	-27.0	22	-30.0	37	-25.0
8	-27.0	23	-32.0	38	-18.0
9	-27.0	24	-34.0	39	-18.0
10	-27.0	25	-34.0	40	-18.0
11	-27.0	26	-34.0	41	-18.0
12	-18.0	27	-34.0	42	0.0
13	-13.0	28	-32.0		
14	-13.0	29	-32.0		
15	-13.0	30	-32.0		

Inlet 1 Cross Section 2

ΔX = 104.00 ft

ΔY = 1625.00 ft

Elevations (ft)

1	0.0	6	-34.0	11	-30.0
2	-30.0	7	-34.0	12	-30.0
3	-33.0	8	-34.0	13	-20.0
4	-33.0	9	-34.0	14	-10.0
5	-33.0	10	-34.0	15	0.0

(Example 2 Input Continued)

Inlet 1 Cross Section 3

ΔX = 104.00 ft

ΔY = 1917.00 ft

Elevations (ft)

1	0.0	9	-34.0	17	-8.0
2	-12.0	10	-34.0	18	-8.0
3	-18.0	11	-34.0	19	-8.0
4	-20.0	12	-34.0	20	-6.0
5	-25.0	13	-34.0	21	-6.0
6	-30.0	14	-30.0	22	-6.0
7	-33.0	15	-18.0	23	-6.0
8	-34.0	16	-12.0	24	0.0

Inlet 1 Cross Section 4

ΔX = 104.00 ft

ΔY = 1250.00 ft

Elevations (ft)

1	0.0	6	-50.0	11	-34.0
2	-18.0	7	-50.0	12	-24.0
3	-37.0	8	-34.0	13	-18.0
4	-37.0	9	-34.0	14	0.0
5	-50.0	10	-34.0		

Inlet 1 Cross Section 5

ΔX = 104.00 ft

ΔY = 0.00 ft

Elevations (ft)

1	0.0	13	-18.0	25	-10.0
2	-11.0	14	-25.0	26	-10.0
3	-11.0	15	-25.0	27	-10.0
4	-11.0	16	-20.0	28	-10.0
5	-12.0	17	-20.0	29	-10.0
6	-12.0	18	-20.0	30	-10.0
7	-17.0	19	-34.0	31	-10.0
8	-17.0	20	-34.0	32	-10.0
9	-17.0	21	-34.0	33	-10.0
10	-15.0	22	-34.0	34	-10.0
11	-15.0	23	-23.0	35	-10.0
12	-15.0	24	-18.0	36	-10.0
				37	0.0

(Example 2 Input Continued)

(F4) Sea(s) Boundary Condition Data Entry

Sea BC	1
Sea BC type	Tab
Sea BC Δt	30.00 min

Tabulated Time-Series Data Elevations (ft)

1	-0.500	21	1.550	41	0.640	61	0.340
2	-0.490	22	1.650	42	0.480	62	0.450
3	-0.470	23	1.740	43	0.320	63	0.560
4	-0.430	24	1.820	44	0.180	64	0.680
5	-0.370	25	1.890	45	0.060	65	0.800
6	-0.300	26	1.940	46	-0.050	66	0.920
7	-0.220	27	1.980	47	-0.150	67	1.030
8	-0.120	28	2.000	48	-0.220	68	1.140
9	-0.020	29	2.000	49	-0.270	69	1.250
10	0.100	30	1.980	50	-0.300	70	1.350
11	0.220	31	1.940	51	-0.300	71	1.440
12	0.350	32	1.880	52	-0.290	72	1.530
13	0.490	33	1.790	53	-0.260	73	1.600
14	0.630	34	1.690	54	-0.230	74	1.670
15	0.770	35	1.570	55	-0.180	75	1.720
16	0.910	36	1.430	56	-0.110	76	1.760
17	1.050	37	1.280	57	-0.040	77	1.780
18	1.190	38	1.130	58	0.040	78	1.800
19	1.310	39	0.970	59	0.130		
20	1.440	40	0.800	60	0.230		

(F5) Bay Boundary Condition Data Entry

Bay	1
Bay Surface Area	1.80E+9 ft^2
Bay Area Variation Parameter α	0.00
Inflow Δt	0 min
Inflow Q units	cfs

(F6) Specify Velocity Output Locations

Inlet	Cross Section	Channel
1	2	2
1	2	1
1	2	3
1	2	4

Example 2 Output

Results from this application are written to three plot output files. In addition, this application generates numerous screen plots.

Plot Output File 1

This file contains tabular summaries of various grid characteristics for equal channel discharge. Summarized by channel for each cross section (for each inlet) are common geometric properties such as area, width, depth, and a weighting factor describing the flow distribution among all the channels. Also provided for each cross section is a table of discharge distribution and water depths for the entire cross section, tabulated at 100 equally spaced segments across the section. Finally, a table of friction loss (per foot of channel) is tabulated by cross section. Table 7-1-4 is a partial list of the data in the output file 1 (default name **PLOTDAT1.OUT**) for cross sections 1 and 5 only.

Table 7-1-4
Partial Listing of Plot Output File 1 for Example Problem 2

Inlet 1 Cross Section 1

Total area (ft^2)	100360.00
Total width (ft)	4264.00

Channel ->	1	2	3	4
Area (ft^2)	23245.7	36558.4	9483.8	31071.7
Width (ft)	912.9	1708.6	288.0	1354.5
Depth (ft)	25.5	21.4	32.9	22.9
Weight	0.2521	0.2458	0.2513	0.2508

X	Discharge (cfs)	Depths (ft)
42.661	0.015	5.541
85.323	0.209	16.622
127.984	0.894	25.949
170.645	1.029	27.014
213.307	1.029	27.014
255.968	1.029	27.014
298.629	1.029	27.014
341.291	1.029	27.014
⇓	⇓	⇓
4138.152	0.235	18.009
4180.813	0.204	17.128
4223.474	0.055	10.712
4266.135	0.004	3.334

(Table 7-1-4 Continued on the Next Page)

(Example 2 Output Continued)

(Table 7-1-4 Concluded)

Inlet 1 Cross Section 5

Total area (ft^2)	60112.00
Total width (ft)	3744.00

Channel ->	1	2	3	4
Area (ft^2)	22912.5	6873.2	5186.1	25139.6
Width (ft)	1507.7	325.9	155.5	1754.9
Depth (ft)	15.3	24.3	34.0	14.7
Weight	0.2850	0.3649	0.0600	0.2901

X	Discharge (cfs)	Depths (ft)
37.459	0.002	1.982
74.917	0.024	5.946
112.376	0.087	9.810
149.835	0.117	11.006
187.294	0.117	11.006
224.752	0.117	11.006
262.211	0.117	11.006
299.670	0.117	11.006
337.129	0.119	11.087
374.587	0.130	11.427
⇓	⇓	⇓
3633.498	0.090	10.005
3670.956	0.064	8.773
3708.415	0.017	5.225
3745.874	0.020	1.626

Summary of Friction Losses

Section	Friction Loss/ft of Channel Length (dimensionless)
1	43.992
2	2.460
3	14.245
4	3.332
5	35.970

(Example 2 Output Continued)

Plot Output File 2

This file (Table 7-1-5, default name **PLOTDAT2.OUT**) contains a table of velocity hydrographs produced by the simulation at selected flow net cell locations. The velocities (feet per second) are reported at the *Tabular Output Time Interval* and represent the velocity condition at the centers of the selected flow net cells. Figure 7-1-10 is a velocity hydrograph at cell (1,2,2) of the inlet.

Table 7-1-5
Listing of Plot Output File 2 for Example Problem 2

Hour	(1,2,2)	(1,2,1)	(1,2,3)	(1,2,4)
0.50	-6.26	-2.48	-6.39	-1.53
1.00	-5.81	-2.30	-5.93	-1.42
1.50	-4.52	-1.79	-4.61	-1.10
2.00	-2.87	-1.14	-2.93	-0.70
2.50	-0.70	-0.28	-0.72	-0.17
3.00	2.10	0.83	2.14	0.51
3.50	3.22	1.28	3.28	0.79
4.00	3.56	1.42	3.63	0.88
⇓	⇓	⇓	⇓	⇓
34.50	4.90	1.99	5.00	1.25
35.00	4.85	1.97	4.94	1.24
35.50	4.79	1.95	4.88	1.23
36.00	4.64	1.89	4.74	1.19
36.50	4.49	1.83	4.58	1.16
37.00	4.25	1.74	4.34	1.10
37.50	3.96	1.62	4.04	1.02
38.00	3.57	1.46	3.64	0.92

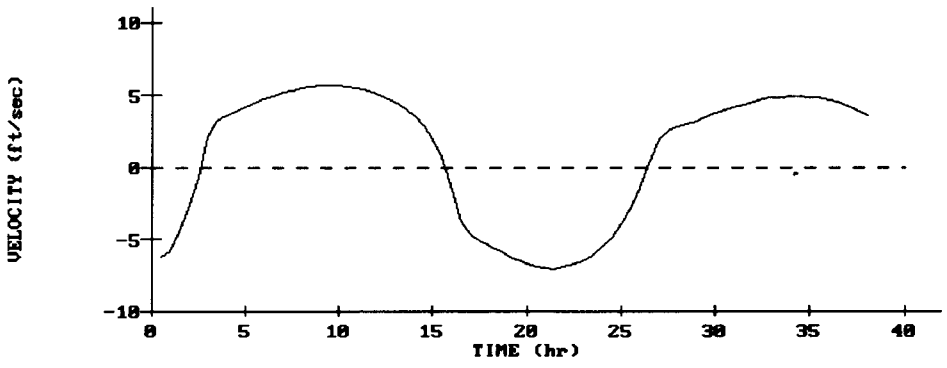

Figure 7-1-10. Velocity Hydrograph at Cell (1,2,2)

(Example 2 Output Continued)

Plot Output File 3

This file contains elevation and discharge hydrographs for the sea boundary conditions, bay, and inlet(s). Results are tabulated at the *Tabular Output Time Interval* and represent summary conditions at the indicated times for the entire system. Included in the file are sea and bay elevations, riverine inflows, average velocity at the controlling cross section, and inlet discharge. Also included in the file is a summary of flood and ebb regimes and volumes identified during the simulation. Table 7-1-6 is a partial listing of data contained in plot output file 3 (default name **PLOTDAT3.OUT**). Figures 7-1-11 through 7-1-13 are hydrograph plots of these parameters.

Table 7-1-6
Partial Listing of Plot Output File 3 for Example Problem 2

Time (hr)	Sea El (ft)	Bay El (ft)	Riverine Inflow (cfs)	Controlling Section Vel (cfs)	Inlet Q (cfs)
0.50	-0.49	-0.08	0.00	-2.83	-121489.60
0.60	-0.49	-0.10	0.00	-2.87	-123317.00
1.00	-0.47	-0.20	0.00	-2.62	-112561.60
1.50	-0.43	-0.30	0.00	-2.04	-87524.16
2.00	-0.37	-0.37	0.00	-1.30	-55659.24
2.50	-0.30	-0.41	0.00	-0.32	-13664.77
2.63	-0.28	-0.41	0.00	0.02	745.18
3.00	-0.22	-0.39	0.00	0.95	40848.79
3.50	-0.12	-0.34	0.00	1.45	62900.23
4.00	-0.02	-0.27	0.00	1.61	69955.90
⇓	⇓	⇓	⇓	⇓	⇓
35.50	1.53	1.10	0.00	2.19	101222.60
36.00	1.60	1.20	0.00	2.12	98549.31
36.50	1.67	1.30	0.00	2.05	95617.21
37.00	1.72	1.39	0.00	1.95	90929.11
37.50	1.76	1.48	0.00	1.81	84919.09
38.00	1.78	1.56	0.00	1.63	76627.07

Inlet 1	Start Time	End Time	Volume (ft^3x1000)
Ebb	0.03	2.60	-735969.80
Flood	2.63	15.67	4240797.00
Ebb	15.70	26.43	-4078206.00
Flood	26.47	38.50	3528005.00

(Example 2 Output Continued)

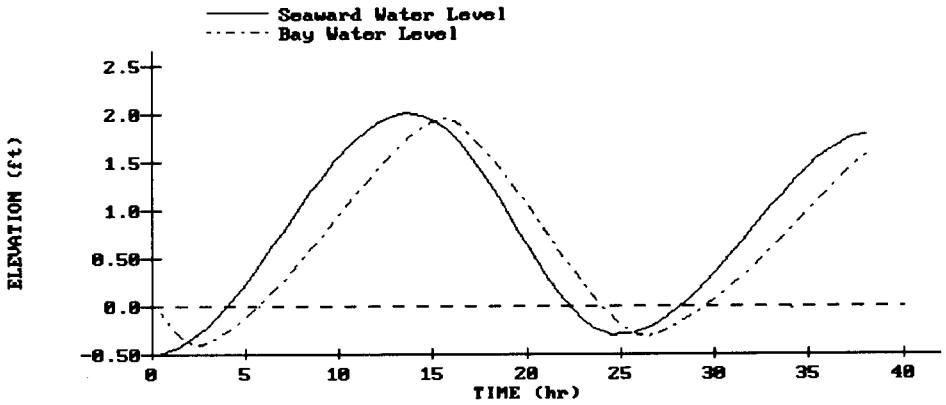

Figure 7-1-11. Sea and Bay Water Elevations at Inlet 1

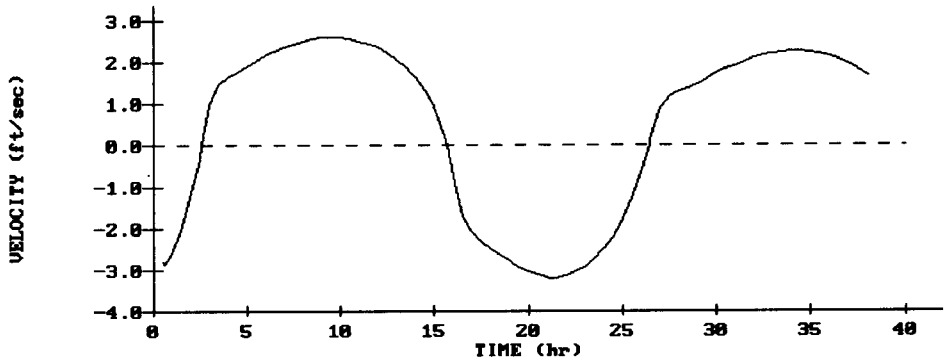

Figure 7-1-12. Average Velocity at Controlling Cross Section

(Example 2 Output Continued)

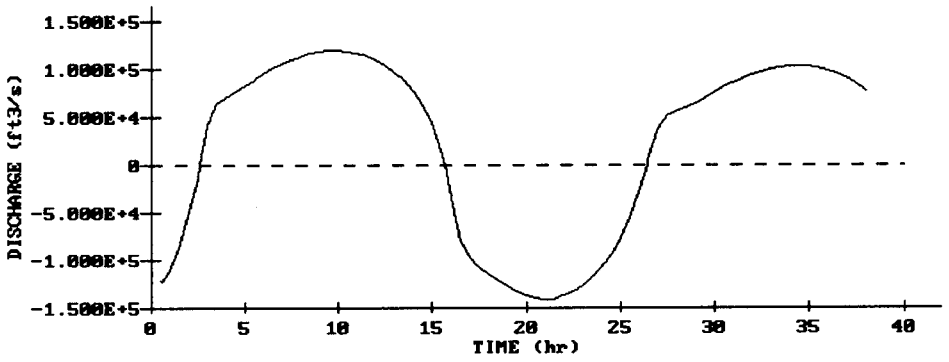

Figure 7-1-13. Inlet Discharge

REFERENCES AND BIBLIOGRAPHY

Harris, D. L., and Bodine, B. R. 1977. "Comparison of Numerical and Physical Models, Masonboro Inlet, North Carolina," CERC GITI Report 6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

International Business Machines. 1970. "System/360 Scientific Subroutine Package, Version II Programmer's Manual," White Plains, NY.

Keulegan, G. H. 1967. "Tidal Flow in Entrances, Water-Level Fluctuations of Basins in Communication with Seas," Technical Bulletin No. 14, Committee on Tidal Hydraulics, US Army Corps of Engineers, Vicksburg, MS.

Masch, F. D., Brandes, R. J., and Reagan, J. D. 1977. "Numerical Simulation of Hydrodynamics (WRE)," Appendix 2, CERC GITI Report 6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Seelig, W. N. 1977. "A Simple Computer Model for Evaluating Coastal Inlet Hydraulics," CERC CETA 77-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Seelig, W. N., Harris, D. L., and Herchenroder, B. E. 1977. "A Spatially Integrated Numerical Model of Inlet Hydraulics," CERC GITI Report 14, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

APPENDICES

The following pages contain the miscellaneous appendices referenced in the main body of the User's Guide. Appendix A consists of various tables of coefficients, grain-size classifications, and tidal constituents. Appendix B describes the target hardware environment and instructions for installing this version of ACES. Appendix C contains instructions for using the graphics options. Appendix D is a table listing the input and output options of the applications in this version of ACES.