18. SUBJECT TERMS (Continued).

Numerical model	User's manual
Sediment transport	Wave refraction/ diffraction
Shoreline evolution	

19. ABSTRACT (Continued).

not made to the original model, the original documentation, presented in CERC's report MR 83-10, should be obtained by any potential user of the model.

The N-line model is useful in showing qualitative trends for a complex case such as Lakeview Park, Lorain, Ohio. Some of the drawbacks of the program when modeling Lakeview Park, such as the inability to reach an equilibrium shoreline, and the low sinuosity of the shoreline when influenced by breakwater segments, could possibly be successfully modeled by modifying the different input parameters, such as the ADEAN parameter and/or initial shoreline location and/or the model code. Perhaps then a quantitative verification of the model could be made. However, in this case, the model would have then been tailored to produce a previously known result.

A project cannot be successfully modeled without experimenting with different time-steps, space-steps, contour depths, shoreline locations, and structure configurations. A wave climate representative of the area being modeled is also very important. Finally, the response of the model to a particular setup must be interpreted with engineering judgment.

PREFACE

This study was authorized as a part of the Civil Works Research and Development Program by the Office, Chief of Engineers (OCE), US Army. The work was jointly performed under Work Unit C31551, Numerical Modeling of Shoreline Response to Coastal Structures, which is part of the Shore Protection and Restoration Program and Work Unit C31232, Evaluation of Navigation and Shore Protection Structures, which is part of the Coastal Structure, Evaluation, and Design Program. Messers. J. H. Lockhart, Jr., and J. Housley were OCE Technical Monitors.

This guide was developed to make the N-line model, developed for the Coastal Engineering Research Center (CERC) by Mr. Marc Perlin and Dr. Robert G. Dean, of the Coastal and Offshore Engineering and Research, Inc., Newark, Delaware, available in an easy-to-use-and-apply format. This has been accomplished by providing detailed examples demonstrating appropriate model applications. Each example includes a listing of the model input parameters and a complete output file for user comparison. The model includes an interactive input data generator for fast and easy application of the model. Program listings are provided in the appendix of this report. Magnetic tape copies of the code can be obtained by contacting the Engineering Computer Programs Library Section of the Technical Information Division, US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi.

This guide was prepared by Dr. Norman W. Scheffner of the Research Division, CERC, and Ms. Julie Dean Rosati of the Engineering Development Division, CERC. The report was prepared under the direction of Dr. James R. Houston, Chief, CERC, and Mr. Charles C. Calhoun, Jr., Assistant Chief, CERC.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
inches	2.54	centimetres

A USER'S GUIDE TO THE N-LINE MODEL: A NUMERICAL MODEL TO SIMULATE SEDIMENT TRANSPORT IN THE VICINITY OF COASTAL STRUCTURES

PART I: INTRODUCTION

1. The US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center (CERC), presently supports a general use numerical model for simulating sediment transport and bathymetric changes in the coastal zone. The original report, "A Numerical Model to Simulate Sediment Transport in the Vicinity of Coastal Structures" (Perlin and Dean 1983), detailed an N-line model developed to simulate the effects of single or multiple, equal length groins and/or offshore dredged material disposal on the shoreline location and the local bathymetry. These changes are the result of wave action from an offshore wave field of known period, height, and direction. Subsequent enhancements to the model include the effects of single or multiple detached breakwaters; the capability of handling multiple unequal length groins; the capability to specify an initial nonstraight shoreline; and the addition of a separate, user-friendly program to generate input data files for the N-line model.

2. The purpose of this report is to provide a user's guide for applying the model to specific cases of interest. Theory of the model, with the exception of the breakwater subroutine, is not covered in this report. Those details can be found in the program documentation (Perlin and Dean 1983). This report includes (a) a description of the capabilities and limitations of the model, (b) a brief documentation of the breakwater subroutine, and (c) details on how to apply the model to specific cases. Since the intent of this report is to provide a potential user with enough guidance to properly use the model, specific input and output listings for detailed applications of the model. This approach will allow the user to become familiar with generating data and running the model are given. The sample output is provided as a check to verify that the model is producing the correct results for a given input condition. This solution also is valuable for comparison when the model is run on different computer systems. Finally, a listing of the model and the data file generation program is provided. Appendix A provides example input and output, while Appendix B provides the program listing.

PART II: CAPABILITIES AND LIMITATIONS

3. The intent of the N-line model is to provide the user with a tool to adequately predict the effects of modifications to the coastal zone if certain criteria are met. For example, the model was developed for specific application to coastal areas that are predominately influenced by waves and that are not characterized by complex bathymetries such as offshore bars, barrier islands, or deep and/or irregular channels. Areas of this complexity require more sophisticated, expensive, and difficult-to-apply numerical models. Physical models may even be required in some cases. The N-line model may, however, provide adequate results even to relatively complex areas if the user is aware of the limitations of the model and interprets the results with these limitations in mind. Incorrectly used, this model, as with any model, can yield erroneous results that must be recognized as resulting from poor input data or from an application to a situation beyond the capabilities of the model. It is the modeler's responsibility to correctly use and interpret the results of the model.

4. The limitations of the N-line model that restrict its applicability are a result of the basic formulation of the model. Certain physical processes are not accounted for in the governing equations. For example, the model simulates refraction and diffraction, onshore/offshore and alongshore sediment transport, and conservation of mass resulting from a known wave field. The model does not simulate tidally induced velocities and water levels nor does it simulate wave-induced currents and setup/setdown. The assumption that these complex effects are minor in comparison to the wave field allows for a simplified set of governing equations that result in a model which can easily and economically be used as a design tool. Cases in which tidal and/or wave-induced effects are significant require the use of additional governing equations resulting in a highly complex numerical model which is both difficult and expensive to apply. The purpose of the N-line model is to provide the user with a tool for the prediction of changes in the primarily wave-dominated coastal zone.

5. The distinction between an appropriate and inappropriate application of the model is difficult to define since certain idealizations and simplifications can be made that might adequately represent the physical system. This will often result in qualitative results that are useful in determining trends

or rates of change. In order to make a decision as to whether or not the model can be applied to a given situation, the following list of major assumptions and limitations of the model must be consulted:

a. The model is based on an equilibrium beach-profile concept. This requires that the beach profile be assumed to monotonically increase in depth in the offshore direction. The relationship used in the model is

$$h = Ay^{2/3}$$

where

h = depth
A = Dean's equilibrium profile coefficient
y = distance offshore

The entire modeled area is assumed to have this profile.

b. The offshore boundary condition for the model is the specification of a single wave climate for the entire offshore boundary. Although this can be changed at each time-step, it must apply to the entire length of coastline being modeled.

c. Shore-connected structures, such as groins or jetties, must be perpendicular to the specified baseline. This requirement is a consequence of the computational grid employed by the model.

d. The model is based on mean sea level and has no provisions for deviations from a mean condition.

e. The addition of offshore dredged material disposal is made by advancing the appropriate depth contours offshore by an amount equivalent to the quantity of material added. Because of the limitations imposed by the monotonically increasing depth assumption, a berm or dredged material island cannot be modeled.

f. Limitations of the modeling of a breakwater will be covered in the next section.

6. Several of the above limitations could be modified. For example, a separate equilibrium profile could be specified for each location along the modeled area. This could be in the form of a spatially variable coefficient A , which could be determined from a series of shore-perpendicular profiles. Similarly, mean sea level changes could be incorporated in the model formulation. Assumptions such as the equilibrium profile concept with a monotonically increasing depth are, however, basic assumptions of the model and cannot be altered. If a particular application cannot be adequately represented with these assumptions, the N-line model should not be used.

PART III: DETACHED OFFSHORE BREAKWATERS

7. A subroutine was added to the original N-line model described in Perlin and Dean (1983) to extend the applicability of the model to include the effects of detached offshore breakwaters. This subroutine was developed to utilize the computational procedure of the existing model. Certain assumptions and simplifications were made in order to achieve compatibility with the basic model. The major simplification is that only the refractive, diffractive, and transmissive effects of the breakwater on the wave field are considered. The physical existence of the breakwater (e.g., a small island) was not possible due to the N-line model formulation of a monotonically increasing depth offshore. The consequences of this assumption will be discussed in paragraph 12.

8. The procedure used for the breakwater computations was to first calculate the entire wave-field distribution using the N-line model as if no breakwater existed. The effects of the breakwater on the wave field can then be determined by adding the diffracted and refracted wave energy vectors from each breakwater tip to the previously computed vector components at each grid point. If the grid point falls in the shadow zone of the breakwater, the N-line-computed contribution is multiplied by a user-supplied transmission coefficient.

9. A more comprehensive description of the computational procedure can be made by referring to Figure 1 and to the list of variables shown in Table 1. The sequence of events is as follows:

- a. Calculate the breakwater orientation angle (BRKANG).
- b. Calculate the depth (DEEPL, DEEPR), angle (THETAL, THETAR), wave height (HLFT, HRT), celerity (CLFT, CRT), and group velocity (CGLFT, CGRT) for the left and right tips of the breakwater based on a linear interpolation of N-line-computed values.
- c. Calculate the left and right X-coordinate for the shadow zone (XXL, XXR).
- d. Calculate the local contour line orientation (CONANG) and the X- and Y-components of the N-line-computed wave height based on the N-line-computed wave angle (THETA).
- e. Calculate the angle from the tip of the breakwater to the grid point (ANG). A separate computation is made for diffraction from the right and left tips of the breakwater.
- f. Calculate wave height at the local point using the diffraction subroutines included in the N-line model (HTEMPR, HTEMPL).

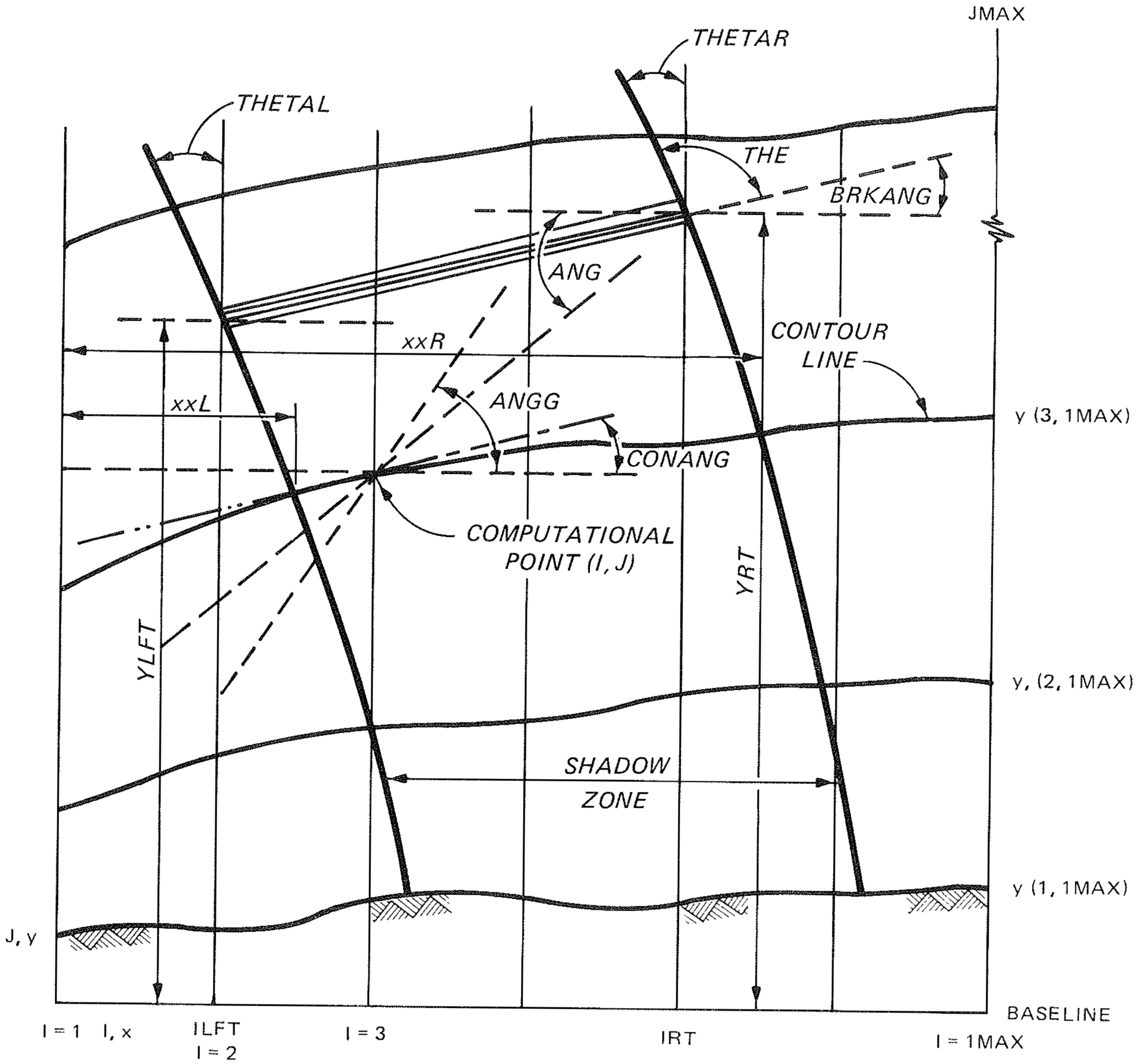


Figure 1. Schematic diagram of breakwater

Table 1

List of Variables

Parameter Name	Used For
ILFT(N)	I-location of left end of breakwater
IRT(N)	I-location of right end of breakwater
YLFT(N)	Distance offshore to left end of breakwater
YRT(N)	Distance offshore to right end of breakwater
NOBKS	Total number of breakwaters
DEEPR(N)	Depth at right end of breakwater
DEEPL(N)	Depth at left end of breakwater
HRT(N)	Wave height at right end of breakwater
HLFT(N)	Wave height at left end of breakwater
THETAL(N)	Wave angle at left end of breakwater
THETLL(N)	Wave angle used at left edge of shadow zone
THETAR(N)	Wave angle at right end of breakwater
THETRR(N)	Wave angle used at right edge of shadow zone
XXL(N)	X-location of left edge of shadow zone
XXR(N)	X-location of right edge of shadow zone
CLFT(N)	Wave celerity at left end of breakwater
CRT(N)	Wave celerity at right end of breakwater
HTEMPR(N)	Wave height contribution of diffraction from right end of breakwater
HTEMPL(N)	Wave height contribution of diffraction from left end of breakwater
HTXL(N)	X-component of HTEMPL
HTYL(N)	Y-component of HTEMPL
HTXR(N)	X-component of HTEMPR
HTYR(N)	Y-component of HTEMPR
YLLFT(N)	Y-location used to calculate left edge of shadow zone
YRRT(N)	Y-location used to calculate right edge of shadow zone
DXL(N)	X-distance used in calculation of left edge of shadow zone
DXR(N)	X-distance used in calculation of right edge of shadow zone
BRKANG(N)	Angle of the breakwater with respect to baseline
CGRT(N)	Group velocity at right end of breakwater
CGLFT(N)	Group velocity at left end of breakwater
XXDIST	X-distance to point (I,J)
HX	X-component of H (I,J)
HY	Y-component of H (I,J)
THETA(I,J)	Wave angle at I-,J-location
Y	Y-distance to I-,J-location
ANG	Diffraction angle from breakwater tip
ANGJET	Angle from breakwater tip to jetty tip
ANGG	Refracted value of ANG at point I,J
THE	Wave angle at breakwater adjusted for BRKANG(N)
AMP	Amplitude factor after diffraction
SHADOW	Zone in lee of breakwater
H(I,J)	Wave height at I-,J-location
HB(I,J)	Breaking wave height at I-,J-location
CONANG	Angle of local contour at I-,J-location

g. Calculate the refracted angle for the wave at the local point by using Snell's Law. For this computation, a shallow-water wave approximation is used for wave celerity. The computed angle is then adjusted to compensate for the local contour angle.

h. Compute the X- and Y-components of the diffracted wave from each tip by using the refracted wave angle (HTXR, HTYR, HTXL, HTYL).

i. Multiply the X- and Y-components of the N-line-computed wave heights by a shadow-zone factor. This coefficient is equal to unity when the point is not in the shadow zone behind the breakwater.

j. Sum all the contributing waves for each grid point, based on conservation of energy, and calculate an effective wave height and angle (H,THETA). For example:

$$XXX = \sum_{i=1}^{NOBKS} \left(HTXL_i * |HTXL_i| + HTXR_i * |HXTR_i| + HX * |HX| \right)$$

$$YYY = \sum_{i=1}^{NOBKS} \left(HTYL_i * |HTYL_i| + HTYR_i * |HTYR_i| + HY * |HY| \right)$$

$$H = \sqrt{|XXX| + |YYY|}$$

$$THETA = ATAN \left[\left(XXX / \sqrt{|XXX|} \right) / \left(YYY / \sqrt{|YYY|} \right) \right]$$

where NOBKS = the number of breakwaters in the modeled area.

10. The above formulation includes some simplifications that were not felt to be significant. These were considered to be justifiable since a rigorous treatment of the process of refraction and diffraction from a detached breakwater would require a total reformulation of the N-line model. In view of the original purpose of the model, reformulation was not considered appropriate.

11. The breakwater subroutine does not include a second diffraction and refraction of the breakwater-diffracted wave around groins or jetties. The program will compute a shadow zone behind each groin or jetty and will set the breakwater-diffracted wave components to zero for that area. Since it is unlikely that shore-perpendicular structures would be located directly behind a detached breakwater, this simplification appears adequate.

12. The unavoidable simplification of not recognizing the physical

presence of the breakwater in the surf zone was mentioned in paragraph 7. This approach introduces two physical processes which must be considered in the numerical model formulation. First, an actual breakwater causes the incoming waves to break, due in part to the decrease in depth in the vicinity of the structure. The exact location of the breaking point is primarily a function of both wave height and water depth. The model formulation assumes the breakwater can be considered as an abrupt barrier so that the wave height at the breakwater is equal to the wave height at the location computed by the N-line model. This value is used to diffract the wave around the breakwater tip. The breaking wave height and depth used in the N-line model for onshore/offshore sediment transport calculations are replaced by the height and depth at the breakwater location unless the wave would have broken seaward of the breakwater. Values between breakwater tips are calculated by linear interpolation of heights and depths at the ends of the breakwater.

13. The second process associated with a real breakwater is that depth contours do not cross the breakwater but tend to show a depth decrease shoreward of the breakwater and a depth increase offshore. This phenomenon cannot be correctly simulated by the N-line model without making alterations to the basic formulation. The solution adopted was to retain the N-line computations as if no breakwater existed. This will allow the contours to cross the breakwater; however, due to the decrease in wave energy inside the breakwater, the tendency is for the contours to behave in a qualitatively correct manner. This can be seen in the contour plots shown in Part IV.

14. The simplifications employed in the formulation and solution approach of the breakwater subroutine were made in order to achieve total compatibility with the existing N-line model. Consequently, very few changes have been made to the original model. Any questions concerning basic assumptions or numerical methods are referred to the program documentation (Perlin and Dean 1983).

PART IV: APPLICATION OF THE MODEL

15. The primary advantage of the N-line model over more complex numerical models is that, if applicable to the situation, the N-line model can be easily and economically used to simulate the physical problem and to provide a great deal of information on two-dimensional (2-D) changes in the modeled area. This simulation includes the capability to make predictions on the order of several months to several years. Simulations of this order of magnitude are not economically feasible with more complex sediment-transport models.

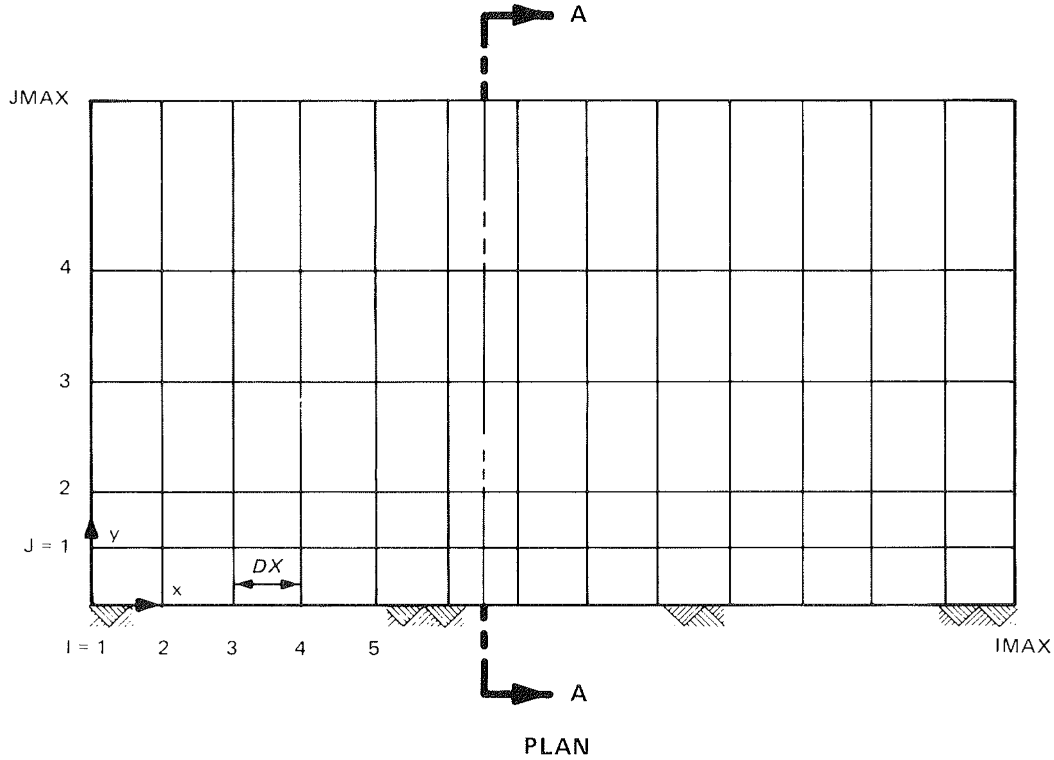
16. Application of the model to a specific or hypothetical situation is relatively easy. For example, there is no requirement for generating a complex computational grid, boundary conditions other than the offshore wave climate do not need to be specified, and a minimum of input data is required. The following list contains variables that are required. These can be classified as the basic model parameters that define the modeled area, and the time-dependent parameters that must be introduced at each time-step. A more complete description of a majority of the input variables can be found in Perlin and Dean (1983). Required variables include:

a. Basic parameters (see Figure 2 and Table 2):

(1) IMAX--The total number of alongshore grid cells used to adequately represent the modeled area. The examples in Perlin and Dean (1983) and in this report used 50. The specification of a total number much exceeding this will significantly increase the cost of running the model; therefore, some care should be exercised in selecting this number.

(2) JMAX--The total number of computational contour lines (Y-direction grid cells) used in the modeled area. Numbers in the vicinity of 8-10 were used in the examples. This number will have to adequately define the bathymetry in the modeled area by defining enough contour lines between the shoreline and the offshore depth defined by the variable WDEPTH. The parameter statements in the code (see Appendix B) must reflect NI = IMAX + 3 and NJ = JMAX + 3 for correct dimensioning.

(3) WDEPTH--The depth of water, defined in metres (as in the original publication), corresponding to the location of the input wave conditions. This depth represents the offshore boundary depth contour and is used as a constant computational boundary condition. A value of 10 m was used in all examples.



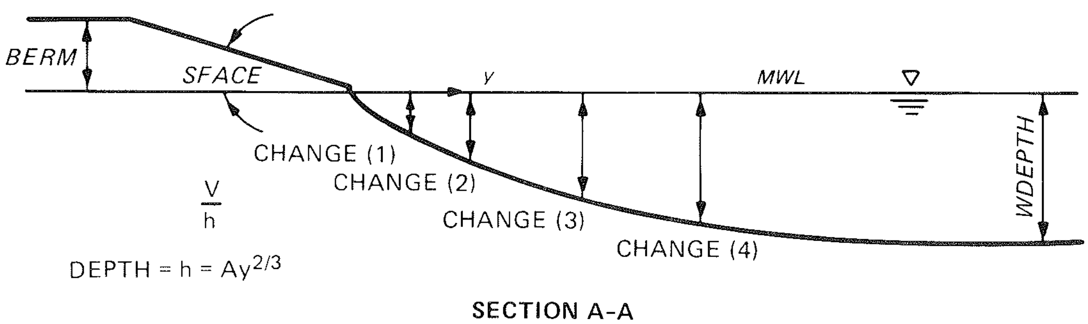


Figure 2. Schematic diagram of modeled area (mwl = mean water level)

Table 2
Input Parameters

Card	Variables	Format	Comment
1	IMAX, JMAX	2I10	
2	WDEPTH	10X,F10.3	In metres
3	CHANGE(N), N = 1, JMAX + 1	10F8.3	
4	NWRITE	I10	
5	BERM, SFACE, DIAM	10X,F10.3,F10.4, F14.3	
6	MMAX	I3	If none exist, enter 1 and see next card
7	IJET, SJETTY	I3,F10.3	One card per structure. If none exist, enter any location and zero length
8	ADEAN	F10.4	
9	DX, DELT	2F10.3	
10	Y(I,1), I = 1, IMAX	10F8.2	
11	NOBKS	I5	If none, enter zero
12	ILFT, IRT, YLFT, YRT	10X,2I10,2F10.2	One card per structure. If none exist, omit card
13	HS, T, ALPWIS, IDDD	I5,5X,3F6.1, I5	This card is repeated for the desired number of time-steps in the total simulation. The simulation is terminated when HS > 50. If dredged material is to be added to any time increment (IDDD = 1), the IDREG, JDREG, and DREDGE cards must be inserted
14	IDREG, JDREG, DREDGE	2I5,F10.2	The dredged material simulation is terminated when IDREG = JMAX

(4) CHANGE--A one-dimensional array that specifies the numerical value of each contour line. For example: CHANGE(1) = 1.0, CHANGE(2) = 2.0, CHANGE(3) = 3.0, ...sets the J = 1,2,3,4, JMAX... + 1 contour lines to be the 1-ft,* 2-ft, 3-ft,... contour intervals. Note that JMAX + 1 values must be specified between a depth of 0 ft (shoreline) and WDEPTH (offshore boundary). The JMAX + 1 contour is merely a boundary condition used in conjunction with WDEPTH to define boundary derivatives. The 1 - JMAX contour lines represent the computational lines which will define the bathymetry of the modeled area.

(5) NWRITE--The desired frequency of printed output. The model provides a complete solution at each time-step. For a 1-month run at a 6-hr interval, 120 time-steps are computed. If, for example, only the weekly values are desired, enter NWRITE = 30 to print only every 30th output (i.e., 30, 60, 90, 120).

(6) BERM--A specified height of the berm (see Figure 2).

(7) SFACE--The slope of the beach face from the berm to the mwl (see Figure 2).

(8) DIAM--The mean diameter of the sediment particles in millimetres.

(9) ADEAN--The value of Dean's equilibrium constant. This value determines the distance offshore to a specified depth contour, $y = (h/A)^{1.5}$ ft; therefore, the values of CHANGE and A must produce the proper degree of resolution in the area of interest if reasonable results are to be expected. For a given A value, an improper selection of desired contour intervals (CHANGE) may result in contours located offshore of the area of interest. For example, a 3-ft contour with an A value of 0.15 will be 89 ft offshore. This contour will not provide much information about shoreline response to a groin that only extends 50 ft offshore.

(10) DX--The X-direction grid spacing in feet (see Figure 2). Exampls used for this report have varied from 50 to 100 ft.

(11) DELT--The time-step in hours. The examples used specify a value of 6 hr.

(12) Y(I,1)--Represents the initial shoreline location with respect to some reference line. A straight shoreline would be represented by Y(I,1) = 0.0 for IMAX values of I.

(13) MMAX--The number of shore-perpendicular structures (two groins, three groins, etc.).

(14) IJET--The I-grid location associated with each of the MMAX shore-perpendicular structures. The computations will consider the structure to be located to the right (increasing I) of the specified I-location.

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

(15) SJETTY--The length of each shore-perpendicular structure measured from the baseline.

(16) NOBKS--The number of detached breakwaters.

(17) ILFT,IRT--The I-grid location to be associated with the left and right end of each detached breakwater. Computationally, the I-value is assumed to be the exact location.

(18) YLFT,YRT--The exact Y-distance, measured from the baseline, offshore to the left and right tips of each detached breakwater.

b. Time-dependent parameters:

(1) HS--Offshore significant wave height (feet) specified at each time-step.

(2) T--Period of each wave in seconds.

(3) ALPWIS--The angle (-90 to +90 deg) of propagation of each wave with respect to the x-axis. Waves propagating onshore from the left of shore-perpendicular are positive (see Figure 2).

(4) IDREG,JDREG--The addition of dredged material, beach fill, or any other alteration to the existing bathymetry is simulated in the model by advancing a contour by an amount which yields the appropriate volume of material. The IDREG and JDREG parameters indicate the location of the contour line that will be moved.

(5) DREDGE--Indicates the amount of movement, in feet, the contours are to be moved to simulate dredging, fill, etc.

(6) IDDD--A dummy variable used to indicate whether or not the dredged material/fill option is used. This is specified at each time increment. When IDDD equals 1, the amount specified by DREDGE is read resulting in a movement of the (I,J) contour by the amount specified. The option is not exercised when 0 is entered.

17. The program can be submitted to the computer by either using cards (batch) or interactively using a remote terminal. If cards are used, the user will have to supply an input card deck. The required and optional cards are shown in Table 2.

18. An alternative to using a card deck is to use the interactive capability of a computer. To simplify the input data requirements, a user-friendly interactive program has been written to generate input data files for the N-line model. Since CERC is presently using CYBERNET services for computer support, the model and input generator are currently operational on the CYBER 176 computer. A detailed description of the steps necessary to generate an input file and execute the model will be presented for terminal entry batch processing for the CYBER 176. A similar procedure is available for any computer system with interactive capabilities.

19. The interactive generation of data and subsequent execution of the N-line model require the following user files:

BLDFIL	Input data file generation program
INPFIL	Input data generated by BLDFIL (excluding dredged material)
SPOOL	Dredged material data (generated by BLDFIL)
RUNLINE	Job control file to submit the N-line model for terminal entry batch processing
TRANSP	The N-line model

Examples will be presented which demonstrate how to create input files for the model using the program BLDFIL. Following the creation of appropriate input files, the N-line model can be submitted and executed in a variety of ways. The following examples use the program RUNLINE to submit the job for terminal entry batch processing:

```
GET,RUNLINE
SUBMIT,RUNLINE,T
```

where the job control file RUNLINE contains the following control entries:

```
/JOB
JOB,T1500,CM200000,P4.
/USER
/CHARGE
GET,TAPE1=INPFIL.
GET,TAPE20=SPOOL.
GET,TRANSP.
FTN5,I=TRANSP,L=OUTPUT,REW=I/L.
BEGIN,IMSL5,IMSLCCL.
$LIBRARY,IMSL5.
LGO.
/EOR
```

Following execution, the job output can be either routed to a remote job entry facility or retrieved at the user's terminal.

20. Before presenting example model applications, an explanation of the model output must be made so that model results can be properly interpreted. This can best be accomplished by reproducing the computational representation of Figure 2 of Perlin and Dean (1985), shown here as Figure 3. As in many numerical models, certain computations are made for midpoints between the I,J modes. For example, Figure 3 shows that the sediment transport values in the

onshore-offshore direction Q_y correspond to the contours specified by the user (CHANGE(1), CHANGE(2), etc.); however, the alongshore values Q_x correspond to a point halfway between the I grid points. Numerical differentiation of the continuity equation then yields a y value corresponding to an I grid location, but a midcontour location:

$$\frac{\partial y}{\partial t} + \frac{\partial Q_x}{\partial x} + \frac{\partial Q_y}{\partial y} = 0$$

For example, if a CHANGE(1) and CHANGE(2) contour was specified as 1.0 and 2.0, the Y(I,2)-distance would correspond to the 1.5-ft depth. In all cases, the Y(I,1)-location corresponds to a zero depth. The understanding of the computational representation of these variables is absolutely necessary if the user intends to compute or tabulate total transport quantities in, for example, cubic yards per year.

21. The results of any numerical model, especially one based on empirical relationships, must be carefully examined to determine whether or not the results are realistic. Empirically based models are generally site specific, requiring the adjustment of various parameters and coefficients to achieve model results that match prototype behavior. The selection of these values can have a substantial effect on the model results. Improper selection can lead to erroneous results or even to numerical instabilities resulting in the model "blowing up." The following list represents some of those parameters and coefficients that can be varied to achieve stability or to obtain better agreement between model and prototype:

a. DELT--The time increment used in the model has a substantial effect on the stability of the model. All example simulations shown in this report used a value of 6 hr.

b. DX--The alongshore grid also has a marked effect on the stability of the model. The selection of a reasonable value must be made based on the structures present, the length of coast being modeled, and the stability of the model. For example, a detached breakwater should be at least three grid spacings. The spacings used in the examples varied from 80 to 100 ft.

c. ADEAN--Dean's equilibrium profile coefficient determines the equilibrium profile for the entire modeled area. This coefficient should be determined by selecting a value that produces a beach profile which most closely matches the specific site being modeled. If no data are available to make this selection, the graph of ADEAN (signified by A in this figure) versus sediment diameter shown in Figure 4 (reproduced from Perlin and Dean 1983) can be used.

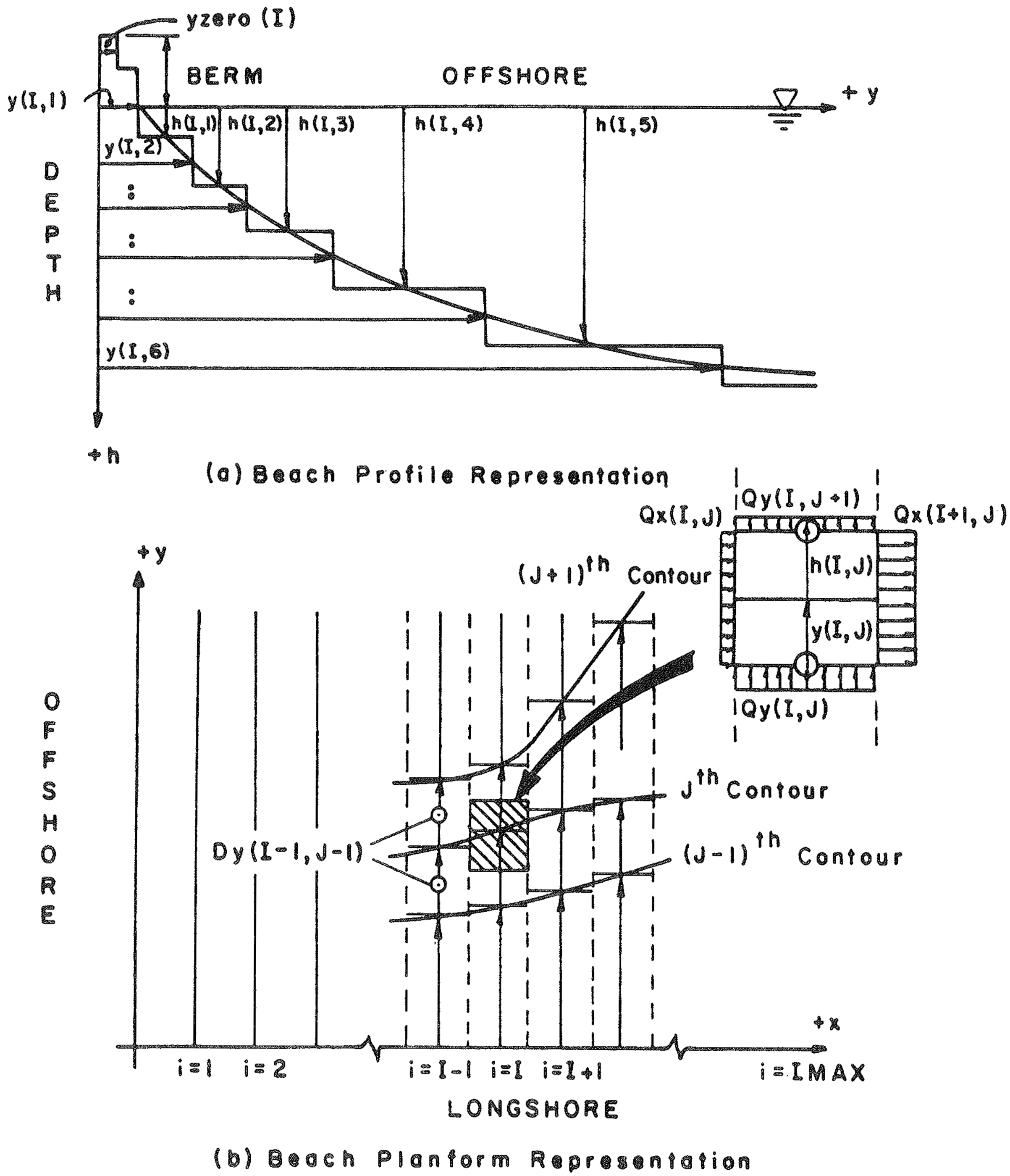


Figure 3. Definition sketch (from Perlin and Dean 1983)

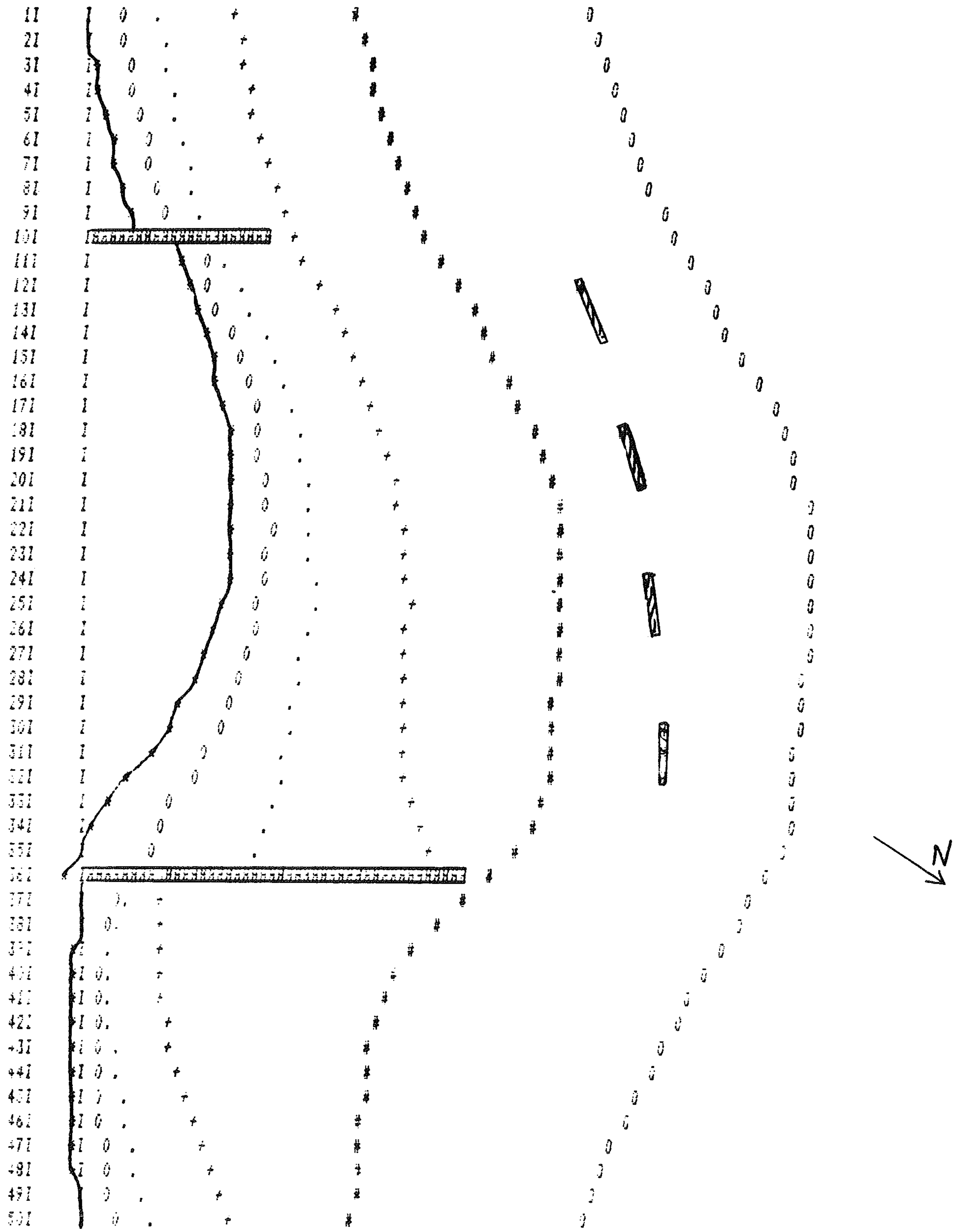


Figure 22. Four short-length breakwater segments, two groins, t = 30 days

```
      CALL FRES(SIGP,CP,SP,FRP,FIP)
      SUM1=XXC*FR+XXS*FI+XXC1*FRP+XXS1*FIP
      SUM2=XXC*FI-XXS*FR+XXC1*FIP-XXS1*FRP
      AMP=SQRT(SUM1**2+SUM2**2)
      RETURN
      END
      SUBROUTINE FRES(A,C,S,FR,FI)
C*FRESNEL INTEGRAL SUBROUTINE****AFTER ABROMOWITZ AND STEGUN.
      Z=ABS(A)
      PO2=1.5707963
      FZ=(1.0+0.926*Z)/(2.0+1.792*Z+3.104*Z*Z)
      GZ=1.0/(2.0+4.142*Z+3.492*Z*Z+6.670*Z*Z*Z)
      XX=PO2*Z*Z
      CZ=COS(XX)
      SZ=SIN(XX)
      C=0.5-GZ*CZ+FZ*SZ
      S=0.5-FZ*CZ-GZ*SZ
      IF(A.GT.0.0)   GO TO 50
      C=-C
      S=-S
   50 FR=0.5*(1.0+C+S)
      FI=-0.5*(S-C)
      RETURN
      END
      SUBROUTINE PREDIF
      PARAMETER(NI=53,NJ=11)
C***********************************************************************
      COMMON/A/ C(NI,NJ),RK(NI,NJ),Y(NI,NJ),DEEP(NI,NJ),ALPHAS(NI,NJ)
      COMMON/AA/YZERO(NI),WDEPTH
      COMMON/B/ THETA(NI,NJ),QXTOT(NI), OLDANG(NI,NJ), DY(NI,NJ)
      COMMON/C/ H(NI,NJ),CG(NI,NJ),HOLD(NI,NJ),HB(NI,NJ),YB(NI)
      COMMON/N USED/JUSE,T,CO,CGEN,CGGEN,ANGGEN,DX,BERM,THETAO(10),MMAX
      COMMON/D/SIGMA,G,ELO,JMAX,IMAX,PI,TWOPI,PIO2,HGEN,IJET(10)
     1,SJETTY(10)
      COMMON/G/IBREAK(NI),HNONBR(NJ)
      DIMENSION J1(NI),J2(NI),J1REF(NI),J3REF(NI)
      DO 99 J=1,IMAX+3
      J1(J)=0
      J2(J)=0
      J1REF(J)=0
   99 CONTINUE
C*THIS SUB CALCS WHERE DIFFRACTION GOVERNS AND WHERE REFRACT GOVERNS.
C*IT WILL CALL REFRAC FOR OFFSHORE AREA(OFF TIP OF STRUCTURE).
C*THEN IT WILL DO THE SHADOW ZONE USING DIFF(IF THETAO .NE.0.0)
C* IT WILL THEN FINISH THE  OTHERS USING REFRAC AGAIN.
C*NOW, LETS FIND C,CG,RK,HB, AND WVNUM.
      DO 202 I=1,IMAX+1
      DO 202 J=1,JMAX+2
      DEPTH=DEEP(I,J)
      CALL WVNUM(DEPTH,T,DUMK)
      RK(I,J)=DUMK
      C(I,J)=CO*TANH(RK(I,J)*DEEP(I,J))
      EN=0.5*(1.0+((2.*RK(I,J)*DEEP(I,J))/SINH(2.*RK(I,J)*DEEP(I,J))))
      CG(I,J)=EN*C(I,J)
      HB(I,J)=0.78*DEEP(I,J)
```