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**US Army Corps
of Engineers**
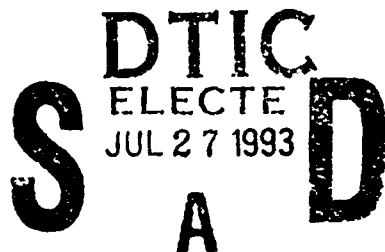Waterways Experiment
Station

Coastal Engineering Research Program

SBEACH: Numerical Model for Simulating Storm-Induced Beach Change

Report 3
User's Manual

by   Julie D. Rosati, Randall A. Wise,
Nicholas C. Kraus
Coastal Engineering Research Center

Magnus Larson
University of Lund

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Coastal Engineering Research Program

Instruction Report CERC-93-2
May 1993

SBEACH: Numerical Model for Simulating Storm-Induced Beach Change

Report 3
User's Manual

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Report 3 of a series

**US Army Corps
of Engineers**
Waterways Experiment
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VICKSBURG, MISSISSIPPI 39180-6199
PHONE : (601)634-2502

STRUCTURES
LABORATORY

SCALE
500   0   500 m

AREA OF RESERVATION - 2 7 sq km

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Preface

This study was conducted at the Coastal Engineering Research Center (CERC), U.S. Army Engineer Waterways Experiment Station (WES) and authorized as a part of the Civil Works Research and Development Program by Headquarters, US Army Corps of Engineers (HQUSACE), and was performed under the Calculation of Cross-Shore Sediment Transport and Beach Profile Change Processes Work Unit 32530, Shore Protection and Restoration Program, CERC. Messrs. John H. Lockhart, Jr., John G. Housley, Barry W. Holliday, and David A. Roellig were HQUSACE Technical Monitors. Dr. C. Linwood Vincent and Ms. Carolyn M. Holmes were CERC Program Managers.

The associated studies were performed and this report written over the period 1 July 1991 through 31 March 1993 by the staff of CERC and the University of Lund (UL), Sweden. Dr. Magnus Larson, UL, and Mr. Randall Wise, Coastal Processes Branch (CPB), Research Division (RD), CERC, who was Principal Investigator (PI) of the Calculation of Cross-Shore Sediment Transport and Beach Profile Change Work Unit, enhanced the Storm-Induced Beach Change (SBEACH) model to include several new capabilities. Messrs. Wise and Mark B. Gravens, CPB, RD, conceptualized the personal computer interface, and Mr. Wayne Tanner, CPB, RD, wrote the interface code. Ms. Julie D. Rosati, CPB, RD, and former PI of the work unit, Mr. Wise, and Dr. Nicholas C. Kraus, Senior Scientist, CERC, wrote this manual. Ms. Marsha Darnell, Engineering Technician, CPB, RD, generated most of the figures presented herein. Ms. Holley Messing, Engineering Technician, CPB, RD, assisted with preparation of the final document. Ms. Jane M. Smith, CPB, RD, Mr. Gravens, and Mr. Bruce A. Ebersole, Chief, CPB, RD, provided technical review of this report.

Work was performed under the general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director, CERC, and the administrative supervision of Mr. H. Lee Butler, Chief, RD, and Mr. Ebersole, Chief, CPB.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

Conversion Factors, Non-SI To SI Units Of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
degrees	0.01745329	radians
feet	0.3048	meters
inches	25.54	centimeters
pounds	0.2248	Newtons

1 Introduction

The purpose of this manual, the third report in a series, is to provide "hands on" guidance for implementing SBEACH, the Storm Induced BEAch CHange model, via a user interface available for the personal computer. SBEACH may also be operated through the Coastal Modeling System (CMS), documented by Cialone et al. (1992). The CMS can be accessed by all Corps elements through the CRAY Y-MP supercomputer that resides at the Information Technology Laboratory, U.S. Army Engineer Waterways Experiment Station (WES). This manual is intended as a supplement for attendance at an SBEACH workshop, and as a reference for those who have attended a workshop or learned to operate the model from an experienced user.

SBEACH simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels. It has potential for many applications in the coastal environment, and has been used to determine the fate of proposed beach fill alternatives under storm conditions and to compare the performance of different beach fill cross-sectional designs (Neilans, in preparation; Hales, Byrnes, and Neilans, in preparation), and to predict volumetric overtopping rates for catastrophic events (Smith et al., in preparation). Research and development of SBEACH are being actively pursued at the WES Coastal Engineering Research Center (CERC), in range of processes simulated, numerical efficiency of the model, and in convenience of the interface.

The PC and CMS versions of SBEACH are accessed through a user interface which facilitates data entry and manipulation, graphical representation of input and simulated results, and execution of the model. Operation of SBEACH within the interface is functionally the same, whether executed from the PC or within CMS. The interface is "smart" in that considerable error and range checking are performed prior to actual running of the model calculations. Default values are also provided or suggested. This interaction with the user via error and warning messages at the data entry level eliminates many obscure run-time error messages and much frustration.

This manual provides an overview of SBEACH, focussing on implementation and application of the model within the user interface. Comprehensive descrip-

tions of development, testing, and application of the model are contained in Reports 1 and 2 of the SBEACH series (Larson and Kraus 1989a; Larson, Kraus, and Pyrnes 1990), and a summary of the model is contained in Larson, Kraus, and Sunamura (1988). Sensitivity testing and additional applications of the model to beach fill design are contained in Kraus and Larson (1988), Larson and Kraus (1989b), and Larson and Kraus (1991a). Some of these papers and other CERC publications on storm-induced beach erosion have been collected in a technical report for convenience (Kraus 1990).

Overview of SBEACH

Capabilities and limitations

SBEACH is a geomorphic-based model founded on extensive analysis of beach profile change produced in large wave tanks and in the field. It is a two-dimensional model in that longshore wave, current, and sediment transport processes are omitted. Therefore, it should only be applied if longshore gradients in transport processes can be neglected. Breaking waves and changing water level are the major driving agents in SBEACH that produce sediment transport and beach profile change. Water level changes are calculated from the storm surge, tide, and wind. SBEACH should not be used to examine profile change in the vicinity of jetties and similar structures that form barriers to longshore sand transport; in such a case, profile change might be controlled more by interruption of longshore transport than by cross-shore processes. Neither should the model be used for long-term analysis of cross-shore transport, in which hydrodynamic forces other than breaking waves and water level may be factors. SBEACH is intended to predict and analyze short-term, storm-induced erosion.

SBEACH is an empirically based model that was developed for sandy beaches with uniform representative grain sizes in the range of 0.20 to 0.42 mm. Although it is expected to produce reasonable results for beaches beyond these limits but in the fine-to-medium sand range, the present version may not be valid for describing profile change if there is significant deviation from grain size uniformity, such as strong bimodality in grain size. Similarly, it cannot be applied to model beaches with underlying clay or rock layers that might become exposed during storm conditions.

SBEACH has significant capabilities that make it useful for quantitative and qualitative study of beach profile response to storms. For example, it accepts as input varying water levels as produced by storm surge and tide, varying wave heights and periods, and an arbitrary grain size in the fine-to-medium sand range. Either a user-specified schematic (idealized) dune and berm configuration or an arbitrary (surveyed) total profile configuration can comprise the initial profile. Version 2.0 documented herein allows for variable cross-shore grid spacing, simulates water-level setup due to wind, includes more advanced procedures for

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calculating the wave breaking index and breaker decay, and provides an estimation of dune overwash (Kraus and Wise 1992, Wise and Kraus 1993). Background information and presentation of relationships for the water-level setup, breaker index, and breaker decay routines are documented by Kraus and Larson (1991) and Larson and Kraus (1991b).

An important feature of SBEACH is that it simulates breakpoint bar formation, the natural beach protective mechanism against storms. The numerical model is capable of simulating beach recovery and berm buildup; however, this process has not been verified owing to the lack of data. Shoreward boundary conditions that may be specified include a vertical structure (that can fail due to either excessive scour or instability caused by wave action/water elevation) or a beach with a dune of arbitrary configuration.

Because of the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model should be tested or calibrated using data from beach profiles surveyed before and after storms on the project coast, or with measurements made from a similar coast if no data are available for the project coast. It should also be noted that due to local variability along a beach, both in the initial profile and in the waves crossing the profile, the actual profile change and model results may each show considerable variability. Engineering judgement must be used in evaluating simulation results. The accuracy and applicability of input to the model must also be considered when evaluating the results. Comparison of simulated and measured profiles will provide feedback with which to adjust the model calibration parameters, with the goal of simulating a profile as close to the measured post-storm profile as possible. In all cases, model predictions should be carefully evaluated based on coastal engineering experience and knowledge, and observation of the project coast. Errors may arise due to incorrect data input, incorrect specification of model parameters, and limitations in the model itself. In spite of these caveats, SBEACH is considered to be robust; that is, it provides realistic answers for a reasonable range of input parameters.

Considerable research is underway to expand the capability of the numerical model. Results from recent large-scale cross-shore laboratory studies (Kraus, Smith, and Sollitt; in preparation) will be investigated to improve simulation of accretionary sand processes, sand transport by random waves, and overwash.

Organization of Report

Chapter 1 describes the purpose of this manual and background information on SBEACH. Chapter 2 provides information for getting started with the model, including hardware requirements, loading SBEACH onto a hard disk, understanding the interface structure through which the numerical model is operated, and guidance for model calibration. Chapter 3 is a tutorial guiding the user in installing, running, and working through several example simulations.

Text that is to be typed on a keyboard is printed in **BOLD** letters in this text. Non-character keys on the keyboard are enclosed in angular brackets. For example, the enter or return key is written as < enter >.

2 Getting Started

System Requirements

The following are recommended minimum hardware requirements for running the SBEACH interface on a PC with a standard Disk Operating System (DOS) Version 3.3 or greater:

a. 386 20-MHz processor (386 33-MHz or 486 25-MHz preferred).

b. 640 K resident memory.

c. VGA monitor.

d. Hard disk with several megabytes free (depending on applications).

e. HP Laserjet II or III, or compatible printer if hard copy graphics are desired.

A compiler is not required because the SBEACH interface and model are distributed as executable files together with several data files. The PC version of the SBEACH interface may access all memory within the 640 K DOS limit. Therefore, the SBEACH interface should be run from the DOS prompt with all resident memory programs removed to ensure enough memory exists for model execution.

The SBEACH interface can be executed from the CRAY Y-MP supercomputer, with a menu format similar to that on the PC version. Use of SBEACH within CMS, and directions for obtaining access to the supercomputer by Corps personnel, are detailed by Cialone et al. (1992).

Input/Output Data Files

As many as seven input files may be used to run SBEACH, with four output files produced. The file-naming convention requires use of the data set name as

the root of the filename; file extensions identify the type of information contained in each file. The SBEACH filename extensions for input and output data and the type of information each file contains are given in Table 1.

Table 1 SBEACH Data Set File Extension			
Input Files		**Output Files**	
Initial Profile	.PRI	Calculated Profile	.PRC
Model Parameters	.CFG	Cross-shore Parameters	.XVR
Water Elevation	.ELV	Log for SBEACH Run	.LOG
Wave Height and Period	.WAV	Report File	.RPT
Measured Profile	.PRM		
Wave Angle	.ANG		
Wind Speed and Direction	.WND		

To run SBEACH, the following five types of input data are required:

a. Initial beach profile ("data_set.PRI" or "data_set.CFG" if a schematic profile).

b. Median grain size representative of the surf zone and beach ("data_set.CFG").

c. Time series of water level ("data_set.ELV" or "data_set.CFG if constant water level).

d. Time series of wave height and period ("data_set.WAV" or "data_set.CFG if constant wave height and period).

e. Values of model parameters ("data_set.CFG").

For calibration, an additional data set -- a profile measurement after the storm, the "final" measured profile -- is required ("data_set.PRM").

Three additional types of information or data can be input as options to further represent the beach configuration and forcing conditions:

a. Shoreward boundary condition ("data_set.CFG"). (At present, the only option is a seawall, including its location and failure mode).

b. Time series of wave direction ("data_set.ANG"). (If wave direction is not specified, the default is normal incidence.)

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c. Time series of wind speed and direction ("data_set.WND"). (If wind speed and direction are not specified, the default is no wind action.)

Output data are reported in four files. Simulated profiles at intermediate time steps (if desired) and the final calculated profile at the end of the simulation are recorded in "data_set.PRC." The cross-shore variation of several parameters supporting visualization programs are given in "data_set.XVR": intermediate (if desired) and maximum wave height; intermediate (if desired) and maximum total water elevation plus setup; maximum water depth; and volume change. The "data_set.LOG" file holds a record of various coastal processes that may occur at any time-step during the simulation: accretion, erosion, overwash, boundary-limited runup, and/or inundation. Reporting of input data, as well as output parameters of interest, are given in the "data_set.RPT" file. The input and output data files are discussed further in the next section and in Chapter 3.

SBEACH User Interface

SBEACH is operated via a user interface that organizes information and commands in an efficient manner suited for both creating project input and exploring "what if?" situations. The interface contains substantial range checking and defaults for user-specified variables.

An overview of the SBEACH interface is contained in Figure 1. The model is operated from a series of screens, of which the first is the title screen that appears when the command **SBEACHI** <enter> (for *SBEACH* *I*nterface) is keyed at the DOS prompt. SBEACHI is rich in features and possibilities. It is not the intent of this manual to describe every feature and combination of features available in the interface; most items on the screens are described in self-explanatory language, and the information necessary to perform a simulation is given in the next chapter of this report.

Figure 1 and subsequent figures will provide an orientation to the structure of the interface. The menus are referred to by the names appearing in capital letters at the top of the monitor. As shown in Figure 1, there are three general types of functions on the screens:

a. Menus.

b. Editors.

c. Actions.

Menus direct the user to other functions within the SBEACH interface. Editors allow entry and modification of data in either page or column form.

```
                    ┌─────────────┐
                    │   SBEACH    │
                    │  INTERFACE  │
                    │   SCREEN    │
                    └──────┬──────┘
                           │
                    ┌──────┴──────┐
                    │  DATA SET   │
                    │SPECIFICATION│
                    │    MENU     │
                    └──────┬──────┘
                           │
                    ┌──────┴──────┐
                    │  MAIN MENU  │
                    └──────┬──────┘
            ┌──────────────┼──────────────┐
            ▼              ▼              ▼
```

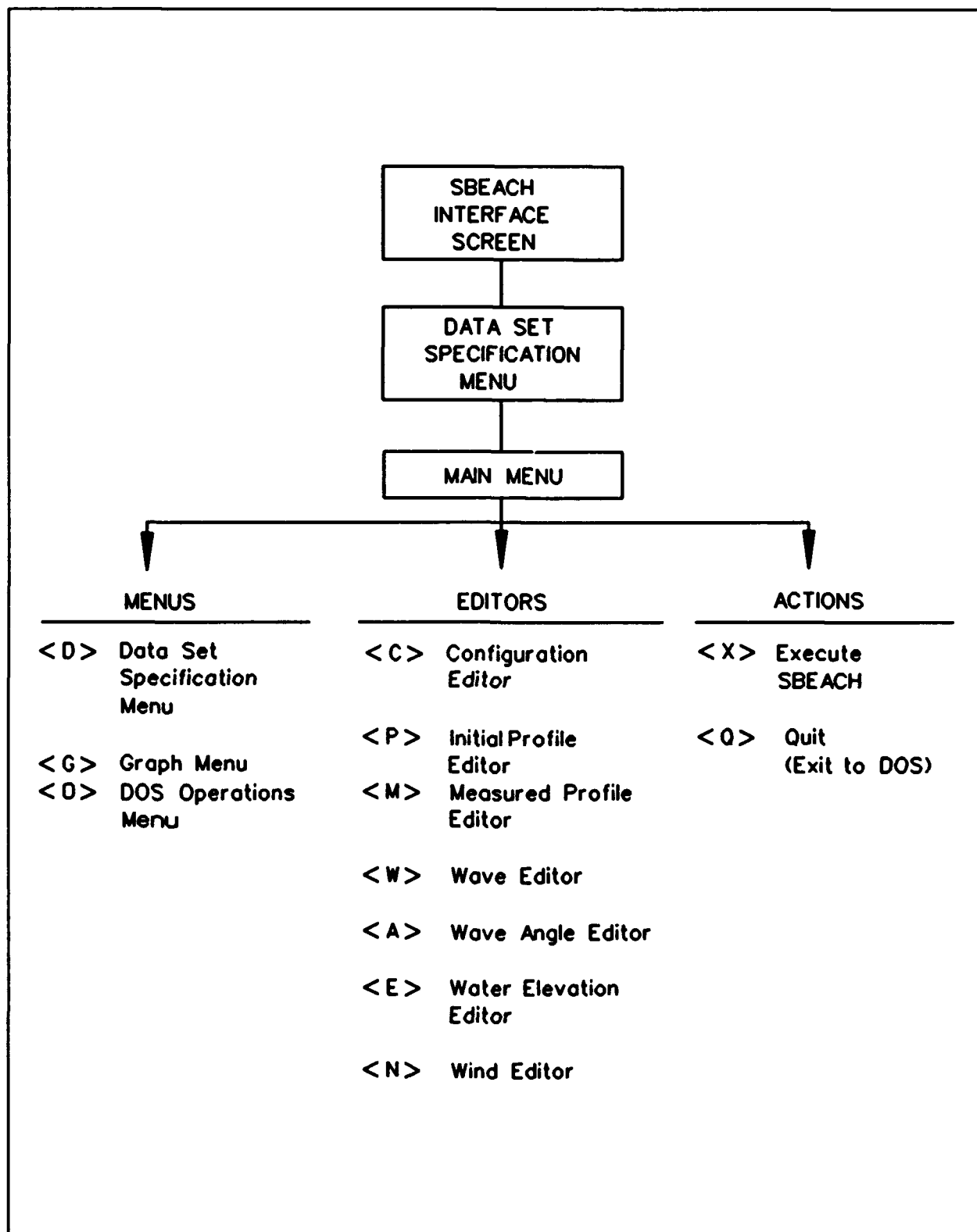| MENUS	EDITORS	ACTIONS
<D> Data Set Specification Menu	<C> Configuration Editor	<X> Execute SBEACH
<G> Graph Menu	<P> Initial Profile Editor	<Q> Quit (Exit to DOS)
<O> DOS Operations Menu	<M> Measured Profile Editor	
	<W> Wave Editor	
	<A> Wave Angle Editor	
	<E> Water Elevation Editor	
	<N> Wind Editor	

Figure 1. Schematic of the SBEACH interface

Much of the range and error checking of the interface is conducted within the editors. The SBEACH interface is intended to be self-contained and not require the user to exit for input file manipulation. Actions are commands that cause calculations or some other operation to be performed. The commands "Execute SBEACH" and "Quit (Exit to DOS)" are representative of the action feature.

Title screen

The title screen gives the version number, date of the version, and points of contact (names and telephone numbers) for obtaining additional information. Pressing any key brings up the DATA SET SPECIFICATION MENU.

Data Set Specification Menu

The DATA SET SPECIFICATION MENU is shown in Figure 2. This menu allows specification of the directory in which data set files reside, selection of an existing data set, as well as initialization of a default data set. An option is selected by pressing the key associated with that activity. For example, entering **W** from the menu allows the user to define a working directory to C:\SBEACH\ TUTOR, and **I** allows the user to initialize a default data set that will reside in this directory. The data set name assigned to this file is the root name for all the files associated with this data set; therefore, it must be different from other data set names. Data filename extensions are assigned by the model and are created or updated automatically as information is changed by the user (see Table 1). File manipulation can be performed in the SBEACH interface, so that manual manipulation of these data files outside of the interface is not necessary. After the data set name is entered, a series of menus will appear in a specified order and must be filled with data or information for the simulation. When first going through this user's manual, do not create a data set, but instead select an existing example for testing.

```
SBEACHI :  D A T A   S E T   S P E C I F I C A T I O N   M E N U
================================================================
 < I >  Initialize Default Data Set
 < S >  Select Existing Data Set          EX_1
 < W >  Assign Working Directory          C:\SBEACH\TUTOR

 < M >  Main Menu
 < Q >  Quit to DOS
================================================================
 Enter Choice -
```

Figure 2. Data Set Specification Menu

Data sets in the working directory can be viewed and selected using the Select Existing Data Set command. The arrow keys are used to highlight the desired data set and the enter key selects that data set. Up to seven data sets may be shown in the Select Existing Data Set window. If more than seven data sets exist in the working directory, the arrow keys can be used to scroll and reveal all the data sets. The example data sets listed are EX_1 and EX_2. The working directory window shows only a portion of the path if it is longer than the 12-character window. The arrow keys can be used to examine the entire path. The working directory may be changed from the default by typing W for Assign Working Directory. After a data set is selected, the next step is to enter the MAIN MENU where data sets can be modified, model calculations are initiated, and results are presented graphically.

MAIN MENU

Overview. To move from the DATA SET SPECIFICATION MENU to the MAIN MENU, select an existing data set (S) or initialize a default data set (I). To explore features of the SBEACH interface, the authors recommend selecting an existing data set. The MAIN MENU, shown in Figure 3, is a routing center that allows selection of other menus, editors, and actions. The user may return to the DATA SET SPECIFICATION MENU, or continue to the GRAPH MENU or DOS OPERATIONS MENU from this screen. Seven editors can be accessed from this menu and are discussed in detail below. The user may also choose the

```
                    SBEACHI:  M A I N     M E N U
    ================================================================
        < D > Data Set Specification Menu

        < C > Configuration File Editor (EX_1.CFG)
        < P > Initial Profile Editor (EX_1.PRI)
        < M > Measured Profile Editor (EX_1.PRM)
        < W > Wave Editor (EX_1.WAV)
        < A > Wave Angle Editor (EX_1.ANG)
        < E > Water Elevation Editor (EX_1.ELV)
        < N > Wind Editor (EX_1.WND)


        < X > Execute SBEACH


        < G > Graph Menu
        < O > DOS Operations Menu
        < Q > Quit (Exit to DOS)
    ================================================================
        Enter Choice -

                                            DATA SET:   EX_1
```

Figure 3. Main menu

action items "Execute SBEACH" or "Quit (Exit to DOS)" from this screen. The name of the "active" data set appears on the lower right side of all SBEACH screens.

Configuration File Editor. The Configuration File Editor is the first MAIN MENU editor listed, and allows entry and manipulation of the "start" file containing basic information necessary for executing SBEACH. The interface allows the configuration file to be modified in a page-editor mode, providing default values and error checking for parameters used in SBEACH simulations. The configuration file is separated into five sections: A - Model Setup; B - Waves/Water Elevation/Wind; C - Beach; D -Beach Fill; E - Seawall/Revetment (Figure 4).

Each item in this file is discussed in detail below. Arrow keys are used to move one line at a time through the configuration file, or the < **page up** > and < **page down** > keys can quickly scroll through the file.

Section A (Model Setup) deals with the initial and measured profiles, grid arrangement, output parameters, and calibration parameters.

A.1. Enter the title of the specific SBEACH run.

A.2. Enter the units which correspond to data entered, either 1 for SI units (meters), or 2 for American Customary units (feet). Care must be taken to make certain that the input data units are consistent with those selected for use in the model, because input data do not change when the units are changed.

A.3. Enter the total number of calculation cells along the profile and position of the landward boundary relative to the established profile coordinate system. The total number of calculation cells must be less than or equal to 1,000. The number of grid cells and cell length (questions A.6 or A.9) determine the cross-shore range of the simulation. The landward boundary is the landward-most point at which calculations are performed. This boundary should be moved further landward if a discontinuity (e.g., sand piling up, scour) is observed at that location; seaward movement of the landward boundary will reduce simulation time. SBEACH gives a warning "[BOUNDARY LIMITED RUNUP]" if the landward boundary is limiting model simulations.

A.4. SBEACH Version 2.0 allows simulations with a constant (uniform spacing) or variable grid (as many as 10 different grid regions). The variable grid option has the potential to reduce computational time; a large grid spacing may be chosen for regions where there will be little profile change (e.g., in the offshore), and the number of calculations in this region will be reduced. Choose 0 for a constant grid spacing, and 1 for variable grid spacing.

```
*****************************************************************
*       SBEACH model configuration file:  EX_1.CFG             *
*****************************************************************
A------------------------------ MODEL SETUP -------------------------A
A.1   RUN TITLE: TITLE
      Example 1
A.2   INPUT UNITS (SI=1; AMERICAN CUST.=2): UNITS
      2
A.3   TOTAL NUMBER OF CALCULATION CELLS AND POSITION OF LANDWARD
      BOUNDARY RELATIVE TO INITIAL PROFILE: NDX, XSTART
         252    -320
A.4   GRID TYPE (CONSTANT=0, VARIABLE=1): IDX
      1
A.5   COMMENT:   IF GRID TYPE IS VARIABLE, CONTINUE TO A.8
A.6   CONSTANT GRID CELL WIDTH: DXC
      0
A.7   COMMENT:   IF GRID TYPE IS CONSTANT, CONTINUE TO A.10
A.8   NUMBER OF DIFFERENT CELL REGIONS: NGRID
      3
A.9   GRID CELL WIDTHS AND NUMBER OF CELLS IN EACH REGION FROM LANDWARD
      TO SEAWARD BOUNDARY: (DXV(I), NDXV(I), I=1,NGRID)
```

GRIDEDIT
5. 96 10. 84 20. 72

```
A.10  NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: NDT, DT
         1440     3
A.11  NUMBER OF TIME STEP(S) INTERMEDIATE OUTPUT IS WANTED: NWR
         3
A.12  TIME STEP(S) OF INTERMEDIATE OUTPUT: (WRI(I), I=1,NWR)
```

WRI
360 720 960

```
A.13  IS A MEASURED PROFILE AVAILABLE FOR COMPARISON? (YES=1, NO=0):
      ICOMP
      1
A.14  THREE PROFILE ELEVATION CONTOURS (MAXIMUM HORIZONTAL RECESSION
      OF EACH WILL BE DETERMINED): ELV1, ELV2, ELV3
      12        5       -5
A.15  THREE PROFILE EROSION DEPTHS AND REFERENCE ELEVATION (DISTANCE
      FROM POSITION OF REFERENCE ELEVATION ON INITIAL PROFILE TO
      POSITION OF LANDWARD MOST OCCURRENCE OF EACH EROSION DEPTH WILL
      BE DETERMINED): EDP1, EDP2, EDP3, REFELV
      5        3       1       0
A.16  TRANSPORT RATE COEFFICIENT (m^4/N): K
      1.5E-06
A.17  COEFFICIENT FOR SLOPE-DEPENDENT TERM (m^2/s):   EPS
      0.002
A.18  TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER:   LAMM
      0.2
```

Figure 4. Configuration file editor (Sheet 1 of 4)

```
****************************************************************
*         SBEACH model configuration file:  EX_1.CFG          *
****************************************************************
A.19 WATER TEMPERATURE IN DEGREES C: TEMPC
     15
B------------------- WAVES/WATER ELEVATION/WIND ----------------B
B.1  WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): WVTYPE
     2
B.2  WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): IWAVE
     1
B.3  COMMENT: IF WAVE HEIGHT AND PERIOD ARE VARIABLE, CONTINUE TO B.6
B.4  CONSTANT WAVE HEIGHT AND PERIOD:  HIN, T
     0         0
B.5  COMMENT: IF WAVE HEIGHT AND PERIOD ARE CONSTANT, CONTINUE TO B.7
B.6  TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MINUTES:
     DTWAV
     60
B.7  WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): IANG
     0
B.8  COMMENT: IF WAVE ANGLE IS VARIABLE, CONTINUE TO B.11
B.9  CONSTANT WAVE ANGLE: ZIN
     0
B.10 COMMENT: IF WAVE ANGLE IS CONSTANT, CONTINUE TO B.12
B.11 TIME STEP OF VARIABLE WAVE ANGLE INPUT IN MINUTES: DTANG
     0
B.12 WATER DEPTH OF INPUT WAVES (DEEPWATER=0): DMEAS
     33.8
B.13 IS RANDOMIZATION OF INPUT WAVE HEIGHT DESIRED? (NO=0,YES=1):
     IRAND
     1
B.14 COMMENT: IF RANDOMIZATION OF WAVE HEIGHT IS NOT DESIRED, CONTINUE
     TO B.16
B.15 SEED VALUE FOR RANDOMIZER AND PERCENT OF VARIABILITY: ISEED,
     RPERC
        7878   20
B.16 TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): IELEV
          1
B.17 COMMENT: IF WATER ELEVATION IS VARIABLE, CONTINUE TO B.20
B.18 CONSTANT TOTAL WATER LEVEL ELEVATION:  TELEV
     0
B.19 COMMENT:  IF WATER ELEVATION IS CONSTANT, CONTINUE TO B.21
B.20 TIME STEP OF VARIABLE TOTAL WATER ELEVATION INPUT IN MINUTES:
     DTELV
     60
B.21 WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE =1): IWIND
     0
B.22 COMMENT:  IF WIND SPEED AND ANGLE ARE VARIABLE, CONTINUE TO B.25
```

Figure 4. (Sheet 2 of 4)

```
*******************************************************************
*          SBEACH model configuration file:  EX_1.CFG          *
*******************************************************************
B.23 CONSTANT WIND SPEED AND ANGLE: W, ZWIND
     0         03
B.24 COMMENT:  IF WIND SPEED AND ANGLE ARE CONSTANT, CONTINUE TO C.
B.25 TIME STEP OF VARIABLE WIND SPEED AND ANGLE INPUT IN MINUTES:
     DTWND
     0
C------------------------------- BEACH -----------------------------C
C.1  TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): TPIN
     1
C.2  COMMENT: IF PROFILE TYPE IS ARBITRARY, CONTINUE TO C.4
C.3  LOCATION AND ELEVATION OF LANDWARD BOUNDARY, LANDWARD BASE OF
     DUNE, LANDWARD CREST OF DUNE, SEAWARD CREST OF DUNE, START OF
     BERM, END OF BERM, AND FORESHORE: XLAND, DLAND, XLBDUNE, DLBDUNE,
     XLCDUNE, DLCDUNE, XSCDUNE, DSCDUNE, XBERMS, DBERMS, XBERME,
     DBERME, XFORS, DFORS
     0        0        0        0        0        0
     0        0        0        0        0        0        0        0
C.4  DEPTH CORRESPONDING TO THE LANDWARD END OF SURF ZONE: DFS
     1.0
C.5  EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: D50
     0.35
C.6  MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: BMAX
     17.2
D-------------------------- BEACH FILL ---------------------------D
D.1  IS A BEACH FILL PRESENT? (NO=0, YES=1): IBCHFILL
     0
D.2  COMMENT: IF NO BEACH FILL, CONTINUE TO E.
D.3  POSITION OF START AND END OF BEACH FILL RELATIVE
     TO INITIAL PROFILE: XBFS, XBFE
     0        0
D.4  NUMBER OF REPRESENTATIVE POINTS BETWEEN START
     AND END OF BEACH FILL: NFILL
        0
D.5  LOCATION AND ELEVATION OF REPRESENTATIVE POINTS RELATIVE TO THE
     INITIAL PROFILE:  (XF(I), EFILL(I), I=1,NFILL)

E-------------------------- SEAWALL/REVETMENT --------------------E
E.1  IS A SEAWALL PRESENT? (NO=0, YES=1): ISWALL
     0
E.2  COMMENT: IF NO SEAWALL, GO TO F.
E.3  LOCATION OF SEAWALL RELATIVE TO INITIAL PROFILE: XSWALL
     0
```

Figure 4. (Sheet 3 of 4)

```
****************************************************************
*          SBEACH model configuration file:  EX_1.CFG          *
****************************************************************
E.4  IS SEAWALL ALLOWED TO FAIL? (NO=0, YES=1): ISWFAIL
     0
E.5  COMMENT: IF NO SEAWALL FAILURE, GO TO F.

E.6  PROFILE ELEVATION AT SEAWALL WHICH CAUSES FAILURE, TOTAL WATER
     ELEVATION AT SEAWALL WHICH CAUSES FAILURE, AND WAVE HEIGHT AT
     SEAWALL WHICH CAUSES FAILURE: PEFAIL, WEFAIL, HFAIL
     0        0        0
F---------------------------- COMMENTS ----------------------------F
   ┌────────────────────────────────────────────────────────┐
   │                PRESS 'ESC' TO END EDITING                │
   └────────────────────────────────────────────────────────┘
```

Figure 4. (Sheet 4 of 4)

A.5. If the grid type is variable, continue to question A.8.

A.6. For a constant grid spacing, enter the cell width (must be greater than zero).

A.7. If the grid is constant, continue to question A.10.

A.8. For a variable grid spacing, enter the number of different cell regions (up to 10). For studies in which the regions of interest are the subaerial beach and dunes, a fine spacing is usually chosen for the subaerial beach (typically 1 to 5 ft)[1], an intermediate spacing for the surf zone (typically 5 to 10 ft), and a coarser spacing for regions offshore of the breaker line (typically 15 to 50 ft) (Figure 5). In this and similar figures, the horizontal (x) axis points offshore, and the vertical (z) axis points upward from some arbitrary datum.

A.9. For the variable grid, enter the cell width and number of cells having that width for each different grid cell region. The total number of cells indicated must equal the total number of cells entered in A.3. For the configuration file shown in Figure 4, there are three different cell regions; 96 cells with a width of 5 ft, 84 cells with a width of 10 ft, and 72 cells with a width of 20 ft. Note that the total cells given in A.9 (96 + 84 + 72 = 252) equals the number entered in A.3. Ordering of the cell regions begins at the landward boundary and progresses seaward.

---

[1]A table of factors for converting non-SI units of measurement to SI units is presented on page vii.
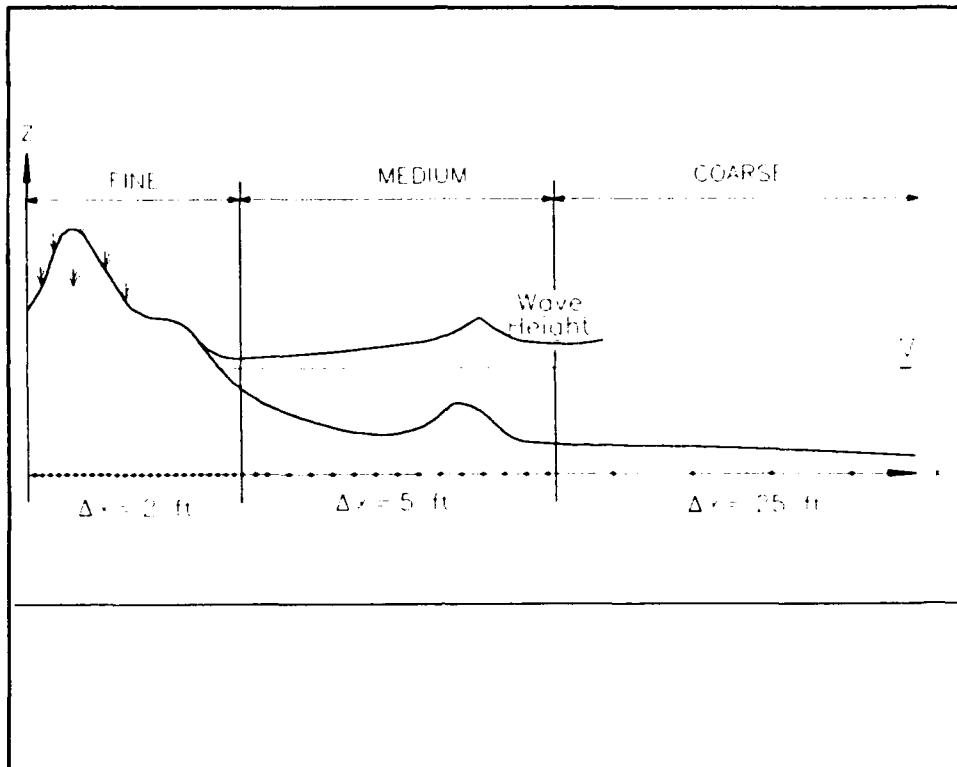
Figure 5. Example of variable grid spacing

A.10. Enter the number of time-steps in the simulation and the time-step in minutes. The duration of the simulation (in minutes) is equal to the product of the number of time-steps and the time-step value. The relationship between the cell length and the time-step is important in determining the numeric stability of the program. A long time-step in relation to a given cell length may cause model instability and a fatal run time error. For a variable grid, the time-step should correspond to the smallest grid cell size. A 10- to 20-ft cell length and a 5- to 10-min time-step are typically used to model storm erosion.

A.11. As many as 10 intermediate calculated beach profiles, and cross-shore distributions of wave height and water elevation can be output. Enter the number of intermediate recordings desired.

A.12. Enter the time-step(s) of the intermediate output.

A.13. A measured profile can be used to compare with final predicted results. Indicate whether a profile is (1) or is not (0) available for comparison.

A.14. The maximum horizontal recession at three elevations along the profile will be output (Figure 6). Enter these desired elevations. The datum of these elevations corresponds to the datum of the entire data set.
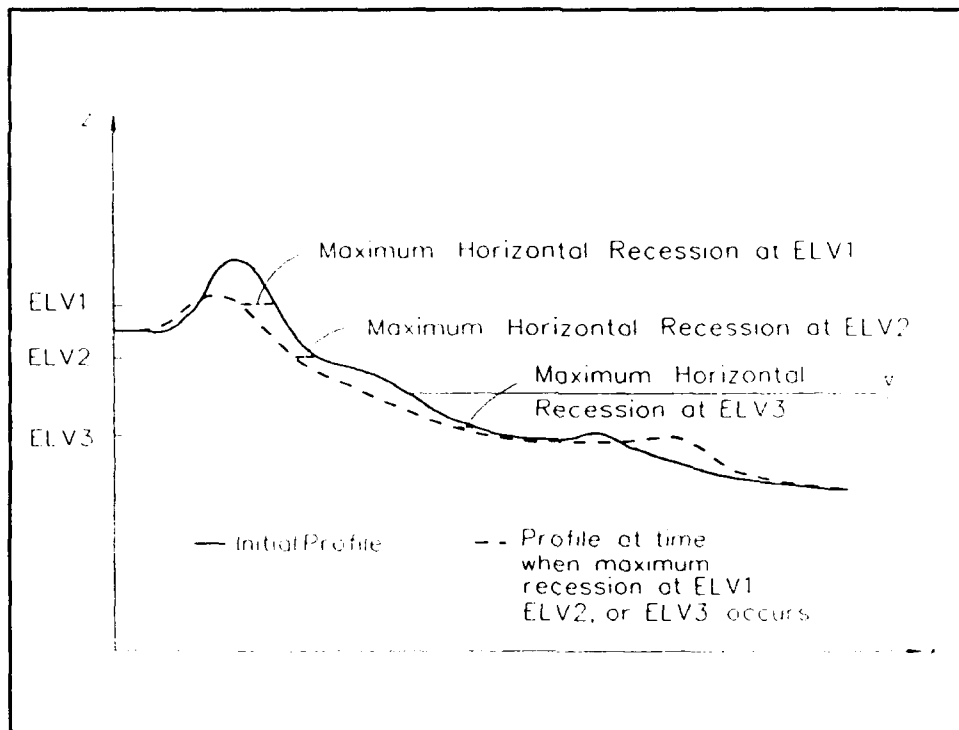
Figure 6. Definition of "Maximum Horizontal Recession" output

A.15. Distances to the landward-most occurrence of three different erosional elevation changes along the profile will be output (Figure 7). Enter the absolute value of these desired elevation changes. Distances are measured relative to the point on the pre-storm profile at elevation REFELV.

A.16. The transport parameters K and Eps (question A.17) are calibration parameters for the sediment transport calculations. Detailed technical information relating to these variables is given in Report 1, Part VI (Larson and Kraus 1989a); and Report 2, Part II (Larson, Kraus, and Byrnes 1990). Default values and appropriate ranges for the empirical transport rate coefficient (K) and the transport rate coefficient for the slope-dependent term (Eps) are given in Table 2. Larger K values produce greater sand transport and more prominent bar features, and larger values of Eps produce a more subd"ed bar. Enter the transport rate coefficient, K (units must be in m^4/N, even if American Customary units are chosen in A.2).

A.17. Enter the coefficient for the slope-dependent term, Eps (units must be in m^2/sec, even if American Customary units are chosen in A.2).

A.18. The transport rate seaward of the breaker line and from the wave reformation point to the next break point (if wave reformation occurs) decays according to this parameter, which can vary from 0.1 to 0.5. Larger values of the parameter result in more rapid transport rate decay.
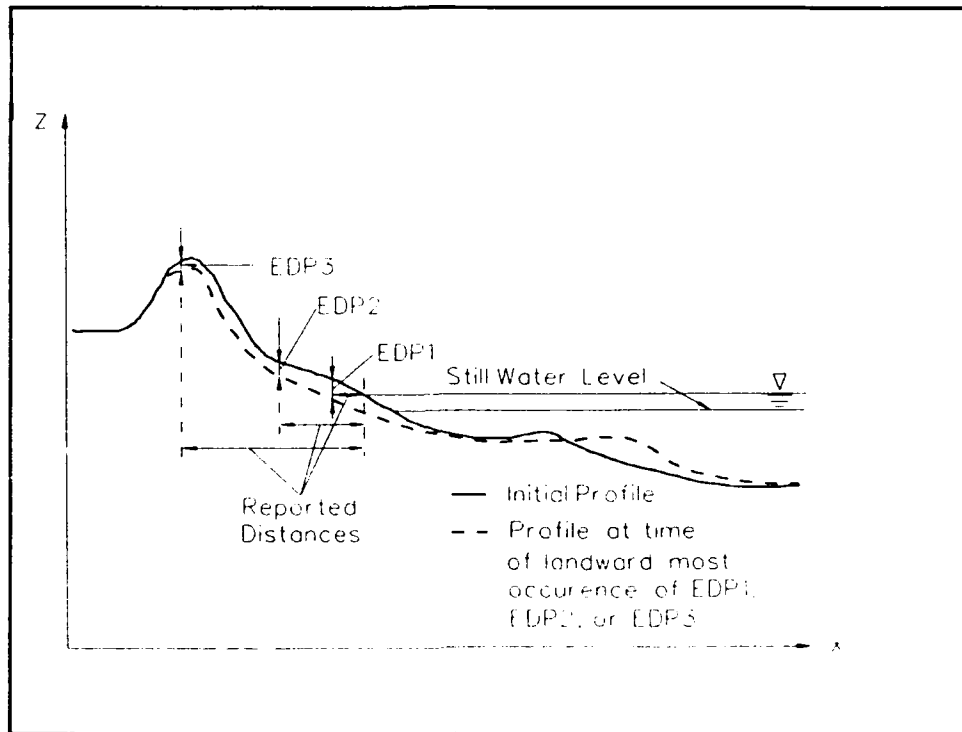
Figure 7. Definition of "Landward-most Occurrence" output

Table 2 SBEACH Calibration Parameters		
Parameter	Default Value	Appropriate Range
K (SI)	1.75×10^6 m^4/N	0.5×10^6 to 2.5×10^6 m^4/N
Eps (SI)	0.002 m^2/sec	0.001 to 0.003 m^2/sec

A.19. The fall speed of sediment depends on the water temperature. Enter the water temperature in degrees Celsius (between 0 and 40 °C).

Section B facilitates entry of information about waves, water elevations, and winds.

B.1. Waves can be either monochromatic (e.g. laboratory data) or irregular (using significant wave height). Enter 1 for monochromatic, 2 for irregular waves.

B.2. Wave data can be either constant (typically, only laboratory data) or variable. Enter 1 for constant, 2 for variable waves.

B.3. If the wave height and period are variable, continue to B.6.

B.4. Enter the constant wave height (feet or meters) and period (seconds).

B.5. If the wave height and period are constant, continue to B.7.

B.6. Enter the time-step of the variable wave height and period data (minutes). This value should correspond to the time between wave data as entered in the file "data_set.WAV."

B.7. Enter 0 for a constant wave angle (usually only for laboratory data), or 1 for variable wave angle.

B.8. If the wave angle is variable, continue to B.11.

B.9. Enter the constant wave angle. A wave angle of 0 deg indicates shore-normal approach; positive angles are from the right-hand quadrant if looking towards the beach, and negative angles are from the left-hand quadrant from the same orientation (see Figure 8).

B.10. If the wave angle is constant, continue to B.12.

B.11. Enter the time-step, in minutes, of the variable wave angle data. This value should correspond to the time between wave angle data as entered in the file "data_set.ANG."
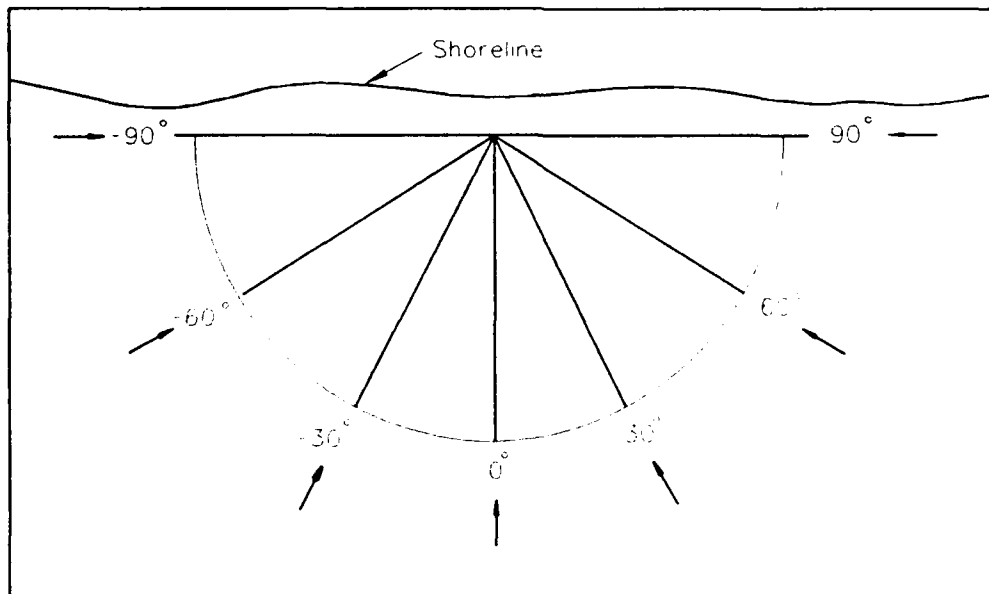

Figure 8. Wave angle convention for SBEACH

B.12. Enter the absolute value of water depth for the location of the input wave data (feet or meters). For deepwater conditions, enter 0.0.

B.13. If the time between consecutive wave entries is long relative to the time-step, some variation of the wave height may be desired to more realistically simulate randomness in the wave field. If the randomizer is not used, waves will be linearly interpolated from one wave entry to the next. The randomizer varies wave heights with a user-specified percent of variability around the linearly interpolated value. Enter 0 for no randomization, and 1 for randomization.

B.14. If randomization of wave height is not desired, continue to B.16.

B.15. Enter the seed value for randomization (value between 1000 and 9999), and the percent of variability (between 0 and 100).

B.16. Will the water level data be a constant value or vary with time? Enter 0 for constant, 1 for variable.

B.17. If the water levels are variable, continue to B.20.

B.18. Enter the constant total water level elevation (feet or meters). Water elevations must be referenced to the same datum as the beach profile data.

B.19. If the water level elevation is constant, continue to B.21.

B.20. Enter the time-step of variable total water elevation (in minutes). This value should correspond to the time between water elevation data as entered in the file "data_set.ELV."

B.21. If the wind speed and angle are constant, enter 0; if they vary, enter 1.

B.22. If wind speed and angle are variable, continue to B.25.

B.23. Enter the constant wind speed (meters per second or feet per second) and angle.

B.24. If wind speed and angle are constant, continue to Section C.

B.25. Enter the time-step of variable wind speed and angle (in minutes). The wind angles may be onshore or offshore, with the angle convention shown in Figure 9. The wind speed and angle time-step should correspond to the time between wind data as entered in the file "data_set.WND."

20
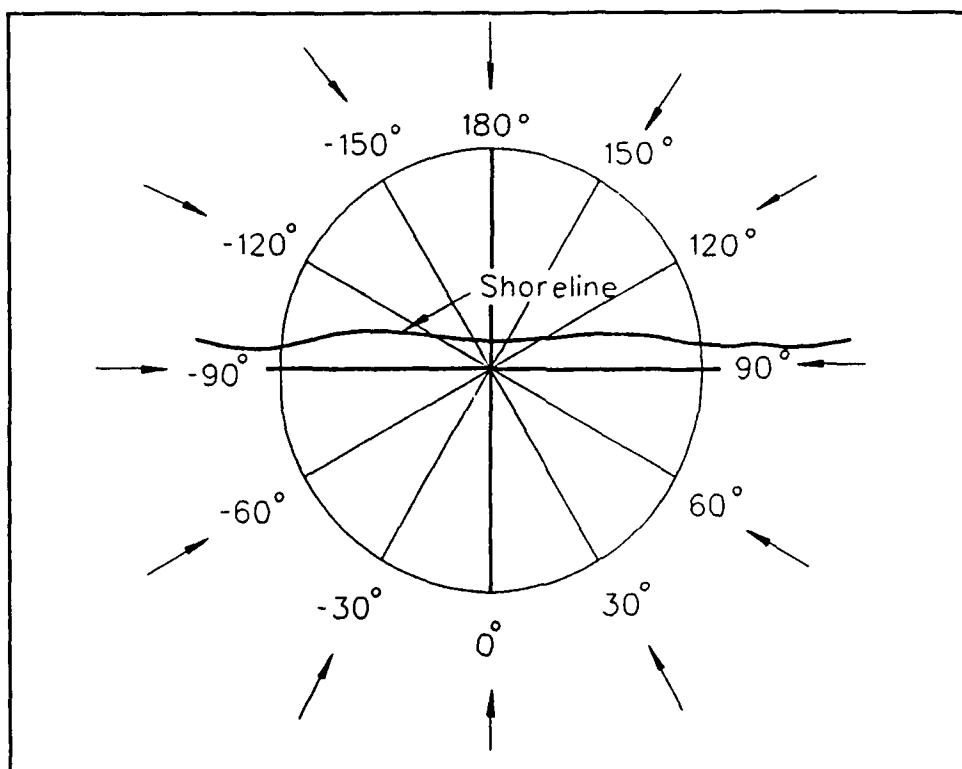
Figure 9. Wind angle convention for SBEACH

Section C allows entry of basic information related to the beach profile data.

C.1. SBEACH accepts either an initial arbitrary or a schematized beach profile. An arbitrary profile is one for which data are available; these data are given in the file "data_set.PRI." A schematized profile allows the initial beach profile to be described with seven range-elevation pairs to define the landward boundary, dune, berm, and foreshore region and an equilibrium beach profile for the subaqueous portion. This type of profile can be used if actual profile data are not available. Enter 1 for arbitrary and 2 for schematized profile.

C.2. If the profile type is arbitrary, continue to C.4.

C.3. Enter the distance along the profile and elevation corresponding to the landward boundary, landward base of the dune, landward crest of the dune, seaward crest of the dune, start of the berm, end of the berm, and foreshore. These locations are shown in Figure 10.

C.4. Enter the depth corresponding to the landward end of the surf zone (feet or meters) (may range from 0.15 to 0.5 m, or 0.5 to 1.6 ft). This depth is where the swash zone begins.
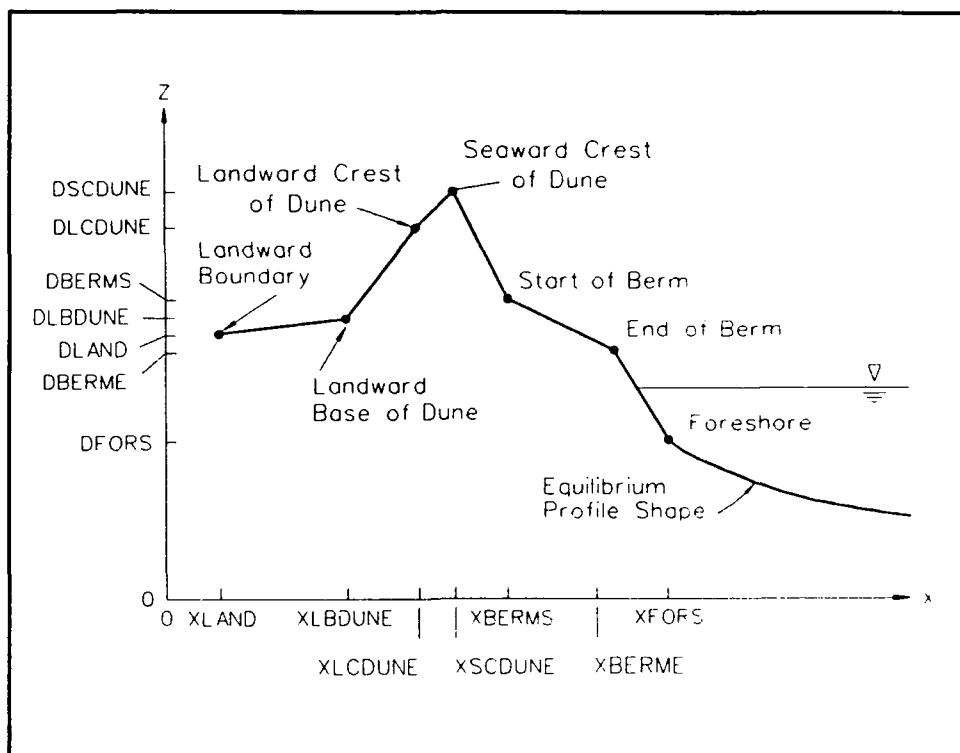
Figure 10. Definition of variables used in schematic profile

C.5. Enter the effective median grain size (mm) (may range from 0.15 to 1.0 mm). Grain size and water temperature determine sediment particle fall speed. Quartz sand particles are assumed.

C.6. The user enters the maximum slope angle (may range from 15 to 30 deg) that the profile is allowed to achieve. If the profile reaches an angle greater than this value at the end of any time-step, avalanching occurs and the slope is reduced to 10 deg less than this value. Enter the maximum profile slope prior to avalanching.

Section D facilitates definition of a beach fill placed on the initial profile.

D.1. If a beach fill is present, enter 1; if not, enter 0.

D.2. If no beach fill, continue to Section E.

D.3. Enter the starting and ending points of the beach fill in the cross-shore direction. The values of these points should correspond to the horizontal axis established for the profile data. Figure 11 shows an example beach fill cross-section, with XBFS and XBFE being the starting and ending points, respectively.

22
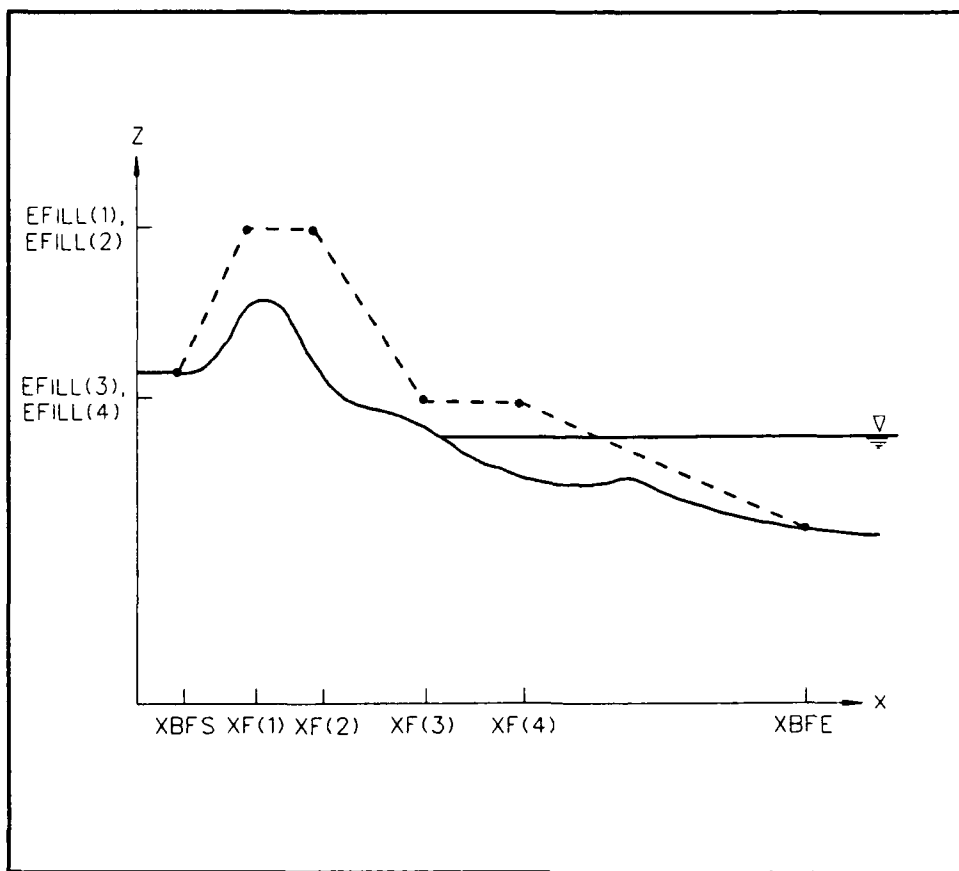
Figure 11. Definition of variables used in specifying a beach fill

D.4. Enter the number of representative points required (up to 10) to describe the beach fill profile. The beach fill shown in Figure 11 has four points (in addition to the starting and ending points) to describe the fill profile.

D.5. Enter the location (corresponding to the horizontal axis already established) and elevation of representative points to describe the beach fill. The number of data pairs entered should equal the value in D.4. For the example in Figure 11, these data pairs are XF(1), EFILL(1); XF(2), EFILL(2); XF(3), EFILL(3); and XF(4), EFILL(4).

In section E, the location and failure criteria for a seawall or revetment can be entered. Note that a seawall/revetment appears infinitely high to the model (no overwash).

E.1. If a seawall is present, enter 1; otherwise, enter 0, which completes the configuration file.

E.2. If no seawall, move to Section F.

E.3. Enter the x-coordinate location of the seawall.

E.4. If the seawall is allowed to fail, enter 1; otherwise, enter 0. Seawalls are allowed to fail by scour at the toe of the structure, by direct wave attack, and by inundation.

E.5. If the seawall is not allowed to fail, move to Section F.

E.6. Enter the profile elevation at the seawall which causes failure, the total water elevation at the seawall which causes failure, and the wave height at the seawall which causes failure (all in feet or meters). Seawall failure will occur if any one of these conditions occurs during a time-step. If one or two of these criteria are known not to cause seawall failures, set them equal to values that will not occur during the simulation. The time-step and mode of seawall failure are reported in the "data_set.RPT" file.

Comments and version update information will be noted in Section F.

Other MAIN MENU editors. Profile (initial and measured), wave (heights, periods, and angles), water level, and wind data can be entered, edited, and imported through the other MAIN MENU file editors. Editors for these data sets use a columnar format, with the working file identified in the lower right-hand corner of the screen (see Figure 12).

As the user enters these editors, the three options listed at the bottom of the screen (called the "Command Line") are active; **E** to edit the data file, **I** to import data, and **M** to return to the MAIN MENU. Keying **E** allows the user to access the Editor Commands listed on the right side of the screen. From the Editor Commands, **Esc** will return the user to the Command Line options; **F3** will insert a new line of data above the cursor location; and **F4** will delete the line at the cursor location. The profile editors also have an additional Editor Command, **F5**, that will locate data that have offshore coordinates out of sequence. The user can move line by line through the file using the **<up arrow>** and **<down arrow>** keys, or scroll through the data file quickly by entering **<page up>** and **<page down>**.

The user may import data by entering **I** at the Command Line. The interface asks "Would you like to replace these data? (Y/N)." Entering **Y** will bring in a new file; **N** will exit the Import option. The profile editors allow import of files in Interactive Survey Reduction Program (ISRP) format (Birkemeier 1984), two-column (distance and elevation) format, or input from another SBEACH run (the file "data_set.PRI;" only designation of the root name ("data_set") is required to import the profile data). If the ISRP import option is chosen, the interface prompts the user for information given in the first record of the ISRP file (see Birkemeier's (1984) Table 3 for complete description of ISRP format): date (positions 11-16), time (position 17-21), identification number (ID #)

```
        SBEACHI:  I N I T I A L    P R O F I L E    E D I T O R
==========================================================================
             Distance
             Offshore              Elevation
No.          (m or ft)             (m or ft)
--------------------------------------------------------------
   1         -328.08     10.70
   2          -90.00     10.70
   3          -52.00     10.20
   4          -18.00      9.50     Editor Commands
   5           -5.00      9.70     ----------------
   6            6.00     10.00     ESC - Command Line
   7           23.00     12.00     F3  - Insert Line
   8           33.00     13.00     F4  - Delete Line
   9           43.00     14.30     F5  - Locate Error
  10           60.00     14.50     PGUP/PGDN
  11           76.00     12.30     HOME/END
  12           77.00     10.60
  13           94.00      8.30
  14          110.00      6.40
  15          126.00      5.10

-------------------------------------------------------
E - Edit  I - Import          M - Main Menu      FILE:    EX_1.PRI
```

Figure 12. Example of a column-type editor

Table 3 SBEACH Interface Graphics Files and Their Function	
File Name	Facilitates Display of...
PROFILE.EXE	Profile elevations across the cross-shore grid
WAVE.EXE	Maximum wave heights across the cross-shore grid
ELVATION.EXE	Maximum water elevations across the cross-shore grid
WAVEINT.EXE	Intermediate wave heights across the cross-shore grid
MAXDEPTH.EXE	Maximum water depths across the cross-shore grid
VOLUME.EXE	Cumulative volume change across the cross-shore grid
ELVINT.EXE	Intermediate water elevations across the cross-shore grid

(positions 6-9), and the number of x- and y- decimal places for the X and Y values, respectively. All other editors ask for a filename to import, and require the new data to be in a column-type format similar to the data in these files.

Entering **M** from the Command Line will return the user to the MAIN MENU. However, before exiting an editor, the interface asks "Would you like to save these data? (Y/N)." Entering **Y** will save all changes made to the file; **N** will keep the file as it was before the editor was invoked.

The initial and measured profile editors are configured with three columns as shown in Figure 12; record number, distance offshore, and corresponding elevation. The wave editor is shown in Figure 13, organized with rows of record number, wave height, and wave period. The water elevation and wave angle editors are organized with re ∘ ·d number corresponding to the respective data (either water elevation wave angle) (Figures 14 and 15). The wind editor has rows of record numbei, ind speed, and wind angle (Figure 16). The time interval between entries for the wave height/period, wave angle, water elevation, and wind files is specified in the configuration file (see entries B.6, B.11, B.20, and B.25, respectively). If the model time-step (specified in question A.10) is the same as the parameter (wave height and period, wave angle, water elevation, wind speed and angle) time-step (question B.6, B.11, B.20, or B.25), the number of parameter entries equals the number of model time-steps. However, if the model time-step differs from the parameter time-step, one additional parameter entry is required for interpolation between parameter values. If the number of entries is insufficient, the interface will print out a message indicating which file(s) needs more data for model simulation.

Execute SBEACH. Once all seven input files are completed, SBEACH can be executed by entering **X** from the MAIN MENU. The model prompts the user for the data set name, then identifies the time-step of the simulation, percent of calculation completed, and whether erosion or accretion is occurring during that time-step. If overwash occurs during the simulation, a note will flash on the screen at that time-step. If the landward boundary of the grid restricts model simulation (runup would normally extend past this boundary), a warning is noted on the screen at the time-steps when it occurs. Finally, if inundation of the entire profile occurs, the user is also notified at that time-step. SBEACH is not intended to simulate an entirely inundated profile, and the user should extend the landward boundary further shoreward to a greater elevation, if possible. These notes are documented in a "data_set.LOG" file.

GRAPH MENU. Once a simulation is completed, the user may enter **G** to go to the GRAPH MENU and view the cross-shore variation of the following: measured (if entered into the file "data_set.PRM") and predicted profiles; maximum and intermediate (if specified in configuration file questions A.11 and

```
        SBEACHI:  W A V E   E D I T O R
==============================================================

        Wave                  Wave
        Height       Period
  No.      (m or ft)        (sec)
      ---------------------------------------------
  1     2.62          11.10
  2     2.62          10.27
  3     2.61           9.45
  4     2.60           8.62          Editor Commands
  5     2.59           7.80          -------------------
  6     2.81           7.68          ESC - Command Line
  7     3.02           7.55          F3  - Insert Line
  8     3.23           7.43          F4  - Delete Line
  9     3.44           7.30          PGUP/PGDN
 10     3.52           7.12          HOME/END
 11     3.59           6.95
 12     3.67           6.78
      ---------------------------------------------
  E - Edit  I - Import    M - Main Menu    FILE:   EX_1.WAV
```

Figure 13. Wave editor

```
        SBEACHI:  W A T E R   E L E V A T I O N   E D I T O R
================================================================================

             Water Level
        No.     (m or ft)
      ---------------------------------------------
         1       1.31
         2       0.82
         3       0.33
         4      -0.16              Editor Commands
         5      -0.66              -----------------------
         6      -0.16              ESC - Command Line
         7       0.33              F3  - Insert Line
         8       0.82              F4  - Delete Line
         9       1.31              PGUP/PGDN
        10       1.80              HOME/END
        11       2.30
        12       2.79
      ---------------------------------------------
  E - Edit   I - Import   M - Main Menu     FILE:   EX_1.ELV
```

Figure 14. Water elevation editor

```
                SBEACHI:  W A V E    A N G L E    E D I T O R
==================================================

                    Wave Angle
              No.      (deg)
         ---------------------------------------
               1       0.00
                                              Editor Commands
                                              ---------------------
                                              ESC - Command Line
                                              F3  - Insert Line
                                              F4  - Delete Line
                                              PGUP/PGDN
                                              HOME/END


         ---------------------------------------
         E - Edit    I - Import    M - Main Menu      FILE:    EX_1.ANG
```

Figure 15. Wave angle editor

```
                SBEACHI:  W I N D    E D I T O R
======================================================================
                    Wind          Wind
                    Speed         Angle
              No.   (m/sec or ft/sec)   (deg)
         ---------------------------------------
               1    0.00          0.00
                                              Editor Commands
                                              ---------------------
                                    ESC - Command Line
                                              F3   - Insert Line
                                              F4   - Delete Line
                                              PGUP/PGDN
                                              HOME/END


         ---------------------------------------
         E - Edit    I - Import    M - Main Menu      FILE:   EX_1.WND
```

Figure 16. Wind editor

A.12) wave heights, maximum and intermediate (if specified in configuration file questions A.11 and A.12) water elevations, maximum water depths, and final volume changes. This menu is detailed in the next section.

DOS OPTIONS MENU. The user may execute various DOS commands by entering **O** from the MAIN MENU. This menu is discussed further in the next section.

Quit (Exit to DOS). The SBEACH interface may be exited by entering **Q** from the MAIN MENU. The interface asks "Are you sure you want to quit? (Y/N)." Enter **Y** for "yes," **N** for "no."

GRAPH MENU

Simulation results can be visualized through options in the GRAPH MENU (Figure 17). Because many of the files necessary for graphics are generated by SBEACH, GRAPH MENU options cannot be accessed until SBEACH has been successfully executed. In addition, each graphics file must be installed if a non-VGA monitor is used, or if hard copies are desired (see Chapter 3 for installation).

The GRAPH MENU options facilitate viewing and manipulation of simulation results using the HGRAPH** software package. The software has several viewing alternatives:

```
         SBEACHI:   G R A P H    M E N U
    ===============================================
    1) Profiles
    2) Volume change
    3) Maximum Wave Heights
    4) Maximum Water Depths
    5) Maximum Water Elevations
    6) Intermediate Wave Heights
    7) Intermediate Water Elevations
    0) Return to Main Menu
    ===============================================
    Enter choice -


                                    DATA   SET:
EX_1
```

Figure 17. GRAPH Menu

---

* The program HGRAPH was developed by Mr. David W. Hyde, Structural Engineer, U.S. Army Engineer Waterways Experiment Station, Structures Laboratory.

a. **Q** Quit - exit graphics.

b. **@** Read *Y* value(s) @ *X* = ?

c. **D** Screen dump to printer.

d. **E** Erase a curve.

e. **L** Relocate a legend.

f. **C** Change labels.

g. **R** Read *X*, *Y* data points from a curve.

h. **V** List peak values.

i. **Z** Zoom.

j. **P** Plotter functions.

k. **M** Display other profiles (measured, maximum, minimum).

l. **I** Display intermediate profiles.

Use of the graphics package and the various alternatives listed are illustrated via example applications in Chapter 3.

DOS OPTIONS MENU

Various DOS operations (delete, rename, and copy a data set) and a shell to DOS are available from the DOS OPTIONS MENU (Figure 18). To delete the active data set (selected in the DATA SET SPECIFICATION MENU), enter **D**. The interface will ask, "Delete project, are you sure? (Y/N)." Entering **Y** will delete all data set files; **N** will return the user to the DOS OPTIONS MENU. The data set files can be renamed or copied by entering **R** or **C** , respectively, and entering the new file name at the interface prompt. The user may temporarily exit the interface by typing **S** ; to re-enter the SBEACH interface, simply type **EXIT < enter >** . Key **M** to return to the MAIN MENU.

Calibration Procedure

Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by a storm. Verification refers to the procedure of applying the calibrated model to reproduce change on the same beach produced

```
        SBEACHI :   D O S   O P T I O N S   M E N U
==============================================================
             < D >  Delete Current Data Set
             < R >  Rename Current Data Set
             < C >  Copy Data Set
             < S >  Shell to DOS

             < M >  Main Menu
==============================================================
             Enter Choice -
```

Figure 18. DOS options menu

by another storm, or to reproduce changes on the same beach for the same storm as used in the calibration but at a different location on the beach (using pre- and poststorm profile measurements for a beach cross section of different shape than the profile used in the original calibration).

This section reviews the calibration procedure, including some consideration of the quality of data typically available in a project study. In most cases, wave and water level data for the site are lacking, so hindcasts must be used. Also, immediately prestorm and immediately poststorm profile survey data are rarely available and must be inferred. Calibration studies made with SBEACH using laboratory data are given in SBEACH Report 1 (Larson and Kraus 1989a), and examples using field data are described in SBEACH Report 2 (Larson, Kraus, and Byrnes 1990) and Larson and Kraus (1991a). The calibration procedure involves successive adjustment of simulation parameters. These parameters and input data should always be in a range representative of the beach and physical processes, and they should never be arbitrarily or radically changed simply to obtain agreement between calculation and measurements. The calibration procedure requires trial-and-error iteration among combinations of values of controlling parameters and ambiguous input data. The time required for calibration is minimized if the initial values of the parameters are close to the final ones determined in the calibration. The purpose of calibration is to reproduce with SBEACH observed changes in the beach profile, particularly in the dune and berm, that were produced by the storm. In broad terms, the success of the simulation depends on the quality of the profile data, suitability of the model parameters, quality of the hydrodynamic data, and skill of the modeler in developing the needed input data sets and running SBEACH. This section provides advice based on the authors' experience with specification of initial values and the overall iterative process leading to a calibrated model.

Profile data

Typically, the modeler has available for calibration beach profile survey data taken considerably before and after the storm erosion event to be modeled, for example, 3 to 6 months before the storm and 1 to 3 months after the storm. It is clear that in such a case the configuration of the beach berm and subaqueous profile will not be the same as that for the profile of the beach when the storm arrived. Similarly, the poststorm survey will contain evidence of significant onshore transport, such as a local but prominent foreshore berm, even if the survey was made just a few days after the storm. If there is a considerable gap between the storm and the time that either the pre- and poststorm profile surveys were made, other storms, as well as recovery processes may have molded the profile shape. Therefore, the initial and final measured profiles rarely represent true initial and final conditions defining the storm-erosion event. As initial guidance on calibration, judgement must be used in avoiding the temptation to exactly reproduce every feature on the measured profile change because of the ambiguity in the initial and final conditions.

Despite the concerns raised in the previous paragraph regarding imprecise knowledge of the actual initial and final profiles, usually the dune and higher portion of the berm are representative of the pre- and poststorm conditions for large storms. The modeler should, however, check that other storms or artificial modification of the beach and dune (such as during post-storm reconstruction) are not factors contaminating the data set. It is important to gather evidence to support the assumption that the storm considered in the calibration produced most of the observed beach change along all or portions of the profile. If this assumption can not be made comfortably, then calibration of the model should be viewed cautiously.

If several profile surveys are available for a section of beach with similar offshore, longshore, and backshore configuration, and with similar grain size along the profiles, an average profile shape can be defined from the survey set and used in the calibration, with the standard deviation in depth-elevation pairs giving a measure of natural variability existing in the profile of the beach.

Grain size data

A gradation of finer sand on the dune and berm, coarser sand on the foreshore, and finer sand in the surf zone (with increase in fineness with distance offshore) exists on most beaches. Some beaches may have more complex cross-shore distributions of grain size. The present version of SBEACH permits use of only a single grain size diameter to represent the beach material. One method for specifying the grain size for the model is to take a composite (weighted average) of surf zone, berm, and dune sands. Because the erosion calculated by SBEACH is driven by surf zone transport processes, the average grain size in the surf zone is considered most representative. However, if the berm and dune complex have a considerably different grain size (for example, coarser, owing

to a beach fill), the initial estimate of the representative grain size might be taken as the composite from only the dune and berm.

Another approach is to fit an equilibrium profile shape, as discussed in SBEACH Reports 1 and 2, to the average of measured beach profiles. Approximating the average profile with the equation proposed by Dean (1977), a profile shape parameter can be determined. From this shape parameter, the corresponding grain size can be calculated based on curves presented by Moore (1982) and Dean (1987, 1990). This is the recommended approach if dealing with a beach that shows great deviation in grain size across shore, either naturally or as a result of a beach fill.

Water temperature is a required input. SBEACH calculates the sand fall speed from the grain size and temperature inputs. The fall speed is then used by the model to calculate the direction of cross-shore transport.

Water level data

The water level is the most important or first-order forcing parameter controlling storm-induced beach profile change, normally exerting greater control over profile change during storms than either waves or wind (although in certain extreme cases, waves and wind can be controlling processes, as discussed below). The water level consists of contributions from the tide, storm surge, wave- and wind-induced setup, and wave runup. Of these, wave setup, wind setup, and wave runup are calculated within SBEACH, leaving the tide and storm surge as the main data inputs of concern. Note that a "surge" can consist of either a rise or fall of the water level, caused by spatial variations in atmospheric pressure, about the normal or predicted water level associated with the tide.

The combined time series of tide and surge is referred to as the "hydrograph of total water level," meaning the combined water level measured (at a gage) or calculated (hindcast) at some point offshore. The hydrograph does not fully contain contributions from wave- and wind-induced setup; setup is only prominent in very shallow water. Beach and dune erosion are strongly controlled by the shape of the hydrograph. The shape of the hydrograph is characterized by its duration (time when erosive wave conditions and higher than normal water elevation occur) and by its peak elevation. Both the duration and peak of the hydrograph must be well hindcast or measured. Larson and Kraus (1989b) give an example of a synthetic hydrograph representing a northeaster (extratropical storm) characterized by a relatively long duration and lower surge producing the same erosion as a hurricane with a considerably shorter duration (for example, 24 or 48 hr for a northeaster as opposed to 6 or 12 hr for a hurricane), but a higher peaked hydrograph.

Phase of the tide in the combined tide and storm hydrograph is also important; a storm peaking in surge at low tide may produce no erosion, whereas a storm peaking at high tide may produce catastrophic erosion.

In summary, the tide and storm hydrograph representing the calibration storm condition must be carefully checked for accuracy of both the duration and peak to the actual event.

Wave data

Elevated water level accompanying storms allows waves to attack portions of the profile that are out of equilibrium with wave action because this area of the beach is not normally inundated. Because waves in shallow water are depth limited, meaning that the wave height will approximately equal the depth in the surf zone no matter what the wave height in the offshore is, the wave height mainly controls the location of the breakpoint bar and the amount of material removed offshore. The deepwater wave height also controls the elevation of the runup, which is an important factor in calculating storm-induced erosion, because, as stated above, water level is the first-order parameter controlling erosion. Similarly, wave period enters in the runup calculation. The runup is proportional to the square root of deepwater wave height and directly proportional to the wave period.

Wave height and period also combine in an empirical equation (Larson and Kraus 1989b; Kraus, Larson, and Kriebel 1991) that is used in SBEACH to determine if the beach will erode or accrete for the time-step. Therefore, from the perspective of beach erosion modeling, a storm is defined neither by the water level nor by the wave height or period alone, but by the combination of these parameters that produces offshore transport.

Input of wave angle includes refraction in the wave-related calculations. Unless the waves are approaching from a highly oblique angle, wave angle is not an important parameter and may be assigned to 0 deg (normally incident waves) if not well known.

Wave-induced setup, the rise in mean water elevation on the shore due to the presence of waves, is mainly controlled by wave height. Higher waves produce greater setup.

Wind data

The importance of wind in storm-induced erosion modeling is just becoming recognized, and SBEACH has been upgraded to include wind influence on water level. For example, on the east coast of the United States, as a storm approaches shore the wind will be directed onshore to the north of the eye and offshore to

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the south of the eye. Wind-induced setup on the north side raises the water level and exacerbates erosion; on the south side, it is possible the setdown or lowering of the water level and knockdown of the wave height will produce accretion!

Model parameters

The main calibration parameter for SBEACH is the transport rate coefficient K. Simulations should begin with the default value, $K = 1.75 \times 10^{-6}$ m^4/N. Increase in K will produce increased erosion and larger bars.

The parameter *Eps* controls the peakedness of the bar (higher values of *Eps* give a more peaked bar) and the flatness of the surf zone profile (higher values of *Eps* produce flatter inner surf zone profiles). The parameter *LAMM*, which is a transport rate decay factor for the offshore portion of the simulation, controls the seaward shape of the bar, with higher values producing a more narrow, peaked bar. It is recommended that the default values of *Eps* and *LAMM* be used.

Two additional model parameters that represent characteristics of the beach are required for SBEACH simulations. The parameter *DFS* is the depth corresponding to the landward end of the surf zone, and it influences the magnitude of transport occurring in the swash zone. The avalanching angle *BMAX* is the maximum achievable profile slope prior to avalanching. The value of *BMAX* can affect the development of profile features subject to steepening, such as dunes and bars. It is recommended that the default values of *DFS* and *BMAX* be used, although slight variation may be required to "fine tune" a calibration. Model calculations are not very sensitive to these parameters.

Calibration strategy

First, the user must understand the limitations of the profile, wave, and water level data. There is no value in trying to obtain a perfect calibration if the data are only ap roximate. Features will exist on the profile that may have been produced by wave and water level conditions unrelated to the simulated storm. Similarly, the user must be aware that variations in longshore processes, both hydrodynamic (produced by variations in offshore bathymetry and tidal elevation) and geomorphologic (produced by variations in dune shape, amount of vegetation on the dune, and dune composition) may introduce natural variability in results that are unaccountable in SBEACH.

The most important step in calibration of SBEACH or any beach change numerical simulation model is to assure that the input data sets are the most accurate possible. Enough emphasis cannot be placed on preparation of quality input data sets.

Unless experience suggests otherwise, the calibration process should begin by using default values of the model parameters. After viewing the initial results, K should be changed to reproduce profile changes observed in the measurements. If the model does not reproduce the elevation of erosion in the dune, a likely possibility is underestimation of the peak surge, or underestimation of the wave period. Inadequate loss of volume above, say, mean sea level, may only be apparent due to the action of recovery processes that normally occur at the waning stage of a storm, when the waves are still high and the period becomes longer.

Finally, volume conservation should be checked between the initial and final measured profiles used in the calibration. SBEACH conserves sand volume, and, if significant volume (order of 20 percent or greater) is lost or gained between measured initial and final profile surveys, longshore processes may have been acting that invalidate basic assumptions upon which SBEACH is founded. In any case, no amount of calibration effort will fully reproduce beach change if volume is not conserved.

3 Tutorial

Lesson 1: Loading the SBEACH Interface

An INST_SB.BAT batch file has been provided with the distribution diskette. Commands in this file will create a C:\SBEACH directory and a C:\SBEACH\ TUTOR subdirectory, and copy the SBEACH interface and associated files to their appropriate directories. To install the SBEACH interface on the C: drive, move to the drive with the distribution diskette, and type

      INST_SB *(installs SBEACH interface)*

Installation of the graphics files is necessary for non-VGA monitors and if hard copies of graphics are desired. There are seven graphics files used for displaying SBEACH simulation results, as listed in Table 3. The INSTALL program must be executed for each graphics file for which hard copy output is required. After asking which file the user would like to install, the INSTALL program asks for information about the type of monitor and printer that will be used. At the C:\SBEACH prompt, type

      INSTALL *(installs graphics file)*

and answer the questions that follow.

In running the SBEACH interface, it is possible to load data set files from any directory. It is recommended that the data files be ported to or created in a subdirectory named after the data set and located in the SBEACH directory. In order that SBEACH and the graphics programs can be executed from these subdirectories, the user must add the following at the end of the PATH statement (in the AUTOEXEC.BAT file),

      C:\SBEACH   *(allows execution of interface programs from any directory on the C: drive)*

The subdirectory TUTOR holds the example data sets used in this tutorial. Files in the subdirectory DEFAULT contain default values of model parameters and are useful when creating a data set. Five lessons using example data set files in the TUTOR and DEFAULT subdirectory are presented below; these lessons were written to be followed while running the SBEACH interface. Refer to Chapter 2 for a discussion of the menus and editors used in the lessons.

Lesson 2: Run SBEACH

Overview. The purpose of this lesson is to become familiar with features of the interface, run SBEACH, then investigate simulation results using the graphics options and output files.

DATA SET SPECIFICATION MENU. To execute the SBEACH interface, move to the C:\SBEACH directory and type **SBEACHI** <enter>; the title screen appears. The title screen gives the version being run, the date of release, and points of contact for questions and further information. Hit any key to move to the DATA SET SPECIFICATION MENU (Figure 2). The working directory can be changed by entering **W** and typing the desired directory; for this lesson, type **C:\SBEACH\TUTOR** <enter> to access the example files available with the distribution diskette. By entering **S**, the user may view the data set files available in the C:\SBEACH\TUTOR directory. For this lesson, choose EX_1 by highlighting this data set with the cursor, then pressing <**ENTER**>. Once the EX_1 data set has been selected, type **M** to move to the MAIN MENU.

MAIN MENU. A listing of all files associated with the data set EX_1 are presented next to their respective editor on the MAIN MENU screen (see Figure 3). The user may explore data in the EX_1 files by entering any of the editors and scrolling through the data. For example, enter **C** to invoke the Configuration File Editor. A file format similar to that presented in Figure 4 will appear; the up and down arrow keys, or the <**page up**> and <**page down**> keys are used to move through the file. Note that data set EX_1 is in American Customary units (A.2), and has a variable grid (A.4) with three regions (A.8) of 252 cross-shore calculation cells (A.3). The model will run for 1,440 time-steps (A.10), and produce three sets of intermediate output (A.11), at time-steps 360, 720, and 960 (A.12). Default values for model parameters are used (A.16 and A.17). The specification of variable wave (B.2) and water elevation (B.16) data indicates to the interface that there should be associated EX_1.WAV and EX_1.ELV files. Because wave angle (B.7) and wind speed/ direction (B.21) are constant values, there is no information in the EX_1.ANG or EX_1.WND files. Note that the EX_1 data set does not have a beach fill (D.1) or seawall/revetment (E.1). When familiar with this editor, enter <Esc> to exit. Save the changes to the file by entering 'Y'; enter **N** to make sure the original EX_1.CFG is retained.

The other six editors have a structure different from the Configuration File Editor. Enter **P** to view the initial profile data in the file EX_1.PRI (Figure 12). To scroll through data in this file, enter **E** to invoke the editor commands on the right-hand side of the screen and hit the arrow keys or **<page down>** and **<page up>** until data in this file are viewed. The initial profile file has 55 points, extending to approximately 2,510 ft offshore and a depth of -30.5 ft. Data are inserted and deleted using the appropriate Editor Commands. Entering **F3** inserts a line below the cursor position; **F4** deletes a line at the cursor position; and **F5** locates points that are out of ascending order. Return to the MAIN MENU by entering **<Esc>** (return to the Command Line) and entering **M** . The interface asks the user if the user would like to save the changes made to the file; enter **N** to ensure that the original EX_1.PRI file is retained. The other editors may be explored from the MAIN MENU (Figures 12-15); Note: as indicated in the Configuration File, there is no information in the EX_1.WND and EX_1.ANG files. SBEACH will therefore assume that wind speed is negligible and that waves approach the beach at a shore-normal angle.

Execute SBEACH. To execute SBEACH using the EX_1 data set, use the MAIN MENU screen, with the original EX_1 data set listed by the editors and in the lower right-hand corner of the screen. Enter **X** to execute the model; the interface prompts the user to enter the appropriate input data set. Type **EX_1** and the simulation begins. A running header listing the percent of the run completed, the time-step of the simulation, and any notes documenting occurrence of accretion, erosion, overwash, boundary-limited runup, and inundation of the profile will appear.

```
RUN:   Example 1
-------------------------------------------------------------------
    10 % COMPLETE      < TIME STEP: 137 >     [ACCRETION]
```

As the model runs, these notes are being recorded in an EX_1.LOG file. The model also is preparing an EX_1.RPT file, which repeats information given in the Configuration File and presents calculated parameters of interest. These files are discussed in detail in a subsequent section. Once the model simulation is complete, the MAIN MENU will return to the screen. Simulation with the EX_1 data set typically takes 7 min on a 386 33-MHz machine, and 3 min on a 486 25-MHz machine.

GRAPH MENU. Now that the simulation is completed, the MAIN MENU should be on the screen. Enter **G** and move to the GRAPH MENU (Figure 17) to view calculated results. View the initial and final profiles by typing **1 <enter>**; these profiles will display on the screen with graphics options at the bottom (Figure 19). Note that there is considerable distortion between the horizontal and vertical scales. The simulation reduced the dune in elevation, and moved the offshore bar further seaward. There was little profile change past the
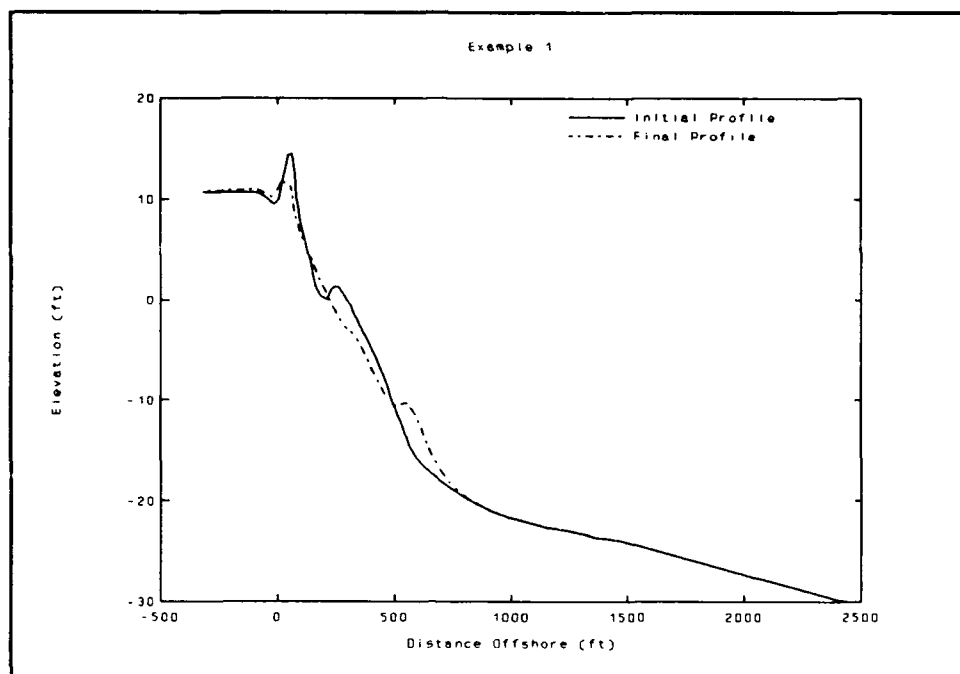
Figure 19. Initial and final profiles for data set EX_1

20-ft depth. Hit the right or left arrow keys to move through the various graphics options as their functions are explained. View the time sequence of profile change by moving to I and pressing <enter> to display intermediate profiles. The graphics option asks whether the user would like to see all intermediate profiles at once, or step through them one at a time. Position the cursor over Step and press <enter> . The profile at time-steps 360, 720, and 960 (specified in Configuration File) displays on the screen, overlaying the initial and final profiles, as the user hits the <enter> key. Read X and Y values from a curve by entering R , locating the cross-hairs on the profile of interest, and moving along a profile with the arrow keys (up arrow moves offshore, down arrow moves onshore). Hit the <insert> key to toggle the cursor speed; the crest of the final calculated offshore bar is located at X = 542.5 ft, Y = -10.30 ft. Hit the <enter> key to return to the options line at the bottom of the screen. Peak values of the profiles will be displayed after keying V. Part of a profile can be enlarged using the zoom feature; enter Z , choose Window to view part of the graph, locate the cross-hairs at a corner of the part to be enlarged, hit <enter> , and repeat for the diagonal corner. Then return to the original plot by entering the zoom feature again (Z), and choosing All to display all of the graph. The graph on the screen may be dumped to the printer by entering D (half-page plot); a finer resolution (full-page) plot is obtained if the plotter function P is used, and the Plotter <enter> option chosen. Other features of the graphics options may be explored as desired. Return to the GRAPH MENU by entering Q .

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Similar graphics options are included with the remaining six graph programs listed in the GRAPH MENU. Entering "2" will display the cumulative volume change to the left of the cursor along the profile. Option "3" shows the cross-shore distribution of the maximum wave heights occurring during the simulation. The cross-shore variation of the maximum water depths can be viewed with option "4," and the maximum water elevations (maximum water elevation plus setup) with option "5." Options "6" and "7" facilitate display of the intermediate wave heights and water elevations, at time-steps indicated in the Configuration File, as they vary in the cross-shore direction. The profile at the intermediate time-step is also displayed with the intermediate wave height and water level cross-shore variation. To view all of the intermediate water levels and corresponding profiles, choose 7 <enter> from the GRAPH MENU, enter I to display other intermediate profiles, position the cursor at All , and press <enter>. Water levels and corresponding profiles at time-steps 360, 720, and 960 will be displayed. Highlight Q and press <enter> to return to the GRAPH MENU.

Output files. As presented in Table 1, SBEACH creates four output files. Two of these, "data_set.PRC" (calculated profiles) and "data_set.XVR" (cross-shore variation of parameters) are primarily used for graphics. The last two files, "data_set.LOG" and "data_set.RPT," provide details of the model run and calculation results that are regularly examined by the modeler.

To inspect the EX_1.LOG file, exit the GRAPH MENU by pressing 0 <enter>, then enter O to move to the DOS OPTIONS MENU, and S to shell to DOS. View this file in any DOS editor on the PC, or print it out by typing **COPY EX_1.LOG PRN** at the C: prompt. The log file contains information about the simulation with the EX_1 data set, including time-steps in which the mode of transport changed to erosion or accretion, when overwash occurred, and when runup across the profile was limited by the landward boundary position (a partial EX_1.LOG file is shown in Figure 20). At the bottom of the file, a note indicates the time that was required for simulation.

The report file EX_1.RPT can be viewed and/or printed out in the same way as discussed above. This file repeats the model configuration information, then details computed results of interest (Figure 21). The first computed result listed indicates that the difference between initial and final profile volumes was very small (-0.1 cu yd/ft); this assures the user that there has been a conservation of material through the simulation. The second computed result, "Difference in total volume between measured and initial profiles," indicates to the user whether material was conserved between the two measured profiles. The "sum of squares difference between measured and final profiles" is useful when the modeler is comparing simulation results with different model calibration parameters; a smaller "sum of squares" value indicates a better calibration. Other values reported in this file are discussed in Chapter 2.

```
**************************************
*   SBEACH output file:     ex_1.LOG   *
**************************************
RUN:       Example 1
_____
TIME STEP:      1  [ACCRETION]
TIME STEP:    140  [EROSION]
TIME STEP:    141  [ACCRETION]
TIME STEP:    146  [EROSION]
TIME STEP:    148  [ACCRETION]
TIME STEP:    153  [EROSION]
TIME STEP:    155  [ACCRETION]
                  .
                  .
                  .
TIME STEP:    321  [ACCRETION]
TIME STEP:    322  [EROSION]
TIME STEP:    660              [OVERWASH]
TIME STEP:    663              [OVERWASH]
TIME STEP:    664              [OVERWASH]
TIME STEP:    665              [OVERWASH]
                  .
                  .
                  .
TIME STEP:    710              [OVERWASH]
TIME STEP:    711              [OVERWASH]
TIME STEP:    712              [OVERWASH]
TIME STEP:    713              [OVERWASH]   [BOUNDARY LIMITED
                                            RUNUP]
                  .
                  .
                  .
TIME STEP:   1021  [ACCRETION]
TIME STEP:   1022  [EROSION]
TIME STEP:   1030  [ACCRETION]
                  .
                  .
                  .
TIME STEP:   1396  [EROSION]
TIME STEP:   1397  [ACCRETION]
TIME STEP:   1400  [EROSION]
TIME STEP:   1401  [ACCRETION]
_____
      <<SBEACH SIMULATION COMPLETED IN   7.0 MINUTES>>
```

Figure 20. Partial printout of "EX_1.LOG" file

```
        ********************************************
        *  SBEACH output file:      ex_1.RPT  *
        ********************************************
RUN:        Example 1
                        <MODEL CONFIGURATION>
INPUT UNITS (SI=1, AMERICAN CUST.=2): 2
NUMBER OF CALCULATION CELLS:   252
GRID TYPE (CONSTANT=0, VARIABLE=1): 1
NUMBER OF GRID CELL REGIONS:   3
NUMBER CELLS AND CELL WIDTH IN REGION  1:   96,   5.0
NUMBER CELLS AND CELL WIDTH IN REGION  2:   84,  10.0
NUMBER CELLS AND CELL WIDTH IN REGION  3:   72,  20.0
NUMBER OF TIME STEPS AND VALUE OF TIME STEP IN MINUTES: 1440, 3.0
TIME STEP(S) OF INTERMEDIATE OUTPUT:     360,     720,     960
PROFILE ELEVATION CONTOUR 1:   12.00
PROFILE ELEVATION CONTOUR 2:    5.00
PROFILE ELEVATION CONTOUR 3:   -5.00
PROFILE EROSION DEPTH 1:    5.00
PROFILE EROSION DEPTH 2:    3.00
PROFILE EROSION DEPTH 3:    1.00
REFERENCE ELEVATION:    0.00
TRANSPORT RATE COEFFICIENT (m^4/N): 1.50E-6
COEFFICIENT FOR SLOPE DEPENDENT TERM (m^2/s): 0.002
TRANSPORT RATE DECAY COEFFICIENT MULTIPLIER: 0.20
WATER TEMPERATURE IN DEGREES C : 15.0

WAVE TYPE (MONOCHROMATIC=1, IRREGULAR=2): 2
WAVE HEIGHT AND PERIOD INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE WAVE HEIGHT AND PERIOD INPUT IN MIN:  60.0
WAVE ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WAVE ANGLE:    0.0
WATER DEPTH OF INPUT WAVES (DEEP WATER = 0.0):  33.8
SEED VALUE FOR WAVE HT RANDOMIZER AND % VARIABILITY: 7878, 20.0
TOTAL WATER ELEVATION INPUT (CONSTANT=0, VARIABLE=1): 1
TIME STEP OF VARIABLE TOTAL WATER ELEV INPUT IN MINUTES: 60.0
WIND SPEED AND ANGLE INPUT (CONSTANT=0, VARIABLE=1): 0
CONSTANT WIND SPEED AND ANGLE:    0.0,   0.0

TYPE OF INPUT PROFILE (ARBITRARY=1, SCHEMATIZED=2): 1
DEPTH CORRESPONDING TO LANDWARD END OF SURF ZONE: 1.00
EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: 0.35
MAXIMUM PROFILE SLOPE PRIOR TO AVALANCHING IN DEGREES: 17.2

NO BEACH FILL IS PRESENT.

NO SEAWALL IS PRESENT.
```

Figure 21. Report file "EX_1.RPT" (Continued)

```
                        <COMPUTED RESULTS>

DIFFERENCE IN TOTAL VOLUME BETWEEN FINAL AND INITIAL PROFILES:
     -0.1 (yd^3/ft)

DIFFERENCE IN TOTAL VOLUME BETWEEN MEASURED AND INITIAL PROFILES:
     24.4 (yd^3/ft)

SUM OF SQUARES OF DIFFERENCES BETWEEN MEASURED AND FINAL PROFILES:
     397.2 (ft^2)

MAXIMUM VALUE OF WATER ELEVATION + SETUP FOR SIMULATION:
     10.27 (ft)

TIME STEP AND POSITION ON PROFILE AT WHICH MAXIMUM VALUE
OF WATER ELEVATION + SETUP OCCURRED:
     719,     75.0 (ft)

A    5.00 (ft) EROSION DEPTH DID NOT OCCUR ANYWHERE ON THE PROFILE.

LANDWARD MOST OCCURRENCE OF A    3.00 (ft) EROSION DEPTH:
     55.0 (ft)

DISTANCE FROM POSITION OF REFERENCE ELEV ON INITIAL PROFILE TO POSITION OF
LANDWARD MOST OCCURRENCE OF A 3.00 (ft) EROSION DEPTH:
     239.9 (ft)

POSITION OF LANDWARD MOST OCCURRENCE OF A    1.00 (ft) EROSION DEPTH:
     30.0 (ft)

DISTANCE FROM POSITION OF REFERENCE ELEV ON INITIAL PROFILE TO POSITION OF
LANDWARD MOST OCCURRENCE OF A 1.00 (ft) EROSION DEPTH:
     264.9 (ft)

THE ENTIRE PROFILE WAS BELOW THE   12.00 (ft) ELEVATION CONTOUR
AT SOME POINT DURING THE SIMULATION.

MAXIMUM RECESSION OF THE    5.00 (ft) ELEVATION CONTOUR:
     3.8 (ft)

MAXIMUM RECESSION OF THE   -5.00 (ft) ELEVATION CONTOUR:
     71.4 (ft)
_____

          <<SBEACH SIMULATION COMPLETED IN   7.0 MINUTES>>
```

Figure 21. (Concluded)

To return to the SBEACH interface from the C:\ prompt, type **EXIT** . Return to the MAIN MENU by typing **M**.

Lesson 3: The Seawall Option

Overview. The purpose of this lesson is to implement the seawall option and failure modes of SBEACH.

Creating the seawall data set. To explore the seawall option, modify the data set used in Lesson 2, but copy it to a new name to retain the original EX_1 files. In the SBEACH interface, hit **O** to go to the DOS OPTIONS MENU, and press **C** to copy the existing data set to a new name. Enter the filename (**EX_1A** < enter >). To select the EX_1A data set, return to the MAIN MENU by entering **M**, and move to the DATA SET SPECIFICATION MENU by typing **D**. Enter **S** to select an existing data set, position the cursor at EX_1A, and press < enter > . Return to the MAIN MENU by entering **M**.

Construct a seawall to be buried under the dune (for aesthetic reasons, and as a last resort for coastal defense) and located at the dune crest. To find out where the dune crest is located along the profile, move to the GRAPHICS MENU (type **G**) and view the profiles (hit **1** < enter >) (view EX_1 output generated in Lesson 2, but the initial profile shapes are the same). Choose option **R** to read data points from a curve; move the cross-hairs to the initial profile and hit < enter > to choose this curve. Press the < up arrow > key to move through the profile (toggle the cursor speed with the < Ins > key); the dune crest is located at $X = 60.0$ ft and $Y = 14.50$ ft. Therefore, the seawall will be located at 60 ft along the cross-shore axis. Hit the < enter > key to return to the option line at the bottom of the screen.

As discussed in Chapter 2, the configuration file specifies the existence of a seawall, whether it fails, and if it fails, the mode of failure (either by profile elevation, water elevation, or wave height). Allow the seawall to fail by scour at the toe (profile elevation). But what elevation should be identified for failure? Choose graphics option **M** and highlight Minimum to view the minimum profile that occurred during the EX_1 simulation. Then choose option **@** and ask for elevations (Y values) at $X = 60$ ft. The minimum profile elevation at $X = 60$ ft is 10.72 ft. For this seawall case, less erosion is expected at this point since a certain amount of erosion for the EX_1 simulation was due to overwash (which will not occur for a seawall). Therefore, allow the seawall to fail at a slightly greater profile elevation equal to 12 ft. Press < enter > and choose **Q** < enter > to return to the GRAPHICS MENU; then return to the MAIN MENU by pressing **0** < enter > .

Edit the EX_1A configuration file to add the seawall option and specify the mode of failure. Press **C** to move into the Configuration File Editor. Change the Run Title (perhaps **Example 1a — seawall failure at 12-ft elevation**).

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Everything else in the file except for the seawall data (Section E) will be the same as EX_1, so hit <page down> to move to Section E. For question E.1, enter 1, identifying the existence of a seawall. Locate the seawall at 60 ft along the initial profile (question E.3), and allow the seawall to fail (enter 1 at question E.4). Since the seawall is allowed to fail by profile elevation only, set unrealistic values for the other modes of failure in question E.6. Enter 12 (for 12-ft profile elevation causing failure) 20 20 for question E.6. It is unlikely that a 20-ft water elevation or a 20-ft wave height will actually occur at the wall to cause failure. (In fact, go to the Maximum Wave Height and Maximum Water Level plots accessed from the GRAPHICS MENU and check these values at the seawall. For the EX_1 output, it turns out that wave heights and water levels were not even calculated at the $X = 60$-ft location, since the water level intersects the profile at $X = 75$ ft.) Press <Esc> to end editing, then enter Y to save the modified EX_1A.CFG file. SBEACH can now be run with the seawall option.

Run SBEACH with the seawall data set. At the MAIN MENU with the EX_1A data set active, enter X to run SBEACH and enter **EX_1A** at the prompt for the input data set. Approximately half-wav through the simulation, the interactive prompt notifies the user:

```
RUN:  Example 1a -- Seawall failure at 12 ft elevation

-----------------------------------------------------------------

50% COMPLETE   <TIME STEP:  719>  [EROSION]

SEAWALL FAILED AT TIME STEP:    720  DUE TO PROFILE
                                ELEVATION = 11.98 (ft)
```

The user is also notified that overwash and boundary-limited runup begin to occur shortly thereafter. Since the seawall appears infinitely high to the model, these processes can not occur until the wall has failed. The time of simulation was approximately the same as that for EX_1. When the simulation is complete, the interface returns to the MAIN MENU.

Output files and graphics. View the final profile and compare it with that from the EX_1 simulation. At the MAIN MENU, enter G to move to the GRAPHICS MENU and hit 1 <enter> to view the final profiles. Although there is some dune erosion, it is reduced from that observed for the EX_1 data set. The dune overwash that occurred after seawall faiiure is apparent when observing the initial and final profile shapes landward of the seawall location. To quantify how much dune crest was saved by constructing a seawall beneath it, choose graphics option M and highlight Minimum to view the minimum profile that occurred for the EX_1A simulation. Then choose option @ and specify elevations at $X = 60$ ft. The minimum profile elevation is now 11.29 ft

versus the 9.64 ft for the EX_1 data set. Hit the <enter> key to return to the options line at the bottom of the screen; other comparisons may be made from this and other graphics programs. Model output in the EX_1A.LOG and EX_1A.RPT files may also be viewed as discussed previously (move to the DOS OPTIONS MENU, Shell to DOS, and use a file editor or copy to the printer; return to the DOS OPTIONS MENU by typing EXIT).

Other seawall data sets. To run SBEACH without a seawall failure, copy the EX_1A data set to another set of files (say, EX_1B), and edit the new configuration file as discussed previously. Set the profile elevation for failure to 10 ft (question E.6), or specify that the seawall cannot fail (question E.4). Then the seawall will not fail and the dune crest will retain its original elevation. It is left to the user to explore these features of the seawall option.

Lesson 4: Schematized Profile

Overview. The purpose of this lesson is to implement the schematized profile option of SBEACH.

The schematized profile data set. Use the EX_2 data set that resides in the C:\SBEACH\TUTOR subdirectory. Note that only three input files are given for this data set: EX_2.CFG, EX_2.WAV, and EX_2.ELV. The file EX_2.PRI is not required because a schematized profile is specified in the Configuration File. Since there is no measured profile with which to compare output, and no wave angle or wind data, the files EX_2.PRM, EX_2.ANG, and EX_2.WND, respectively, are not required.

Examine specification of the schematized profile option in the Configuration File. The DATA SET SPECIFICATION MENU should be present on the screen; either move to this menu from within the interface, or invoke the interface from the C:\SBEACH prompt by following the instructions discussed previously. Choose C:\SBEACH\TUTOR as a working directory, as described in the previous lessons. Select the EX_2 data set from the DATA SET SPECIFICATION MENU by entering S, highlighting the EX_2 data set, and pressing <enter>. Move to the MAIN MENU by keying M, and enter the Configuration File by pressing C.

Scan the Configuration File to see that this example is in SI units (question A.2), has a constant grid type (question A.4), with cell width of 2.5 m (question A.6), and simulates profile change for 4 days (1,152 time-steps at 5 min/time-step, question A.10). In Section B, irregular waves are identified (question B.1) in hourly increments (question B.6). Water level is variable (question B.16), and is input in hourly increments (question B.20). Section C specifies that the profile will be schematized (question C.1); locations and elevations of the profile are detailed in question C.3. The profile shape gradually decreases from a 3-m elevation at $X = 0$ m to 55 m, then has a constant decrease in elevation from $X =$

55 m to 100 m. The EX_2 data set does not have a beach fill or seawall/ revetment (Sections D and E, respectively). The "0" entries for questions A.13, B.7, and B.21 indicate that SBEACH will not access the files EX_2.PRM, EX_2.ANG, and EX_2.WND, respectively. Specification of the schematized profile in question C.1 indicates that the file EX_2.PRI is not required for simulation. Finish scanning the Configuration File; then enter <Esc> to exit, and N to retain the original file contents.

View the wave data and water elevation files by entering the respective editors from the MAIN MENU as discussed previously. The wave entries increase from a wave height of 1 m and period of 7 sec to a peak with a 4-m wave height and 14-sec period occurring between entries 55 and 67. The water elevations oscillate around 0 until time-step 26, when the storm surge begins to influence the water level. The water elevation reaches a peak of 2 m at time-step 61. Both the wave and water elevation data files have 97 entries. View these files; then return to the MAIN MENU.

Execute SBEACH. At the MAIN MENU, press X to begin simulation of SBEACH using the EX_2 data set. At the prompt asking for the input data set, enter EX_2 <enter> , and the simulation begins. The note at the bottom of the screen indicates that boundary-limited runup occurs for the simulation at time-step 557, and the entire profile becomes inundated for several calculations after time-step 718. Repeated occurrence of boundary-limited runup or profile inundation indicates that extension of the profile landward is required. Simulation with the EX_2 data set takes approximately 8.4 min on a 386 33-MHz machine. After the simulation is completed, the MAIN MENU will appear on the screen.

Results. To view the initial and final profiles, enter G to move to the GRAPHICS MENU and press 1 <enter>. Material for the berm portion of the profile has moved offshore to form a bar; the R graphics option allows the user to determine that this bar peaks at $X = 190$ m. This same feature may be used to find that there was little profile change past $X = 375$ m. Plot the minimum profile (option M , Minimum <enter>) and use the R option to see that there has been some recovery of the profile between elevations -0.2 m and -7.0 m. Exit the profile graphics (Q <enter>), and move to the Intermediate Wave Heights (6 <enter>), to view all the intermediate wave height output (choose graphics option I , All <enter>). Use the R graphics option to determine that there were different breaker locations at each intermediate output: $X = 105$ m (time-step 228), $X = 190$ m (time-step 576), $X = 330$ m (time-step 725), and $X = 117.5$ m (time-step 1152). To return to the GRAPHICS MENU, choose option Q and press <enter>. Other variations in cross-shore parameters can be viewed via the GRAPHICS MENU as desired. When finished with the GRAPHICS MENU, enter 0 <enter> to move back to the MAIN MENU. Shell to DOS through the DOS OPTIONS MENU (O) and inspect the EX_2.LOG and EX_2.RPT output files as discussed previously. Type EXIT to return to the SBEACH interface.

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Lesson 5: Beach Fill Option

Overview. The purpose of this lesson is to illustrate use of the beach fill option using the EX_2 data set.

Create beach fill data set. Modify the EX_2 data set to include a dune feature, eliminating the profile inundation problem encountered during Lesson 4. As discussed in Lesson 3, the EX_2 data set may be copied to a new data set name (EX_2A) from the DOS OPTIONS MENU (from the MAIN MENU, choose **O** to go to the DOS OPTIONS MENU, **C** to copy the data set, and enter the new filename **EX_2A**). Return to the MAIN MENU by typing **M**. Make the EX_2A data set active by going to the DATA SET SPECIFICATION MENU and selecting EX_2A (enter **D**, select a data set **S**, highlight EX_2A, and press <enter>). Once again, return to the MAIN MENU by entering **M**.

Build a simple (four-point) dune feature at the landward part of the profile using the beach fill option. Start the dune from the existing profile at $X = 0$, bring it to an elevation of 5.5 m at $X = 10$ m, end the dune crest at the 5.4-m elevation at $X = 30$ m, and return to the existing profile at $X = 40$ m. This feature can be detailed very easily in the Configuration File. Type **C** to enter the Configuration File Editor and modify the Run Title to reflect the beach fill example (**Example 2a -- beach fill option**). Everything except the beach fill data will be the same as the EX_2.CFG file, so move to Section D by hitting the <page down> key. Modify the configuration file for the presence of a beach fill (**1** for question D.1). Start and end the beach fill at $X = 0$ and $X = 40$ m, respectively, along the initial profile (**0.0** and **40.0** for question D.3). Add two more points to describe the dune shape (**2** for question D.4). At question D.5, enter the alongshore coordinate and elevation corresponding to the two additional points (enter **10 5.5 30 5.4**). Modification of the Configuration File has been completed, so enter <Esc> and **Y** to exit and save the changes. SBEACH can now be run with the beach fill option.

Execute SBEACH. At the MAIN MENU, enter **X** to begin the SBEACH simulation. At the prompt for an input data set, enter **EX_2A**. Time for the simulation is approximately the same as for EX_2.

Output files and graphics. The user may scan and print out the EX_2A.LOG and EX_2A.RPT files as discussed previously. Note that addition of the dune feature eliminated the profile inundation encountered for EX_2, but boundary-limited runup still occurred, beginning at time-step 671. The dune feature was overwashed intermittently from time-steps 580 through 873. In the EX_2A.RPT file, 76.3 m^3/m of beach fill was added to the profile with the dune feature. View the initial and final profile shapes by moving to the GRAPHICS MENU and pressing **1** <enter>. Using the **R** option, the initial four-point dune feature eroded slightly at the landward crest (from 5.5 to 5.47 m) and more at the seaward crest (from 5.4 to 4.98 m). This material moved offshore and a bar

formed at $X = 190$ m and elevation -3.3 m. There was little profile change past 400 m offshore. Continue evaluation of the EX_2A simulation with this and other graphics programs from the GRAPHICS MENU. When analysis has been completed, return to the MAIN MENU by entering **0** from the GRAPHICS MENU.

Other beach fill data sets. The user may explore the beach fill option further to include placement of fill on the berm and out into the foreshore. Eliminate the "boundary-limited runup" warning that occurs for the EX_2A simulation by extending the landward boundary (use negative X coordinates). Copy the EX_2A data set to another set of files (say, EX_2B), select this new data set from the DATA SET SPECIFICATION MENU, and edit the Configuration File as discussed previously.

Lesson 6: Creating a New Data Set -- DEFAULT.CFG File

Overview. The purpose of this lesson is to create a new data set.

Initializing a new data set. As illustrated through the lessons in this manual, it is often easiest to create a new data set by copying and modifying files from an existing data set. In a similar manner, the SBEACH interface creates a new data set with the Initialize Default Data set option (at the DATA SET SPECIFICATION MENU) by copying an existing file. This option asks for a new data set file name, and copies the DEFAULT.CFG file from the C:\SBEACH\DEFAULT subdirectory to this new file name. At the DATA SET SPECIFICATION MENU, enter **I** to Initialize Default Data Set, and type the new data set name (perhaps **EX_3**). Information in the DEFAULT.CFG file will be copied to this file.

A cautionary note: Changing the working directory to C:\SBEACH\ DEFAULT and editing the DEFAULT.CFG file is not recommended. Because the SBEACH interface copies this file to the new data set name in the Initialization process, the original default parameters would then be lost, which may be undesirable.

Information in default data set. Move to the Configuration File Editor and scan the information in this file (type **M** to go to the MAIN MENU, and **C** to invoke the Configuration File Editor). Default values for model transport parameters are given (questions A.16 and A.17), and constant wave heights and periods (question B.2), wave angles (question B.7), water elevations (question B.16), and wind speed and angle (question B.21) are specified. Therefore, the EX_3.WAV, EX_3.ANG, EX_3.ELV, and EX_3.WND files, respectively, are not required for model simulation. The file indicates that a measured profile is not available (question A.13), and a schematized beach profile is specified

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(question C.1); therefore, the EX_3.PRM and EX_3.PRI files, respectively, are also not required. Thus, SBEACH may be run using only this configuration file as input. The user may modify this file and move to the other editors to add variable parameter values representing a aata set. It is left to the user to execute SBEACH with the default parameters (simulation takes about 3.4 min on a 386 33-MHz machine), or modify the EX_3 files to represent a project.

Lesson 7: Obtaining Assistance, Updates, and Reporting Problems

Prospective users of SBEACH are encouraged to attend the periodic workshops given to fully exercise and learn the model, including application of new enhancements. SBEACH users are also encouraged to call CERC points of contact (listed in the Title Screen) for assistance with model simulations; suggestions for improvements as well as reports of problems will be appreciated. A database of District and Division personnel interested in SBEACH has been developed to rapidly release model and documentation updates. As discussed in Chapter 1, research and development of SBEACH are under way at CERC to improve simulation of accretionary sand processes, sand transport by random waves, and overwash. As these research results are incorporated and tested in the model, code updates will be transferred to SBEACH users.

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This report provides guidance for implementing SBEACH, the Storm-Induced BEAch CHange model, via a user interface available for the personal computer. SBEACH simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels. The personal computer version of SBEACH is accessed through a user interface which facilitates data entry and manipulation, graphical representation of input and output, and execution of the model. The interface also provides considerable error and range checking prior to actual running of the model. The first two chapters of the report present information about applying the model, including hardware requirements, loading SBEACH onto a hard disk, discussion of the interface structure through which the numerical model is operated, and guidance for model calibration. The final chapter is written as a tutorial, guiding the user in installing, running, and working through several example simulations.

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