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1 OF 2
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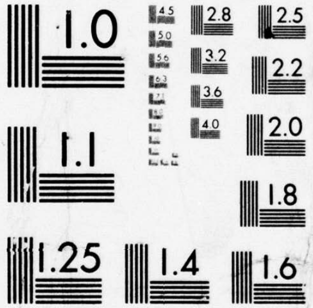

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TR 76-3

Storm Surge Simulation in Transformed Coordinates

VOLUME II

Program Documentation

by

John J. Wanstrath

TECHNICAL REPORT NO. 76-3
NOVEMBER 1976

Prepared for
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Kingman Building
Fort Belvoir, Va. 22060

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Hurricane Carla	Storm surge

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

A two-dimensional time-dependent numerical storm surge model using orthogonal curvilinear coordinates is presented. The curvilinear coordinate system is based on a conformal mapping of the interior region bounded by the actual coast, the seaward boundary (taken as the 180-meter depth contour) and two parallel lateral boundaries into a rectangle in the image plane. Three regions of the Continental Shelf of the Gulf of Mexico and two regions of the eastern seaboard of the United States are mapped. next pg

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Since the transformation is conformal, the associated modifications of the vertically integrated equations of motion and mass continuity are minimized. The coast, seaward boundary, and the lateral boundaries of the computing grid are straight lines in the image plane thus facilitating the application of the boundary conditions. The final coordinates allow for the greatest resolution near the coast in a central area of principal storm surge development and modification.

The model is employed in the simulation of the storm surge induced by Hurricanes Carla (1961) and Camille (1969) which crossed the gulf coast of the United States and Hurricane Gracie (1959) which crossed the east coast. Analytical interpretations of the wind and atmospheric pressure-forcing functions are used in the computations.

PREFACE

This report is published to provide coastal engineers with the results of a study to develop an operational program for numerical simulation of storm surges on a given segment of the Continental Shelf, using a curvilinear coordinate system. The report consists of two volumes. Volume I discusses the theory and application of the transformation procedure for generating the curvilinear shelf coordinate system for particular regions, and the theory, numerical algorithm, and application of the storm surge program for simulation of Hurricanes Carla (1961), Camille (1969), and Gracie (1959). Volume II presents the program documentation and the coded programs for carrying out the coordinate transformation (CONFORM), for establishing the spatial lattice (GRID), and for carrying out the storm surge calculations on the shelf (SSURGE). The work was carried out under the wave mechanics program of the U.S. Army Coastal Engineering Research Center (CERC).

This volume was prepared by John J. Wanstrath; Volume I was prepared by John J. Wanstrath, Robert E. Whitaker, Robert O. Reid, and Andrew C. Vastano, Department of Oceanography, Texas A&M University, College Station, Texas, under CERC Contract No. DACW72-73-C-0014. Most of the computational work in the development and application was carried out at the National Center for Atmospheric Research which is supported by the National Science Foundation.

The authors express their appreciation to Thomas J. Reid for assistance in program coding, and to Dr. D. Lee Harris, CERC, for very constructive comments on the draft of this report.

Dr. D. Lee Harris, Chief, Oceanography Branch, was the CERC technical monitor of the report, under the general supervision of Mr. R.P. Savage, Chief, Research Division.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

John H. Cousins
JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: C = (5/9) (F – 32). To obtain Kelvin (K) readings, use forumla: K = (5/9) (F – 32) + 273.15.

STORM SURGE SIMULATION IN TRANSFORMED COORDINATES

Volume II. Program Documentation

by
John J. Wanstrath

I. INTRODUCTION

Presented in this volume are the program documentation and listings of the coded programs for carrying out a simulation of a hurricane-induced storm surge on the Continental Shelf in curvilinear coordinates for a given reach of shelf. There are three separate programs detailed here for this purpose.

The first program, CONFORM, is employed for evaluation of the transformation coefficients which map the given reach of the Continental Shelf into a rectangle in the image plane, the shelf region being delineated by a smoothed version of the coastline, the shelf break (taken as the 180-meter depth contour in the examples), and bounded laterally by two parallel straight lines. The theory and several example applications of the transformation procedure are given in Section II of Volume I. The example input for CONFORM contained in the listings here are for the mapping of the region from a section across Laguna Madre about 90 kilometers south of Brownsville to Marsh Island. Particular care must be taken to follow the procedure exactly for the example if CONFORM is to be verified by obtaining the given transformation coefficients. This procedure is given *explicitly in the CONFORM documentation.*

The second program, GRID, develops the detailed computing grid information, based on the mapping coefficients evaluated by CONFORM plus coordinate stretching information supplied by the user (see Section III of Volume I). Part of the output of GRID is a listing of the grid positions which are required by the user in order to read from appropriate charts the detailed bathymetry field, which is necessary input for the final program SSURGE. The example data supplied here for GRID are for the Laguna Madre to Marsh Island region.

Program SSURGE (Shelf Surge) carries out the numerical integration of the storm surge equations in the transformed coordinate system supplied by CONFORM and GRID, using a parametric representation of a hurricane wind field and pressure field. The theory is given in Section III of Volume I. The particular example data given here are for Hurricane Carla and the Laguna Madre-Marsh Island grid system.

The appendixes to this volume contain detailed FORTRAN listings of the three programs in this application. The data to be supplied by the user for other applications are discussed in the documentation of each of these programs.

II. COMPUTER PROGRAM DOCUMENTATION FOR PROGRAM-CONFORM

1. Program Purpose.

The purpose of the program is to determine the transformation coefficients which will conformally map the interior region bounded by the actual coastline, a seaward boundary curve, and two parallel lateral boundaries into a rectangle in the image plane.

2. Program Description.

The program is written in FORTRAN IV language. This program and the program GRID provide all the necessary computing grid data for input to program SSURGE. The program GRID takes, as input, the transformation coefficients and determines the computing grid information (such as, scale factors, grid point locations, and, at each grid point, the orientation of the ξ-axis to the x-axis).

The program CONFORM is composed of:

MAIN	Defines constants. Reads and writes the coordinates delineating the given coastline and seaward boundary curve. Calls Subroutine COEFFS.
SUBROUTINE COEFFS	Determines the transformation coefficients. At the completion of each iteration, the coefficients, the variance between the transform-generated curves and that specified, and other pertinent information are written. COEFFS interfaces all other program subroutines and functions.
FUNCTION XTRAN	Is the transformation function $x(\xi,\eta)$.
FUNCTION YTRAN	Is the transformation function $y(\xi,\eta)$.
SUBROUTINE SLFAC	Determines the scale factor and derivatives, $\partial x/\partial\xi$, $\partial y/\partial\xi$, for a given value of ξ and η .
SUBROUTINE CUR1YB	Determines the necessary parameters to fit a spline under tension through the given coastline coordinates. The spline is fitted with Y2 as a function of X2 .
FUNCTION CURVYB	Interpolates the given coastline, returning a value of y at a specified value for x .

FUNCTION CURDYB	Differentiates the given coastline, returning a value of dy/dx at a specified value for x.
SUBROUTINE CUR2YB	Determines the necessary parameters to fit a spline under tension with X2 as a function of coastline arclength.
FUNCTION CUR4YB	Interpolates the given coastline returning a value of x at a specified value for arclength.
SUBROUTINE CUR3YB	Determines the necessary parameters to fit a spline under tension with Y2 as a function of coastline arclength.
FUNCTION CUR5YB	Interpolates the given coastline returning a value of y at a specified value for arclength.

There are identical subroutines and functions as delineated above for the seaward boundary curve specified by coordinates X2P and Y2P . These subroutines and functions are recognized by the same names as their counterparts with a terminal letter A. For example, SUBROUTINE CUR1YA determines the necessary parameters to fit a spline under tension through the given seaward boundary curve.

3. Type of Computer.

The program CONFORM can be run on any computer with minimum core requirements of approximately 24K (based on the present sample program). However, significantly more computer memory would be required if one desires a large number of coefficients and/or numerous integration points. The program has been executed successfully on IBM 360, CDC/6600 and 7600, and GE/635. The present sample program requires no auxiliary storage devices, peripherial devices, or magnetic tape input or output. No site-orientated computer plot routines are involved in the program. Approximately 20 minutes of machine time on a CDD/7600 is required for the sample program (total number of coefficients, $2 \times \mathrm{NMAX} = 220$; number of integration points, $0 < \xi < \lambda$, = 110; and number of iterations = 80).

4. Input Data.

Input data, other than constants defined in MAIN, are read in MAIN on IBM cards prepared according to the following list:

(1) Card 1

IWANT, MQ, MOP, NMAX, JMAS1, IL, VARWT	Continuation flag, number of shoreline and seaward boundary coordinates

number of mapping coefficients, maximum number of iterations, number of integration points, and the convergence criterion in format 6I5, F5.3.

(2) Card Group 2

X2,Y2	The x,y coordinates (units in x,y space) of the given coastline in the region $0 \le x \le \lambda$ are read with one pair per card in format 3X, F7.2, 3X, F7.2 (limit 150).

(3) Card Group 3

X2P,Y2P	The x,y coordinates (units in x,y space) of the given seaward boundary curve in the region $0 \le x \le \lambda$ are read with one pair per card in format F7.2, 3X, F7.2 (limit 150).
Optional	Card 4, Card Group 3, and Card 6 If IWANT = 1, indicating the program is being restarted, the following cards must be supplied:

(4) Card 4

B, BZRO	The values of β and B_o in units of length of x,y space from the last iteration of the previous run in format 2E14.7.

(5) Card Group 5

COB,COC	The NMAX cards containing the dimensionless Fourier-type transformation coefficients from the last iteration of the previous run in sequential order with one pair per card (format 2E14.7). If more coefficients are desired in the present run than the previous one, blank cards should be supplied for the difference.

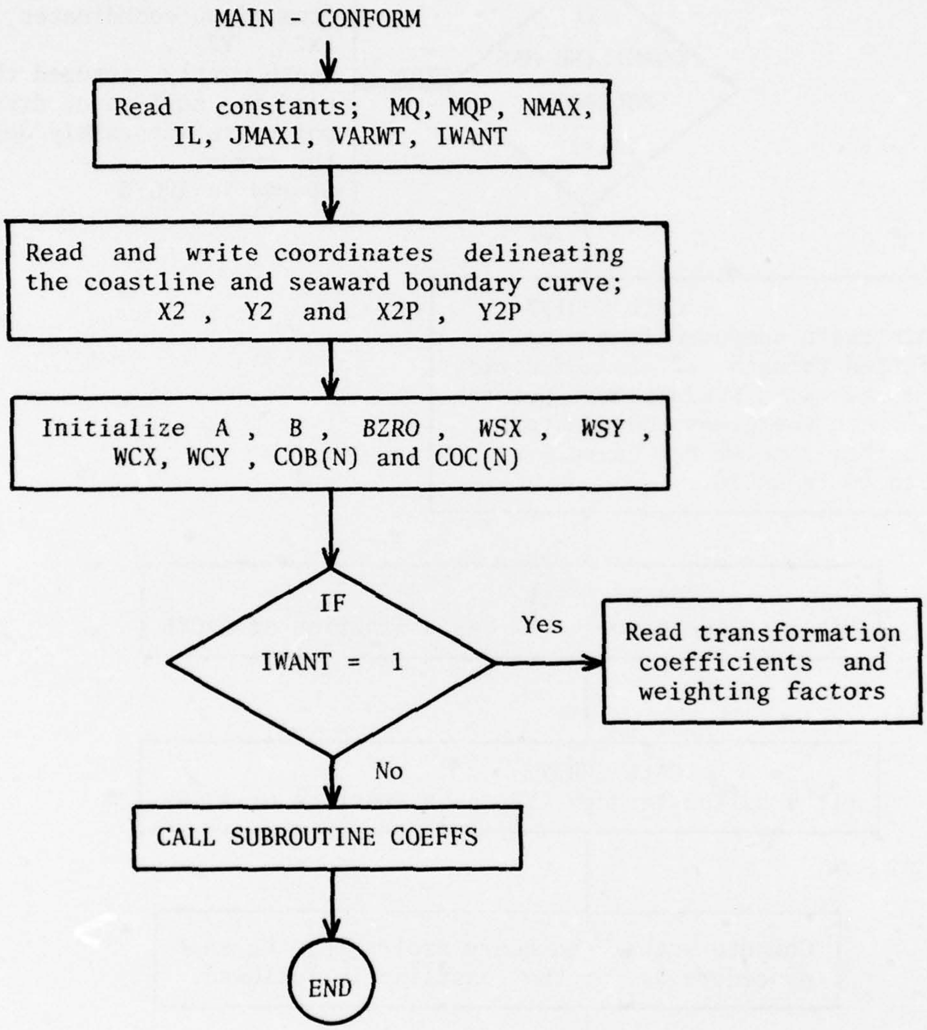
(6) Card 6

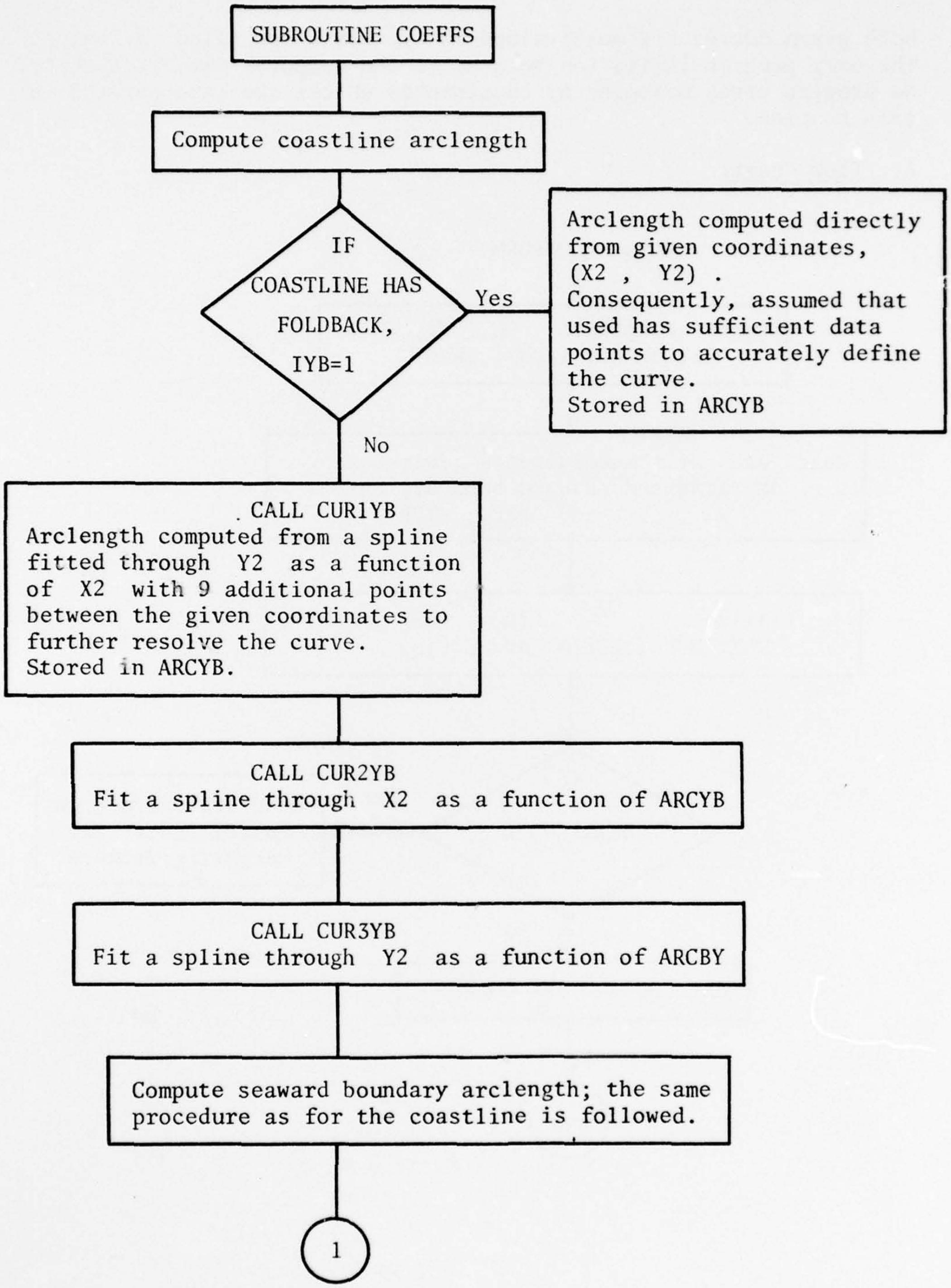
WSX,WSY WCX,WCY	The value of the weighting factors for the seaward boundary curve (x and y component) and coastline (x and y component) from the last iteration of the previous run (4E14.7).

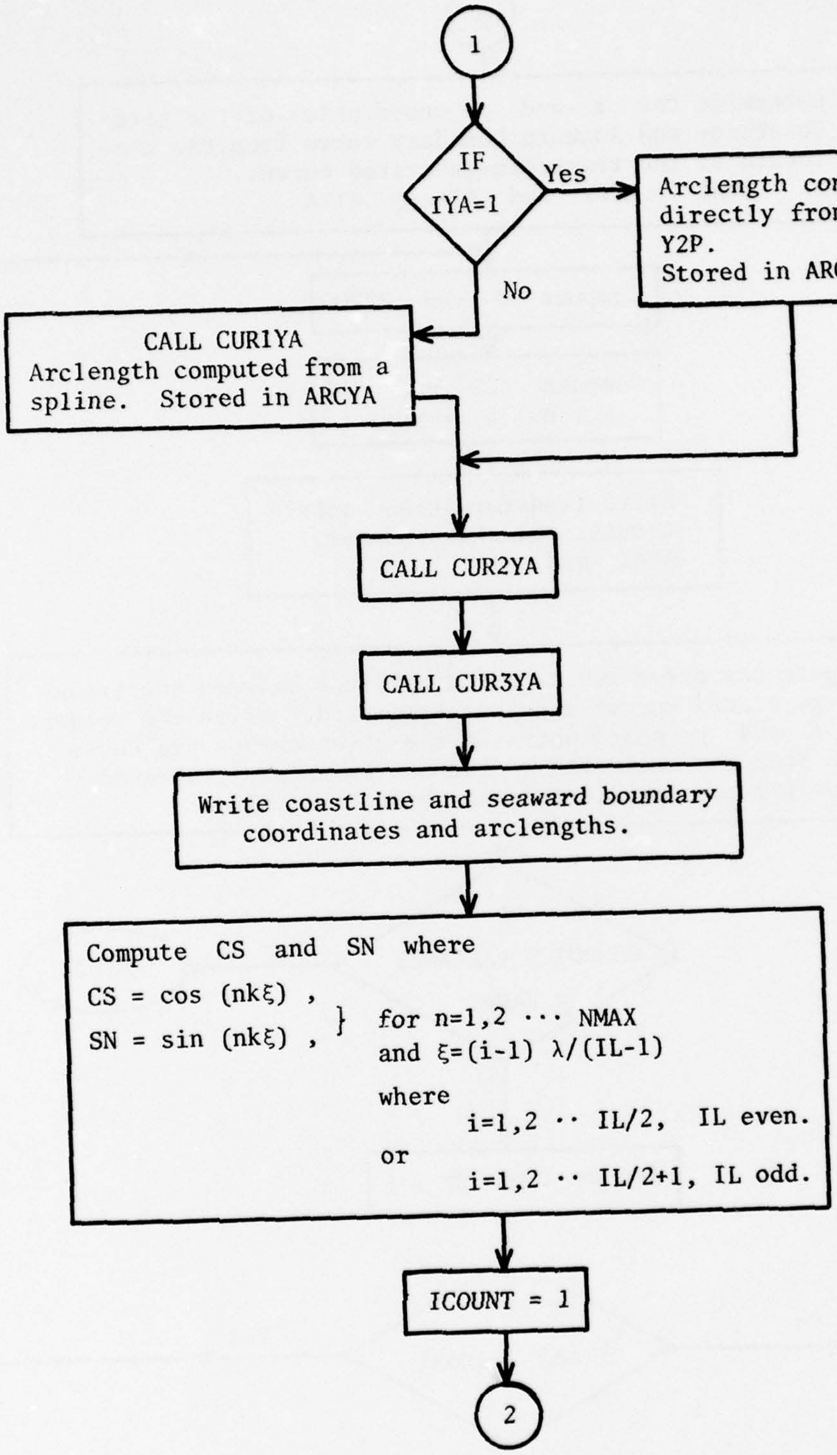
5. Mathematical Procedures and Program Limitations.

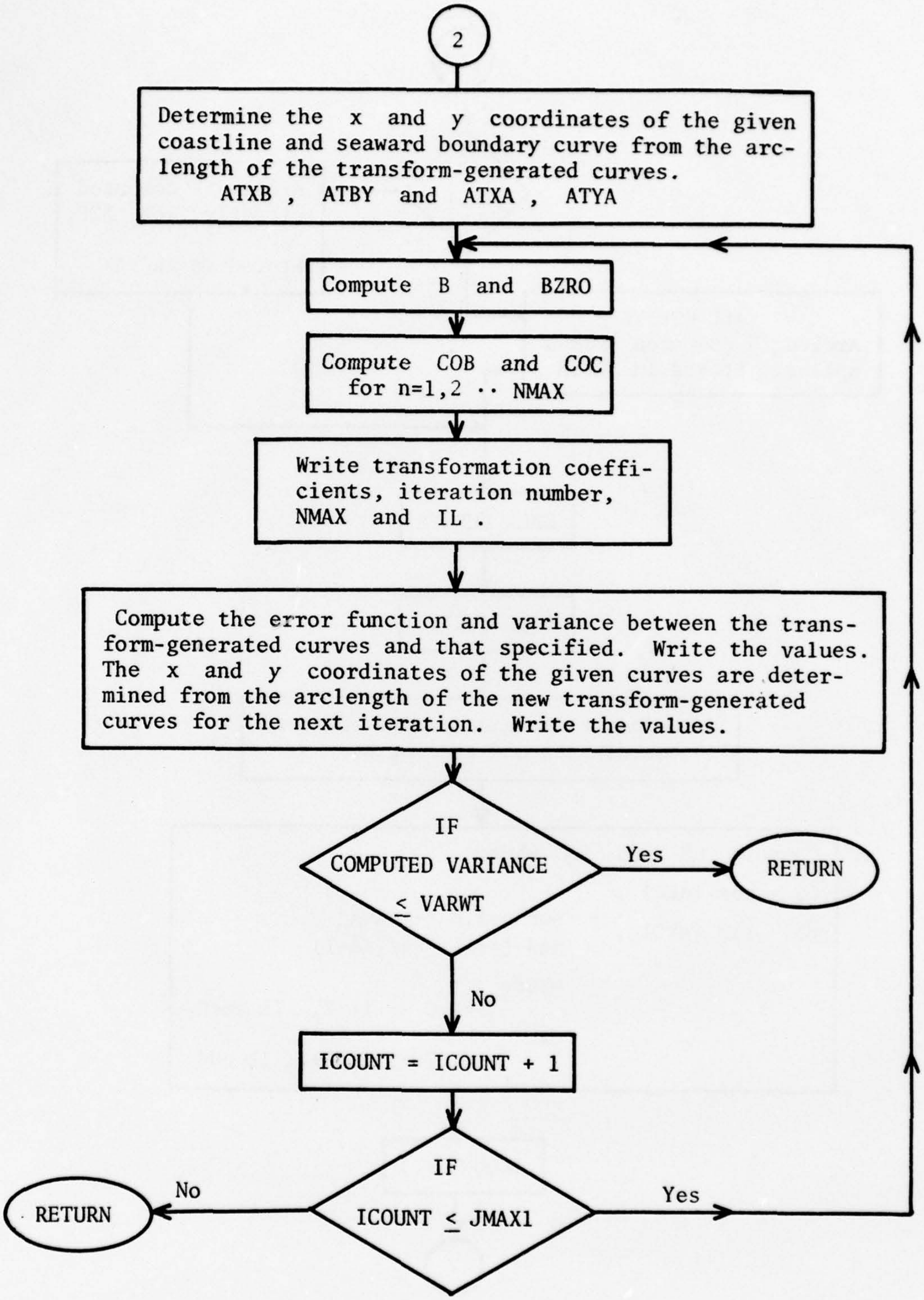
The conformal mapping relations, solutions for the transformation coefficients, and the iterative procedure for determining the coefficients are presented in Volume I of this report. The mapping equations are sufficiently general to treat the situation where either or both given curves are multivalued in y for a specified x value. The only program limitation relates to the computer memory capacity. No program error messages or consistency checks are incorporated in this routine.

6. <u>Flow Chart</u>.




SUBROUTINE COEFFS
Compute coastline arclength
IF COASTLINE HAS FOLDBACK, IYB=1
Yes
Arclength computed directly from given coordinates, (X2 , Y2) . Consequently, assumed that used has sufficient data points to accurately define the curve. Stored in ARCYB
No
CALL CUR1YB Arclength computed from a spline fitted through Y2 as a function of X2 with 9 additional points between the given coordinates to further resolve the curve. Stored in ARCYB.
CALL CUR2YB Fit a spline through X2 as a function of ARCYB
CALL CUR3YB Fit a spline through Y2 as a function of ARCBY
Compute seaward boundary arclength; the same procedure as for the coastline is followed.
1


1
IF
IYA=1
Yes
Arclength computed directly from X2P, Y2P.
Stored in ARCYA
No
CALL CUR1YA
Arclength computed from a spline. Stored in ARCYA
CALL CUR2YA
CALL CUR3YA
Write coastline and seaward boundary coordinates and arclengths.
Compute CS and SN where
CS = cos (nkξ) ,
SN = sin (nkξ) ,
for n=1,2 ··· NMAX
and ξ=(i-1) λ/(IL-1)
where
i=1,2 ·· IL/2, IL even.
or
i=1,2 ·· IL/2+1, IL odd.
ICOUNT = 1
2


2
Determine the x and y coordinates of the given coastline and seaward boundary curve from the arclength of the transform-generated curves.
ATXB , ATBY and ATXA , ATYA
Compute B and BZRO
Compute COB and COC for n=1,2 ·· NMAX
Write transformation coefficients, iteration number, NMAX and IL .
Compute the error function and variance between the transform-generated curves and that specified. Write the values. The x and y coordinates of the given curves are determined from the arclength of the new transform-generated curves for the next iteration. Write the values.
IF COMPUTED VARIANCE ≤ VARWT
Yes
RETURN
No
ICOUNT = ICOUNT + 1
IF ICOUNT ≤ JMAX1
No
RETURN
Yes

7. Glossary and Description of Terms.

Arrays

X2	Dimensioned MQ. Contains values of the x coordinate in units of x,y space of the given coastline (max. 150).
Y2	Dimensioned MQ. Contains values of the y coordinate in units of x,y space of the given coastline (max. 150).
X2P	Dimensioned MQP. Contains values of the x coordinate in units of x,y space of the given seaward boundary curve (max. 150).
Y2P	Dimensioned MQP. Contains values of the y coordinate in units of x,y space of the given seaward boundary curve (max. 150).
COB	Dimensioned NMAX. Contains values of the dimensionless transformation coefficient B_n (max. 200).
COC	Dimensioned NMAX. Contains values of the dimensionless transformation coefficient C_n (max. 200).
DUMB	Dimensioned NMAX. Contains the iterative value for B_n (max. 200).
DUMC	Dimensioned NMAX. Contains the iterative value for C_n (max. 200).
ARCYB	Dimensioned MQ. Contains values of the arclength for the given coastline coordinates X2 , Y2 (max. 150).
ARCYA	Dimensioned MQP. Contains values of the arclength for the given seaward boundary coordinates X2P , Y2P (max. 150).
SN	Dimensioned NMAX × IL1 where IL1 is IL/2 for even IL or IL1 is IL/2 + 1 for odd IL. Contains values of $\sin(nk\xi)$.
CS	Dimensioned NMAX × IL1. Contains values of $\cos(nk\xi)$.
ATXB	Dimensioned IL. Contains values of the x coordinate of the given coastline as determined from the arclength of the transform-generated curve (max. 400).
ATYB	Dimensioned IL. Contains values of the y coordinate of the given coastline as determined from the arclength of the transform-generated curve (max. 400).

ATXA	Dimensioned IL. Contains values of the x coordinate of the given seaward boundary curve as determined from the arclength of the transform-generated curve (max.400).
ATYA	Dimensioned IL. Contains values of the y coordinate of the given seaward boundary curve as determined from the arclength of the transform-generated curve (max.400).
Z	Dimensioned IL. Contains values of ξ (max.400).
R,S,T,U, V,W,X,Y	Dimensioned IL. Temporary storage.

Constants

MQ	Number of coordinates delineating the given coastline (max.150).
MQP	Number of coordinates delineating the given seaward boundary curve (max.150).
NMAX	Number of transformation coefficients, B_n or C_n (max.200).
IL	Number of equally spaced integration points for $0 \leq \xi \leq \lambda$ with IL $\geq$ NMAX (max.400).
IWANT	If IWANT = 1, the program is to be re-started requiring input from the previous run. If IWANT $\neq$ 1, it is the initial mapping of the region.
VARWT	Desired variance (in units of x,y space squared) between the transform-generated curves and that specified.
XLAMDA	λ = X2(MQ) = X2P(MQP)
XK	$k = \pi/\lambda$
A	$-B$
B	β
BZRO	B_o
WSX,WSY	The x and y component of the weighting factor for the seaward boundary curve.
WCX,WCY	The x and y component of the weighting factor for the coastline.

8. Input and Output.

The input data required by CONFORM to determine the transformation coefficients which conformally map the Laguna Madre, Mexico, to Marsh Island, Louisiana, region into a rectangle are presented here as an example. The first card image gives the continuation code, number of coastline and seaward boundary coordinates, number of coefficients desired, maximum number of iterations, number of integration points, and the convergence criterion. The next 47 paired numbers are the coastline coordinates and the last 40 card images give the seaward boundary coordinates.

Program CONFORM provides detailed and voluminous output concerning primarily the rate of convergence. These output statements are not necessary for program completion and can be easily deleted with little alteration to the sequence of instructions. Optional output statements are indicated in the program listing (App. A) by an arrow (←) on the right-hand side of the page.

The results from CONFORM required by Program GRID are β , B_o , and the coefficients, B_n and C_n . These are given in the next section as input to program GRID.

Reference to Table 4 in Volume I of this report shows the values for the number of coefficients, maximum number of iterations, and number of integration points are only indicative of the final steps of this particular application. Explicitly, in order to obtain the given coefficients to conformally map the Laguna Madre to Marsh Island region into a rectangle in the image plane, the following steps must be followed:

(1) Set NMAX to 40 and IL to 80 for the first 20 iterations.

(2) For the next 10 iterations, NMAX is 60 and IL is 120.

(3) Set NMAX to 80 and IL to 160 for iterations 31 through 50.

(4) Take NMAX as 90 and IL as 180 for the next 10 iterations.

(5) For iterations 61 through 70, NMAX is 100 and IL is 200.

(6) Over the next 10 iterations, NMAX is 110 and IL is 220.

(7) Starting with the 81st iteration, WCX and WSX are set to 0 and NMAX is 110 and IL is 220 through the 100th interation.

(8) From iteration 101 through 110, NMAX is 130 and IL is 260.

(9) Over the last 10 iterations, NMAX is 150 and IL is 300.

Note that steps (7) through (9) utilize the alternate solution to the mapping equations (9) and (10) in Section II of Volume I of this report. The instructions which must be altered or removed are indicated in the program listing by parenthesis with the proper instruction enclosed.

The following input is required by CONFORM to conformally map the Laguna Madre, Mexico to Marsh Island, Louisiana region into a rectangle in the image plane. Note the fourth and fifth parameters on the first card image are only indicative of the final results. See Input and Output text for explanation of procedure used to obtain the mapping coefficients given as input to Program GRID.

```
C
C     I N P U T   D A T A
C
    1   47   40  150   1500.001                   360.00    110.00
C                                                C
C                                                C
C     COASTLINE COORDINATES                      C     SEAWARD BOUNDARY COORDINATES
C                                                C
C                                                C
     000.00     035.00                            000.00     002.00
     005.60     040.00                            007.50     005.00
     010.50     044.80                            016.00     010.00
     018.00     051.00                            021.50     014.50
     028.00     059.00                            028.00     019.00
     040.00     066.80                            036.00     023.00
     050.50     073.00                            045.00     028.00
     056.50     076.50                            054.00     032.00
     063.00     082.00                            060.00     036.00
     070.00     093.00                            066.00     040.00
     074.00     102.00                            077.00     046.00
     076.50     108.50                            085.00     051.00
     079.00     116.00                            089.00     055.00
     082.50     127.00                            095.00     064.00
     088.00     137.80                            104.00     076.00
     095.00     146.00                            110.00     084.00
     106.00     154.00                            112.00     089.00
     121.00     162.00                            113.50     095.00
     136.00     167.00                            114.50     101.00
     153.00     168.30                            117.50     108.00
     158.00     168.00                            121.00     112.00
     161.50     167.30                            127.00     116.00
     166.00     168.80                            139.00     121.00
     171.00     169 00                            153.00     123.50
     183.00     168.00                            165.00     123.00
     197.00     166.00                            179.00     119.00
     214.00     165.00                            193.00     115.00
     230.00     166.00                            213.00     104.00
     242.00     167.00                            229.00     092.00
     250.00     166.70                            244.00     080.00
     253.40     167.20                            257.00     071.00
     257.00     169.50                            267.00     066.00
     265.00     169.00                            276.00     062.00
     280.00     166.00                            289.00     056.00
     291.00     163.00                            298.00     049.00
     296.00     159.30                            307.00     042.00
     298.50     159.90                            318.00     035.00
     303.00     159.00                            333.00     027.00
     314.00     153.00                            347.00     020.00
     323.00     148.00                            360.00     014.00
     328.00     142.00
     331.00     137.20
     335.50     129.20
     342.50     121.00
     349.50     115.00
     352.50     113.00
```

III. COMPUTER PROGRAM DOCUMENTATION FOR PROGRAM-GRID

1. Program Purpose.

The purpose of this program is to determine the grid point array in the stretched curvilinear shelf coordinate system and appropriate scale factors needed for program SSURGE. The detailed grid is needed in order for the user to read off depths from an appropriate bathymetric chart of the shelf region at grid locations.

2. Program Description.

The program is written in FORTRAN IV language. This program interfaces between Programs CONFORM and SSURGE. It is assumed that the conformal mapping of the storm surge region has been completed to the user's satisfaction. The program GRID takes, in part, as input, the transformation coefficients and determines computing grid information of scale factors, grid point locations, and, at each grid point, the orientation of the ξ-axis to the x-axis .

The program GRID is composed of

MAIN	Defines constants. Reads transformation coefficients outputed from CONFORM. Reads water depths along a line near center of grid from the seaward boundary to the coast. Computes grid point locations, scale factors (μ , ν , and F), and, at each grid point, cos θ and sine θ . Writes computing grid information.
SUBROUTINE XUT	Writes information transferred into XUT.
SUBROUTINE SHCOR	Determines and writes grid point coordinates in x,y space and the distance in nautical miles between points.
SUBROUTINE TRAN	Computes the x and y coordinates of the transform-generated coastline and seaward boundary curve.
SUBROUTINE TRAN1	Computes $x(\xi,\eta)$ and $y(\xi,\eta)$.
SUBROUTINE TRAN2	Computes $\partial x/\partial\xi$, $\partial y/\partial\xi$ and $\theta = \tan^{-1}\left(\frac{\partial y/\partial\xi}{\partial x/\partial\xi}\right)$.
SUBROUTINE CURV9	Contains the expansion curve $Y = Z + B(X^C)$ where A , B , and C are constants. The term Y is either Sp (units, nautical miles) or T (units, minutes). The term X is either S* (units, nautical miles) or T* (units, minutes). This subroutine computes Y and dY/dX given the coefficients and X .

SUBROUTINE CURV1 - Determines the necessary parameters to compute an interpolatory spline under tension through a sequence of functional values contained in arrays X2 and Y2 .

FUNCTION CURV2 - Interpolates the given curve, Y2 as a function of X2 , returning a value for y given x .

SUBROUTINE CURV3 - Determines the necessary parameters to compute an interpolatory spline under tension through a sequence of functional values contained in arrays X2P and Y2P.

FUNCTION CURV4 - Interpolates the given curve, Y2P as a function of X2P , returning a value for y given x .

3. Type of Computer.

The program GRID may be run on any computer with minimum core requirements of approximately 26K words (based on the present sample program appropriate to the Hurricane Carla surge simulation grid). GRID requires no auxiliary storage devices, peripheral devices, or magnetic tape input or output. No site-oriented computer plot routines are involved in the program. Approximately 25 minutes of machine time on a GE/635 is required for the sample program to determine the computing grid information. This time is based on the following pertinent program parameters:

a) 150 transformation coefficients, B_n or C_n ;

b) 121 evenly spaced values of ξ for determining the transform-generated coastline arclength as a function of ξ ;

c) 51 evenly spaced values of η for determining the arclength along a particular isoline of ξ as a function of η ;

d) the computing grid of 47 ξ (or S*) lines and 15 η (or T*) lines;

e) for determining the scale factor F , the area in x,y space of each quadrangle is approximated by using 4 evenly spaced increments between ξ isolines and 2 evenly spaced increments between η isolines.

For production runs, smaller sampling intervals might be required in b, c and especially, c .

4. Input Data.

Input data, other than constants defined in MAIN, are read in MAIN and are on IBM cards prepared according to the following list:

(1) Card 1

NMAX, NUMXI, NUMETA, DELSS, SSTRT, DELTT, ND, NS	Number of mapping coefficients, number of ξ lines + 2, number of η lines, ΔS^* in nautical miles, first value of S^* in nautical miles, ΔT^* in minutes, number of depths, number of points in format 3I4, 3F5.1, 2I4.

(2) Card 2

BETA BZRO	The value of β and B_o from the conformal mapping solution in format 2E14.7.

(3) Card Group 3

COB,COC	The NMAX cards containing the Fourier-type transformation coefficients, B_n and C_n , in format 2E14.7.

(4) Card Group 4

SY	Temporary storage for the ND values of the water depth (fathoms) along a line from the seaward boundary to the coast. This information is needed to evaluate the traveltime coordinate T.

5. Mathematical Procedures and Program Limitations.

Information concerning the expanding grid procedure and the relations transforming ξ, η to S^*, T^* space is presented in Volume I of this report. The user is required to know the coefficients of the expansion function

$$S_p = A + B(S^*)^C$$

for each region of the curve where S_p is arclength (nautical miles) along the transform-generated coastline. For the sample program, there are five regions of the expansion curve. Selecting $\Delta S^* =$ 6 nautical miles, the number of ΔS^* intervals of each region and the value of $\partial Sp/\partial S^*$ at the end points of each region, we can determine the coefficients of each region from three simultaneous equations derived from the constraints:

For region I, 176 nautical miles $\leq S^* \leq$ 236 nautical miles (10 intervals of ΔS^*)

$\frac{\partial Sp}{\partial S^*} = 2.6225$ at $S^* = 176$ nautical miles

$\frac{\partial Sp}{\partial S^*} = 1.5$ at $S^* = 236$ nautical miles

$S_p = S_p$ at $S^* = 236$ nautical miles

For region II, 236 nautical miles $\leq S^* \leq$ 260 nautical miles (4 intervals of ΔS^*)

$\frac{\partial Sp}{\partial S^*} = 1.5$ at $S^* = 236$ nautical miles

$\frac{\partial Sp}{\partial S^*} = 1.5$ at $S^* = 260$ nautical miles

$S_p = S_p$ at $S^* = 260$ nautical miles

For region III, 260 nautical miles $\leq S^* \leq$ 302 nautical miles (7 intervals of ΔS^*)

$\frac{\partial Sp}{\partial S^*} = 1.5$ at $S^* = 260$ nautical miles

$\frac{\partial Sp}{\partial S^*} = 1.0$ at $S^* = 302$ nautical miles

S_p = 302 nautical miles at $S^* = 302$ nautical miles

For region IV, 302 nautical miles $\leq S^* \leq$ 356 nautical miles (9 intervals of ΔS^*)

$\frac{\partial Sp}{\partial S^*} = 1.0$ at $S^* = 302$ nautical miles

$\frac{\partial Sp}{\partial S^*} = 1.0$ at $S^* = 356$ nautical miles

S_p = 302 nautical miles at $S^* = 302$ nautical miles

For region V, 356 nautical miles $\leq S^* \leq$ 452 nautical miles (16 intervals of ΔS^*)

$\frac{\partial Sp}{\partial S^*} = 1.0$ at $S^* = 356$ nautical miles

$\frac{\partial Sp}{\partial S^*} = 2.7$ at $S^* = 452$ nautical miles

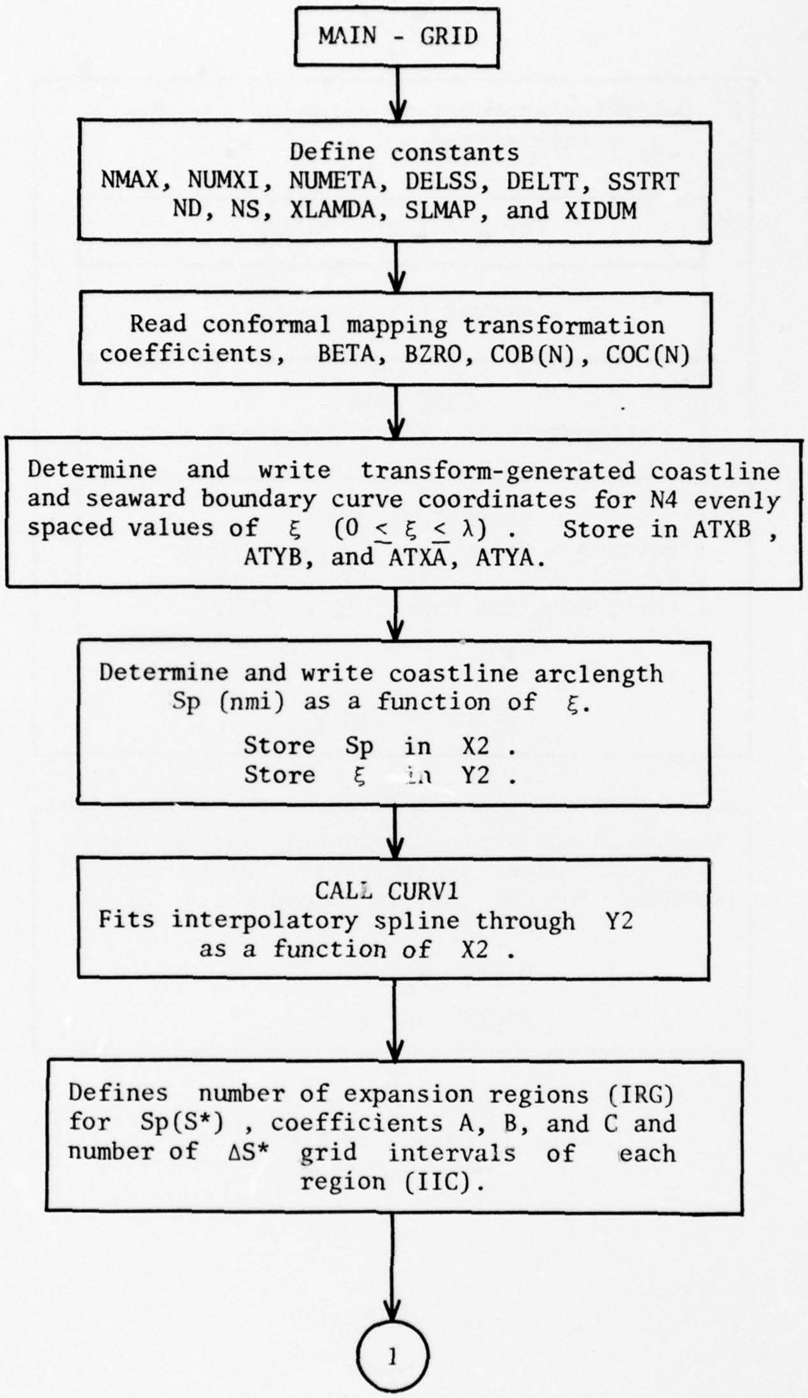
$S_p = 356$ nautical miles at $S^* = 356$ nautical miles

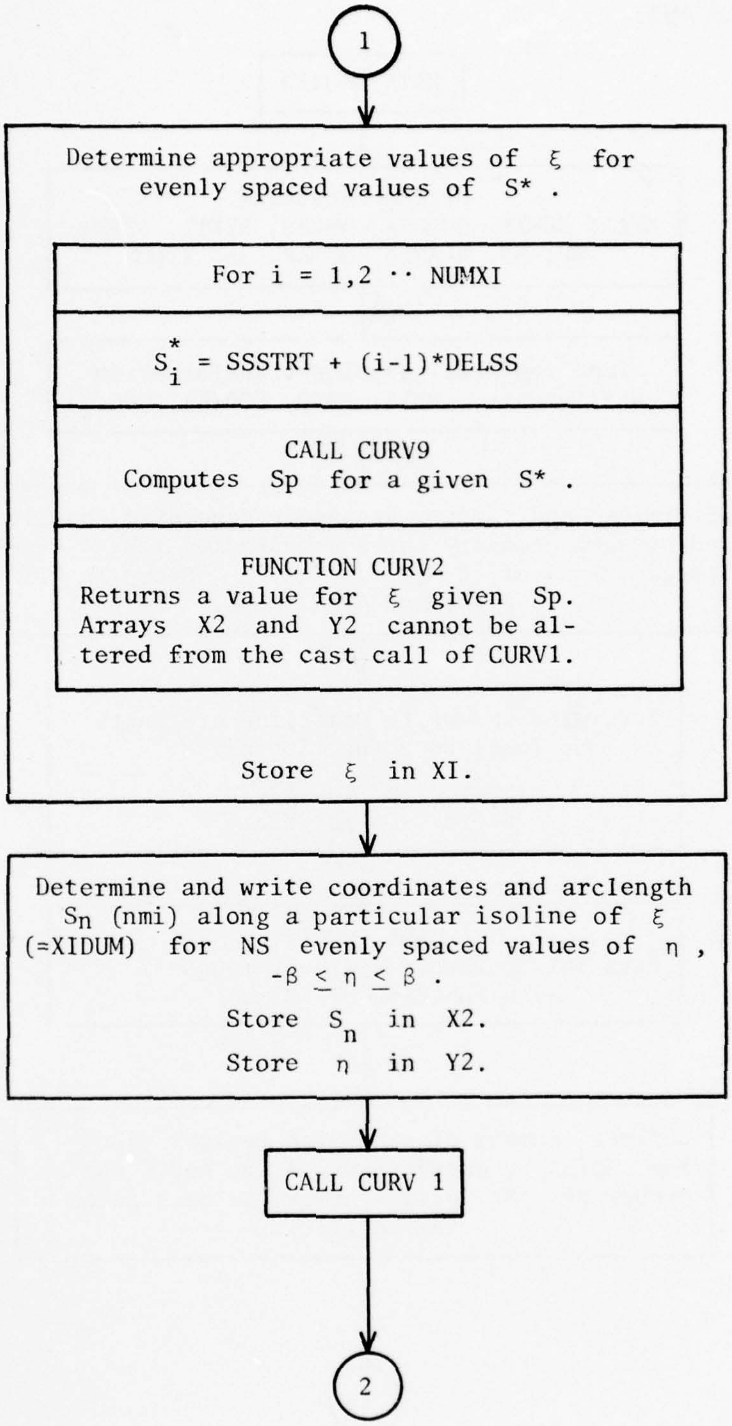
A similar procedure is followed for the expansion function

$$T = A + B(T^*)^C$$

where T is the long wave traveltime (minutes) along the particular isoline of ξ. The program assumes that there are, at most, two regions of the expansion curve with the second region being $\Delta T = \Delta T^*$. The expansion coefficients are determined by the program. If the user desires only one region (i.e., $T = T^*$ and ΔT^* = total long wave traveltime-number of η grid intervals), the program computes ΔT^*.

6. Flow Chart.


MAIN - GRID
Define constants
NMAX, NUMXI, NUMETA, DELSS, DELTT, SSTRT
ND, NS, XLAMDA, SLMAP, and XIDUM
Read conformal mapping transformation
coefficients, BETA, BZRO, COB(N), COC(N)
Determine and write transform-generated coastline
and seaward boundary curve coordinates for N4 evenly
spaced values of ξ $(0 \leq \xi \leq \lambda)$. Store in ATXB ,
ATYB, and ATXA, ATYA.
Determine and write coastline arclength
Sp (nmi) as a function of ξ.
Store Sp in X2 .
Store ξ in Y2 .
CALL CURV1
Fits interpolatory spline through Y2
as a function of X2 .
Defines number of expansion regions (IRG)
for Sp(S*) , coefficients A, B, and C and
number of ΔS* grid intervals of each
region (IIC).
1



Determine appropriate values of ξ for evenly spaced values of S^* .

For i = 1,2 ·· NUMXI

$S_i^* = SSSTRT + (i-1)*DELSS$

CALL CURV9
Computes Sp for a given S^* .

FUNCTION CURV2
Returns a value for ξ given Sp. Arrays X2 and Y2 cannot be altered from the cast call of CURV1.

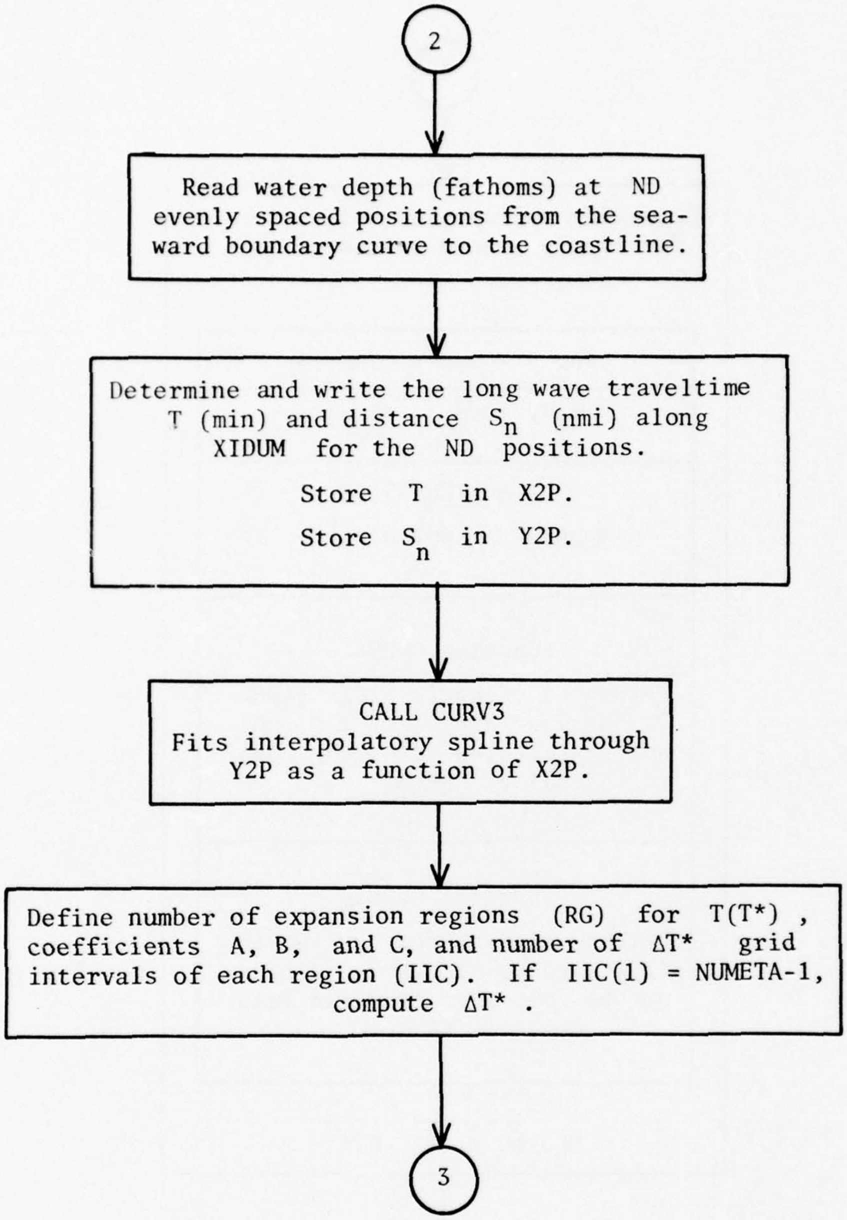
Store ξ in XI.

Determine and write coordinates and arclength S_n (nmi) along a particular isoline of ξ (=XIDUM) for NS evenly spaced values of η , $-\beta \leq \eta \leq \beta$.

Store S_n in X2.

Store η in Y2.

CALL CURV 1



Read water depth (fathoms) at ND evenly spaced positions from the seaward boundary curve to the coastline.

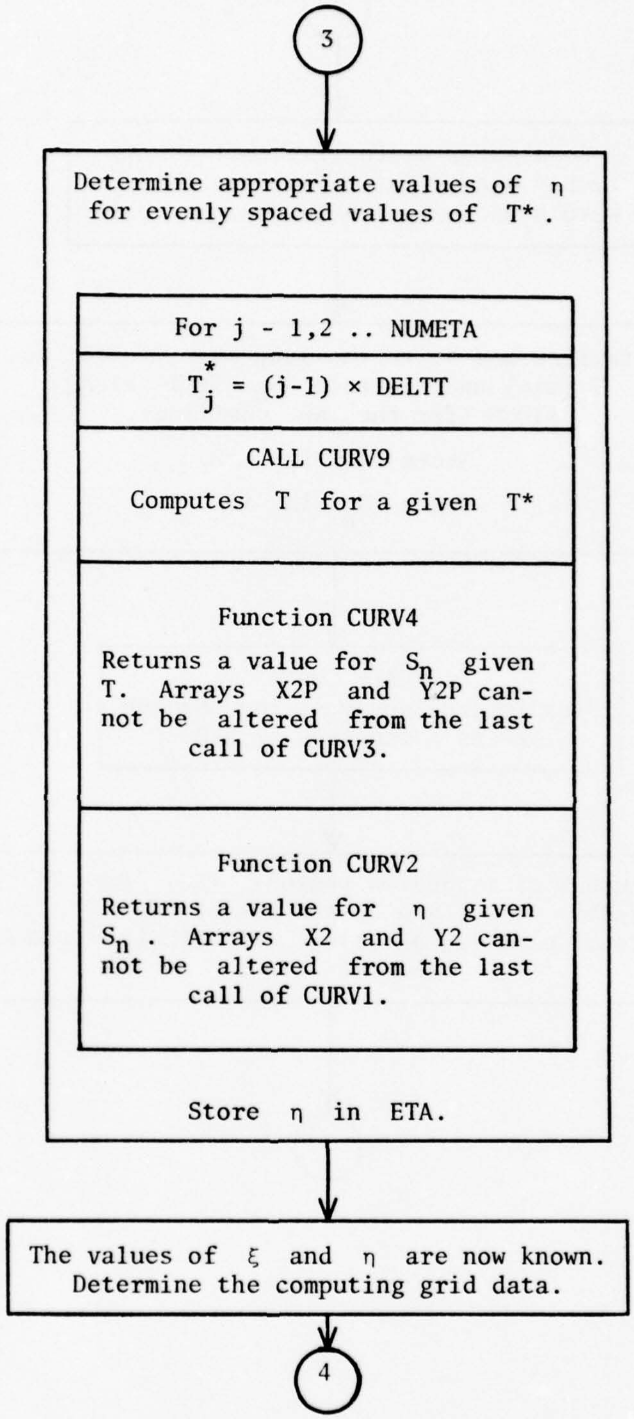
Determine and write the long wave traveltime T (min) and distance S_n (nmi) along XIDUM for the ND positions.

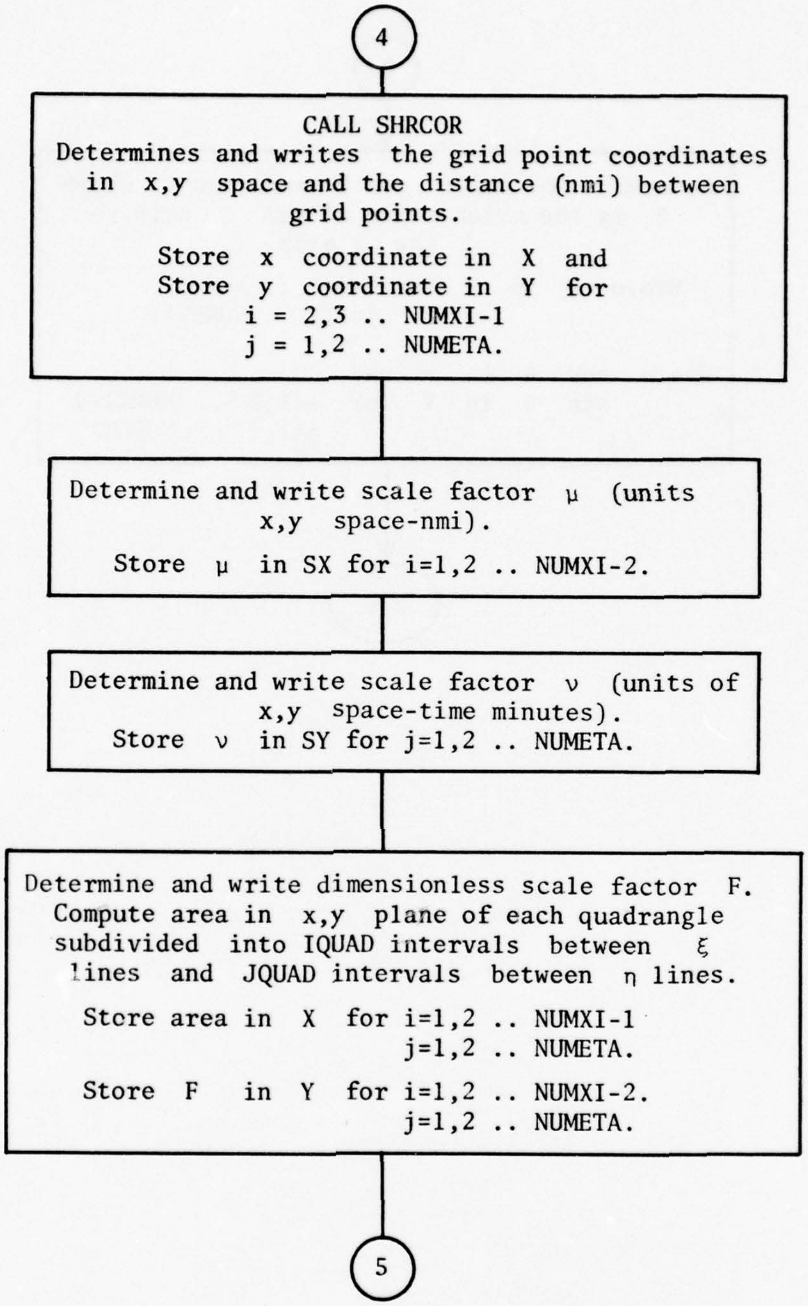
Store T in X2P.

Store S_n in Y2P.

CALL CURV3
Fits interpolatory spline through Y2P as a function of X2P.

Define number of expansion regions (RG) for T(T*), coefficients A, B, and C, and number of ΔT^* grid intervals of each region (IIC). If IIC(1) = NUMETA-1, compute ΔT^*.


3
Determine appropriate values of η for evenly spaced values of T*.
For j - 1,2 .. NUMETA
$T_j^* = (j-1) \times \text{DELTT}$
CALL CURV9
Computes T for a given T*
Function CURV4
Returns a value for S_η given T. Arrays X2P and Y2P cannot be altered from the last call of CURV3.
Function CURV2
Returns a value for η given S_η. Arrays X2 and Y2 cannot be altered from the last call of CURV1.
Store η in ETA.
The values of ξ and η are now known. Determine the computing grid data.
4



CALL SHRCOR
Determines and writes the grid point coordinates in x,y space and the distance (nmi) between grid points.

Store x coordinate in X and
Store y coordinate in Y for
i = 2,3 .. NUMXI-1
j = 1,2 .. NUMETA.

Determine and write scale factor μ (units x,y space-nmi).

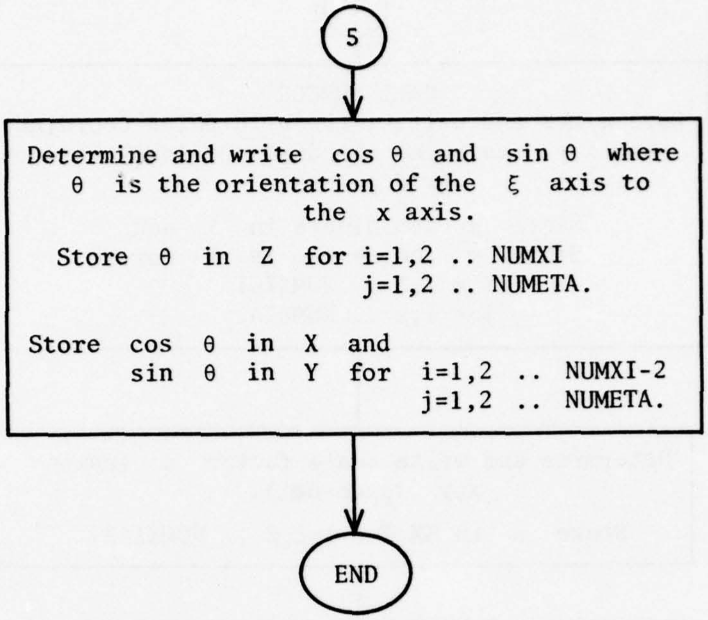
Store μ in SX for i=1,2 .. NUMXI-2.

Determine and write scale factor ν (units of x,y space-time minutes).
Store ν in SY for j=1,2 .. NUMETA.

Determine and write dimensionless scale factor F.
Compute area in x,y plane of each quadrangle subdivided into IQUAD intervals between ξ lines and JQUAD intervals between η lines.

Store area in X for i=1,2 .. NUMXI-1
j=1,2 .. NUMETA.

Store F in Y for i=1,2 .. NUMXI-2.
j=1,2 .. NUMETA.



Determine and write cos θ and sin θ where θ is the orientation of the ξ axis to the x axis.

Store θ in Z for i=1,2 .. NUMXI
j=1,2 .. NUMETA.

Store cos θ in X and
sin θ in Y for i=1,2 .. NUMXI-2
j=1,2 .. NUMETA.

7. Description of Terms.

Arrays

All arrays except COB, COC, XI and ETA are reused throughout the program. The user is cautioned to consult each major program division for assessment of array contents.

X,Y,Z	Dimensioned NUMXI × NUMETA.
X2,Y2 X2P,Y2P ATXA,ATYA ATXB,ATYB	Dimensioned the larger of N4, NS, ND, or IQUAD.
A, B, C IIC	Dimensioned IRG (the number of Sp(S*) expansion regions).
SX	Dimensioned NUMXI-2.
SY	Dimensioned NUMETA.
COB	Dimensioned NMAX. Contains the conformal mapping transformation coefficients, B_n.
COC	Dimensioned NMAX. Contains the conformal mapping transformation coefficients, C_n.
XI	Dimensioned NUMXI. Contains the values of ξ for determining the computing grid data.
ETA	Dimensioned NUMETA. Contains the values of η for determining the computing grid data.

Constants

NMAX	Number of conformal mapping transformation coefficients, B_n or C_n .
NUMXI	Number of computing grid ξ lines. With respect to the computing grid in Program SSURGE, there is an extra ξ line at each lateral end. This requirement results from the averaging procedure used in determining the grid data.
NUMETA	Number of computing grid η lines. This is the same number as in Program SSURGE.

DELSS	The value in nautical miles of ΔS^*. This corresponds to DXI in Program SSURGE. Since in SSURGE the product, $\mu \Delta S^*$, is always computed in the surge equations, we determine DXI in meters such that μ values are dimensionless, i.e., $\mathrm{DXI} = 1852 \frac{\mathrm{m}}{\mathrm{nmi}} \times \Delta S^* \ \mathrm{nmi} \times \left[\mathrm{SLMAP} \frac{\mathrm{nmi}}{\mathrm{x,y\ unit}} \times \mu \ \mathrm{unit} \right]$
DELTT	The value in minutes at ΔT^*. This corresponds to DETA in Program SSURGE. Since in SSURGE, the product, $\nu \Delta T^*$, is always computed in the surge equations, we determine DETA in meters such that ν values are dimensionless, i.e., $\mathrm{DETA} = 1852 \frac{\mathrm{m}}{\mathrm{nmi}} \times \Delta T^* \ \mathrm{min} \times \left[\mathrm{SLMAP} \frac{\mathrm{nmi}}{\mathrm{x,y\ unit}} \times \nu \ \mathrm{unit} \right]$
SSSTRT	The first value of S^* in nautical miles.
ND	The number of water depths (fathoms) inputed from the seaward boundary to the coast for determining distance as a function of long wave traveltime.
NS	The number of points along XIDUM for determining η as a function of arclength S_n.
XLAMDA	Horizontal extent of the mapped region in units of x,y space.
XIDUM	The particular value of ξ used in determining $\eta(S_n)$.
SLMAP	The chart scale relating distance in nautical miles to distance in x,y units (i.e., nmi is equivalent to 51 units of length in x,y space).
G	Acceleration due to gravity ($\mathrm{feet} \cdot \mathrm{s}^{-2}$).
N4	The number of points used in determining ξ as a function of arclength Sp.
IRG	The number of expansion regions of SP(S^*) or t(T^*).

IQUAD and JQUAD	The area in x,y space of each grid quadrangle is subdivided into IQUAD intervals between ξ lines and JQUAD intervals between η lines.

8. Input and Output.

The first card input to Program GRID gives the number of conformal transformation coefficients NMAX , the number of ξ lines NUMXI, the number of η lines NUMETA, ΔS^* in nautical miles DELSS, the first value of S^* in nautical miles SSSTRT, ΔT^* in minutes DELTT, the number of water depths ND , and the number of points US used to establish $\eta = \eta(S_n)$.

The second card gives β and B_o and the next 150 cards give the mapping coefficients B_n and C_n . These 151 cards are the punched output from Program CONFORM.

The remaining 31 cards are the depths picked off a bathymetric chart of the northwestern Gulf of Mexico. These depths are on a constant ξ-line selected by the user.

Expansion coefficients, provided by the user, appear as statements within the program after format 135.

The reader must refer to Section III of Volume I of this report for an explanation of the parameters associated with the stretched shelf coordinate system for the Hurricane Carla surge simulation.

Output from GRID consists of the transform-generated coastline and seaward boundary coordinates, the transform-generated arclengths along the coastline and seaward boundary, and for each of the five sections, $\partial Sp/\partial S^*$, S^* , Sp , and ξ are listed. Additionally, the transform-generated arclengths at values of η for evenly spaced increments of T^* and at η values for constant increments of T along the chosen ξ-line, the η values along the specified ξ-line such that ΔT^* is constant, and the traveltime and depths along the constant ξ-line are printed.

The following output is required by Program SSURGE for simulating the Hurricane Carla surge. This includes the x,y coordinates of the grid intersections, the scale factors μ and ν related to the transformation of ξ to S^* and η to T^* , respectively, the scale factor F , and the sines and cosines of theta giving the orientation of the ξ-axis to the x-axis. The program listing indicates when these may be punched or written on tape or disk for convenient input to SSURGE.

```
C
C
C     INPUT   DATA
 150   47  15  6.0176.0  8.0   31   51
C
 2.1109529E&01 9.5078648E&01
-4.3493873E&01-6.8176833E&01
-3.1662011E&01 1.9427266E&01
 1.2422513E&01-1.1738220E&00
-5.0636502E&00-1.4470718E-02
 1.6711864E&00-1.9216334E&00
-3.5976884E&00-6.7330628E-01
 1.4192860E&00 1.3667185E&00
-1.1794944E&00-3.0913591E-01
 4.1190876E-01 1.3357793E-01
-3.7759354E-01 4.8326302E-03
 7.9716016E-02 5.3212199E-02
-1.0800307E-01 1.6050344E-01
-1.2900839E-02-1.5598876E-01
-5.9636976E-02 1.4032560E-01
-1.3795311E-02-6.3873108E-02
-3.5084819E-02 9.6181509E-02
 6.6049823E-03-4.1274305E-02
-1.4301171E-02 2.1339955E-02
 9.3927601E-03-2.2868277E-02
-1.1320465E-02 2.3924600E-02
-1.0776871E-03-2.2690670E-03
-1.2749315E-02 6.3207995E-03
 4.0667667E-03 1.4119754E-03
-1.6674068E-03 4.6394670E-04
 3.9955978E-04-2.6365887E-04
-1.8862189E-03 5.6826825E-04
 9.0772255E-04 7.6038904E-04
-1.5591983E-03-4.9427928E-04
 9.1903310E-04 3.3489094E-04
-1.1438246E-03-1.0357530E-04
 3.7952317E-04 1.7815754E-04
-6.7125324E-04 9.4876230E-05
 4.3712874E-04-5.7567649E-06
-5.8352881E-04 1.4706647E-04
 1.8351595E-04-3.2129894E-05
-2.5129644E-04 3.0412098E-04
-1.0435642E-05-2.4449992E-04
 1.0222874E-05 2.3269936E-04
-8.8439003E-06-1.9700862E-04
-1.2788127E-05 1.5418616E-04
-2.6134267E-05-9.3259390E-05
-1.4402952E-05 1.0334477E-04
-5.0798231E-06-5.2779377E-05
-2.3834472E-05 3.2466107E-05
 2.6851103E-05-2.6723894E-06
-4.3115519E-05-2.0363452E-06
 2.6351927E-05 1.1422953E-05
-2.3699234E-05 2.3080753E-06
 1.0604752E-05-2.8166598E-06
-1.1909960E-05 5.3967162E-06
 7.9691199E-06-7.3427355E-07
-9.4350325E-06 3.0569014E-06
 3.5921445E-06-2.8028600E-06
-3.1637869E-06 5.2027666E-06
 8.0697328E-07-3.2049353E-06
-3.1561970E-06 2.9766627E-06
 2.0821353E-06-3.1002452E-07
-2.7802158E-06 7.3753532E-07
 1.1309917E-06-7.1686702E-07
-6.1223962E-07 1.4500429E-06
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-3.3654205E-07 1.1018965E-06
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-3.0120364E-07 5.2354470E-07
-3.6734064E-09-3.5825709E-07
-1.4140850E-07 4.2440585E-07
 7.3883689E-08-1.2894558E-07
-3.2262466E-07 5.8860751E-08
 2.7314736E-07 1.0023264E-07
-2.8025699E-07-3.2327544E-08
 1.2341097E-07 1.0892806E-08
-9.4987154E-08 8.2818260E-08
 1.9075643E-08-6.2296973E-08
-3.8559006E-08 7.6237884E-08
 1.2275724E-08-4.7253453E-08
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-4.7725860E-09-3.9176467E-08
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-3.1784570E-08-4.0184008E-11
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-2.8336831E-08-5.5426978E-09
 1.3901584E-08 4.2920931E-09
-1.0413049E-08 3.6289344E-09
 2.9425597E-09-3.9004828E-09
-2.4943488E-09 7.0901496E-09
-2.1406560E-09-6.0237420E-09
 1.8588779E-09 8.3994990E-09
-3.7924576E-09-6.9248194E-09
 1.9027985E-09 6.0966206E-09
-9.6309918E-10-2.9732490E-09
-1.5450322E-09 1.5369158E-09
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-2.4545629E-09-5.5504161E-10
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-2.0184501E-09-6.3272967E-10
 1.3540433E-09 7.4956038E-10
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 5.6070780E-10 9.2289986E-11
-2.8726818E-10 3.0458069E-10
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 8.7366526E-11 3.4544234E-10
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 3.5082522E-11 7.7559977E-12
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-2.0626798E-11 5.8511549E-12
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-1.0974893E-11 6.7709536E-12
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-4.5852351E-13-5.9469672E-12
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-6.7456496E-13 1.1497485E-13
 2.6952090E-13-1.5477038E-13
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 1.7026387E-14 2.9116468E-13
 1.2898778E-15-1.2329175E-13
-1.0197886E-13 9.0332572E-14
 9.0036274E-14-6.3540502E-15
-1.2530695E-13-1.0823757E-15
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 7.0773632E-14 2.4508613E-14
-6.2031906E-14 3.0256047E-15
 3.4432727E-14-1.1037802E-14
-1.9762800E-14 3.7600672E-14
95.
63.
53.
46.
39.
32.
30.
28.
28.
26.5
25.
23.5
22.
21.
21.
20.7
18.5
17.5
16.
15.3
14.5
13.5
12.7
11.
11.
11.
10.5
9.
7.5
4.5
2.
```

IV. COMPUTER PROGRAM DOCUMENTATION FOR PROGRAM-SSURGE

1. Program Purpose.

The purpose of the program is to numerically simulate the storm surge in orthogonal curvilinear coordinates with the vertically integrated form of the quasi-linear long-wave equations.

2. Program Description.

The program is written in FORTRAN IV language. It is assumed that the conformal mapping of the region under investigation has been completed. The transformation coefficients for three regions of the continental shelf of the Gulf of Mexico and two regions of the eastern seaboard are provided in Appendixes A and E in Volume I of this report.

An interfacing program is required which inputs the coefficients and generates a curvilinear computing grid to the user's satisfaction. The output from the program (and, in part, also the input to SSURGE) must be the scale factors, grid point locations, and, at each grid point, the orientation of the ξ-axis to the x-axis.

The Program SSURGE is composed of:

MAIN	Defines constants and interfaces the subroutines.
SUBROUTINE ZERO	Initializes all arrays to zero.
SUBROUTINE FIELD	Reads data and writes the water depth field relative to mean sea level, the wind field parameters and the storm positions.
SUBROUTINE WINDF	Calculates the wind and atmospheric pressure fields.
SUBROUTINE ELEV	Computes the water level anomaly, H .
SUBROUTINE FLUX	Computes transports, Q_{S*} and Q_{T*} .
SUBROUTINE DRAW1	Outputs H and vertically averaged water velocities, $Q_{S*}/\overline{D}$ and $Q_{T*}/\overline{D}$, at hourly time intervals and saves the water level anomaly at prescribed grid locations for output at program completion.

SUBROUTINE METER	Calculates and saves the vertically averaged water velocities at prescribed grid locations for output at program completion.
SUBROUTINE HUV	Outputs the saved information of the simulated hydrographs, simulated current meters, and observed water levels at program completion.

3. Type of Computer.

The program SSURGE may be run on any computer with minimum core requirements of approximately 30K words of memory (based on the present sample program appropriate to the Hurricane Carla surge simulation). The program has been executed successfully on the IBM 360, CDC/6600 and 7600, and GE/635. The present sample program requires no auxiliary storage devices, peripheral devices or magnetic tape input or output. No site-dependent computer plot routines are involved in the program. Approximately 14.4 minutes of machine time on a GE/635 is required for the sample program to complete 66 hours of surge simulation.

4. Input Data.

Input data, other than constants defined in MAIN, are read in SUBROUTINE FIELD. These data are on cards prepared according to the following list.

(1) Card 1

NT1 - Number of cards (max. 50) containing on each TIM, ROT, RAD, VRMAX and PZRO (format I5).

(2) Card Group 2

NT1 cards with each card containing values of

a) TIM The time in hours at which the hurricane wind and atmospheric pressure parameters are recorded (format F10.1).

b) ROT The angle in degrees between the direction the storm is moving and the region of maximum winds (format F10.1).

c) RAD The distance in nautical miles from the storm center to the region of maximum winds (format F10.1).

d)	VRMAX	Maximum observed windspeed in knots (format F10.1).
e)	PZRO	Atmospheric pressure in millibars of the storm center (format F10.1).

(3) Card 3

NT2 - Number of cards (max. 150) containing on each TIMPOS, XPOS and YPOS (format I5).

(4) Card Group 4

NT2 cards with each card containing values of

a)	TIMPOS	The time in hours at which the hurricane position is recorded (format F10.1).
b)	XPOS	The x-coordinate in units of x,y space of the hurricane center (format F10.1).
c)	YPOS	The y-coordinate in units of x,y space of the hurricane center (format F10.1).

(5) Card Group 5

GRID2 The fluid depth in fathoms relative to mean sea level along each column, i=1,2..IM, is read with a nested do-loop for j=1,2..JM (format 11F7.2). The program will zero those values for even i+j prior to computations. The depth data are positive numbers which the program converts to negative values (in meters) to be consistent with the coordinate system.

(6) Card Group 6

S The values of the dimensionless scale factor relating the (x,y) plane to the (ξ,η) plane are read along each column, i=1,2..IM, with a nested do-loop for j=1,2..JM (format 5E14.7).

(7) Card Group 7

DSDXI The values of the dimensionless scale factor, μ, transforming ξ to S^* are read with one value per card for i=1,2..IM (format E14.7).

(8) Card Group 8

DTDET	Values of the dimensionless scale factor ν transforming η to T^* are read with one value per card for j-1,2..JM (format 2X,E14.7).

(9) Card Group 9

HOBS1	The values of the observed hourly water level in feet at grid location (IH1, JH1) are read with 19 values per card in format F4.1.

(10) Card Groups 10 through 14

HOBXk	The values of the observed hourly water level in feet at grid location (IHk, JHk) are read sequentially with the same format as above.

(11) Card Group 15

XX, YY	The paired x,y coordinates (units in x,y space) of the computational grid points are read along each column, 1-1,2..IM, with a nested do-loop for j=1,2..JM (format 10F7.2).

(12) Card Group 16

COSG, SING	The paired values of the cosine θ and sine θ where θ is the angle between the ξ and x axis are read along each column, i=1,2..IM, with a nested do-loop for j=1,2..JM (format 10F8.5).

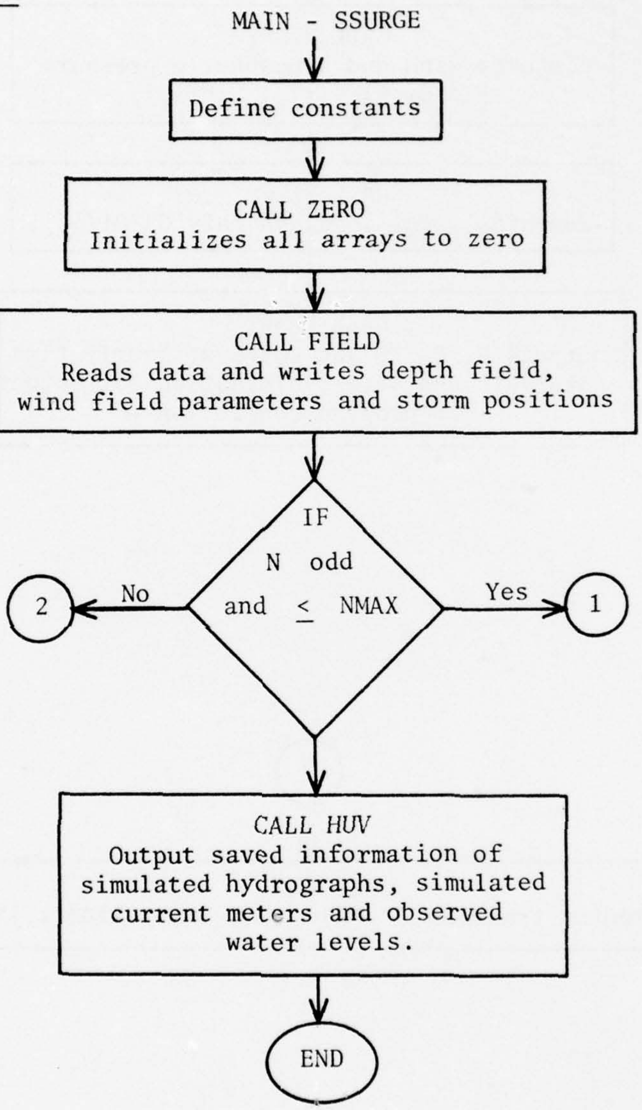
A computer printout of the sample program and data cards are given later in this section.

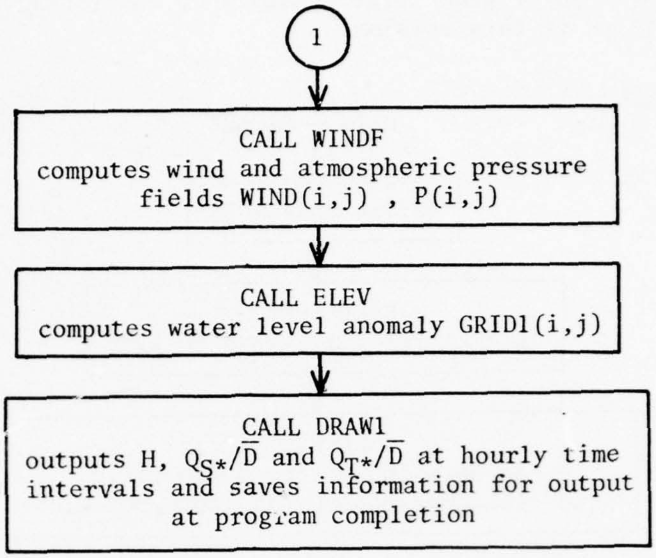
5. Mathematical Procedures and Program Limitations.

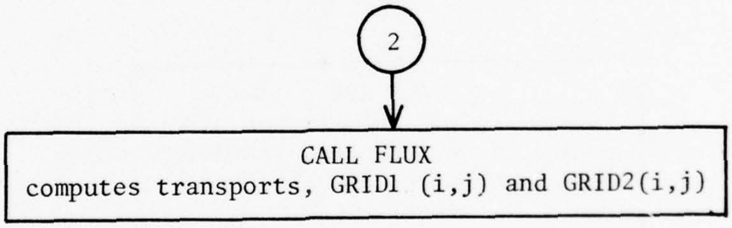
The storm surge equations, solutions, and algorithms are described in the text of Volume I of this report.

Basically, the model utilizes a centered difference, leapfrog analog of the vertically integrated, quasi-linear form of the long-wave equations. The algorithm treats the time dependency explicitly and employs a computing lattice in which the transports, Q_{S*} and Q_{T*}, are computed at the same location but are staggered in time and space with respect to the water level anomaly. The program assumes that seabed scouring does not occur. No program error messages or consistency checks are incorporated in this version.

6. Flow Chart.




1
CALL WINDF
computes wind and atmospheric pressure fields WIND(i,j) , P(i,j)
CALL ELEV
computes water level anomaly GRID1(i,j)
CALL DRAW1
outputs H, $Q_{S*}/\overline{D}$ and $Q_{T*}/\overline{D}$ at hourly time intervals and saves information for output at program completion


2
CALL FLUX
computes transports, GRID1 (i,j) and GRID2(i,j)

7. Glossary and Description of Terms.

Arrays

GRID1	Dimensioned IM × JM. Contains H values in meters at odd i+j and Q_{S*} in meters squared per second at even i+j .
GRID2	Dimensioned IM × JM. Contains fluid depth values, D_o , in meters at odd i+j and Q_{T*} in meters squared per second at even i+j .
S	Dimensioned IM × JM. Contains dimensionless scale factor, F, determined from the conformal mapping of (x,y) space to (ξ,η) space.
DSDXI	Dimensioned IM. Contains the dimensionless scale factor, μ, transforming ξ to S* .
DTDET	Dimensioned JM. Contains dimensionless scale factor, ν , transforming η to T* .
XX	Dimensioned IM × JM. Contains the x-coordinate in units of (x,y) space of the grid point locations.
YY	Dimensioned IM × JM. Contains the y-coordinate in units of (x,y) space of the grid point locations.
COSG	Dimensioned IM × JM. Contains cosine values of θ relating the orientation of the ξ-axis to the x-axis at the computational grid points.
SING	Dimensioned IM × JM. Contains sine value of θ relating the orientation of the ξ-axis to the x-axis at the computational grid points.
WIND	Dimensioned IM + 1 × JM. Contains values of the windspeed in meters per second. At a transport computational grid point (i,j), the S*-component is stored in WIND at (i,j) and the T*-component is stored at (i+1,j).
P	Dimensioned IM × JM. Contains values of H_B (the hydrostatic elevation in meters of the sea surface corresponding to the atmospheric pressure anomaly) and stored at odd i+j.
HOBSk k=1,2..6	Each array is dimensioned 67. Contains the observed hourly water levels in meters at grid locations (IHk, JHk).

HYDk k=1,2..6	Each array is dimensioned 300. Contains values of the computed water level H in meters at grid locations (IHk, JHk).
UCMk k=1,2..6	Each array is dimensioned 300. Contains values of the vertically averaged water velocity, $Q_{S*}/\overline{D}$, in meters per second at grid location (ITk, JTk).
VCMk k-1,2..6	Each array is dimensioned 300. Contains values of the vertically averaged water velocity, $Q_{T*}/\overline{D}$, in meters per second at grid location (ITk, JTk).
TIM	Dimensioned 50. Contains the time in hours at which the wind and atmospheric pressure field parameters (ROT, RAD, VRMAX and PZRO) are recorded.
ROT	Dimensioned 50. Contains the angle in degrees between the direction the storm is moving and the region of maximum winds.
RAD	Dimensioned 50. Contains the distance in nautical miles from the storm center to the region of maximum winds.
VRMAX	Dimensioned 50. Contains the maximum observed windspeed in knots.
PZRO	Dimensioned 50. Contains the atmospheric pressure in millibars of the storm center.
TIMPOS	Dimensioned 150. Contains the time in hours at which the storm position is recorded.
XPOS	Dimensioned 150. Contains the x-coordinate in units of (x,y) space of the storm center.
YPOS	Dimensioned 150. Contains the y-coordinate in units of (x,y) space of the storm center.

Constants

IM	Number of grid points in the S* direction.
JM	Number of grid points in the T* direction.
NMAX	Maximum number of time steps.

INC	Number of time steps between saving of surge results in HYDk, UCMk and VCMk. INC must be an even integer number.
DXI	Grid *increment* in *meters* in the S* direction.
DETA	Grid increment in units of meters in the T* direction. The units of DTDET·DETA (that is, $\nu \cdot \Delta T^*$) are in meters.
DELT	Time increment in seconds. DELT must be less than that required for numerical stability and, also, be an even integer multiple of 60 minutes.
GRAV	Acceleration due to *gravity* (=9.8 meters per second squared).
F	Dimensionless seabed drag coefficient (=0.0025).
IHk,JHk k=1,2..6	Grid point location for saving the computed water level. The sum of the indexes must be odd. Index IHk cannot exceed IM. Index JHk cannot exceed JM.
ITk,JTk k=1,2..6	Grid point location for saving the vertically averaged water velocities. *The sum of the* indexes must be even. Index ITk cannot exceed IM. Index JTk cannot exceed JM-1.
CORIO	Coriolis parameter (=6.70875 × 10^{5} second^{1}) for latitude 27° 23.232' N.
PHI	Wind ingress angle in units of degrees.
PINF	Far field atmospheric pressure in millibars (=1016 millibars).

Comments

1. A symmetric analytical hurricane wind field representation as given by C. Jelesnianski (1965, A numerical calculation of storm tides induced by a tropical storm impinging on a continental shelf, *Mon. Wea. Rev.*, 94, 379-394) is employed in the surge model).

2. The wind stress coefficients, K_1 and K_2 , are 1.1×10^{-6} and 2.5×10^{-6} and are defined in SUBROUTINE FLUX.

3. Constants YRANGE, THIT, XHIT and YHIT are not used in this program version.

8. Input and Output.

Data statements in Program SSURGE establish the number of computational points, number of time steps, output interval, values of the grid and time steps, acceleration due to gravity, bottom stress coefficient, and locations of the simulated hydrographs and current meters, and the Coriolis parameter corresponding to latitude 27° 23.232' N.

Card input provides the number (NT1) of hurricane description sets, followed by NT1 cards giving the time (in hours after start of computations) and the three required storm parameters. These are succeeded by one card giving the number (NT2) of hurricane positions to be used, followed by NT2 cards providing the time and storm center positions in the original arbitrary Cartesian grid (see Volume I of this report). NT1 need not be equal to NT2, nor must the observed storm parameters and positions coincide in time.

For the Carla surge computations, the hurricane characteristics are stipulated at 6-hour intervals for the first 18 hours and at 3-hour intervals for the remainder of the 66-hour prototype time simulation. Note the radius to maximum winds are in *nautical miles,* the maximum winds are in *knots,* and the central pressures are in *millibars.* Due to the erratic movement of Hurricane Carla, the coordinates of the center of the storm are specified at hourly intervals, except for a single 6-hour interval spanning the end of the simulation. These coordinates are specified in x,y space (100 units = 219 kilometers).

The depth field, in *fathoms,* is introduced followed by the array of scale factors, S . The array of scale factors, DSDXI (an alias for μ) is read along the specified row and the scale factor array DTDET (an alias for ν) is specified along the chosen column.

The following six arrays are the observed hourly water levels (in feet) from Padre Island (HOBS1), Aransas Pass (HOBS2), Port O'Connor (HOBS 3), Pleasure Pier, Galveston (HOBS4), Mud Bayou (HOBS5), and Sabine Pass (HOBS6). These data are not necessary for any phase of the surge calculations and may be omitted.

The last two arrays input to SSURGE give the coordinates (XX,YY) of the grid points in units of x,y space, and the sines and cosines of theta at the computational points.

All input not in the MKS system of units is converted internally to the MKS system.

The storm parameters, hurricane center coordinates, and depth field are printed out immediately following input. At hourly time intervals, the water level anomalies and the depth averaged velocity component fields are printed. The six simulated hydrographs and current meters are printed out with their positions and the corresponding observed water levels at the completion of the surge simulation.

```
C
C
C     The following data are required for the Hurricane Carla surge
C     simulation.  The reader is referred to the documentation of
C     Program GRID for definition of the scale factors, grid point
C     coordinates, and the sines and cosines of theta.
C
C
C
C
C
C
C
C
 21      HURRICANE CARLA STORM PARAMETERS
     0.          60.         23.         90.        949.
     6.          35.         22.         95.        943.
    12.          65.         21.        100.        940.
    18.          65.         24.        100.        937.
    21.          60.         23.        100.        937.
    24.          80.         22.        100.        937.
    27.          65.         25.        100.        937.
    30.          80.         27.        100.        936.
    33.         150.         19.        100.        936.
    36.          15.         21.        100.        936.
    39.          15.         20.        100.        937.
    42.          65.         22.        100.        937.
```

```
      45.         23.         26.        100.        937.
      48.         65.         28.        100.        938.
      51.        105.         28.         95.        938.
      54.        160.         33.         90.        939.
      57.        145.         62.         70.        940.
      60.        158.         98.         55.        942.
      63.        136.        142.         55.        943.
      66.        140.        167.         50.        945.
      69.        117.        200.         55.        947.
62        HURRICANE CARLA TRACK
       0.        249.7       -82.1
       1.        247.9       -75.3
       2.        245.4       -68.5
       3.        243.1       -61.0
       4.        238.1       -53.1
       5.        232.8       -50.0
       6.        225.3       -44.3
       7.        219.0       -37.7
       8.        213.5       -32.0
       9.        208.9       -26.5
      10.        204.8       -21.2
      11.        203.2       -12.6
      12.        199.2        -8.1
      13.        191.7        -6.2
      14.        188.0        -4.1
      15.        188.0        -1.0
      16.        188.9         3.1
      17.        189.9         9.0
      18.        191.0        13.4
```

```
    19.      192.1      18.5
    20.      192.1      25.0
    21.      191.9      31.0
    22.      190.2      38.0
    23.      188.5      43.8
    24.      182.7      48.2
    25.      181.1      51.3
    26.      181.3      54.9
    27.      184.0      61.2
    28.      186.0      69.0
    29.      186.8      74.0
    30.      182.3      81.0
    31.      177.5      88.7
    32.      172.0      93.3
    33.      162.4      92.4
    34.      155.6      93.2
    35.      152.7      95.7
    36.      152.8      98.1
    37.      154.3     103.1
    38.      156.3     107.1
    39.      158.9     112.8
    40.      158.0     121.0
    41.      152.2     131.3
    42.      145.0     134.9
    43.      141.6     130.2
    44.      145.1     126.8
    45.      148.8     129.4
    46.      151.9     136.7
    47.      155.5     146.3
    48.      157.0     152.2
    49.      157.4     158.2
```

```
            50.        158.9      164.8
            51.        160.1      174.1
            52.        162.7      183.5
            53.        161.0      190.6
            54.        160.0      195.5
            55.        158.8      200.1
            56.        158.6      204.5
            57.        159.3      213.4
            58.        160.4      220.9
            59.        167.0      232.2
            60.        170.3      239.9
            66.        193.8      303.7
  110.00   32.50   26.50   24.00   23.00   22.00   21.00   17.00   15.00   13.00   11.00
    9.00    9.00    7.00    2.30
   95.00   37.00   27.00   24.00   23.50   21.70   21.00   18.50   16.00   12.00   10.00
    9.00    8.00    7.00    2.30
  100.00   52.00   39.00   35.00   26.00   23.00   21.50   19.50   17.00   16.00   13.00
   10.20    8.00    6.50    2.30
  100.00   54.00   44.00   35.00   32.00   26.50   23.50   21.00   18.50   16.00   14.00
   12.00    9.00    7.70    2.30
  100.00   57.00   46.00   38.00   33.00   29.00   25.00   22.00   19.00   17.00   14.40
   12.50    9.00    7.70    2.00
  100.00   57.00   41.00   37.00   33.00   28.50   24.00   22.00   18.00   16.00   14.00
   12.50    9.00    7.00    2.00
  105.00   58.00   46.50   38.00   33.00   28.00   25.00   21.50   18.50   16.00   14.00
   12.50    9.50    6.50    1.70
  105.00   58.00   47.00   38.00   32.00   29.00   25.00   22.00   18.00   16.00   13.00
   12.00    9.50    7.00    1.50
  105.00   57.00   46.00   40.00   32.00   28.00   25.50   21.00   17.50   15.00   13.50
   11.70    8.00    6.50    1.50
  100.00   59.00   48.50   37.00   33.00   27.00   24.00   20.00   17.00   15.00   12.50
```

```
 10.70    8.50    6.00    1.50
108.00   60.00   47.00   36.00   33.00   28.00   23.50   19.00   16.50   14.00   12.00
 10.50    8.00    6.00    1.50
108.00   61.00   47.00   37.50   32.00   27.00   22.00   19.00   16.00   14.00   12.00
 10.00    8.00    6.00    1.50
102.00   61.00   36.00   36.00   31.00   27.00   22.00   17.50   15.70   13.00   11.70
  9.50    8.00    6.00    1.50
108.00   60.00   40.00   35.00   30.00   25.00   21.50   18.00   15.00   13.50   11.50
  9.00    7.70    5.50    1.30
110.00   55.00   35.00   33.00   26.50   22.50   20.00   16.00   14.00   13.00   11.50
 11.00    7.70    5.50    1.30
102.00   36.00   31.00   27.50   24.00   21.00   17.50   15.00   13.70   12.70   11.50
 11.00    7.70    5.50    1.30
110.00   35.00   31.00   25.00   22.50   20.00   17.00   14.00   12.50   12.00   11.50
  9.50    8.00    6.00    1.30
115.00   34.50   29.00   25.00   21.50   18.00   16.00   13.70   13.00   11.50   11.00
  9.00    8.00    6.00    1.30
100.00   34.00   28.00   24.00   21.50   18.00   15.00   13.50   12.50   11.50   10.50
  8.50    7.50    5.50    1.30
100.00   34.00   27.00   24.00   21.00   17.50   15.50   14.00   12.00   11.50   11.00
  8.70    7.00    5.50    1.30
100.00   35.00   27.00   24.00   20.50   16.50   15.00   14.50   14.00   11.00   10.00
  8.50    7.00    5.50    1.30
100.00   36.00   27.00   24.00   20.50   17.50   15.70   15.70   14.00   11.00   10.00
  8.70    7.50    5.50    1.20
102.00   34.00   26.50   22.00   19.00   18.00   16.00   15.00   13.00   10.50   10.00
  8.00    7.30    5.50    1.20
100.00   35.00   27.00   23.00   18.50   18.00   16.00   15.00   14.00   10.50   10.00
  9.00    7.30    5.00    1.20
100.00   36.00   27.00   22.00   19.00   18.50   16.00   15.00   13.50   12.00   10.00
  7.00    6.20    4.00    1.00
```

```
100.00   30.00   26.70   21.00   21.00   18.00   16.00   15.00   13.00   11.50   11.00
 10.00    7.00    4.00    1.20
 95.00   32.00   26.00   21.00   20.50   17.00   15.00   14.20   12.00   11.00   11.00
  9.00    8.00    5.00    1.20
100.00   31.00   26.00   21.00   19.00   17.00   15.00   14.00   11.50   10.50   10.50
  9.00    8.00    5.50    1.20
 95.00   31.00   24.50   21.50   19.00   17.00   15.00   12.50   11.00    9.00   10.50
  9.00    7.70    5.70    1.20
100.00   31.50   24.00   21.50   18.50   16.00   14.50   11.50   11.00    9.00    9.50
  9.00    7.50    5.70    1.20
 90.00   31.00   24.00   21.50   18.50   15.00   13.00   10.00   11.00    9.00    9.00
  9.00    7.50    5.40    1.20
 90.00   31.00   26.00   21.00   18.00   14.00   13.00   10.00   10.50    9.00    9.00
  9.00    7.50    5.00    1.20
 90.00   32.00   26.00   21.00   18.00   15.50   14.00   11.00    8.50    8.70    8.70
  8.50    7.00    5.00    1.20
100.00   33.00   26.50   21.50   17.50   15.00   13.50   11.00    6.50    8.50    8.50
  8.00    7.00    5.20    1.20
105.00   37.00   27.00   21.50   17.00   14.00   13.00   11.00    7.50    7.50    7.50
  8.00    7.00    5.30    1.20
 95.00   37.50   28.00   20.50   16.00   13.50   12.50   10.50    9.00    8.50    7.20
  7.20    6.70    5.30    1.20
 95.00   37.00   28.00   19.50   14.50   13.00   12.50   11.00   10.00    8.00    7.00
  7.00    6.30    5.00    1.20
 95.00   36.00   27.50   18.00   18.00   12.00   12.00   10.50    9.00    8.00    7.20
  5.00    6.30    4.00    1.00
 90.00   35.50   26.00   19.00   14.50   11.50   11.50   11.50    8.50    7.50    7.50
  5.00    6.00    4.00    1.00
 95.00   34.00   26.00   19.00   15.00   11.00   12.00   11.00    8.70    8.00    7.00
  5.00    6.00    4.20    1.00
110.00   34.00   23.50   19.00   14.70   13.00   13.00   11.00    9.00    9.00    6.00
```

```
   6.50    5.50    3.50    1.00
  90.00   33.00   24.00   18.00   14.00   13.70   13.50   10.00    9.00    8.50    7.50
   6.50    5.30    4.00    1.00
 100.00   30.00   24.00   18.50   14.50   12.00   12.50   10.00   10.00    8.70    8.00
   7.00    5.50    3.50    1.00
  95.00   32.50   23.00   17.50   16.00   14.00   12.50   11.50    9.50    9.00    8.00
   7.00    5.00    3.00    1.00
 100.00   32.00   23.00   18.00   14.50   12.00    9.00    7.00    4.50    4.00    4.50
   4.50    3.50    2.00    1.00
1.0172672E+00 9.9516271E-01 9.4466743E-01 9.1536421E-01 8.9332403E-01
8.7534267E-01 8.5939932E-01 8.4452997E-01 8.3051112E-01 8.1688751E-01
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1.0423636E+00 1.0918313E+00 1.1416816E+00 1.1926742E+00 1.2470160E+00
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2.2581083E+00   2
1.8063600E+00   3
1.3889950E+00   4
1.1300950E+00   5
1.0143083E+00   6
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7.5768167E-01   18
7.2820500E-01   19
7.1056167E-01   20
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3.7770917E-01   33
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4.1661167E-01   37
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4.9022000E-01   40
5.2170083E-01   41
5.5028417E-01   42
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  1.1034909E+00     1
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  6.0627519E-01     3
  4.6429162E-01     4
  3.7648970E-01     5
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  2.0193244E-01    13
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  1.2858375E-01    15
  .   .   .   .   .   .   .   .   .   .   .   .  3.1 3.2 3.5 3.7 3.8 3.9 3.9 PI1
 3.8 3.8 3.8 3.8 3.8 3.9 3.9 4.1 4.1 4.0 4.1 4.1 4.0 4.1 4.0 4.0 4.2 4.1 4.1 PI2
 4.2 4.1 4.3 4.4 4.0 4.0 4.0 3.8 3.7 3.9 3.6 3.5 3.8 3.7 3.8 3.9 3.6 3.6 3.5 PI3
  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  PI4
 2.3 2.5 2.6 2.7 2.6 2.5 2.4 2.4 2.4 2.8 3.0 3.1 3.3 3.5 3.7 3.9 4.0 4.1 4.2 PA1
 4.2 4.2 4.3 4.4 4.6 4.7 4.9 5.0 5.1 5.2 5.3 5.0 5.2 5.5 5.7 6.1 6.5 7.0 7.3 PA2
 7.5 7.8 8.0  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  PA3
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 5.7 6.0 5.9 6.0 6.1 6.3 6.4 6.7 6.9 7.1 7.3 7.5 7.8 8.2 8.4 8.7 9.3 9.610.0 PO2
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  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  PO4
 3.2 3.3 3.2 3.4 3.7 3.9 3.7 3.7 3.7 4.0 3.8 4.8 5.0 5.1 5.0 5.1 5.4 6.2 5.8 PP1
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8.5 8.2 8.2 8.2 8.5 8.8 8.6 8.1 8.1 8.1 8.0 8.0 8.6 8.5 7.8 8.0 7.9 7.3 7.2 PP3
7.4 6.6 6.6 5.9 6.0 6.4 6.3 6.2 6.2 5.7 5.2                                 PP4
2.2 2.3 2.4 2.5 2.8 2.9 3.1 3.1 3.1 2.9 2.7 2.6 2.6 2.4 2.3 2.4 2.5 2.6 2.6 MB1
3.0 3.7 4.3 4.6 5.0 5.4 5.6 5.7 5.9 6.1 6.3 6.7 6.9 7.1 7.2 7.2 7.3 7.3 7.5 MB2
7.7 8.0 8.2 8.4 8.6 8.7 8.9 8.7 8.5 8.2 8.2 8.2 8.4 8.6 8.6 8.6 8.6 8.5 8.4 MB3
8.2 8.0 8.0 8.0 8.0 8.0 8.1 8.1 8.2 8.2 8.2 8.1 8.2 8.2 8.2 8.2  .   .   .  MB4
3.4 3.3 3.3 3.3 3.5 3.5 3.1 2.8 3.0 3.2 3.2 3.7 3.9 4.2 4.7 4.7 5.0 5.0 5.3 SP1
5.4 5.4 5.5 5.3 5.4 5.8 5.6 5.7 6.0 6.1 6.4 6.2 6.2 6.2 6.1 6.1 6.1 6.0 6.0 SP2
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5.4 5.7 5.6 5.9 5.7 5.8 5.8 6.3 6.2 5.9 5.8 5.3 4.8 4.4 4.0 4.1  .   .   .  SP4
103.01   74.99   95.97   80.17   91.56   83.09   88.30   85.18   85.80   86.74
 83.71   88.02   81.80   89.16   80.02   90.20   78.37   91.14   76.85   91.99
 75.35   92.79   73.93   93.53   72.65   94.17   71.63   94.66   70.90   95.00
112.05   89.59  103.36   92.98   98.57   95.32   95.06   97.12   92.38   98.51
 90.10   99.68   88.01  100.73   86.04  101.70   84.18  102.59   82.45  103.38
 80.76  104.14   79.12  104.83   77.65  105.43   76.48  105.89   75.64  106.20
114.46  100.83  107.91  103.32  103.63  105.47  100.31  107.25   97.65  108.70
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.99285 -.11940  .99823 -.05949  .99973  .02337  .99121  .13227  .97918  .20300
.79843 -.60209  .85892 -.51211  .89870 -.43855  .92041 -.39095  .93517 -.35419
.94671 -.32210  .95667 -.29116  .96565 -.25985  .97376 -.22758  .98103 -.19385
.98763 -.15677  .99300 -.11807  .99615 -.08762  .99650 -.08362  .99596 -.08982
```

```
.80272 -.59636  .86002 -.51026  .89583 -.44441  .91604 -.40109  .92978 -.36812
.94054 -.33968  .94988 -.31261  .95832 -.28568  .96596 -.25870  .97273 -.23193
.97866 -.20548  .98297 -.18376  .98438 -.17607  .98173 -.19030  .97651 -.21549
.80179 -.59760  .85830 -.51315  .89318 -.44969  .91094 -.41253  .92300 -.38480
.93245 -.36130  .94065 -.33937  .94806 -.31808  .95475 -.29739  .96070 -.27759
.96614 -.25804  .97116 -.23842  .97599 -.21781  .98034 -.19732  .98343 -.18127
.82272 -.56845  .86571 -.50054  .89152 -.45299  .90628 -.42268  .91629 -.40051
.92410 -.38215  .93085 -.36540  .93693 -.34952  .94240 -.33448  .94720 -.32063
.95137 -.30805  .95478 -.29731  .95829 -.28580  .96486 -.26277  .96849 -.24904
.82930 -.55880  .86722 -.49792  .89070 -.45460  .90213 -.43146  .90987 -.41490
.91579 -.40165  .92082 -.38999  .92531 -.37921  .92940 -.36908  .93304 -.35977
.93597 -.35207  .93632 -.35115  .92833 -.37176  .90009 -.43571  .87539 -.4834
.86681 -.49863  .88012 -.47474  .89045 -.45509  .89694 -.44215  .90120 -.43340
.90410 -.42733  .90620 -.42285  .90787 -.41925  .90947 -.41576  .91151 -.41128
.91498 -.40350  .92196 -.38729  .93617 -.35156  .95943 -.28196  .97113 -.23855
.90070 -.43445  .89046 -.45506  .89036 -.45525  .89325 -.44957  .89472 -.44662
.89493 -.44620  .89418 -.44771  .89274 -.45057  .89106 -.45389  .88980 -.45635
.88981 -.45633  .89168 -.45266  .89291 -.45023  .88477 -.46604  .87805 -.47857
.92147 -.38845  .89657 -.44290  .89003 -.45591  .88974 -.45646  .88829 -.45928
.88531 -.46500  .88077 -.47355  .87469 -.48469  .86728 -.49781  .85900 -.51197
.85034 -.52623  .84349 -.53714  .84323 -.53755  .85462 -.51926  .86235 -.50631
.92608 -.37732  .89746 -.44110  .88936 -.45721  .88767 -.46047  .88411 -.46727
.87842 -.47789  .87033 -.49247  .85951 -.51113  .84566 -.53371  .82847 -.56004
.80644 -.59132  .77884 -.62722  .74684 -.66501  .71381 -.70034  .69442 -.71957
.89096 -.45409  .88837 -.45913  .88977 -.45640  .88870 -.45849  .88386 -.46774
.87594 -.48243  .86466 -.50237  .84939 -.52777  .82942 -.55862  .80363 -.59513
.76860 -.63973  .72071 -.69324  .65803 -.75299  .58212 -.81310  .52378 -.85185
.83846 -.54496  .87963 -.47565  .90023 -.43541  .90256 -.43056  .89834 -.43929
.89011 -.45575  .87807 -.47854  .86183 -.50719  .84105 -.54095  .81540 -.57889
.78316 -.62182  .74425 -.66791  .70267 -.71152  .66849 -.74372  .64624 -.76314
.87400 -.48593  .92811 -.37230  .94366 -.33092  .94736 -.32016  .94562 -.32526
```

```
.94090 -.33868  .93360 -.35831  .92358 -.38340  .91067 -.41314  .89473 -.44661
.87471 -.48465  .85035 -.52622  .82288 -.56822  .79417 -.60770  .77273 -.63473
```

APPENDIX A

FORTRAN Listing of Program CONFORM

```
C   PROGRAM CCNFORM. DETERMINES TRANSFROMATICN COEFFS FOR CONFORMAL
C     MAPPING OF INTERIOR REGION BOUNDED BY 2 CURVES INTO RECTANGLE.
C
        DIMENSICN  X2(150) ,  Y2(150)
        DIMENSICN X2P(150) , Y2P(150)
        DIMENSICN    COB(200) , COC(200)
C
        COMMON/YB/ X2, Y2 , MQ
        COMMON/YA/ X2P , Y2P , MQP
        COMMON/COEF/         VARWT,JMAX1,IL
        CCMMCN/FORIA/         COB , COC              , BZRO,XK,NMAX
C
C       READ CONTINUATION FLAG, NUMBER OF SHORELINE COORDS, NUMBER OF
C       SEAWARD BORY COORDS, NUMBER OF COEFFS, MAX NUMBER OF ITERATIONS,
C       NUMBER OF INTEGRATION POINTS AND CONVERGENCE CRITERION
         READ(5,1)IWANT, MQ, MQP, NMAX, JMAX1, IL, VARWT
      1 FORMAT (6FI5, F5.3)
C
C
C
C   READ COORDS DELINEATUNG SHORELINE
        DO 20 L=1,MQ
        READ(5,11)          X2(L) , Y2(L)
 11     FORMAT(      3X , F7.2 , 3X , F7.2 )
 20     CONTINUE
C   READ COORDS DELINEATING SEAWARD BDRY
        DO 30 J=1,MQP
         READ (5,31) X2F(J) , Y2P(J)
 30     CONTINUE
 31     FORMAT( F7.2 , 3X , F7.2 )
C
```

```
      PI= 3.1415927
      XLAMDA= X2(MQ)
      XK=     PI/XLAMDA
C
      WRITE(6,9) MQ,MQP,XLAMDA,VARWT                                         ←
 9    FORMAT( 1H1 ,/////                                                   ,
     9//,20X,40HNUMBER OF COORDS DELINEATING SHORELINE=    ,I3             ,
     9//,20X , 43HNUMBER OF COORDS DELINEATING SEAWARD BDRY=  ,I3          ,
     9        //,20X,32HHORIZONTAL EXTENT OF SHORELINE=    ,F7.2           ,
     9//,20X,29HCONVERGENCE VARIANCE, VARWT= ,F9.6                         )
      WRITE(6,60) NMAX,JMAX1,IL                                              ←
 60   FORMAT( //,20X,  39HNUMBER OF TRANSFORMATION COEFFS ,NMAX=  ,I3      ,
     9//,20X,  29HNUMBER OF ITERATIONS ,JMAX1 =  ,I3                       ,
     9//,20X,  34HNUMBER OF INTEGRATION POINTS ,IL=  ,I3                   )
      WRITE(6,70)                                                            ←
 70   FORMAT( 1H1   ,62X,16HSHORELINE COORDS  ,///     )
      MQ13= MQ/3
      MQ3= MQ13*3
      IADD= MQ-MQ3
      DO 71  I=1,MQ13
      J= I+MQ13
      K= J+MQ13
 71   WRITE(6,72) I,I,X2(I),Y2(I), J,J,X2(J),Y2(J),K,K,X2(K),Y2(K)           ←
 72   FORMAT( /,3( 7X,3HX2(,I3,5H),Y2(,I3,3H)= ,F7.2,3X,F7.2) )
      IF( IADD .EQ. 0 ) GO TO 75
      IF( IADD .EQ. 1 ) NUM1= MQ
      IF( IADD .EQ. 2 ) NUM1= MQ-1
      DO 73  I=NUM1,MQ
 73   WRITE(6,74) I,I,X2(I),Y2(I)                                            ←
 74   FORMAT( /,  89X,3HX2(,I3,5H),Y2(,I3,3H)= ,F7.2,3X,F7.2   )
 75   CONTINUE
```

```
      WRITE(6,80)                                                           ←
 80   FORMAT( 1H1      ,61X,19HSEAWARD BDRY COORDS        ,//   )
      MQP13= MQP/3
      MQP3= MQP13*3
      IADD= MQP-MQP3
      DO 81 I=1,MQP13
      J= I+MQP13
      K= J+MQP13
 81   WRITE(6,82)I,I,X2P(I),Y2P(I),J,J,X2P(J),Y2P(J),K,K,X2P(K),Y2P(K)      ←
 82   FORMAT(/,3(5X,4HX2P(,I3,6H),Y2P(,I3,3H)= ,F7.2,3X,F7.2) )
      IF( IADD .EQ. 0 ) GO TO 85
      IF( IADD .EQ. 1 ) NUM1= MQP
      IF( IADD .EQ. 2 ) NUM1= MQP-1
      DO 83 I=NUM1,MQP
 83   WRITE(6,84)I,I,X2P(I),Y2P(I)                                          ←
 84   FORMAT(/, 87X,4HX2P(,I3,6H),Y2P(,I3,3H)= ,F7.2,3X,F7.2   )
 85   CONTINUE
C
C  DETERMINE COEFFS
C
      A= 0.0
      B= 0.0
      BZRO= 0.0
      WSX= 1.0                                                      (WSX = 0.0)
      WCX= 1.0                                                      (WCX = 0.0)
      WSY= 1.0
      WCY= 1.0
      DO 100 N=1,200
      COB(N)= 0.0
      COC(N)= 0.0
 100  CONTINUE
```

```
      IF( IWANT .EQ. 1 ) GO TO 101
      GO TO 105
 101  READ(5,102) B , BZRO
 102  FORMAT( 2E14.7 )
      DO 103 N=1,NMAX
 103  READ(5,102) COB(N) , COC(N)
      READ(5,104) WSX,WSY,WCX,WCY
 104  FORMAT( 4E14.7 )
 105  CONTINUE
C
      A= -B
      CALL COEFFS( XLAMDA , A , B ,         WSX,WSY,WCX,WCY )
C
C     PUNCH 102, B,BZRO
C     DO 107 N=1,NMAX
C107  PUNCH 102, COB(N) , COC(N)
C     PUNCH 104, WSX,WSY, WCX, WCY
C
 999  STOP
      END
      SUBROUTINE COEFFS( XLAMDA , A , B ,         WSX,WSY,WCX,WCY )
      DIMENSION     COB(200) , COC( 200)
      DIMENSION    DUMB(200) , DUMC(200)
      DIMENSION  X2(150) ,  Y2(150)
      DIMENSION X2P(150) , Y2P( 150 )
      DIMENSION ARCYA(150) , ARCYB(150)
      DIMENSION SN( 30,30  ) , CS( 30,30  )
      DIMENSION ATXA(400) , ATYA(400) , ATXB(400) , ATYB(400)
      DIMENSION U(400) , V(400) , Z(400)
      DIMENSION R(408) , S(408) , T(408) , W(400)
      DIMENSION X(408) , Y(408)
```

```
      COMMON X,Y
      COMMON/YB/ X2, Y2 , MQ
      COMMON/YA/ X2P , Y2P , MQP
      COMMON/JOHNR/ R
      COMMON/JOHNS/ S
      COMMON/JOHNT/ T
      COMMON/UVW/ U , V , W
      COMMON/AYA/ ARCYA
      COMMON/AYB/ ARCYB
      COMMON/COEF/        VARWT,JMAX1,IL
      COMMON/FORIA/        COB , COC                 , BZRO,XK,NMAX
C
      SIGMA= -1.0
      SIGMA1= -1.0
C  DETERMINE THE NECESSARY PARAMETERS TO COMPUTE AN INTERPOLATORY
C  SPLINE UNDER TENSION THROUGH A SEQUENCE OF FUNCTIONAL VALUES.
      MQ1= MQ-1
      MQP1= MQP-1
      IYB= 0
      DO 10  I=1,MQ1
      IF( X2(I+1) .LT. X2(I) ) IYB= 1
 10   CONTINUE
      IF( IYB .EQ. 1 ) GO TO 15
      CALL CUR1YB( SLP1 , SLPN , SIGMA )
      INC= 11
      XINC= INC-1
      ARCYB(1)= 0.0
      DO 13 I=1,MQ1
      K= I
      II=I+1
      DELX= X2(II)-X2(I)
```

```
      DELX= DELX/XINC
      SUM=0.0
      DO 12  J=1,INC
      XJ= J-1
      XDUM= X2(I) + XJ*DELX
      U(J)= CURDYB( XDUM , SIGMA , K )
      U(J)= U(J)*U(J) + 1.0
      U(J)= SQRT( U(J) )
 12   SUM= SUM + U(J)
      SUM= SUM -0.5*U(1) - 0.5*U(INC)
 13   ARCYB(II)= ARCYB(I) + SUM*DELX
      ARCB= ARCYB(MQ)
      GO TO 19
 15   CONTINUE
      ARCYB(1)= 0.0
      DO 18  I=1,MQ1
      II= I+1
      DELX= X2(II)-X2(I)
      DELX= DELX*DELX
      DELY= Y2(II)-Y2(I)
      DELY= DELY*DELY
 18   ARCYB(II)= ARCYB(I) + SQRT( DELX + DELY )
      ARCB= ARCYB(MQ)
 19   CONTINUE
C
      CALL CUR2YB( SLP1 , SLPN , SIGMA)
      CALL CUR3YE( SLP1 , SLPN , SIGMA)
C
      IYA= 0
      DO 20  I=1,MQP1
      IF( X2P(I+1) .LT. X2P(I) ) IYA= 1
```

```
20    CONTINUE
      IF( IYA .EQ. 1 ) GO TO 25
      CALL CUR1YA( SLP1 , SLPN , SIGMA )
      INC= 11
      XINC= INC-1
      ARCYA(1)= 0.0
      DO 23 I=1,MQP1
      K= I
      II=I+1
      DELX= X2P(II)-X2P(I)
      DELX= DELX/XINC
      SUM=0.0
      DO 22 J=1,INC
      XJ= J-1
      XDUM= X2P(I) + XJ*DELX
      U(J)= CURDYA( XDUM , SIGMA1 , K )
      U(J)= U(J)*U(J) + 1.0
      U(J)= SQRT( U(J) )
22    SUM= SUM + U(J)
      SUM= SUM -0.5*U(1) - 0.5*U(INC)
23    ARCYA(II)= ARCYA(I) + SUM*DELX
      ARCA= ARCYA(MQP)
      GO TO 29
25    CONTINUE
      ARCYA(1)= 0.0
      DO 28 I=1,MQP1
      II= I+1
      DELX= X2P(II) - X2P(I)
      DELX= DELX*DELX
      DELY= Y2P(II) - Y2P(I)
      DELY= DELY*DELY
```

```
 28   ARCYA(II)= ARCYA(I) + SQRT( DELX + DELY )
      ARCA= ARCYA(MGF)
 29   CONTINUE
C
      CALL CUR2YA( SLP1 , SLPN , SIGMA1 )
      CALL CUR3YA( SLF1 , SLPN , SIGMA1 )
C
      WFITE(6,30)                                                          ←
 30   FORMAT( 1H1,//,45X,40HARCLENGTH CF SEAWARC BDRY AND COASTLINE     .
     9//,10X,25HARCLENGTH OF SEAWARD BDRY,8X,3HX2P,9X,3HY2P             .
     915X,22HARCLENGTH CF COASTLINE,7X,2HX2,10X,2HY2         )
      DO 31 IT=1,MQP
       IK= IT
      ALNA= AFCYA(IT)
      ATXA(IT)= CUR4YA( ALNA , SIGMA1 , IK )
 31   ATYA(IT)= CUR5YA( ALNA , SIGMA1 , IK )
      DO 32 IT=1,MC
      IK= IT
      ALNB= ARCYE(IT)
      ATXB(IT)= CUR4YB( ALNE , SIGMA , IK )
 32   ATYB(IT)= CUR5YB( ALNB , SIGMA , IK )
      IF( MQ .GE. MQP ) NUM2= MQP
      IF( MQ .LE. MGP ) NUM2= MC
      DO 33 I=1,NUM2
 33    WRITE(6,34)AFCYA(I),ATXA(I),ATYA(I), ARCYB(I),ATXB(I),ATYB(I)       ←
 34   FORMAT(25X,F8.2,7X,F7.2,5X,F7.2,25X,F8.2,7X,F7.2,5X,F7.2     )
      IF( MQ .EQ. MQP ) GO TO 41
      IF( MQ .GT. MCF ) GO TO 35
      IF( MQ .LT. MQP ) GO TO 38
 35   NUM1= MQP+1
      DO 36 I=NUM1,MC
```

```
 36   WRITE(6,37)                                     ARCYB(I),ATXB(I),ATYB(I)       ←
 37   FORMAT( 84X,F8.2,7X,F7.2,5X,F7.2                  )
      GO TO 41
 38   NUM1= MC+1
      DO 39 I=NUM1,MQP
 39   WRITE(6,40) ARCYA(I),ATXA(I),ATYA(I)                                           ←
 40   FORMAT( 25X,F8.2,7X,F7.2,5X,F7.2                  )
 41   CONTINUE
C
C
      IL12= IL/2
      IL2= 2*IL12
      IADD= 0
      IF( IL2 .NE. IL ) IADD= 1
      IL1= IL12 + IADD
      XIL= IL-1
      DELXI= XLAMDA/XIL
      FT= DELXI/XLAMDA
      DO 45 IT=1,IL
      XIT= IT-1
 45   Z(IT)= XIT*DELXI
      NUM1= 1
 46   NUM2= NMAX
      DO 50 N=NUM1,NUM2
      XN= N
      XNK= XN*XK
      DO 50 IT=1,IL1
      XNKXI= XNK*Z(IT)
      SN(N,IT)= SIN( XNKXI )
 50   CS(N,IT)= COS( XNKXI )
C
```

```
      ICOUNT= 1
55    CONTINUE
      IF( ICOUNT .EQ. 1 ) GO TO 70
      GO TO 79
70    IF( ABS(B) .LT. 0.001 ) GO TO 71
      GO TO 76
71    YSUMA= 0.0
      YSUMB= 0.0
      DO 74 IT=1,IL
      IK= IT
      ALNA= ARCA*Z(IT)/XLAMDA
      ALNB= ARCB*Z(IT)/XLAMDA
      ATXA(IT)= CUR4YA( ALNA , SIGMA1 , IK )
      ATYA(IT)= CUR5YA( ALNA , SIGMA1 , IK )
      ATXB(IT)= CUR4YB( ALNB , SIGMA , IK )
      ATYB(IT)= CUR5YB( ALNB , SIGMA , IK )
      ATXA(IT)= ATXA(IT)-Z(IT)
      ATXB(IT)= ATXB(IT)-Z(IT)
      YSUMA= YSUMA + ATYA(IT)
74    YSUMB= YSUMB + ATYB(IT)
      YSUMA= YSUMA - 0.5*ATYA(1) - 0.5*ATYA(IL)
      YSUMB= YSUMB - 0.5*ATYB(1) - 0.5*ATYB(IL)
      ADUM= YSUMA*FT*WSY
      BDUM= YSUMB*FT*WCY
      GO TO 81
C
76    CONTINUE
      A= -B
      ETAA= A
      ETAB= B
      SUMA= 0.0
```

```
      SUMB= 0.0
      DO 77 IT=1,IL
      XI= Z(IT)
      CALL SLFAC( XI,ETAA,DXDETA,DYDETA,SCFACA,SF)
      CALL SLFAC( XI,ETAB,DXDETA,DYDETA,SCFACB,SF)
      SUMA= SUMA + SCFACA
      SUMB= SUMB + SCFACB
      U(IT)= SCFACA
77    V(IT)= SCFACB
      SUMA= SUMA - 0.5*U(1) - 0.5*U(IL)
      SUMB= SUMB - 0.5*V(1) - 0.5*V(IL)
      ALNA= SUMA*DELXI
      ALNB= SUMB*DELXI
      XMODA= ARCA/ALNA
      XMODB= ARCB/ALNB
      SUMA= 0.0
      SUMB= 0.0
      ALNA= 0.0
      ALNB= 0.0
      DO 78 IT=1,IL
      IK= IT
      ATXA(IT)= CUR4YA( ALNA , SIGMA1 , IK )
      ATYA(IT)= CUR5YA( ALNA , SIGMA1 , IK )
      ATXB(IT)= CUR4YB( ALNB , SIGMA , IK )
      ATYB(IT)= CUR5YB( ALNB , SIGMA , IK )
      IF( IT .EQ. IL ) GO TO 78
      II= IT+1
      SUMA= SUMA + ( U(IT) + U(II) )*DELXI/2.0
      SUMB= SUMB + ( V(IT) + V(II) )*DELXI/2.0
      ALNA= SUMA*XMODA
      ALNB= SUMB*XMODB
```

```
 78     CONTINUE
C
 79     YSUMA= 0.0
        YSUMB= 0.0
        DO 80  IT=1,IL
        ATXA(IT)= ATXA(IT)-Z(IT)
        ATXB(IT)= ATXB(IT)-Z(IT)
        YSUMA= YSUMA + ATYA(IT)
 80     YSUMB= YSUMB + ATYB(IT)
        YSUMA= YSUMA - 0.5*ATYA(1) - 0.5*ATYA(IL)
        YSUMB= YSUMB - 0.5*ATYB(1) - 0.5*ATYB(IL)
        ADUM= YSUMA*FT*WSY
        BDUM= YSUMB*FT*WCY
C
 81     CONTINUE
        A11= WCY+WSY
        A12= WCY-WSY
        B1= BDUM-ADUM
        B2= BDUM+ADUM
        BOTTOM= A11*A11-A12*A12
        BTDUM= ( B1*A11-B2*A12 )/BOTTOM
        BZDUM= ( B2*A11-B1*A12 )/BOTTOM
        BERR= BTDUM-B
        BZERR= BZDUM-BZRO
        B= BTDUM
        BZRO= BZDUM
        A= -B
C
        AVGWX= ( WSX+WCX )*0.5
        AVGWY= ( WSY+WCY )*0.5
        WBAR= ( WCX-WSX+WCY-WSY )*0.5
```

```
C
 82   NUM2= NMAX
      XKB= XK*B
      DO 89 N=1,NUM2
      XASUMS= 0.0
      XBSUMS= 0.0
      YASUMC= 0.0
      YBSUMC= 0.0
      N12= N/2
      N2= 2*N12
      DO 87 IT=1,IL
      IF( IT .GT. IL1 ) GO TO 83
      GO TO 85
 83   IIT= IL-IT+1
      SINN= SN(N,IIT)
      COSS= CS(N,IIT)
      IF( N .EQ. N2 ) GC TO 84
      R(IT)=  ATXA(IT)*SINN
      S(IT)=  ATXB(IT)*SINN
      T(IT)= -ATYA(IT)*COSS
      W(IT)= -ATYE(IT)*COSS
      GO TO 86
 84   R(IT)= -ATXA(IT)*SINN
      S(IT)= -ATXB(IT)*SINN
      T(IT)=  ATYA(IT)*COSS
      W(IT)=  ATYB(IT)*COSS
      GC TO 86
 85   SINN= SN(N,IT)
      COSS= CS(N,IT)
      R(IT)=  ATXA(IT)*SINN
      S(IT)=  ATXB(IT)*SINN
```

```
      T(IT)=   ATYA(IT)*COSS
      W(IT)=   ATYB(IT)*COSS
86    CONTINUE
      XASUMS= XASUMS + R(IT)
      XBSUMS= XBSUMS + S(IT)
      YASUMC= YASUMC + T(IT)
      YBSUMC= YBSUMC + W(IT)
87    CONTINUE
      XASUMS= XASUMS - 0.5*R(1) - 0.5*R(IL)
      XBSUMS= XBSUMS - 0.5*S(1) - 0.5*S(IL)
      YASUMC= YASUMC - 0.5*T(1) - 0.5*T(IL)
      YBSUMC= YBSUMC - 0.5*W(1) - 0.5*W(IL)
      XASUMS= XASUMS*FT*WSX
      XBSUMS= XBSUMS*FT*WCX
      YASUMC= YASUMC*FT*WSY
      YBSUMC= YBSUMC*FT*WCY
      XN= N
      XNKB= XN*XKB
      SHB= SINH( XNKB )
      CHB= COSH( XNKB )
      TB= SHB/CHB
      SM= TB*TB
      TM= SM/SHB
      A11= SM*AVGWX + AVGWY
      A12= TB*WBAR
      A22= SM*AVGWY + AVGWX
      B1= TM*(-XASUMS+XBSUMS) + (+YASUMC+YBSUMC)/CHB
      B2= TM*(-YASUMC+YBSUMC) + (+XASUMS+XBSUMS)/CHB
      BOTTOM= A11*A22 - A12*A12
      DUMB(N)= ( B1*A22-B2*A12 )/BOTTOM
      DUMC(N)= ( B2*A11-B1*A12 )/BOTTOM
```

```
 89   CONTINUE
C
      EB1= DUME(1)-COB(1)
      EB2= DUMB(2)-COB(2)
      EC1= DUMC(1)-COC(1)
      EC2= DUMC(2)-COC(2)
C
      WRITE(6,250) ICOUNT , NMAX , IL                                   ←
 250  FORMAT( 1H1,20X,18HITERATION NUMBER= ,I3,10X ,6HNMAX= ,I2,10X     •
     912HNUM POINTS= ,I4 )
C
      WRITE(6,260) A, B, BERR                                           ←
 260  FORMAT( 49X,7HALPHA= ,F11.6                                       •
     9/       ,50X,6HBETA= ,F11.6,3X,8HCHANGE= ,E10.3)
C
      WRITE(6,261) BZRO , BZERR                                         ←
 261  FORMAT (48X,8HB-ZERO= ,F11.6,3X,8HCHANGE= ,E10.3  ,/              )
C
      NUMB= 0
      NUMC= 0
      XKB= XK*B
      DO 270 N=1,NMAX
      XN= N
      XNKB= XN*XKB
      PRB= DUMB(N)*COB(N)
      PRC= DUMC(N)*COC(N)
      IF( PRB .LT. 0.0 ) NUMB= NUMB + 1
      IF( PRC .LT. 0.0 ) NUMC= NUMC + 1
      ERRB= DUMB(N)-COB(N)
      ERRC= DUMC(N)-COC(N)
      COB(N)= DUMB(N)
```

```
      COC(N)= DUMC(N)
      AMPB=   ABS( COB(N)*COSH(XNKB) )
      AMPC=   ABS( CCC(N)*SINH(XNKB) )
  270 WRITE(6,271) N,COB(N),ERRB    ,AMPB ,N,CCC(N),ERRC    ,AMPC
  271 FORMAT(  7X,2HB(, I3,3H)= ,E14.7,3X,E10.3,3X,E10.3 , 27X          ,
     92HC(,I3,3H)= ,E14.7,3X,E10.3,3X,E10.3    )
C
      WRITE(6,272) NUMB , NUMC
  272 FORMAT(/,7X,34HNUM OF COEFFS  THAT CHANGED SIGN=    ,I3           ,
     937X          ,34HNUM OF COEFFS  THAT CHANGED SIGN=    ,I3  ,//     )
C
C
C  DETERMINE THE VARIANCE BETWEEN THE PREDICTED COASTLINE AND
C  SEAWARD BOUNDARY AND THAT SPECIFIED.
      ETAA= A
      ETAB= B
      SUMA= 0.0
      SUMB= 0.0
      SUMEXA= 0.0
      SUMEYA= 0.0
      SUMEXB= 0.0
      SUMEYB= 0.0
      DO 277 IT=1,IL
      XI= Z(IT)
      R(IT)= XTRAN( XI , ETAA )
      S(IT)= YTRAN( XI , ETAA )
      T(IT)= XTRAN( XI , ETAB )
      W(IT)= YTRAN( XI , ETAB )
      CALL SLFAC( XI,ETAA,DXDETA,DYDETA,SCFACA,SF)
      CALL SLFAC( XI,ETAB,DXDETA,DYDETA,SCFACB,SF)
      SUMA= SUMA + SCFACA
```

```
      SUMB= SUMB + SCFACB
      SUMXA= (ABS(ATXA(IT)+Z(IT)-R(IT)))**2
      SUMYA= (ABS(ATYA(IT)-S(IT)))**2
      SUMXB= (ABS(ATXB(IT)+Z(IT)-T(IT)))**2
      SUMYB= (ABS(ATYB(IT)-W(IT)))**2
      SUMEXA= SUMEXA + SUMXA
      SUMEYA= SUMEYA + SUMYA
      SUMEXB= SUMEXB + SUMXB
      SUMEYB= SUMEYB + SUMYB
      U(IT)= SCFACA
  277 V(IT)= SCFACB
      SUMEXA= SUMEXA - 0.5*SUMXA - 0.5*( ABS(ATXA(1)+Z(1)-R(1)) )**2
      SUMEYA= SUMEYA - 0.5*SUMYA - 0.5*( ABS(ATYA(1)-S(1)) )**2
      SUMEXB= SUMEXB - 0.5*SUMXB - 0.5*( ABS(ATXB(1)+Z(1)-T(1)) )**2
      SUMEYB= SUMEYB - 0.5*SUMYB - 0.5*( ABS(ATYB(1)-W(1)) )**2
      EFXA= SUMEXA*FT*WSX
      EFYA= SUMEYA*FT*WSY
      EFXB= SUMEXB*FT*WCX
      EFYB= SUMEYB*FT*WCY
      EF= EFXA+EFYA+EFXB+EFYB
      EBAR= EF/4.0
      WSY= EFYA/EBAR
      WCY= EFYB/EBAR
      WSX= EFXA/EBAR                                                  (Remove)
      WCX= EFXB/EBAR                                                  (Remove)
      SUMA= SUMA - 0.5*U(1) - 0.5*U(IL)
      SUMB= SUMB - 0.5*V(1) - 0.5*V(IL)
      ALNA= SUMA*DELXI
      ALNB= SUMB*DELXI
      XMODA= ARCA/ALNA
      XMODB= ARCB/ALNB
```

```
C
      SUMA= 0.0
      SUMB= 0.0
      ALNA= 0.0
      ALNB= 0.0
      VARXA= 0.0
      VARYA= 0.0
      VARXB= 0.0
      VARYB= 0.0
      DO 278  IT=1,IL
      IK= IT
      X( IT )= ALNA
      Y (IT)= ALNB
      ATXA(IT)= CUR4YA( ALNA , SIGMA1 , IK )
      ATYA( IT )= CUR5YA( ALNA , SIGMA1 , IK )
      ATXB(IT)= CUR4YB( ALNB , SIGMA , IK )
      ATYB(IT)= CUR5YB( ALNB , SIGMA , IK )
      VARXA= VARXA + ABS( ATXA(IT)-R( IT ))**2
      VARYA= VARYA + ABS( ATYA(IT)-S(IT))**2
      VARXB= VARXB + ABS( ATXB( IT )-T( IT ))**2
      VARYB= VARYB + ABS( ATYB(IT)-W( IT ))**2
      IF( IT .EQ. IL ) GO TO 278
      II= IT+1
      SUMA= SUMA + ( U(IT) + U(II) )*DELXI/2.0
      SUMB= SUMB + ( V(IT) + V(II) )*DELXI/2.0
      ALNA= SUMA*XMCDA
      ALNB= SUMB*XMCDB
  278 CONTINUE
C
      VARXA= VARXA/XIL
      VARYA= VARYA/XIL
```

```
      VARXB= VARXB/XIL
      VARYB= VARYB/XIL
      VAR=             ( VARXA+VARYA+VARXB+VARYB )/4.0
      VARA=            0.5*( VARXA+VARYA )
      VARB=            0.5*( VARXB+VARYB )
C
C
      WRITE(6,280) XMODE,XMODA, VARXB,EFXB,           VARYB,VARB,EFYB        ,   ←
     9VARXA,EFXA,           VARYA,VARA,EFYA, VAR , EF
 280  FORMAT(        35X,56HRATIO OF COASTLINE ARCLENGTH TO *TRANSFORM* GEN
     9ERATED =   ,F8.4                                                       ,
     9/,32X,59HRATIO OF SEAWARD BDRY ARCLENGTH TO *TRANSFORM* GENERATED
     9=  ,F8.4 ,//, 66X,8HVARIANCE ,26X,7HER FNCT                            ,
     9//,7X,48HTRANSFORM COASTLINE FROM THAT SPECIFIED USING X   ,E14.7 ,
     920X,E14.7                                                              ,
     9/ ,7X,48HTRANSFORM COASTLINE FROM THAT SPECIFIED USING Y   ,E14.7 ,
     92X,E14.7,4X,E14.7                                                      ,
     9/,4X,51HTRANSFORM SEAWARD BDRY FROM THAT SPECIFIED USING X ,E14.7,
     920X,E14.7                                                              ,
     9/,4X,51HTRANSFORM SEAWARD BDRY FROM THAT SPECIFIED USING Y ,E14.7,
     92X,E14.7,4X,E14.7                                                      ,
     9/,71X,E14.7,20X,E14.7                                                  )
      WRITE(6,281)                                                              ←
 281  FORMAT(//        ,15X,42HSEAWARD BDRY COORDS , 0--XI--LAMDA , ETA=A,
     923X                  ,39HCOASTLINE COORDS , 0--XI--LAMDA , ETA=B   ,
     9/,3X,9HX(XI,ETA),2X,7HX-GIVEN,4X,9HY(XI,ETA),2X,7HY-GIVEN,4X          ,
     98HARC-TRAN,4X,1HI                                                      ,
     98X   ,9HX(XI,ETA),2X,7HX-GIVEN,4X,9HY(XI,ETA),2X,7HY-GIVEN,4X         ,
     98HARC-TRAN                                                             )
C
      DO 285 I=1,IL
```

```
 285  WRITE(6,286) I,R(I),ATXA(I),S(I),ATYA(I),X(I)                          .    ←
     9I,T(I),ATXE(I),W(I),ATYB(I),Y(I)
 286  FORMAT( 4X,I3,2X,F7.2,3X,F7.2,5X,F7.2,3X,F7.2,4X,F8.2,4X,1HI           .
     94X         ,I3,2X,F7.2,3X,F7.2,5X,F7.2,3X,F7.2,4X,F8.2                 )
C
C
      ICOUNT= ICOUNT + 1
      IF( VAR .LE. VARWT ) GO TO 375
 300  IF( ICOUNT .LE. JMAX1 ) GO TO 55
 375  RETURN
      END
      FUNCTION XTRAN( XI , ETA )
      DIMENSION    COB(200) , COC(200)
      COMMON/FORIA/        COB , COC                    , BZRO,XK,NMAX
      XTRAN= 0.0
      XKA= XK*ETA
      XKXI= XK*XI
      DO 10 N=1,NMAX
      XN= N
      XNKA= XN*XKA
      XNKXI= XN*XKXI
      CSH= COSH(XNKA)
      SNH= SINH(XNKA)
      XTRAN=XTRAN+(COC(N)*CSH        +COB(N)*SNH        )*SIN(XNKXI)
 10   CONTINUE
      XTRAN= XTRAN + XI
      RETURN
      END
      FUNCTION YTRAN( XI , ETA )
      DIMENSION    COB(200) , COC(200)
      COMMON/FORIA/        COB , COC                    , BZRO,XK,NMAX
```

```
      YTRAN= 0.0
      XKA= XK*ETA
      XKXI= XK*XI
      DO 10 N=1,NMAX
      XN= N
      XNKA= XN*XKA
      XNKXI= XN*XKXI
      CSH= COSH(XNKA)
      SNH= SINH(XNKA)
      YTRAN=YTRAN+(COB(N)*CSH        +COC(N)*SNH        )*COS(XNKXI)
10    CONTINUF
      YTRAN= YTRAN + ETA + BZRO
      RETURN
      END
      SUBROUTINE SLFAC( XI , ETA , DXDETA , DYDETA , SCFAC , SF )
      DIMENSICN    CCE(200) , COC(200)
      COMMON/FORIA/        CCB , COC                 , BZRC,XK,NMAX
      XKA= XK*ETA
      XKXI = XK*XI
      DXDETA= 0.0
      DYDETA= 0.0
      DO 10 N=1,NMAX
      XN= N
      XNKA= XN*XKA
      XNKXI = XN*XKXI
      CSH= COSH(XNKA)
      SNH= SINH(XNKA)
       XDETA= XN*XK*(COB(N)*CSH        +CCC(N)*SNH        )*SIN(XNKXI)
       YDETA= XN*XK*(COB(N)*SNH        +COC(N)*CSH        )*COS(XNKXI)
      DXDETA= DXCETA + XDETA
      DYDETA= DYDETA + YDETA
```

```
 10    CONTINUE
       DYDETA= DYDETA + 1.0
       SF= (ABS(DXDETA))**2 + (ABS(DYDETA))**2
       SCFAC= SQRT( SF )
       RETURN
       END
       SUBROUTINE CUR1YB( SLP1 , SLPN , SIGMA )
       DIMENSION  X2(150) ,  Y2(150)
       DIMENSION A(150) , S(408)
       COMMON/JOHNA/ A
       COMMON/JOHNS/ S
       COMMON/YB/ X2, Y2 , MQ
C   FITS SPLINE-- Y2 AS A FUNCTION OF X2
       N= MQ
       NM1 = N-1
       NP1 = N+1
       DELX1 = X2(2)-X2(1)
       DX1 = (Y2(2)-Y2(1))/DELX1
       IF (SIGMA.LT.0.) GO TO 5
       SLPP1 = SLP1
       SLPPN = SLPN
     1 SIGMAP = ABS(SIGMA)*(N-1)/(X2(N)-X2(1))
       DELS = SIGMAP*DELX1
       EXPS = EXP(DELS)
       SINHS = .5*(EXPS-1./EXPS)
       SINHIN = 1./(DELX1*SINHS)
       DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
       DIAGIN = 1./DIAG1
        A(1) = DIAGIN*(DX1-SLPP1)
       SPDIAG = SINHIN*(SINHS-DELS)
          S(1) = DIAGIN*SPDIAG
```

```
    IF (N.EQ.2) GO TO 3
    DO 2 I = 2,NM1
      DELX2 = X2(I+1)-X2(I)
      DX2= (Y2(I+1)-Y2(I))/DELX2
      DELS = SIGMAP*DELX2
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX2*SINHS)
      DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
      DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
       A(I) = DIAGIN*(DX2-DX1-SPDIAG* A(I-1))
      SPDIAG = SINHIN*(SINHS-DELS)
         S(I) = DIAGIN*SPDIAG
      DX1 = DX2
  2   DIAG1 = DIAG2
  3 DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
     A(N) = DIAGIN*(SLPPN-DX2-SPDIAG* A(NM1))
    DO 4 I = 2,N
      IBAK = NP1-I
  4     A(IBAK) =  A(IBAK)-    S(IBAK)* A(IBAK+1)
    RETURN
  5 IF (N.EQ.2) GO TO 6
    DELX2 = X2(3)-X2(2)
    DELX12 = X2(3)-X2(1)
    C1 = -(DELX12+DELX1)/DELX12/DELX1
    C2 = DELX12/DELX1/DELX2
    C3 = -DELX1/DELX12/DELX2
    SLPP1 = C1*Y2(1) + C2*Y2(2) + C3*Y2(3)
    DELN = X2(N)-X2(NM1)
    DELNM1 = X2(NM1)-X2(N-2)
    DELNN = X2(N)-X2(N-2)
```

```
      C1 = (DELNN+DELN)/DELNN/DELN
      C2 = -DELNN/DELN/DELNM1
      C3 = DELN/DELNN/DELNM1
      SLPPN = C3*Y2(N-2) + C2*Y2(NM1) + C1*Y2(N)
      GO TO 1
    6  A(1) = 0.
       A(2) = 0.
      RETURN
      END
      FUNCTION CURVYB( T , SIGMA , IT )
      DIMENSION  X2(150) ,  Y2(150)
      DIMENSION A(150)
      COMMON/JOHNA/ A
      COMMON/YB/ X2, Y2 , MQ
C   THIS FUNCTION INTERPOLATES THE COASTLINE      AT A GIVEN VALUE FOR X.
C   THE VALUE RETURNED IN CURVYB IS THE VALUE OF Y AT X.
C   SUBROUTINE CUR1YB MUST BE CALLED EARLIER.
      N= MQ
      S = X2(N)-X2(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
        IF( X2(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( X2(I-1) .LE. T .OR. T .LE. X2(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-X2(I-1)
      DEL2 = X2(I)-T
      DELS = X2(I)-X2(I-1)
```

```
      EXPS1  = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS  =  EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS  =  EXPS1*EXPS
      SINHS  = .5*(EXPS-1./EXPS)
      CURVYB= ( A(I)*SINHD1+ A(I-1)*SINHD2)/SINHS+((Y2(I)-A(I))*DEL1     +
     9(Y2(I-1) - A(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      FUNCTION CURDYB( T , SIGMA , IT )
      DIMENSION  X2(150) ,  Y2(150)
      DIMENSION A(150)
      COMMON/JOHNA/ A
      COMMON/YB/ X2, Y2 , MQ
C  THIS FUNCTION DIFFERENTIATES THE COASTLINE     AT A GIVEN VALUE
C  FOR X. THE VALUE RETURNED IN CURDYE IS THE VALUE OF DY/DX AT X.
C  SUBROUTINE CURIYE MUST BE CALLED EARLIER.
      N= MQ
      S = X2(N)-X2(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
        IF( X2(I)-T ) 2,2,3
    2   CONTINUE
      I = N
  3   IF( X2(I-1) .LE. T .OR. T .LE. X2(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-X2(I-1)
```

```
      DEL2 = X2(I)-T
      DELS = X2(I)-X2(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      COSHD1 = .5*(EXPS1+1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      COSHD2 = .5*(EXPS+1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)/SIGMAP
      CURDYB= ( A(I)*COSHD1- A(I-1)*COSHD2)/SINHS+((Y2(I)-A(
     1         I))-(Y2(I-1)-A(I-1)))/DELS
      I1 = I
      RETURN
      END
      SUBROUTINE CUR2YB( SLP1 , SLPN , SIGMA )
      DIMENSION ARCYB(150)
      DIMENSION  X2(150) ,  Y2(150)
      DIMENSION C(150) , S(408)
      COMMON/JOHNC/ C
      COMMON/JOHNS/ S
      COMMON/AYB/ ARCYB
      COMMON/YB/ X2, Y2 , MQ
C   FITS SPLINE-- X2 AS A FUNCTION OF ARCYB
      N= MQ
      NM1 = N-1
      NP1 = N+1
      DELX1 = ARCYB(2)-ARCYB(1)
      DX1 = (X2(2)-X2(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(ARCYB(N)-ARCYB(1))
```

```
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       C(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = ARCYB(I+1)-ARCYB(I)
        DX2= (X2(I+1)-X2(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
         C(I) = DIAGIN*(DX2-DX1-SPDIAG* C(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
        DX1 = DX2
    2   DIAG1 = DIAG2
    3 DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
       C(N) = DIAGIN*(SLPPN-DX2-SPDIAG* C(NM1))
      DO 4 I = 2,N
        IBAK = NP1-I
    4    C(IBAK) =  C(IBAK)-   S(IBAK)* C( IBAK+1)
      RETURN
    5 IF (N.EQ.2) GO TO 6
```

AD-A034 651 TEXAS A AND M RESEARCH FOUNDATION COLLEGE STATION F/G 4/2
STORM SURGE SIMULATION IN TRANSFORMED COORDINATES. VOLUME II. P--ETC(U)
NOV 76 J H WANSTRATH DACW72-73-C-0014
UNCLASSIFIED CERC-TR-76-3-VOL-2 NL

2 OF 2
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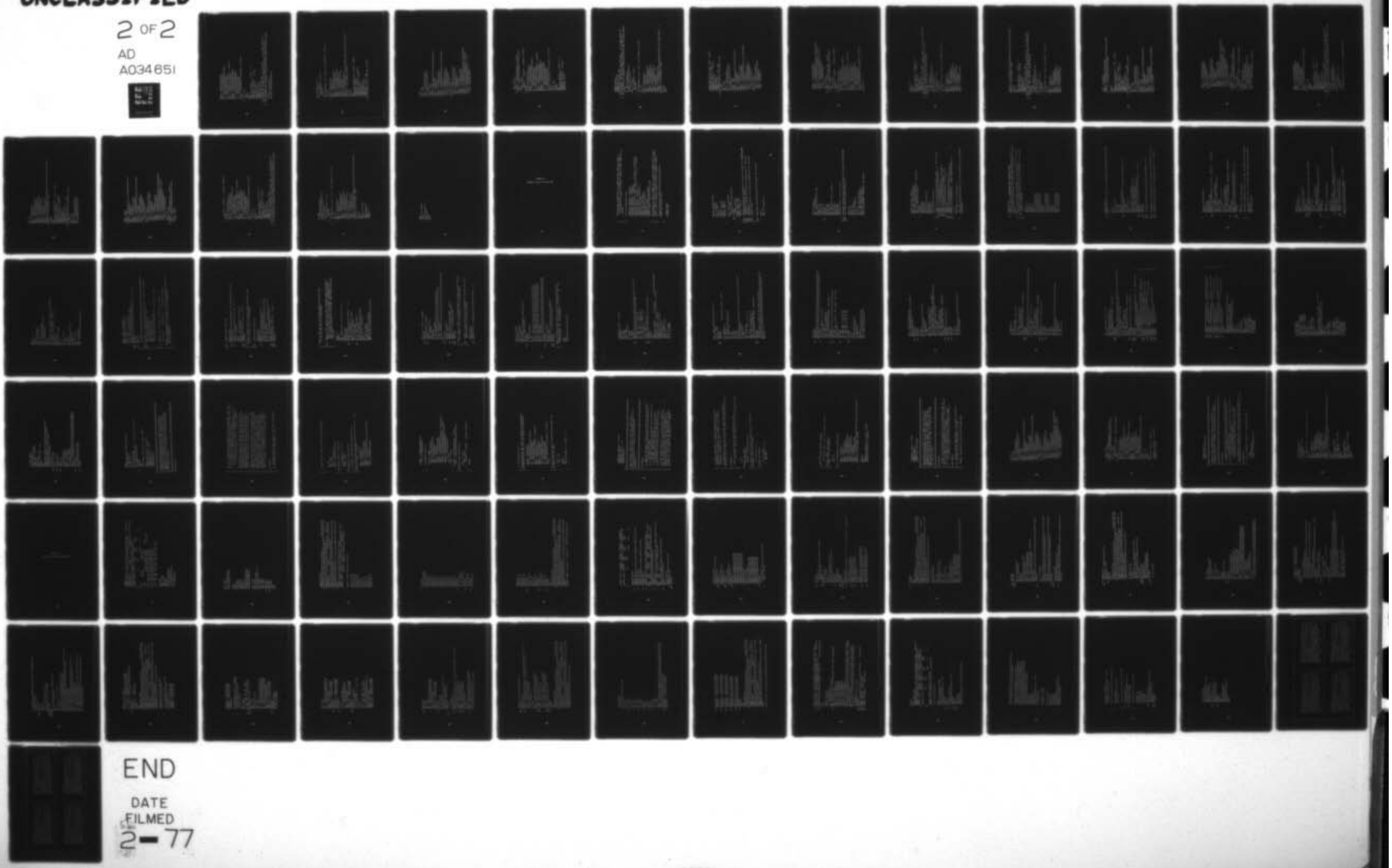
A034651



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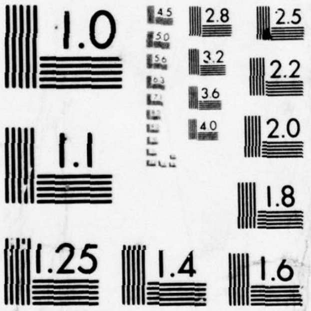

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      DELX2 = ARCYB(3)-ARCYB(2)
      DELX12 = ARCYB(3)-ARCYB(1)
      C1 = -(DELX12+DELX1)/DELX12/DELX1
      C2 = DELX12/DELX1/DELX2
      C3 = -DELX1/DELX12/DELX2
      SLPP1 = C1*X2(1) + C2*X2(2) + C3*X2(3)
      DELN = ARCYB(N)-ARCYB(NM1)
      DELNM1 = ARCYB(NM1)-ARCYB(N-2)
      DELNN = ARCYB(N)-ARCYB(N-2)
      C1 = (DELNN+DELN)/DELNN/DELN
      C2 = -DELNN/DELN/DELNM1
      C3 = DELN/DELNN/DELNM1
      SLPPN = C3*X2(N-2) + C2*X2(NM1) + C1*X2(N)
      GO TO 1
    6  C(1) = 0.
       C(2) = 0.
      RETURN
      END
      FUNCTION CUR4YB( T , SIGMA , IT )
      DIMENSION ARCYB(150)
      DIMENSION  X2(150) ,  Y2(150)
      DIMENSION C(150)
      COMMON/JOHNC/ C
      COMMON/AYE/ ARCYB
      COMMON/YB/ X2, Y2 , MQ
C  THIS FUNCTION INTERPOLATES THE COASTLINE     AT A GIVEN VALUE FOR
C  THE ARCLENGTH. THE VALUE RETURNED IN CUR4YB IS THE VALUE OF X
C  AT ITS PARTICULAR ARCLENGTH. SUBROUTINE CUR2YB MUST BE CALLED BEFORE.
       N= MQ
      S = ARCYB(N)-ARCYB(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
```

```
      IF (IT.EG.1) I1 = 2
    1 DO 2 I = I1,N
       .IF( ARCYE(I)-T ) 2,2,3
    2   CONTINUF
      I = N
3     IF( ARCYE(I-1) .LE. T .OR. T .LE. ARCYB(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-ARCYB(I-1)
      DEL2 = ARCYB(I)-T
      DELS = ARCYP(I)-ARCYB( I-1)
      EXPS1 = EXF(SIGNAF*CEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXFS-1./EXPS)
      EXPS = FXPS1*EXPS
      SINHS = .5*(FXPS-1./EXPS)
      CUR4YB= ( C(I)*SINHD1+ C(I-1)*SINHD2)/SINHS+((X2(I)-C( I))*DEL1    +
     9(X2( I-1) - C(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      SUBROUTINE CUR3YB( SLP1 , SLPN , SIGMA )
      DIMENSICN ARCYB(150)
      DIMENSION  X2(150) ,   Y2(150)
      DIMENSICN D(150) , S(408)
      COMMON/JOHND/ D
      COMMON/JOHNS/ S
      COMMON/AYF/ ARCYB
      COMMON/YB/ X2, Y2 , MQ
C   FITS SPLINE-- Y2 AS A FUNCTION OF ARCYB
```

```
      N= MQ
      NM1 = N-1
      NP1 = N+1
      DELX1 = ARCYB(2)-ARCYB(1)
      DX1 = (Y2(2)-Y2(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(ARCYB(N)-ARCYB(1))
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       D(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = ARCYB(I+1)-ARCYB(I)
        DX2= (Y2(I+1)-Y2(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
         D(I) = DIAGIN*(DX2-DX1-SPDIAG* D(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
```

```
      DX1 = DX2
 2    DIAG1 = DIAG2
 3  DIAGIN = 1./(CIAG1-SPDIAG*   S(NM1))
     D(N) = DIAGIN*(SLPFN-DX2-SPCIAG* D(NM1))
    DO 4 I = 2,N
      IBAK = NF1-I
 4     D(IBAK) =  D(IBAK)-   S(IBAK)* D(IEAK+1)
    RETURN
 5  IF (N.EQ.2) CO TO 6
    DELX2 = ARCYB(3)-ARCYB(2)
    DELX12 = ARCYB(3)-ARCYB(1)
    C1 = -(CELX12+DELX1)/CELX12/CELX1
    C2 = DELX12/DELX1/DELX2
    C3 = -DELX1/DELX12/DELX2
    SLPP1 = C1*Y2(1) + C2*Y2(2) + C3*Y2(3)
    DELN = ARCYB(N)-ARCYB(NM1)
    DELNM1 = AFCYE(NM1)-ARCYB(N-2)
    DELNN = AFCYB(N)-AFCYE(N-2)
    C1 = (DELNN+DELN)/DELNN/DELN
    C2 = -CELNN/CELN/DELNM1
    C3 = DELN/DELNN/DELNM1
    SLPPN = C3*Y2(N-2) + C2*Y2(NM1) + C1*Y2(N)
    GO TO 1
 6   D(1) = 0.
     D(2) = 0.
    FETURN
    END
    FUNCTION CURSYB( T , SIGMA , IT )
    DIMENSION ARCYB(150)
    DIMENSICN  X2(150) ,  Y2(150)
    DIMENSION D(150)
```

```
      COMMON/JCHND/ D
      COMMON/AYE/ ARCYB
      COMMON/YB/ X2, Y2 , MG
C   THIS FUNCTION INTERPOLATES THE COASTLINE      AT A GIVEN VALUE FOR
C   THE ARCLENGTH. THE VALUE RETURNED IN CUR5YB IS THE VALUE OF Y
C   AT ITS PARTICULAR ARCLENGTH. SUERCUTINE CUR3YE MUST BE CALLED BEFORE.
      N= MQ
      S = ARCYE(N)-ARCYB(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
        IF( ARCYB(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( ARCYB(I-1) .LE. T .OR. T .LE. ARCYB(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-ARCYB(I-1)
      DEL2 = ARCYB(I)-T
      DELS = ARCYB(I)-ARCYB(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
      CUR5YB= ( D(I)*SINHD1+ D(I-1)*SINHD2)/SINHS+((Y2(I)-D(I))*DEL1    +
     9(Y2(I-1) - D(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
```

```
      SUBROUTINE CUR1YA( SLP1 , SLPN , SIGMA )
      DIMENSION B(150) , S(408)
      DIMENSION X2P(150) , Y2P( 150)
      COMMON/JCHNE/ B
      COMMON/JOHNS/ S
      COMMON/YA/ X2P , Y2P , MQP
C   FITS SPLINE--Y2P AS A FUNCTION OF X2P
      N= MQP
      NM1 = N-1
      NP1 = N+1
      DELX1 = X2P(2)-X2P(1)
      DX1 = (Y2P(2)-Y2P(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(X2P(N)-X2P(1))
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       B(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = X2P(I+1)-X2P(I)
        DX2= (Y2P(I+1)-Y2P(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
```

```
       SINHS = .5*(EXPS-1./EXPS)
       SINHIN = 1./(DELX2*SINHS)
       DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
       DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
        B(I) = DIAGIN*(DX2-DX1-SPDIAG* B(I-1))
       SPDIAG = SINHIN*(SINHS-DELS)
          S(I) = DIAGIN*SPDIAG
       DX1 = DX2
2      DIAG1 = DIAG2
3     DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
       B(N) = DIAGIN*(SLPPN-DX2-SPDIAG* B(NM1))
      DO 4 I = 2,N
        IBAK = NP1-I
4        B(IBAK) =  B(IBAK)-    S(IBAK)* B(IBAK+1)
      RETURN
5     IF (N.EQ.2) GO TO 6
      DELX2 = X2P(3)-X2P(2)
      DELX12 = X2P(3)-X2P(1)
      C1 = -(DELX12+DELX1)/DELX12/DELX1
      C2 = DELX12/DELX1/DELX2
      C3 = -DELX1/DELX12/DELX2
      SLPP1 = C1*Y2P(1)+ C2*Y2P(2)+ C3*Y2P(3)
      DELN = X2P(N)-X2P(NM1)
      DELNM1 = X2P(NM1)-X2P(N-2)
      DELNN = X2P(N)-X2P(N-2)
      C1 = (DELNN+DELN)/DELNN/DELN
      C2 = -DELNN/DELN/DELNM1
      C3 = DELN/DELNN/DELNM1
      SLPPN = C3*Y2P(N-2)+ C2*Y2P(NM1)+ C1*Y2P(N)
      GO TO 1
6      B(1) = 0.
```

```
       B(2) = 0.
      RETURN
      END
      FUNCTION CURVYA( T , SIGMA , IT )
      DIMENSICN X2F(150) , Y2P(150)
      DIMENSICN B(150)
      COMMON/JOHNB/ B
      COMMON/YA/ X2F , Y2F , MQP
C  THIS FUNCTION INTERPOLATES THE SEAWARD BDRY  AT A GIVEN VALUE FOR X.
C  THE VALUE RETURNEC IN CURVYA IS THE VALUE OF  Y AT X.
C  SUBROUTINE CUR1YA MUST BE CALLED EARLIER.
      N= MQP
      S = X2F(N)-X2F(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EG.1) I1 = 2
    1 DO 2 I = I1,N
      IF( X2P(I)-T ) 2,2,3
    2   CONTINLE
      I = N
 3    IF( X2P(I-1) .LE. T .OR. T .LF. X2P(1) ) GC TC 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-X2P(I-1)
      DEL2 = X2P(I) - T
      DELS = X2P(I)-X2P(I-1)
      EXPS1 = EXF(SIGMAF*CEL1)
      SINHD1 = .5*(EXFS1-1./EXPS1)
      EXPS = FXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXFS-1./EXPS)
      EXPS = FXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
```

```
      CURVYA= ( E(I)*SINHD1+ B(I-1)*SINHD2)/SINHS+((Y2P(I)-B(I))*DEL1   +
     9(Y2P(I-1) -E(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      FUNCTION CURDYA( T , SIGMA , IT )
      DIMENSION X2P(150) , Y2P( 150)
      DIMENSION E(150)
      COMMON/JOHNB/ B
      COMMON/YA/ X2P , Y2P , MQP
C   THIS FUNCTION DIFFERENTIATES THE SEAWARD BDRY  AT A GIVEN VALUE
C   FOR X. THE VALUE RETURNED IN CURDYA IS THE VALUE OF DY/DX AT X.
C   SUBROUTINE CURIYA MUST BE CALLED EARLIER.
      N= MQP
      S = X2P(N)-X2P(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
      IF( X2P(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( X2P(I-1) .LE. T .OR. T .LE. X2P(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-X2P(I-1)
      DEL2 = X2P(I) - T
      DELS = X2P(I)-X2P(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      COSHD1 = .5*(EXPS1+ 1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      COSHD2 = .5*(EXPS+1./EXPS)
```

```
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)/SIGMAP
      CURDYA= ( B(I)*COSHD1- B(I-1)*COSHD2)/SINHS+((Y2P(I)-B(
     1        I))-(Y2P(I-1)-B(I-1)))/DELS
      I1 = I
      RETURN
      END
      SUBROUTINE CUR2YA( SLP1 , SLPN , SIGMA )
      DIMENSION ARCYA(150)
      DIMENSION E(150) , S(408)
      DIMENSION X2P(150) , Y2P(150)
      COMMON/JOHNE/ E
      COMMON/JOHNS/ S
      COMMON/AYA/ ARCYA
      COMMON/YA/ X2P , Y2P , MQP
C   FITS SPLINE--X2P AS A FUNCTION OF ARCYA
      N= MQP
      NM1 = N-1
      NP1 = N+1
      DELX1 = ARCYA(2)-ARCYA(1)
      DX1 = (X2P(2)-X2P(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(ARCYA(N)-ARCYA(1))
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
```

```
       E(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = ARCYA(I+1)-ARCYA(I)
        DX2= (X2P(I+1)-X2P(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
         E(I) = DIAGIN*(DX2-DX1-SPDIAG* E(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
        DX1 = DX2
2       DIAG1 = DIAG2
3     DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
       E(N) = DIAGIN*(SLPPN-DX2-SPDIAG* E(NM1))
      DO 4 I = 2,N
        IBAK = NP1-I
4        E(IBAK) =   E(IBAK)-    S(IBAK)* E(IBAK+1)
      RETURN
5     IF (N.EQ.2) GO TO 6
      DELX2 = ARCYA(3)-ARCYA(2)
      DELX12 = ARCYA(3)-ARCYA(1)
      C1 = -(DELX12+DELX1)/DELX12/DELX1
      C2 = DELX12/DELX1/DELX2
      C3 = -DELX1/DELX12/DELX2
      SLPP1 = C1*X2P(1)+ C2*X2P(2)+ C3*X2P(3)
```

```
      DELN = ARCYA(N)-ARCYA(NM1)
      DELNM1 = ARCYA(NM1)-ARCYA(N-2)
      DELNN = ARCYA(N)-ARCYA(N-2)
      C1 = (DELNN+DELN)/DELNN/DELN
      C2 = -DELNN/DELN/DELNM1
      C3 = DELN/DELNN/DELNM1
      SLPPN = C3*X2P(N-2)+ C2*X2P(NM1)+ C1*X2P(N)
      GO TO 1
    6  E(1) = 0.
       E(2) = 0.
      RETURN
      END
      FUNCTION CUR4YA( T , SIGMA , IT )
      DIMENSION ARCYA(150)
      DIMENSION X2P(150) , Y2P(150)
      DIMENSION E(150)
      COMMON/JOHNE/ E
      COMMON/AYA/ ARCYA
      COMMON/YA/ X2P , Y2P , MQP
C  THIS FUNCTION INTERPOLATES THE SEAWARD BDRY  AT A GIVEN VALUE FOR
C  THE ARCLENGTH. THE VALUE RETURNED IN CUR4YA IS THE VALUE OF X
C  AT ITS PARTICULAR ARCLENGTH. SUBROUTINE CUR2YA MUST BE CALLED BEFORE.
      N= MQP
      S = ARCYA(N)-ARCYA(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
        IF( ARCYA(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( ARCYA(I-1) .LE. T .OR. T .LE. ARCYA(1) ) GO TO 4
```

```
      I1 = 2
      GO TO 1
    4 DEL1 = T-ARCYA(I-1)
      DEL2 = ARCYA(I)-T
      DELS = ARCYA(I)-ARCYA(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
      CUR4YA= ( E(I)*SINHD1+ E(I-1)*SINHD2)/SINHS+((X2P(I)-E(I))*DEL1  +
     9(X2P(I-1) -E(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      SUBROUTINE CUR3YA( SLP1 , SLPN , SIGMA )
      DIMENSION ARCYA(150)
      DIMENSION X2P(150) , Y2P(150)
      DIMENSION E(150) , S(408)
      COMMON/JOHNE/ E
      COMMON/JOHNS/ S
      COMMON/AYA/ ARCYA
      COMMON/YA/ X2P , Y2P , MGP
C   FITS SPLINE--Y2P AS A FUNCTION OF ARCYA
      N= MGP
      NM1 = N-1
      NP1 = N+1
      DELX1 = ARCYA(2)-ARCYA(1)
      DX1 = (Y2P(2)-Y2P(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
```

```
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(ARCYA(N)-ARCYA(1))
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       F(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = ARCYA(I+1)-ARCYA(I)
        DX2=  (Y2P(I+1)-Y2P(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*   S(I-1))
         F(I) = DIAGIN*(DX2-DX1-SPDIAG* F(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
        DX1 = DX2
    2   DIAG1 = DIAG2
    3 DIAGIN = 1./(DIAG1-SPDIAG*   S(NM1))
       F(N) = DIAGIN*(SLPPN-DX2-SPDIAG* F(NM1))
      DO 4 I = 2,N
        IBAK = NP1-I
```

```
4    F(IBAK) =   F(IBAK)-    S(IBAK)* F( IBAK+1)
   RETURN
5  IF (N.EQ.2) GO TO 6
   DELX2 = ARCYA(3)-ARCYA(2)
   DELX12 = ARCYA(3)-ARCYA(1)
   C1 = -(DELX12+DELX1 )/DELX12/DELX1
   C2 = DELX12/DELX1/DELX2
   C3 = -DELX1/DELX12/DELX2
   SLPP1  = C1*Y2P(1)+ C2*Y2P(2)+ C3*Y2P(3)
   DELN = ARCYA(N)-ARCYA(NM1 )
   DELNM1  = ARCYA(NM1)-ARCYA(N-2)
   DELNN  = ARCYA(N)-ARCYA(N-2)
   C1 = (DELNN+DELN)/DELNN/DELN
   C2 = -DELNN/DELN/DELNM1
   C3 = DELN/DELNN/DELNM1
   SLPPN  = C3*Y2P(N-2)+ C2*Y2P(NM1)+ C1*Y2P(N)
   GO TO 1
6   F(1) = 0.
    F(2) = 0.
   RETURN
   END
   FUNCTION CURSYA( T , SIGMA , IT )
   DIMENSION ARCYA(150 )
   DIMENSION X2P(150) , Y2P(150)
   DIMENSION F(150)
   COMMON/JCHNF/ F
   COMMON/AYA/ ARCYA
   COMMON/YA/ X2P , Y2P , MQP
C  THIS FUNCTION INTERPOLATES THE SEAWARD BDRY  AT A GIVEN VALUE FOR
C  THE ARCLENGTH. THE VALUE RETURNED IN CURSYA IS THE VALUE OF Y
C  AT ITS PARTICULAR ARCLENGTH. SUBROUTINE CUR3YA MUST BE CALLED BEFORE.
```

```
      N= MQP
      S = ARCYA(N)-ARCYA(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
        IF( ARCYA(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( ARCYA(I-1) .LE. T .OR. T .LE. ARCYA(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-ARCYA( I-1)
      DEL2 = ARCYA(I)-T
      DELS = ARCYA(I)-ARCYA(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
      SINHS = .5*(EXPS-1./EXPS)
      CUR5YA= ( F(I)*SINHD1+ F(I-1)*SINHD2)/SINHS+((Y2P(I)-F(I))*DEL1   +
     9(Y2P(I-1) -F(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      FUNCTION SINH(X)
      Y=-X
      S=EXP(X)-EXP(Y)
      SINH= S/2.
      RETURN
```

```
END
FUNCTION COSH(X)
Y=-X
S= EXP( X)+EXP(Y)
COSH= S/2.
RETURN
END
```

APPENDIX B

FORTRAN Listing of Program GRID

```
C     PROGRAM GRID. DETERMINES THE COMPUTING GRID DATA FOR INPUT
C       TO PROGRAM SSURGE. IT IS ASSUMED THAT THE CONFORMAL MAPPING
C       OF THE REGION IS COMPLETE ( PROGRAM CONFORM ) WITH OUTPUT OF THE
C       COEFFS.
C
C     GRID FOR HURRICANE CARLA
C
      DIMENSICN COB(200) , COC(200)
      DIMENSICN X2(1000) , Y2(1000)
      DIMENSICN X2P(1000) , Y2P(1000)
      DIMENSICN ATXA(1000) , ATYA(1000) , ATXB(100) , ATYB(1000)
      DIMENSION XI(47) , ETA(15) , X(47,15) , Y(47,15) , Z(47,15)
      DIMENSICN SX(100) , SY(100)
      DIMENSION A(5),B(5),C(5),IIC(5)
      COMMON /YE/ X2,Y2,MQ
      CCMMON /YA/ X2P,Y2P,MQP
      COMMON/XIETXY/ XI,ETA,X,Y
      CCMMCN/SXY/ SX,SY
      COMMON/ED/ XKBETA,BZPBT,BZMBT
      CCMMON /FORIA/ COB,COC,BZRC,XK,NMAX
C
C     READ NUMBER OF COEFFS, NUMBER OF XI LINES+2, NUMBER OF ETA LINES,
C     VALUE OF DELTA S STAR IN NM, FIRST VALUE OF S STAR IN NM, VALUE OF
C     DELTA T STAR IN MINUTES, NUMBER OF DEPTHS, NUMBER OF POINTS
C
      READ(5,1)NMAX,NUMXI,NUMETA,DELSS,SSTRT,DELTT,ND,NS
    1 FORMAT(3I4, 3F5.1, 2I4)
C
C
      SLMAP=60./51.
      XLAMDA= 360.
```

```
      XIDUM= 360.0*26.0/33.0
      PI = 3.141593
      XK = PI/XLAMDA
      SIGMA = -1.
      G= 32.2
      NUMETI= NUMETA-1
      NUMXI1= NUMXI-1
      NUMXI2= NUMXI-2
C
      READ (5,27) BETA,BZRO
      DO 26 N=1,NMAX
         READ (5,27) COE(N),COC(N)
   26 CONTINUE
   27    FORMAT (2E14.7)
      BZPBT= BZRO + BETA
      BZMBT= BZRO - BETA
      XKBETA= XK*BETA
C
C***  DETERMINE SHORELINE COORDINATES (XI,ETA) IN TERMS OF A STRETCHED SHELF
C***   COORDINATE SYSTEM (S*,T*).
C***   S* AXIS IS PARALLEL TO XI AND IS REPRESENTIVE OF COASTLINE
C***   ARCLENGTH.
C***  T* AXIS IS PARALLEL TO ETA AND IS REPRESENTIVE OF LONG WAVE
C***   TRAVEL TIME.
C
C
C***  DETERMINE TRANSFORM GENERATED COASTLINE AND SEA BDRY
C
      N3=1
      N4= 121
      DELXI= XLAMDA/(N4-1)
```

```
      DO 85  I=N3,N4
      XID   = (I-1)*DELXI
      CALL TRAN( XC,YC,XS,YS, XID    )
      ATXB(I)= XC
      ATYB(I)= YC
      ATXA(I)= XS
      ATYA(I)= YS
 85   CONTINUE
      WRITE(6,29)
      WRITE(6,39)
      WRITE(6,79)
      CALL XUT( ATXB , ATYB , N3,N4 )
      WRITE(6,29)
      WRITE(6,49)
      WRITE(6,69)
      WRITE(6,79)
      CALL XUT( ATXA , ATYA , N3 , N4 )
C
C***  DETERMINE TRANSFORM GENERATED ARCLENGTH OF COASTLINE AND SEA BDRY
C***  AS A FUNCTION OF (EVENLY SPACED) XI.
C
      Y2(1)= 0.
      X2(1)= 0.
      X2P(1)= 0.
      DO 91  I=N3,N4
      Y2(I)= (I-1)*DELXI
      II= I+1
      IF( I .EQ. N4 ) GO TO 91
      DELX= ABS( ATXB(II)-ATXB(I) )
      DELY= ABS( ATYB(II)-ATYB(I) )
      X2(II)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
```

```
      X2(II)= X2(II) + X2(I)
      DELX= ABS( ATXA(II)-ATXA(I) )
      DELY= ABS( ATYA(II)-ATYA(I) )
      X2P(II)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
      X2P(II)= X2P(II) + X2P(I)
 91   CONTINUE
      WRITE(6,29)
      WRITE(6,79)
      WRITE(6,89)
      CALL XUT( X2,Y2,N3,N4 )
      WRITE(6,29)
      WRITE(6,79)
      WRITE(6,99)
      CALL XUT( X2P,Y2,N3,N4 )
C
 29   FORMAT( 1H1,//,46X,39HREGION---LAGUN MADRE  TO  MARSH ISLAND      )
   39 FORMAT (///,55X,21HCOASTLINE COORDINATES,//)
   40 FORMAT (    62X,8HORIGINAL,////)
   49 FORMAT (///,51X,28HSEAWARD BOUNDARY COORDINATES)
   50 FORMAT (53X,24H( 100 FM DEPTH CONTOUR ) ,//)
   59 FORMAT (54X,23HINTERPOLATION BY SPLINE,////)
 69   FORMAT( // )
 79   FORMAT( 56X,19HTRANSFORM GENERATED ,/// )
 89   FORMAT( 50X,30HARCLENGTH,XI    ALONG COASTLINE,///              )
 99   FORMAT( 47X,37HARCLENGTH,XI    ALONG SEAWARD BOUNDARY,///         )
C
      MQ= N4
      CALL CURV1( SLP1,SLPN,SIGMA )
C
C     DETERMINE APPROPIATE VALUES OF XI SUCH THAT DELTA S* IS CONSTANT.
      WRITE(6,29)
```

```
      WRITE(6,113)
  113 FORMAT( ///,53X,33HSTRETCHED SHELF COORDINATE SYSTEM                 ,
     9/,39X,52HEVENLY SPACED IN S-STAR (DISTANCE PARALLEL TO COAST)      ,
     9/,39X,57HAND EVENLY SPACED IN T-STAR (TRAVEL TIME NORMAL TO COAST)
     9,/// )
C   TOTAL OF IIC(IRG)=NUM OF INCREMENTS OF DEL S*. REMEMBER THERE ARE
C      TWO EXTRA XI LINES- ONE AT EACH END OF THE GRID.
C   USER SUPPLIES EXPANSION COEFFS A,B,C FOR EACH REGION OF THE CURVE
C        S-PAR= A+B*(S*)**C
C
      IRG= 5
      IIC(1)= 10
      IIC(2)= 4
      IIC(3)= 7
      IIC(4)= 9
      IIC(5)= 16
      A(1)= 0.6058735E+03
      B(1)=-0.5479735E+05
      C(1)=-0.9044300E+00
      A(2)=-0.1395315E+03
      B(2)=1.5
      C(2)=1.
      A(3)= 0.4788464E+03
      B(3)=-0.3038714E+07
      C(3)=-0.1707694E+01
      A(4)=0.
      B(4)=1.
      C(4)=1.
      A(5)= 0.2870103E+03
      B(5)= 0.4707750E-11
      C(5)= 0.5160192E+01
```

```
      WRITE(6,114)
  114 FORMAT(29X,11HD S PL/D S*   ,9X,6HS-STAR,7X,10HS-PARALLEL,11X,2HXI,
     9//)
C
      K2= 0
      K1= 1
      DO 120 I=1,IRG
      A1= A(I)
      B1= B(I)
      C1= C(I)
      WRITE(6,115) I,A1,B1,C1
  115 FORMAT(/,1X,7HREGION  ,I1,3X,6HA,B,C= ,3(2X,F14.7),//)
      K2= K2+IIC(I)
      K3= K2+1
      DO 119 J=K1,K3
      K=J
      XDUM= SSSTRT + (J-1)*DELSS
      CALL CURVS( XDUM,SDUM,DDUM,A1,B1,C1 )
      XI(J)= CURV2( SDUM,SIGMA,K )
      WRITE(6,117) DDUM,XDUM,SDUM,XI(J),J
  117 FORMAT( 30X,F8.4,10X,F6.1,9X,F6.1,9X,F6.1 , 4X,I2 )
  119 CONTINUE
      K1= K3
  120 CONTINUE
C
C***  XI VALUES NOW KNOWN FOR EVENLY SPACED INCREMENTS OF S*.
C
C
C***  PROCEEDING TO FIND ETA VALUES FOR EVENLY SPACED INCREMENTS OF T*.
C
C***  DETERMINE ARCLENGTH ALONG A PARTICULAR ISOLINE OF XI ( XIDUM ).
```

```
C
      DELETA= 2.0*BETA/(NS-1)
      X2(1)= 0.
      WRITE(6,29)
      WRITE(6,79)
      WRITE(6,999) XIDUM
 999  FORMAT( 41X,33HARCLENGTH (N MI),ETA    ALONG XI=     ,F8.3,///      )
      DO 94 J=1,NS
      Y2(J) = -BETA + (J-1)*DELETA
      CALL TRAN1( XDUM,YDUM, XIDUM,Y2(J)  )
      X2P(J)= XDUM
      Y2P(J)= YDUM
      IF( J .EQ. 1 ) GO TO 94
      JJ= J-1
      DELX= ABS( X2P(J)-X2P(JJ) )
      DELY= ABS( Y2P(J)-Y2P(JJ) )
       X2(J)=  X2(JJ) + SLMAP*SQRT( DELX*DELX + DELY*DELY )
  94  CONTINUE
      DO 98 I=1,NS
      WRITE(6,97) I,X2(I),Y2(I) ,X2P(I),Y2P(I)
  97  FORMAT( 42X,I2,2X,F6.1,1H,,F7.3,10X,F6.1,1H,,F6.1                  )
  98  CONTINUE
C
      MQ= NS
      CALL CURV1( SLP1,SLPN,SIGMA )
C
C     DETERMINE APPROPIATE VALUES OF ETA SUCH THAT DELTA T* IS CONSTANT.
C
C     READ WATER DEPTH (FN) AT ND PLACES EVENLY SPACED ALONG XI=XIDUM.
      ND1= ND-1
      DELS= X2(NS)/ND1
```

```
      Y2P(1)= 0.
      DO 123 I=1,ND
      READ(5,124) SY(I)
      J=I+1
      IF( I .EQ. ND ) GO TO 123
      Y2P(J)= Y2P(I) + DELS
 123  CONTINUE
 124  FORMAT( F8.2 )
C  DETERMINE LONG WAVE TRAVEL TIME (MIN) ALONG XI=XIDUM.
      X2P(1)= 0.0
      DO 128 I=1,ND1
      J=I+1
      F1= 1.0/SQRT( G*SY(I)*6.0 )
      F2= 1.0/SQRT( G*SY(J)*6.0 )
      X2P(J)= X2P(I) + (F1+F2)*(Y2P(J)-Y2P(I))*50.0
 128  CONTINUE
      TIM= X2P(ND)
C
      MQP= ND
      CALL CURV3( SLP1,SLPN,SIGMA )
C
      WRITE(6,29)
      WRITE(6,131) XIDUM
 131  FORMAT( 70X,3HXI=,F6.1,/,13X,8HD T/D T* ,12X,6HT-STAR ,6X,4HTIME ,
     96X,8HS-NORMAL ,8X,3HETA ,10X, 5HDEPTH, // )
      DO 133 I=1,ND
 133  WRITE(6,134) X2P(I),Y2P(I),SY(I)
 134  FORMAT( 43X,F6.1,6X,F6.1,21X,F6.1 )
C
C  TOTAL OF IIC(IRG)=NUM OF INCREMENTS OF DEL-T*.
C  EXPANSION CURVE-- T= A+B*(T*)**C
```

```
C
      IRG= 2
      IIC(1)= 4
      IIC(2)= 10
      TIM1= IIC(1)*DELTT
      TIM2= IIC(2)*DELTT
      A(1)= 0.
      C(1)= TIM1/(TIM-TIM2)
      B(1)= (TIM-TIM2)*TIM1**(-C(1))
      A(2)= TIM-TIM1-TIM2
      B(2)=1.
      C(2)=1.
      IF( IIC(1)+1 .EQ. NUMETA ) DELTT= TIM/(NUMETA-1)
      IF( IIC(1)+1 .EQ. NUMETA ) B(1)=1.
      IF( IIC(1)+1 .EQ. NUMETA ) C(1)=1.
      WRITE(6,29)
      WRITE(6,113)
      WRITE(6,131) XIDUM
      K2= 0
      K1= 1
      DO 146 I=1,IRG
      A1= A(I)
      B1= B(I)
      C1= C(I)
      WRITE(6,115) I,A1,B1,C1
      K2= K2+IIC(I)
      K3= K2+1
      DO 145 J=K1,K3
      K=J
      WDUM= (J-1)*DELTT
      CALL CURV9( WDUM,XDUM,DDUM,A1,B1,C1 )
```

```
       YDUM= CURV4( XDUM,SIGMA, K )
       ZDUM= CURV2( YDUM,SIGMA,K )
       ETA(J)= ZDUM
       IF( J .EQ. 1 ) ETA(J)=-BETA
       IF( J .EQ. NUMETA ) ETA(J)=  BETA
       WRITE(6,143) DDUM,WDUM,XDUM,YDUM,ZDUM, J
 143   FORMAT( 11X,F8.4,12X,F6.1,6X,F6.1,6X,F6.1,7X,F7.3,2X,I2 )
 145   CONTINUE
       KI= K3
 146   CONTINUE
C
C      ***********************************************************************
C
C***  THE VALUES OF XI AND ETA ARE NOW DETERMINED  PERMITTING OUTPUT/
C***   PUNCH OF ALL COMPUTING GRID DATA.
C        X,Y GRID POINT LOCATIONS
C        SCALE FACTOR MU (XI)
C        SCALE FACTOR NU (ETA)
C        SCALE FACTOR S (X,Y/XI,ETA)
C        COS AND SIN THETA - ORIENTATION OF XI AXIS TO X AXIS
C
C
C***   COMPUTE X,Y COORDINATES OF GRID POINT LOCATIONS
C
       CALL SHECCR(      DELSS,NUMXI,    DELTT,NUMETA, SLMAP )
C
C  PUNCH X,Y COORDINATES HERE AS READ IN PROGRAM SSURGE WITH NAME XX,YY.
C     THESE COORDINATES ARE IN ARRAYS X,Y FOR I=2,3--NUMXI-1
C     AND J=1,2--NUMETA
C
C
```

```
C***   COMPUTE SCALE FACTOR MU
C
       WRITE(6,200)
 200   FORMAT( 1H1,//,50X,35HHURRICANE CARLA COMPUTING GRID DATA          )
       WRITE(6,201)
 201   FORMAT( //,60X,15HSCALE FACTOR MU   ,//   )
       DO 204 I=2,NUMXI1
       J=I-1
       SX(J)= ( XI(I+1)-XI(I-1) )/2./DELSS
       WRITE(6,202) J,SX(J)
 202   FORMAT( 60X,3HMU( ,I2, 3H)=   ,E14.7   )
 204   CONTINUE
C
C  PUNCH MU HERE AS READ IN PROGRAM SSURGE WITH NAME DSDXI.
C     MU IS IN ARRAY SX FOR I=1,2--NUMXI-2
C
C
C***   COMPUTE SCALE FACTOR NU
C
       WRITE(6,200)
       WRITE(6,210)
 210   FORMAT( //,60X,15HSCALE FACTOR NU    ,//   )
       SY(1)= (ETA(2)-ETA(1))/DELTT
       SY(NUMETA)= (ETA(NUMETA)-ETA(NUMET1))/DELTT
       DO 214 J=1,NUMETA
       IF( J .EQ. 1 .OR. J .EQ. NUMETA ) GO TO 211
       SY(J)= (ETA(J+1)-ETA(J-1))/2./DELTT
 211   WRITE(6,212) J , SY(J)
 212   FORMAT( 60X,3HNU( ,I2, 3H)=   ,E14.7   )
 214   CONTINUE
C
```

```
C  PUNCH NU HERE AS READ IN PROGRAM SSURGE WITH NAME DTDET.
C      NU IS IN ARRAY SY FOR J=1,2--NUMETA.
C
C
C***  COMPUTE SCALE FACTOR F AS READ IN PROGRAM SSURGE WITH NAME S.
C       RECALL F IS SCRT CF AREA IN X,Y PLANE / MU*NU*DELSS*DELTT
C       FIRST CCMPUTE AREA OF EACH QUADRANGLE SLB-DIVEDED INTO
C       IQUAD INTERVALS BETWEEN XI LINES ANC JQUAD INTERVALS BETWEEN
C       ETA LINES
C
      IQUAD= 4
      JQUAD= 2
      KCP= 1
      CALL TRAN2( KCP, 0., 0., 0., 0., 0. )
      KOP= 2
      WRITE(6,200)
      WRITE(6,3CC)
  300 FORMAT(//,60X,14HSCALE FACTOR F    ,// )
      DC 330 I=1,NUMXI1
      DELXI= (XI(I+1)-XI(I))/IQUAD
      FRST= XI(I) +DELXI/2.
      DO 310 K=1,IGUAD
  310 X2(K)= FRST + (K-1)*DELXI
      DC 330 J=1,NUMET1
      DELETA= (ETA(J+1)-ETA(J))/JQUAC
      FRST= ETA(J) + DELETA/2.
      SUM= 0.
      DC 320 K=1,IGUAC
      DO 320 L=1,JQUAD
      DUMETA= FRST + (L-1)*DELETA
      CALL TRAN2( KOP,X2(K),DUMETA,0.,DF1,DF2 )
```

```
      SUM= SUM + DF1*DF1 + DF2*DF2
  320 CONTINUE
      X(I,J)= SUM*DELXI*DELETA
  330 CONTINUE
      FAC1= 2.*DELSS*DELTT
      FAC2= 2.*FAC1
      N= NUMETA
      DO 370 I=1,NUMXI2
      Z(I,1)=SQRT((X(I,1)+X(I+1,1))/FAC1/SX(I)/SY(1))
      Z(I,N)= SQRT((X(I,N-1)+X(I+1,N-1))/FAC1/SX(I)/SY(N))
      DO 370 J=2,NUMET1
      Z(I,J)= SQRT((X(I,J)+X(I+1,J)+X(I,J-1)+X(I+1,J-1))/FAC2/SX(I)/SY(J
     9))
  370 CONTINUE
      DO 390 J=1,NUMETA
      WRITE(6,381) J
  381 FORMAT( //,10X,11HROW NUMBER    ,I2,//   )
      WRITE(6,382) ( I,Z(I,J),I=1,NUMXI2 )
  382 FORMAT(      5(I4,2X,E14.7,4X))
  390 CONTINUE
C
C  PUNCH F HERE AS READ IN PROGRAM SSURGE WITH NAME S. SCALE FACTOR F
C     IS IN ARRAY Z FOR I=1,2--NUMXI-2  AND   J=1,2--NUMETA
C
C
C***  COMPUTE COS AND SIN THETA - ORIENTATION OF XI AXIS TO X AXIS.
C      RECALL, THETA IS A WEIGHTED AVERAGE.
C
      WRITE(6,200)
      WRITE(6,395)
  395 FORMAT( //, 60X, 27HVALUES OF COS AND SIN THETA  , // )
```

```
      DO 400 I=1,NUMXI
      XID= XI(I)
      DO 400 J=1,NUMETA
      ETAD= ETA(J)
      CALL TRAN2( KDF,XID,ETAD, ANGLE,DF1,DF2 )
      Z(I,J)= ATAN2( DF2,DF1 )
  400 CONTINUE
      N= NUMETA
      DO 410 I=2,NUMXI1
      K= I-1
      X(K,1)= COS((Z(I-1,1)+2.*Z(I,2)+Z(I+1,1)+ 4.*Z(I,1))/8.)
      Y(K,1)= SIN((Z(I-1,1)+2.*Z(I,2)+Z(I+1,1)+ 4.*Z(I,1))/8.)
      X(K,N)= COS((Z(I-1,N)+2.*Z(I,N-1)+Z(I+1,N)+4.*Z(I,N))/8.)
      Y(K,N)= SIN((Z(I-1,N)+2.*Z(I,N-1)+Z(I+1,N)+4.*Z(I,N))/8.)
      DO 410 J=2,NUMET1
      X(K,J)= COS((Z(I-1,J)+Z(I,J-1)+Z(I+1,J)+Z(I,J+1)+4.*Z(I,J))/8.)
      Y(K,J)= SIN((Z(I-1,J)+Z(I,J-1)+Z(I+1,J)+Z(I,J+1)+4.*Z(I,J))/8.)
  410 CONTINUE
      DO 440 J=1,NUMETA
      WRITE(6,381) J
      WRITE(6,430) ( I,X(I,J),Y(I,J),I=1,NUMXI2)
  430 FORMAT(     5(I3,2X,F8.5,1X,F8.5,4X))
  440 CONTINUE
C
C  PUNCH COS AND SIN THETA HERE AS READ IN PROGRAM SSURGE WITH
C     NAMES COSG AND SING. THESE VALUES ARE IN ARRAYS X AND Y FOR
C     I=1,2--NUMXI-2   AND   J=1,2--NUMETA.
C
      STOP
      END
      SUBROUTINE XUT( X,Y,N1,N2 )
```

```
      DIMENSION X(1000) , Y(1000)
      M= N2-N1+1
      M14= M/4
      M4= M14*4
      IADD= M-M4
      DO 10 I=N1,M14
      J= I+M14
      K= J+M14
      L= K+M14
10    WRITE(6,11) I,X(I),Y(I),J,X(J),Y(J),K,X(K),Y(K),L,X(L),Y(L)
11    FORMAT( 4(6X,I4,2X,F6.1,1X,1H,,1X,F6.1,6X) )
      IF( IADD .EQ. 0 ) GO TO 25
      IF( IADD .EQ. 1 ) NUM1= N2
      IF( IADD .EQ. 2 ) NUM1= N2-1
      IF( IADD .EQ. 3 ) NUM1= N2-2
      DO 20 I=NUM1,N2
20    WRITE(6,21) I,X(I),Y(I)
21    FORMAT( 105X,I4,2X,F6.1,1X,1H,,1X,F6.1,6X   )
25    CONTINUE
      RETURN
      END .
      SUBROUTINE SHRCOR(        DELXI,NUMXI,        DELETA,NUMETA,SLMAP )
      DIMENSION XI(47) , ETA(15) , X(47,15) , Y(47,15)
      DIMENSION SX(100) , SY(100)
      COMMON/XIETXY/ XI,ETA,X,Y
      COMMON/SXY/ SX,SY
      NUMPG= NUMXI/5
      IADD= NUMXI-5*NUMPG
      NPAGE= 1
      DO 40 I=1,NUMXI
      DO 40 J=1,NUMETA
```

```
      CALL TRAN1( XDUM,YDUM,XI(I),ETA(J) )
      X(I,J)= XDUM
      Y(I,J)= YDUM
   40 CONTINUE
   55 CONTINUE
                           WRITE(6,900) DELXI , DELETA
      N1= NPAGE*5 -4
      N2= NPAGE*5
      IF( N2 .GT. NUMXI ) GO TO 80
      IF( NUMPG .EQ. 0 ) GO TO 80
      I1= N1
      I2= N1+1
      I3= N1+2
      I4= N1+3
      I5= N1+4
      WRITE(6,903) XI(I1),XI(I2),XI(I3),XI(I4),XI(I5),I1,I2,I3,I4,I5
      DO 70 K=1,NUMETA
      J= NUMETA-K+1
      JJ= J-1
      DO 60 I=N1,N2
      IF( I .EQ. NUMXI ) GO TO 62
      II= I+1
      DELX= ABS( X(II,J)-X(I,J) )
      DELY= ABS( Y(II,J)-Y(I,J) )
      SX(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
   60 CONTINUE
   62 CONTINUE
      IF( IACC .EQ. 0 .AND. N2 .EQ. NUMXI ) GO TO 64
      WRITE(6,904) ETA(J),X(I1,J),Y(I1,J),SX(I1),X(I2,J),Y(I2,J),SX(I2),
     9X(I3,J),Y(I3,J),SX(I3),X(I4,J),Y(I4,J),SX(I4),X(I5,J),Y(I5,J)     ,
     9SX(I5),  J
```

```
      GO TO 66
64    CONTINUE
      WRITE(6,905) ETA(J),X(I1,J),Y(I1,J),SX(I1),X(I2,J),Y(I2,J),SX(I2),
     9X(I3,J),Y(I3,J),SX(I3),X(I4,J),Y(I4,J),SX(I4),X(I5,J),Y(I5,J), J
66    CONTINUE
      IF( K .EQ. NUMETA ) GO TO 70
      DO 68 I=N1,N2
      DELX= ABS( X(I,JJ)-X(I,J) )
      DELY= ABS( Y(I,JJ)-Y(I,J) )
      SY(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
68    CONTINUE
      WRITE(6,906) SY(I1),SY(I2),SY(I3),SY(I4),SY(I5)
70    CONTINUE
      IF( IADD .EQ. 0 .AND. N2 .EQ. NUMXI ) GO TO 150
      NPAGE= NPAGE + 1
      GO TO 55
80    CONTINUE
      IF( IADD .EQ. 1 ) GO TO 100
      IF( IADD .EQ. 2 ) GO TO 110
      IF( IADD .EQ. 3 ) GO TO 120
      IF( IADD .EQ. 4 ) GO TO 130
100   CONTINUE
      I1= N1
      I= I1
      WRITE(6,910) XI(I1),I1
      DO 102 K=1,NUMETA
      J= NUMETA-K+1
      JJ= J-1
      WRITE(6,911) X(I1,J),Y(I1,J)
      IF( K .EQ. NUMETA ) GO TO 102
      DELX= ABS( X(I,JJ)-X(I,J) )
```

```
      DELY= ABS( Y(I,JJ)-Y(I,J) )
      SY(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
      WRITE(6,912) SY(I1)
 102  CONTINUE
      GO TO 150
 110  CONTINUE
      I1= N1
      I2= N1+1
      WRITE(6,914) XI(I1),XI(I2),I1,I2
      DO 114 K=1,NUMETA
      J= NUMETA-K+1
      JJ= J-1
      DELX= ABS( X(I2,J)-X(I1,J) )
      DELY= ABS( Y(I2,J)-Y(I1,J) )
      SX(I1)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
      WRITE(6,915) X(I1,J),Y(I1,J),SX(I1),X(I2,J),Y(I2,J)
      IF( K .EQ. NUMETA ) GO TO 114
      DO 112 I=I1,I2
      DELX= ABS( X(I,JJ)-X(I,J) )
      DELY= ABS( Y(I,JJ)-Y(I,J) )
      SY(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
 112  CONTINUE
      WRITE(6,916) SY(I1),SY(I2)
 114  CONTINUE
      GO TO 150
 120  CONTINUE
      I1= N1
      I2= N1+1
      I3= N1+2
      WRITE(6,917)XI(I1),XI(I2),XI(I3),I1,I2,I3
      DO 128 K=1,NUMETA
```

```
      J= NUMETA-K+1
      JJ= J-1
      DO 122 I=I1,I3
      IF( I .EQ. NUMXI ) GO TO 124
      II= I+1
      DELX= ABS( X(II,J)-X(I,J) )
      DELY= ABS( Y(II,J)-Y(I,J) )
      SX(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
  122 CONTINUE
  124 CONTINUE
      WRITE(6,918) ETA(J),X(I1,J),Y(I1,J),SX(I1),X(I2,J),Y(I2,J),SX(I2),
     9X(I3,J),Y(I3,J), J
      IF( K .EQ. NUMETA ) GO TO 128
      DO 126 I=I1,I3
      DELX= ABS( X(I,JJ)-X(I,J) )
      DELY= ABS( Y(I,JJ)-Y(I,J) )
      SY(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
  126 CONTINUE
      WRITE(6,919) SY(I1),SY(I2),SY(I3)
  128 CONTINUE
      GO TO 150
  130 CONTINUE
      I1= N1
      I2= N1+1
      I3= N1+2
      I4= N1+3
      WRITE(6,921) XI(I1),XI(I2),XI(I3),XI(I4),I1,I2,I3,I4
      DO 138 K=1,NUMETA
      J= NUMETA-K+1
      JJ= J-1
      DO 132 I=I1,I4
```

```
      IF( I .EQ. NUMXI ) GO TO 134
      II= I+1
      DELX= ABS( X(II,J)-X(I,J) )
      DELY= ABS( Y(II,J)-Y(I,J) )
      SX(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
 132  CONTINUE
 134  CONTINUE
      WRITE(6,922) ETA(J),X(I1,J),Y(I1,J),SX(I1),X(I2,J),Y(I2,J),SX(I2),
     9X(I3,J),Y(I3,J),SX(I3),X(I4,J),Y(I4,J), J
      IF( K .EQ. NUMETA ) GO TO 138
      DO 136 I=I1,I4
      DELX= ABS( X(I,JJ)-X(I,J) )
      DELY= ABS( Y(I,JJ)-Y(I,J) )
      SY(I)= SLMAP*SQRT( DELX*DELX + DELY*DELY )
 136  CONTINUE
      WRITE(6,923) SY(I1),SY(I2),SY(I3),SY(I4)
 138  CONTINUE
 150  CONTINUE
 900  FORMAT(    1H1,46X,39HREGION---LAGUNA MADRE  TO  MARSH ISLAND      .
     9//  ,55X,21HSHORELINE COORDINATES                                  .
     9//,58X,16HHURRICANE CARLA                                          .
     9//  ,46X,10HDELTA-S*= ,F6.3,6X,10HDELTA-T*=  ,F6.3,  ///           )
 903  FORMAT( 2X,5(14X,3HXI=,F7.2),/   ,5(19X,1H(,I2,1H),1X),//          )
 904  FORMAT(     1X,4HETA=,F7.3,2X,F6.1,1H,,F6.1                        .
     94(3X,F4.1,4X,F6.1,1H,,F6.1), 3X,F4.1,/  ,5X,1H(,I2,1H)             )
 905  FORMAT(     1X,4HETA=,F7.3,2X,F6.1,1H,,F6.1                        .
     94(3X,F4.1,4X,F6.1,1H,,F6.1),           /  ,5X,1H(,I2,1H)           )
 906  FORMAT(  5(18X,F4.1,2X),/                                          )
 910  FORMAT(      16X,3HXI=,F7.2,/  ,19X,1H(,I2,1H),//                  )
 911  FORMAT(      14X,F6.1,1H,,F6.1,/                                   )
 912  FORMAT(      18X,F4.1,/                                            )
```

```
914  FORMAT( 2X,2(14X,3HXI=,F7.2),/    ,2(19X,1H(,I2,1H),1X),//          )
915  FORMAT(     14X,F6.1,1H,,F6.1,3X,F4.1,4X,F6.1,1H,,F6.1,/            )
916  FORMAT(  2(18X,F4.1,2X),/                                           )
917  FORMAT( 2X,3(14),3HXI=,F7.2),/    ,3(19X,1H(,I2,1H),1X),//          )
918  FORMAT(     1X,4HETA=,F7.3,2X,F6.1,1H,,F6.1                         ,
    92(3X,F4.1,4X,F6.1,1H,,F6.1),                /  ,5X,1H(,I2,1H)       )
919  FORMAT(  3(18X,F4.1,2X),/                                           )
921  FORMAT( 2X,4(14X,3HXI=,F7.2),/    ,4(19X,1H(,I2,1H),1X),//          )
922  FORMAT(     1X,4HETA=,F7.3,2X,F6.1,1H,,F6.1                         ,
    93(3X,F4.1,4X,F6.1,1H,,F6.1),                /  ,5X,1H(,I2,1H)       )
923  FORMAT(  4(18X,F4.1,2X),/                                           )
     RETURN
     END
     SUBROUTINE TRAN( XCST,YCST,XSEA,YSEA,XI )
     DIMENSION COB(200), CCC(200)
     COMMON/ED/ XKBETA,BZPBT,BZMBT
     COMMON/FORIA/ COB,CCC,BZRC,XK,NMAX
     XCST= 0.
     YCST= 0.
     XSEA= 0.
     YSEA= 0.
     XKXI= XK*XI
     DO 10 N=1,NMAX
     XN=N
     XNKBT= XN*XKBETA
     XNKXI= XN*XKXI
     CSH= COSH( XNKBT )
     SNH= SINH( XNKBT )
     A= COC(N)*CSH
     B= COB(N)*SNH
     C= CCC(N)*SNH
```

```
      D= COB(N)*CSH
      E= SIN( XNKXI )
      F= COS( XNKXI )
      XCST= XCST + (A+B)*E
      XSEA= XSEA + (A-B)*E
      YCST= YCST + ( D+C)*F
      YSEA= YSEA + ( D-C)*F
10    CONTINUE
      XCST= XCST + XI
      XSEA= XSEA + XI
      YCST= YCST + BZPBT
      YSEA= YSEA + BZMBT
      RETURN
      END
      SUBROUTINE TRAN1( XDUM , YDUM , XI , ETA )
      DIMENSION COB(200), COC(200)
      COMMON/FORIA/ COB,COC,BZRO,XK,NMAX
      XDUM= 0.
      YDUM= 0.
      XKXI= XK*XI
      XKETA= XK*ETA
      DO 10 N=1,NMAX
      XN=N
      XNKBT= XN*XKETA
      XNKXI= XN*XKXI
      CSH= COSH( XNKBT )
      SNH= SINH( XNKBT )
      A= COC(N)*CSH
      B= COB(N)*SNH
      C= COC(N)*SNH
      D= COB(N)*CSH
```

```
      E= SIN( XNKXI  )
      F= COS( XNKXI  )
      XDUM= XDUM  +  (A+B)*E
      YDUM= YDUM  +  ( D+C)*F
10    CONTINUE
      XDUM= XDUM  +  XI
      YDUM= YDUM  +  EZRO  +  ETA
      RETURN
      END
      SUBROUTINE TRAN2( KOP,XI,ETA,ANGLE,DXDXI,DYDXI  )
      DIMENSION COB(200) , COC(200) , XNK(200)
      COMMON/FORIA/COB,COC,BZRO,XK,NMAX
      IF(KOP.EQ.1)GO TO 100
      GO TO 200
100   DO 105 N=1,NMAX
      XN= N
105   XNK(N)= XN*XK
      GO TO 999
200   DXDXI= 1.
      DYDXI= 0.
      DO 205 N=1,NMAX
      XNKETA= XNK(N)*ETA
      XNKXI= XNK(N)*XI
      SNH= SINH( XNKETA  )
      CSH= COSH( XNKETA  )
      DXDXI= DXDXI+XNK(N)*(COB(N)*SNH+COC(N)*CSH)*COS(XNKXI)
      DYDXI= DYDXI-XNK(N)*(COB(N)*CSH+COC(N)*SNH)*SIN(XNKXI)
205   CONTINUE
      IF( KOP.EQ.2) GO TO 999
      ANGLE= ATAN2(DYDXI,DXDXI)
999   RETURN
```

```
      END
      SUBROUTINE CURVS( XDUM,Y,Y1,A,B,C )
      Z= ABS( XDUM )
      W= ABS( C-1. )
      Y1= B
      Y= A+B*(XDUM)**C
      IF( Z .LT. 0.0001 .OR.  W .LT. 0.001 ) GO TO 10
      Y1= B*C*(XDUM)**(C-1.)
 10   CONTINUE
      RETURN
      END
      SUBROUTINE CURV1( SLP1 , SLPN , SIGMA )
C
      DIMENSION X2(1000) , Y2(1000)
      DIMENSION R(800) , S(800)
      COMMON/YE/ X2, Y2 , NG
      COMMON/JOHN1/ R
      COMMON/JOHN2/ S
C
C***********************************************************************
C
C THIS SUBROUTINE DETERMINES THE PARAMETERS NECESSARY TO
C COMPUTE AN INTERPOLATORY SPLINE UNDER TENSION THROUGH
C A SEQUENCE OF FUNCTIONAL VALUES. THE SLOPES AT THE TWO
C ENDS OF THE CURVE MAY BE SPECIFIED OR OMITTED. FOR ACTUAL
C COMPUTATION OF POINTS ON THE CURVE IT IS NECESSARY TO CALL
C THE FUNCTION CURV2.
C
C***********************************************************************
C
C ON INPUT--
```

```
C
C   N=  MC   IS THE NUMBER OF VALUES TO BE INTERPOLATED ( .GE. 2)
C   X2 IS AN ARRAY OF N INCREASING ABCISSAE OF THE FUNCTIONAL VALUES
C   Y2 IS AN ARRAY OF N ORDINATES OF THE VALUES
C      I.E. Y2(K) IS THE FUNCTIONAL VALUES CORRESPONDING TO X2(K).
C   R  IS AN ARRAY OF LENGTH AT LEAST N ( PERMANENT STORAGE )
C   S     IS AN ARRAY OF LENGTH AT LEAST N ( SCRATCH STORAGE ).
C
C   SLP1 AND SLPN CONTAIN THE DESIRED VALUES FOR THE FIRST
C   DERIVATIVE OF THE CURVE AT X2(1) AND X2(N), RESPECTIVELY.
C   IF THE QUANTITY SIGMA IS NEGATIVE THESE VALUES WILL BE
C   DETERMINED INTERNALLY AND THE USER NEED ONLY FURNISH
C   PLACE-HOLDING PARAMETERS FOR SLP1 AND SLPN. SUCH PLACE-
C   HOLDING PARAMETERS WILL BE IGNORED BUT NOT DESTROYED.
C
C   SIGMA CONTAINS THE TENSION FACTOR. THIS IS NON-ZERO AND
C   INDICATES THE CURVINESS DESIRED. IF ABS(SIGMA) IS NEARLY
C   ZERO (E.G. .001) THE RESULTING CURVE IS APPROXIMATELY A
C   CUBIC SPLINE. IF ABS(SIGMA) IS LARGE (E.G. 50.) THE
C   RESULTING CURVE IS NEARLY A POLYGONAL LINE. THE SIGN
C   OF SIGMA INDICATES WHETHER THE DERIVATIVE INFORMATION
C   HAS BEEN INPUT OR NOT.. IF SIGMA IS NEGATIVE THE ENDPOINT
C   DERIVATIVES WILL BE DETERMINED INTERNALLY. A STANDARD
C   VALUE FOR SIGMA IS APPROXIMATELY 1. IN ABSOLUTE VALUE.
C
C
C ON OUTPUT--
C
C   R  CONTAINS VALUES PROPORTIONAL TO THE SECOND DERIVATIVE
C   OF THE CURVE AT THE GIVEN NODES ( X2,Y2 ) .
C
```

```
C
C    N (MQ), X2, Y2, SLP1, SLPN, SIGMA ARE UNALTERED.
C
C
C
      N= MQ
      NM1 = N-1
      NP1 = N+1
      DELX1 = X2(2)-X2(1)
      DX1 = (Y2(2)-Y2(1))/DELX1
C
C DETERMINE SLOPES IF NECESSARY
C
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
C
C DENORMALIZE TENSION FACTOR
C
    1 SIGMAP = ABS(SIGMA)*(N-1)/(X2(N)-X2(1))
C
C SET UP RIGHT HAND SIDE AND TRIDIAGONAL SYSTEM FOR  R AND
C PERFORM FORWARD ELIMINATION
C
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       R(1) = DIAGIN*(DX1-SLPP1)
```

```
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
C
      IF (N.EQ.2) GO TO 3
C
      DO 2 I = 2,NM1
        DELX2 = X2(I+1)-X2(I)
        DX2= (Y2(I+1)-Y2(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
         R(I) = DIAGIN*(DX2-DX1-SPDIAG* R(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
        DX1 = DX2
    2   DIAG1 = DIAG2
C
    3 DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
        R(N) = DIAGIN*(SLPPN-DX2-SPDIAG* R(NM1))
C
C PERFORM BACK SUBSTITUTION
C
      DO 4 I = 2,N
        IBAK = NP1-I
    4    R(IBAK) =  R(IBAK)-    S(IBAK)* R(IBAK+1)
C
      RETURN
C
```

```
C
    5 IF (N.EQ.2) GO TO 6
C
C IF NO DERIVATIVES ARE GIVEN USE SECOND ORDER POLYNOMIAL
C INTERPOLATION ON INPUT DATA FOR VALUES AT ENDPOINTS.
C
       DELX2 = X2(3)-X2(2)
       DELX12 = X2(3)-X2(1)
       C1 = -(DELX12+DELX1)/DELX12/DELX1
       C2 = DELX12/DELX1/DELX2
       C3 = -DELX1/DELX12/DELX2
       SLPP1 = C1*Y2(1) + C2*Y2(2) + C3*Y2(3)
       DELN = X2(N)-X2(NM1)
       DELNM1 = X2(NM1)-X2(N-2)
       DELNN = X2(N)-X2(N-2)
       C1 = (DELNN+DELN)/DELNN/DELN
       C2 = -DELNN/DELN/DELNM1
       C3 = DELN/DELNN/DELNM1
       SLPPN = C3*Y2(N-2) + C2*Y2(NM1) + C1*Y2(N)
       GO TO 1
C
C IF ONLY TWO POINTS AND NO DERIVATIVES ARE GIVEN, USE
C STRAIGHT LINE FOR CURVE
C
    6   R(1) = 0.
        R(2) = 0.
C
       RETURN
       END
       FUNCTION CURV2( T , SIGMA , IT )
C
```

```
      DIMENSION X2(1000) , Y2(1000)
      DIMENSION R(800)
      COMMON/YB/ X2, Y2 , MQ
      COMMON/JOHN1/ R
C
C***********************************************************************
C
C THIS FUNCTION INTERPOLATES A CURVE AT A GIVEN POINT
C USING A SPLINE UNDER TENSION. THE SUBROUTINE CURV1 SHOULD
C BE CALLED EARLIER TO DETERMINE CERTAIN NECESSARY
C PARAMETERS.
C
C***********************************************************************
C
C ON INPUT--
C
C   T (X-COORD) CONTAINS A REAL VALUE TO BE MAPPED ONTO THE CURVE
C   N= (MQ) IS THE NUMBER OF POINTS WHICH WERE INTERPOLATED TO
C          DETERMINE THE CURVE.
C   X2,Y2 ARE ARRAYS CONTAINING THE ABCISSAS AND ORDINATES OF THE
C          ORIGINAL INTERPOLATED POINTS.
C    R IS AN ARRAY WITH VALUES PROPORTIONAL TO THE SECOND
C       DERIVATIVE OF THE CURVE AT THE NODES (X2,Y2) .
C   SIGMA CONTAINS THE TENSION FACTOR (ITS SIGN IS IGNORED)
C
C   IT IS AN INTEGER SWITCH. IF IT IS NOT 1 THIS INDICATES
C   THAT THE FUNCTION HAS BEEN CALLED PREVIOUSLY (WITH N,X2,
C   Y2,R, AND SIGMA UNALTERED) AND THAT THIS VALUE OF T
C   EXCEEDS THE PREVIOUS VALUE. WITH SUCH INFORMATION THE
C   FUNCTION IS ABLE TO PERFORM THE INTERPOLATION MUCH MORE
C   RAPIDLY. IF A USER SEEKS TO INTERPOLATE AT A SEQUENCE
```

```
C    CF PCINTS, EFFICIENCY IS GAINEC BY ORDERING THE VALUES
C    INCREASING ANC SETTING IT TC THE INDEX CF THE CALL.
C    IF IT IS 1 THE SEARCH FOR THE INTERVAL (X2(K),X2(K+1))
C    CONTAINING T STARTS WITH K=1.
C
C   THE PARAMETERS N (MQ), X2, Y2, R, AND SIGMA SHOULD BE INPUTTED
C   UNALTERED FRCM THE OUTPUT OF CURV1 AND THESE ARE UNALTERED IN CURV2 .
C
C
C  CN OUTPUT--
C
C    CURV2 (=Y-CCORD) CCNTAINS THE INTERPOLATED VALUE.
C          FCR T .LT. X2(1), CURV2= Y2(1). FOR T .GT. X2(N),CURV2= Y2(N).
C
C
      N= MQ
C
C DENORMALIZE SIGMA
      S = X2(N)-X2(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
C
C IF IT.NE.1 START SEARCH WHERE PREVICUSLY TERMINATED,
C CTHERWISE START FROM BEGINNING
C
      IF (IT.EQ.1) I1 = 2
C
C SEARCH FOR INTERVAL
C
    1 DC 2 I = I1,N
        IF( X2(I)-T ) 2,2,3
    2   CONTINUE
```

```
C
      I = N
C CHECK TC INSURE CCRRECT INTERVAL
C
 3    IF( X2(I-1) .LE. T .OR. T .LE. X2(1) ) GO TO 4
C
C RESTART SEARCH  AND RESET I1
C ( INPUT ''IT'' WAS INCORRECT )
C
      I1 = 2
      GC TO 1
C
C SET UP AND FERFCRM INTERFCLATICN
C
    4 DEL1 = T-X2(I-1)
      DEL2 = X2(I)-T
      DELS = X2(I)-X2(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
      CURV2 = ( R(I)*SINHD1+ R(I-1)*SINHD2)/SINHS+((Y2(I)-R(I))*DEL1    +
     9(Y2(I-1) - R(I-1))*DEL2 )/DELS
C
      I1 = I
      RETURN
      END
      SUBROUTINE CURV3( SLP1 , SLPN , SIGMA )
      DIMENSICN X2P(1000) , Y2P(1000)
```

```
      DIMENSION  V(800) , S(800)
      COMMON/JOHN2/ S
      COMMON/JOHN4/ V
      COMMON /YA/ X2P,Y2P,MQP
C
C**********************************************************************
C
C THIS SUBROUTINE DETERMINES THE PARAMETERS NECESSARY TO
C COMPUTE AN INTERPOLATORY SPLINE UNDER TENSION THROUGH
C A SEQUENCE OF FUNCTIONAL VALUES. THE SLOPES AT THE TWO
C ENDS OF THE CURVE MAY BE SPECIFIED OR OMITTED. FOR ACTUAL
C COMPUTATION OF POINTS ON THE CURVE IT IS NECESSARY TO CALL
C THE FUNCTION CURV4.
C
C**********************************************************************
C
C ON INPUT--
C
C   N= MQP  IS THE NUMBER OF VALUES TO BE INTERPOLATED ( .GE. 2)
C  X2P IS AN ARRAY OF N INCREASING ABCISSAE OF THE FUNCTIONAL VALUES
C  Y2P IS AN ARRAY OF N ORDINATES OF THE VALUES
C  V   IS AN ARRAY OF LENGTH AT LEAST N (PERMANENT STORAGE )
C  S      IS AN ARRAY OF LENGTH AT LEAST N ( SCRATCH STORAGE ).
C
C ON OUTPUT--
C
C  V   CONTAINS VALUES PROPORTIONAL TO THE SECOND DERIVATIVE
C   OF THE CURVE AT THE GIVEN NODES ( X2P,Y2P )
C
C   N(MQP), X2P,Y2P,SLP1, SLPN, SIGMA ARE UNALTERED.
C
```

```
      N= MQP
      NM1 = N-1
      NP1 = N+1
      DELX1 = X2P(2)-X2P(1)
      DX1 = (Y2P(2)-Y2P(1))/DELX1
      IF (SIGMA.LT.0.) GO TO 5
      SLPP1 = SLP1
      SLPPN = SLPN
    1 SIGMAP = ABS(SIGMA)*(N-1)/(X2P(N)-X2P(1))
      DELS = SIGMAP*DELX1
      EXPS = EXP(DELS)
      SINHS = .5*(EXPS-1./EXPS)
      SINHIN = 1./(DELX1*SINHS)
      DIAG1 = SINHIN*(DELS*.5*(EXPS+1./EXPS)-SINHS)
      DIAGIN = 1./DIAG1
       V(1) = DIAGIN*(DX1-SLPP1)
      SPDIAG = SINHIN*(SINHS-DELS)
         S(1) = DIAGIN*SPDIAG
      IF (N.EQ.2) GO TO 3
      DO 2 I = 2,NM1
        DELX2 = X2P(I+1)-X2P(I)
        DX2= (Y2P(I+1)-Y2P(I))/DELX2
        DELS = SIGMAP*DELX2
        EXPS = EXP(DELS)
        SINHS = .5*(EXPS-1./EXPS)
        SINHIN = 1./(DELX2*SINHS)
        DIAG2 = SINHIN*(DELS*(.5*(EXPS+1./EXPS))-SINHS)
        DIAGIN = 1./(DIAG1+DIAG2-SPDIAG*    S(I-1))
         V(I) = DIAGIN*(DX2-DX1-SPDIAG* V(I-1))
        SPDIAG = SINHIN*(SINHS-DELS)
           S(I) = DIAGIN*SPDIAG
```

```
      DX1 = DX2
2     DIAG1 = DIAG2
3 DIAGIN = 1./(DIAG1-SPDIAG*    S(NM1))
   V(N) = DIAGIN*(SLPPN-DX2-SPDIAG* V(NM1))
  DO 4 I = 2,N
    IBAK = NP1-I
4     V(IBAK) =  V(IBAK)-    S(IBAK)* V(IBAK+1)
  RETURN
5 IF (N.EQ.2) GO TO 6
  DELX2 = X2P(3)-X2P(2)
  DELX12 = X2P(3)-X2P(1)
  C1 = -(DELX12+DELX1)/DELX12/DELX1
  C2 = DELX12/DELX1/DELX2
  C3 = -DELX1/DELX12/DELX2
  SLPP1 = C1*Y2P(1)+ C2*Y2P(2)+ C3*Y2P(3)
  DELN = X2P(N)-X2P(NM1)
  DELNM1 = X2P(NM1)-X2P(N-2)
  DELNN = X2P(N)-X2P(N-2)
  C1 = (DELNN+DELN)/DELNN/DELN
  C2 = -DELNN/DELN/DELNM1
  C3 = DELN/DELNN/DELNM1
  SLPPN = C3*Y2P(N-2)+ C2*Y2P(NM1)+ C1*Y2P(N)
  GO TO 1
6  V(1) = 0.
   V(2) = 0.
  RETURN
  END
  FUNCTION CURV4( T , SIGMA , IT )
C
  DIMENSION X2P(1000) , Y2P(1000)
  DIMENSION  V(800)
```

```
      COMMON/JOHN4/ V
      COMMON /YA/ X2P,Y2P,MGP
C
C************************************************************************
C
C THIS FUNCTION INTERPOLATES A CURVE AT A GIVEN POINT
C USING A SPLINE UNDER TENSION. THE SUBROUTINE CURV3 SHOULD
C BE CALLED EARLIER TO DETERMINE CERTAIN NECESSARY  PARAMETERS.
C
C************************************************************************
C
C ON INPUT--
C
C   T (X-COORD) CONTAINS A REAL VALUE TO BE MAPPED ONTO THE CURVE
C   N= MGP  IS THE NUMBER OF POINTS WHICH WERE INTERPOLATED TO
C        DETERMINE THE CURVE.
C  X2P,Y2P ARE ARRAYS CONTAINING THE ABCISSAS AND ORDINATES OF THE
C        ORIGINAL INTERPOLATED POINTS.
C    V IS AN ARRAY WITH VALUES PROPORTIONAL TO THE SECOND
C       DERIVATIVE OF THE CURVE AT THE NODES ( X2P,Y2P ).
C
C  THE PARAMETERS N(MGP),X2P,Y2P, V AND SIGMA SHOULD BE INPUTTED
C  UNALTERED FROM THE OUTPUT OF CURV3 AND THESE ARE UNALTERED IN CURV4 .
C
C ON OUTPUT--
C
C   CURV4 (=Y-COORD) CONTAINS THE INTERPOLATED VALUE.
C
      N= MGP
      S = X2P(N)-X2P(1)
      SIGMAP = ABS(SIGMA)*(N-1)/S
```

```
      IF (IT.EQ.1) I1 = 2
    1 DO 2 I = I1,N
      IF( X2P(I)-T ) 2,2,3
    2   CONTINUE
      I = N
 3    IF( X2P(I-1) .LE. T .OR. T .LE. X2P(1) ) GO TO 4
      I1 = 2
      GO TO 1
    4 DEL1 = T-X2P(I-1)
      DEL2 = X2P(I) - T
      DELS = X2P(I)-X2P(I-1)
      EXPS1 = EXP(SIGMAP*DEL1)
      SINHD1 = .5*(EXPS1-1./EXPS1)
      EXPS = EXP(SIGMAP*DEL2)
      SINHD2 = .5*(EXPS-1./EXPS)
      EXPS = EXPS1*EXPS
      SINHS = .5*(EXPS-1./EXPS)
      CURV4 = ( V(I)*SINHD1+ V(I-1)*SINHD2)/SINHS+((Y2P(I)-V(I))*DEL1  +
     9(Y2P(I-1) -V(I-1))*DEL2 )/DELS
      I1 = I
      RETURN
      END
      FUNCTION COSH(XDAM)
      YDAM= -XDAM
      COSH= EXP(XDAM) + EXP(YDAM)
      COSH= COSH/2.0
      RETURN
      END
      FUNCTION SINH(XDAM)
      YDAM= -XDAM
      SINH= EXP(XDAM) - EXP(YDAM)
      SINH= SINH/2.0
      RETURN
      END
```

APPENDIX C

FORTRAN Listing of Program SSURGE

```
C      SSURGE
       COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,     IMM,JMM, N
       COMMON /BLK20/  CORIO,CS,C3,C4,ROT,IMM2,IMM3,JMM2
       COMMON/BLK3/            GRAV,                NMAX,IH1,JH1,IT1,JT1,IH2,
      1JH2,IT2,JT2,IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4,INC
       COMMON/BLK6/IH5,JH5,IT5,JT5,IH6,JH6,IT6,JT6
       COMMON /HURR1/ YRANGE    ,THIT      ,XHIT      ,YHIT      ,
      3                         C10       ,C11       ,PHI       ,
      4                NT1      ,NT2       ,
      5                                    PINF      ,IX        ,IY
       DATA       IM,JM,                NMAX,INC/
      1           45,15,                1321, 10/
       DATA                DXI,    DETA,   DELT,        GRAV,    F/
      1                13081.3,17441.7, 180.0,          9.8,.0025/
       DATA IH1,JH1,IT1,JT1,IH2,JH2,IT2,JT2/
      1      18, 15, 18, 14, 10, 15, 10, 14/
       DATA IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4/
      1      16, 15, 16, 14, 32, 15, 32, 14/
       DATA IH5, JH5, IT5, JT5, IH6, JH6, IT6, JT6/
      1      36,  15,  36,  14,  38,  15,  38,  14/
C
       IMM=IM-1
       IMM2 = IM-2
       IMM3= IM-3
       JMM=JM-1
       JMM2=JM-2
       CORIO= 6.70875E-05
       CC=SQRT(GRAV*DELT)
       CS = SQRT(GRAV*3048.)
       C2=2.0*DELT
       C3 = CORIO*DELT
```

```
      C4 = C3*C3
      RCT = C3
      C1XI=GRAV*DELT/DXI
      C1ETA=GRAV*DELT/DETA
C
      IX=IM
      IY=JM
      XHIT=160.
      YHIT=168.
      THIT=49.35
      YRANGE=17.
      PHI=20.
      PINF=1016.
      DEGRAD=3.141593/180.
      C10=COS(PHI*DEGRAD)
      C11=SIN(PHI*DEGRAD)
C
      CALL ZERO
      CALL FIELD
      DO 100 N=1 ,NMAX
      IF((N/2)*2.EQ.N)GO TO 30
      CALL WINDF
      CALL ELEV
      CALL DRAW1
      GO TO 100
   30 CONTINUE
      CALL FLUX
  100 CONTINUE
      CALL HUV
      STOP
      END
```

```
      SUBROUTINE ZERO
      COMMON/BLK1/GRID1(45,15),GRID2(45,15),           S(45,15),HYD1(30
     10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
     24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
      COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      COMMON/BLK3/          GRAV,              NMAX,IH1,JH1,IT1,JT1,IH2,
     1JH2,IT2,JT2,IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4,INC
      COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
     1(300),VCM5(300),VCM6(300)
      COMMON/BLK7/HOBS1(67),HOBS2(67),HOBS3(67),HOBS4(67),HOBS5(67),HOBS
     16(67)
      COMMON/STORM/NO,XEYE,YEYE,P(45,15),WIND(46,15)
      COMMON /TRANS/  XX(45,15)  ,YY(45,15)  ,COSG(45,15),SING(45,15)
      COMMON /HURR/  TIM(50)  ,RCT(50)  ,RAD(50)  ,VRMAX(50)       ,
     1               PZRO(50) ,TIMPOS(150),XPOS(150),YPOS(150)
C
      COMMON /EXTRA/ X(45,15) ,Y(45,15)
C
      DO 100 I=1,IM
      DSDXI(I)= 0.
      DO 100 J=1,JM
      GRID1(I,J)=0.
      GRID2(I,J)=0.
      S(I,J)=0.
      P(I,J)= 0.
      X(I,J)= 0.
      Y(I,J)= 0.
      XX(I,J)= 0.
      YY(I,J)= 0.
      COSG(I,J)= 0.
      SING(I,J)= 0.
```

```
100   CONTINUE
      NDEX= NMAX/INC+1
      DO 200 K=1,NDEX
      HYD1(K)=0.0
      HYD2(K)=0.0
      HYD3(K)=0.0
      HYD4(K)=0.0
      HYD5(K)=0.0
      HYD6(K)=0.0
      UCM1(K)=0.
      UCM2(K)=0.
      UCM3(K)=0.
      UCM4(K)=0.
      UCM5(K)=0.
      UCM6(K)=0.
      VCM1(K)=0.
      VCM2(K)=0.
      VCM3(K)=0.
      VCM4(K)=0.
      VCM5(K)=0.
      VCM6(K)=0.
200   CONTINUE
      IMAX = IM+1
      DO 300 I=1,IMAX
      DO 300 J=1,JM
      WIND(I,J) = 0.0
300   CONTINUE
      DO 400 J=1,JM
      DTDET(J)= 0.
400   CONTINUE
      DO 500 K=1,67
```

```
      HOBS1(K)= 0.
      HOBS2(K)= 0.
      HOBS3(K)= 0.
      HOBS4(K)= 0.
      HOBS5(K)= 0.
      HOBS6(K)= 0.
500   CONTINUE
      DO 600 K=1,50
      TIM(K)= 0.
      RCT(K)= 0.
      RAD(K)= 0.
      VRMAX(K)= 0.
      PZRO(K)= 0.
600   CONTINUE
      DO 700 K=1,150
      TIMPOS(K)= 0.
      XPOS(K)= 0.
      YPOS(K)= 0.
700   CONTINUE
      RETURN
      END
      SUBROUTINE FIELD
      COMMON/BLK1/GRID1(45,15),GRID2(45,15),           S(45,15),HYD1(30
     10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
     24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
      COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
     1(300),VCM5(300),VCM6(300)
      COMMON/BLK7/HOBS1(67),HOBS2(67),HOBS3(67),HOBS4(67),HOBS5(67),HOBS
     16(67)
      COMMON /TRANS/  XX(45,15)  ,YY(45,15)  ,COSG(45,15),SING(45,15)
```

```
      COMMON /HURR/  TIM(50)   ,ROT(50)  ,RAD(50)  ,VRMAX(50)
     1               PZRO(50)  ,TIMPOS(150),XPOS(150),YPOS(150)
      COMMON /HURR1/ YRANGE    ,THIT     ,XHIT     ,YHIT      ,
     3                          C10      ,C11      ,PHI       ,
     4               NT1       ,NT2      ,
     5                                    PINF     ,IX        ,IY
C
      READ(5,11) NT1
   11 FORMAT( I5 )
      READ(5,12)(TIM(I),ROT(I),RAD(I),VRMAX(I),PZRO(I),I=1,NT1)
   12 FORMAT( 5F10.1)
      READ(5,11) NT2
      READ(5,13)(TIMPOS(I),XPOS(I),YPOS(I),I=1,NT2)
   13 FORMAT(3F10.1)
      WRITE(6,15)
   15 FORMAT(1H1,15X,24HTHE STORM PARAMETERS ARE ,//,1X,
     151H     TIME      ROTATION     RADIUS  MAX WINDS CEN PRESS ,/,1X,
     250H   (HRS)        (DEG)       (NM)      (KNOTS)     (MB)     ,/)
      WRITE(6,16)(TIM(I),ROT(I),RAD(I),VRMAX(I),PZRO(I),I=1,NT1)
   16 FORMAT(1X,F8.0,F10.0,2F10.1,F10.0)
      WRITE(6,17)
   17 FORMAT(1H1,15X,37HTHE POSITIONS FOR THE STORM TRACK ARE ,//,1X,
     129H     TIME     X COORD   Y COORD ,/,1X,
     210H   (HRS)    ,/)
      WRITE(6,18)(TIMPOS(I),XPOS(I),YPOS(I),I=1,NT2)
   18 FORMAT(1X,F8.0,2F10.1)
      NU1 = 5
      DO 400  I=1,IM
      READ(NU1,5) (GRID2(I,J),J=1,JM)
    5 FORMAT(11F7.2)
  400 CONTINUE
```

```
      DO 500  I=1,IM
      READ(NU1,6) (S(I,J),J=1,JM)
    6 FORMAT(5E14.7)
  500 CONTINUE
      DO 600 I=1,IM
      READ(NU1,7) DSDXI(I)
    7 FORMAT(E14.7)
  600 CONTINUE
      DO 700 J=1,JM
      READ(NU1,8) DTDET(J)
    8 FORMAT(2X,E14.7)
  700 CONTINUE
      READ(NU1,9)(HOBS1(II),II=1,67)
      READ(NU1,9)(HOBS2(II),II=1,67)
      READ(NU1,9)(HOBS3(II),II=1,67)
      READ(NU1,9)(HOBS4(II),II=1,67)
      READ(NU1,9)(HOBS5(II),II=1,67)
      READ(NU1,9)(HOBS6(II),II=1,67)
    9 FORMAT(19F4.1)
      DO 300 II=1,67
      HOBS1(II)= 99999.
C     HOBS1(II)=HOBS1(II)*0.3048
      HOBS2(II)=HOBS2(II)*0.3048
      HOBS3(II)=HOBS3(II)*0.3048
      HOBS4(II)=HOBS4(II)*0.3048
      HOBS5(II)=HOBS5(II)*0.3048
      HOBS6(II)=HOBS6(II)*0.3048
  300 CONTINUE
      DO 101 I=1,IM
        READ (5,10) (XX(I,J),YY(I,J),J=1,JM)
   10   FORMAT (10F7.2)
```

```
  101 CONTINUE
      DO 102 I=1,IM
         READ(5,19) (COSG(I,J),SING(I,J),J=1,JM)
   19    FORMAT (10F8.5)
  102 CONTINUE
      DO 200 J=1,JM
      DO 100 I=1,IM
      IJ=I+J
      IF((IJ/2)*2.EQ.IJ)GO TO 110
      GRID2(I,J)=-GRID2(I,J)*0.3048*6.0
      GO TO 100
  110 CONTINUE
      GRID1(I,J)=0.
      GRID2(I,J)=0.0
  100 CONTINUE
  200 CONTINUE
CCC*****
      WRITE(6,210)
 210  FORMAT(1H1,////,20X,16HD E P T H S  (M) ,///,7X,5HS E A ,58X,9HC O
     9 A S T ,//)
      WRITE(6,211)(J,J=2,JMM,2)
 211  FORMAT(8X,7(6X,2HJ=,I2),/)
      WRITE(6,212)(J,J=1,JM,2)
 212  FORMAT(4X,8(6X,2HJ=,I2),//)
      DO 215 I=1,IM,2
      K= I+1
      WRITE(6,213)I,(GRID2(I,J),J=2,JMM,2)
 213  FORMAT(1X,2HI=,I2,3X,7(4X,F6.1),/ )
      IF( I .EQ. IM ) GO TO 215
      WRITE(6,214)K,(GRID2(K,J),J=1,JM,2)
 214  FORMAT(1X,2HI=,I2,8(4X,F6.1),/ )
```

```
 215  CONTINUE
      RETURN
      END
      SUBROUTINE ELEV
      COMMON/BLK1/GRID1(45,15),GRID2(45,15),              S(45,15),HYD1(30
     10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
     24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
      COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      COMMON /BLK20/  CORIO,CS,C3,C4,RCT,IMM2,IMM3,JMM2
      COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
     1(300),VCM5(300),VCM6(300)
      COMMON/STORM/NC,XEYE,YEYE,P(45,15),WIND(46,15)
C
      DO 180  J=3,JMM
      DTET=DTDET(J)*DETA
       IS= 4
       IMS= IMM3
       IF((J/2)*2.EQ.J) IS = 3
       IF(IS.EQ.3) IMS = IMM2
       JP1 = J+1
       JM1 = J-1
      DO 130  I=IS,IMS,2
       IP1 = I+1
       IM1 = I-1
       C9= DELT/S(I,J)/S(I,J)
       DSXI=DSDXI(I)*DXI
      URIT = GRID1(IP1,J)*S(IP1,J)
      ULEF = GRID1(IM1,J)*S(IM1,J)
      VTOP = GRID2(I,JP1)*S(I,JP1)
      VBOT = GRID2(I,JM1)*S(I,JM1)
      GRID1(I,J) = GRID1(I,J)- C9*( (URIT-ULEF)/DSXI+(VTOP-VBOT)/DTET )
```

```
  130 CCNTINUE
  180 CONTINUE
CC***
      DTET= DTDET(JM)*DETA
      DO 170 II=2,IMM,2
      IP1=II+1
      IM1= II-1
      C9= DELT/S(II,JM)/S(II,JM)
      DSXI= DSDXI(II)*DXI
      URIT= GRID1(IP1,JM)*S(IP1,JM)
      ULEF= GRID1(IM1,JM)*S(IM1,JM)
      IF( II .EQ. 2 .OR. II .EQ. IMM ) ULEF=URIT
      VBOT= GRID2(II,JMM)*S(II,JMM)
      VTOP= -VBOT
      GRID1(II,JM)=GRID1(II,JM)-C9*((URIT-ULEF)/DSXI+(VTOP-VBOT)/DTET)
 170  CONTINUE
C
      DC 30 J=3,JMM2,2
      II= 2
      GRID1(II,J)=GRID1(II,J)-(DELT/S(II,J)/S(II,J))*(S(II,J+1)*GRID2(II
     1,J+1)-S(II,J-1)*GRID2(II,J-1))/(DETA*DTDET(J))
      II= IMM
      GRID1(II,J)=GRID1(II,J)-(DELT/S(II,J)/S(II,J))*(S(II,J+1)*GRID2(II
     1,J+1)-S(II,J-1)*GRID2(II,J-1))/(DETA*DTDET(J))
   30 CONTINUE
CC***
      DC 150 II=2,IMM
      IF((II/2)*2.EQ.II) GO TO 140
CCC   GRID1(II,2)= P(II,2)- GRID2(II,3)/CS
      GRID1(II,2)=0.25*(P(II-1,1)+GRID1(II-1,3)+P(II+1,1)+GRID1(II+1,3))
      GO TO 150
```

```
  140 BARO=P(II,1)
CCC   GRID1(II,1) = BARO-GRID2(II,2)/CS
      GRID1(II,1)= BARO
  150 CONTINUE
      RETURN
      END
      SUBROUTINE FLUX
      COMMON/ELK1/GRID1(45,15),GRID2(45,15),             S(45,15),HYD1(30
     10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
     24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
      COMMON/ELK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      COMMON /BLK20/  CORIO,CS,C3,C4,RCT,IMM2,IMM3,JMM2
      COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
     1(300),VCM5(300),VCM6(300)
      COMMON/STORM/NO,XEYE,YEYE,P(45,15),WIND(46,15)
C
      DO 8999 J=1,JM
      DO 8999 I=1,IM,2
      IP1=I+1
      WABS=SQRT(WIND(I,J)**2+WIND(IP1,J)**2)
      IF(WABS.LE.7.0)GO TO 9998
      WCOF=1.100E-06+((1.-7./WABS)**2)*2.50E-06
      GO TO 9997
 9998 WCOF=1.100E-06
 9997 DUWX=WIND(I,J)
      DUWY=WIND(IP1,J)
      WIND(I,J)=WCOF*WABS*DUWX
      WIND(IP1,J)=WCOF*WABS*DUWY
 8999 CONTINUE
C
      DO 130 J=2,JMM
```

```
      IS = 3
      IMS = IMM2
      IF((J/2)*2.EQ.J) IS=4
      IF(IS.EQ.4)IMS=IMM3
      JP1 = J+1
      JM1 = J-1
      DO 80 I=IS,IMS,2
      IP1 = I+1
      IM1 = I-1
      IWX=I
      IWY=IP1
      IF(IS-4)270,280,270
280   IWX=IM1
      IWY=I
270   CONTINUE
      CXI= C1XI/S(I,J)/DSDXI(I)
      CETA= C1ETA/S(I,J)/DTDET(J)
      D1 = GRID1(IM1,J)-GRID2(IM1,J)
      D2 = GRID1(IP1,J)-GRID2(IP1,J)
      D3 = GRID1(I,JM1)-GRID2(I,JM1)
      D4 = GRID1(I,JP1)-GRID2(I,JP1)
      DELHX = GRID1(IP1,J)-GRID1(IM1,J)-(P(IP1,J)-P(IM1,J))
      DELHY = GRID1(I,JP1)-GRID1(I,JM1)-(P(I,JP1)-P(I,JM1))
      Q = SQRT(GRID1(I,J)*GRID1(I,J)+GRID2(I,J)*GRID2(I,J))
      AVHX = 0.5*(D1+D2)
      AVHY = 0.5*(D3+D4)
      DBAR = 0.5*(AVHY+AVHX)
      G = (1.0+C2*F*Q/(DBAR*DBAR))
      G2 = G*G
      A = GRID1(I,J)+ROT*GRID2(I,J)-CXI*AVHX*DELHX+C2*WIND(IWX,J)
      B = GRID2(I,J)-ROT*GRID1(I,J)-CETA*AVHY*DELHY+C2*WIND(IWY,J)
```

```
      GRID1(I,J) = (G*A+C3*B)/(G2+C4)
      GRID2(I,J) = (G*B-C3*A)/(G2+C4)
   80 CONTINUE
  130 CONTINUE
CC*****
      DO 140 I=3,IMM2,2
      CXI=C1XI/(S(I,JM)*DSDXI(I))
      DELHX = GRID1(I+1,JM)-GRID1(I-1,JM)-(P(I+I,JM)-P(I-I,JM))
      Q = ABS(GRID1(I,JM))
      DBAR = 0.5*(GRID1(I-1,JM)-GRID2(I-1,JM)+GRID1(I+1,JM)-
     +GRID2(I+1,JM))
      G = (1.0+C2*F*Q/(DBAR*DBAR))
      GRID1(I,JM) = (GRID1(I,JM)-CXI*DBAR*DELHX+C2*WIND( I  ,JM))/G
  140 CONTINUE
      GRID1(1,JM)= GRID1(3,JM)
      GRID1(IM,JM)= GRID1(IMM2,JM)
CC*****
      DO 9000 II=2,IMM,IMM3
      DO 9000 J=3,JMM
      IF( (J/2)*2 .EQ. J ) GO TO 8100
      GO TO 8900
 8100 CONTINUE
      CETA= C1ETA/S(II,J)/CTDET(J)
      DELHY=GRID1(II,J+1)-GRID1(II,J-1)-(P(II,J+1)-P(II,J-1))
      AVHY=0.5*(GRID1(II,J+1)-GRID2(II,J+1)+GRID1(II,J-1)-GRID2(II,J-1))
      Q= SQRT( GRID1(II,J)*GRID1(II,J)+GRID2(II,J)*GRID2(II,J) )
      G= (1.0+C2*F*Q /(AVHY*AVHY))
      III=3
      IF( II .EQ. IMM ) III= IMM2
      UBAR= 0.5*( GRID1(III,J+1)+GRID1(III,J-1) )
      UFLUX= UBAR + GRID1(II,J)
```

```
      E= GRID2(II,J)-ROT*UFLUX-CETA*AVHY*DELHY+C2*WIND(II,J)
      GRID2(II,J)=B/G
      GRID1(II,J)= UBAR
      GO TO 9000
 8900 CONTINUE
      III= 1
      IIII= 3
      IF( II .EQ. IMM ) III= IM
      IF( II .EQ. IMM ) IIII= IMM2
      GRID1(III,J)= GRID1(IIII,J)
 9000 CONTINUE
CC*****
CC  SPECIAL CALCULATIONS FOR SEAWARD CORNERS
      DO 9050 I=2,IMM,IMM3
      II= 3
      IF( I .EQ. IMM ) II= IMM2
      IS= II-I
      Q1= SQRT(GRID1(II,1)**2+GRID2(II,1)**2)
      Q2= SQRT(GRID1(I,2)**2+GRID2(I,2)**2)
      D1=(GRID1(II-1,1)-GRID2(II-1,1)+GRID1(II+1,1)-GRID2(II+1,1))/2.
      D2=(GRID1(I,1)-GRID2(I,1)+GRID1(I,3)-GRID2(I,3))/2.
      G1=(1.+C2*F*Q1/(D1**2))
      G2=(1.+C2*F*Q2/(D2**2))
      DELHX= GRID1(II+1,1)-GRID1(II-1,1)-(P(II+1,1)-P(II-1,1))
      DELHY= GRID1(I,3)-GRID1(I,1)-(P(I,3)-P(I,1))
      CXI = C1XI/S(II,1)/DSDXI(II)
      CETA = C1ETA/S(I,2)/DTDET(2)
      AB = GRID1(II,1)+C3*GRID2(II,1)-CXI*D1*DELHX+C2*WIND(II,1)
      AP = AB+.5*C3*GRID2(II+IS,2)
      BB = GRID2(I,2)-C3*GRID1(I,2)-CETA*D2*DELHY+C2*WIND(I,2)
      BP = BB-.5*C3*GRID1(II,3)
```

```
      DENOM = G1*G2+.25*C4
      GRID1(II,1) = (AP*G2+BP*.5*C3)/DENOM
      GRID2(I,2) = (BP*G1-AP*.5*C3)/DENOM
      GRID1(I,2) = .5*(GRID1(II,3)+GRID1(II,1))
      GRID2(II,1) = .5*(GRID2(I,2)+GRID2(II+IS,2))
 9050 CONTINUE
      GRID1(1,1) = GRID1(3,1)
      GRID1(IM,1) = GRID1(IMM2,1)
      RETURN
      END
      SUBROUTINE DRAW1
      COMMON/BLK1/GRID1(45,15),GRID2(45,15),           S(45,15),HYD1(30
     10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
     24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
      COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      COMMON /BLK20/  CORIO,CS,C3,C4,ROT,IMM2,IMM3,JMM2
      COMMON/BLK3/           GRAV,             NMAX,IH1,JH1,IT1,JT1,IH2,
     1JH2,IT2,JT2,IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4,INC
      COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
     1(300),VCM5(300),VCM6(300)
      COMMON/BLK6/IH5,JH5,IT5,JT5,IH6,JH6,IT6,JT6
C
      DIMENSION UVEL(45,15),VVEL(45,15)
      EQUIVALENCE (UVEL(2),VVEL)
C
      MIN = ((N-1)*DELT)/60.  + 1.E-5
      IF(MOD(MIN,30).NE.0)RETURN
      NH = N/INC + 1
      HYD1(NH) = GRID1(IH1,JH1)
      HYD2(NH) = GRID1(IH2,JH2)
      HYD3(NH) = GRID1(IH3,JH3)
```

```
      HYD4(NH) = GRID1(IH4,JH4)
      HYD5(NH) = GRID1(IH5,JH5)
      HYD6(NH) = GRID1(IH6,JH6)
      CALL METER
C
      IF (MOD(MIN,60) .NE. 0)  RETURN
C     CALCULATE THE X AND Y VELOCITIES
C       AT THE INTERIOR POINTS
      DO 100 J=2,JMM
      IS = 3
      IMS = IMM2
      IF ((J/2)*2 .EQ. J)  IS = 4
      IF (IS .EQ. 4)  IMS = IMM3
CCC  FOR RAD. LBC  IS=2 AND IMS=IMM
CCC REM CHANGE IN DO 310
      JP1 = J+1
      JM1 = J-1
      DO 100 I=IS,IMS,2
      IP1 = I+1
      IM1 = I-1
      D1 = GRID1(IM1,J)-GRID2(IM1,J)
      D2 = GRID1(IP1,J)-GRID2(IP1,J)
      D3 = GRID1(I,JM1)-GRID2(I,JM1)
      D4 = GRID1(I,JP1)-GRID2(I,JP1)
      DBAR = .25*(D1+D2+D3+D4)
      UVEL(I,J) = GRID1(I,J)/DBAR
      VVEL(I,J) = GRID2(I,J)/DBAR
  100 CONTINUE
C     BOUNDARY POINTS
      DO 201 J=1,JM,JMM
      DO 200 I=3,IMM2,2
```

```
      IP1 = I+1
      IM1 = I-1
      D1 = GRID1(IM1,J)-GRID2(IM1,J)
      C2 = GRID1(IP1,J)-GRID2(IP1,J)
      DBAR = .5*(C1+D2)
      UVEL(I,J) = GRID1(I,J)/DBAR
      VVEL(I,J) = GRID2(I,J)/DBAR
  200 CONTINUE
      UVEL( IM,J ) = GRID1( IM,J)/DBAR
      VVEL( IM,J ) = GRID2( IM,J)/DBAR
  201 CONTINUE
      I = 1
      DC 202  J=1,JM,JMM
      D1 = GRID1(2,J)-GRID2(2,J)
      D2 = GRID1(4,J)-GRID2(4,J)
      DBAR = .5*(C1+D2)
      UVEL( I,J)  = GRID1(I,J)/DBAR
      VVEL(I,J) = GRID2(I,J )/DBAR
  202 CONTINUE
      CO 310  I=2,IMM,IMM3
      DO 310  J=2,JMM
      IF ((J/2)*2 .EQ. J)   GC TC 305
      II = 1
      IIII= 4
      IF (I .EQ. IMM)   II = IM
      IF( I .EQ. IMM ) IIII= IMM3
      D1= GRIC1(I,J)-GRID2(I,J)
      D2= GRID1(IIII,J)-GRID2(IIII,J)
      DBAR= 0.5*(C1+D2)
      UVEL(II,J) = GRID1(II,J)/CBAR
      VVEL(II,J) = GRID2(II,J)/DBAR
```

```
      GO TO 310
  305 CONTINUE
      JP1 = J+1
      JM1 = J-1
      D3 = GRID1(I,JP1)-GRID2(I,JP1)
      D4 = GRID1(I,JM1)-GRID2(I,JM1)
      DBAR= 0.5*(D3+D4)
      UVEL(I,J) = GRID1(I,J)/DBAR
      VVEL(I,J) = GRID2(I,J)/DBAR
  310 CONTINUE
      DO 311 I=1,IM
      DO 311 J=1,JM
      IF( MOD(I+J ,2) .EQ. 1 ) GO TO 311
      UVEL(I,J)= UVEL(I,J)*100.
      VVEL(I,J)= VVEL(I,J)*100.
  311 CONTINUE
C
      T = MIN/60.
      WRITE (6,400) T
  400 FORMAT (1H1,6X,13HTIME (HRS) = ,F6.2,///,20X,12HE L E V  (M),
     1///,7X,5HS E A,58X,9HC O A S T,//)
      WRITE (6,405) (J,J=2,JMM,2)
  405 FORMAT (8X,7(6X,2HJ=,I2),/ )
    - WRITE (6,406) (J,J=1,JM,2)
  406 FORMAT (4X,8(6X,2HJ=,I2),//)
      DO 415 I=1,IM,2
      K = I+1
      WRITE (6,410) I,(GRID1(I,J),J=2,JMM,2)
  410 FORMAT (1X,2HI=,I2,3X,7(4X,F6.2),/ )
      IF (I .EQ. IM)  GO TO 415
      WRITE (6,411) K,(GRID1(K,J),J=1,JM,2)
```

```
411 FORMAT (1X,2HI=,I2,8(4X,F6.2),/ )
415 CONTINUE
    WRITE (6,419) T
419 FORMAT (1H1,6X,13HTIME (HRS) = ,F6.2,///,20X,35HX AND Y  V E L O C
   1 I T I E S (CM/S),///,7X,5HS E A,58X,9HC O A S T,//)
    WRITE (6,405) (J,J=2,JMM,2)
    WRITE (6,406) (J,J=1,JM,2)
    DO 425 I=1,IM,2
    K = I+1
    WRITE (6,421) I,(UVEL(I,J),J=1,JM,2)
    WRITE (6,422) (VVEL(I,J),J=1,JM,2)
421 FORMAT (1X,2HI=,I2,8(4X,F6.1))
422 FORMAT (5X,8(4X,F6.1),/ )
    IF (I .EQ. IM)  GO TO 425
    WRITE (6,423) K,(UVEL(K,J),J=2,JMM,2)
    WRITE (6,424) (VVEL(K,J),J=2,JMM,2)
423 FORMAT (1X,2HI=,I2,3X,7(4X,F6.1))
424 FORMAT (8X,7(4X,F6.1), /)
425 CONTINUE
    RETURN
    END .
    SUBROUTINE METER
    COMMON/BLK1/GRID1(45,15),GRID2(45,15),             S(45,15),HYD1(30
   10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
   24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
    COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
    COMMON/BLK3/           GRAV,                  NMAX,IH1,JH1,IT1,JT1,IH2,
   1JH2,IT2,JT2,IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4,INC
    COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
   1(300),VCM5(300),VCM6(300)
    COMMON/BLK6/IH5,JH5,IT5,JT5,IH6,JH6,IT6,JT6
```

```
C
      NUV= N/INC+1
      DO 10 KK=1,6
      GO TO (20,30,40,50,60,70),KK
   20 II = IT1
      JJ = JT1
      GO TO 80
   30 II = IT2
      JJ = JT2
      GO TO 80
   40 II = IT3
      JJ = JT3
      GO TO 80
   50 II = IT4
      JJ = JT4
      GO TO 80
   60 II=IT5
      JJ=JT5
      GO TO 80
   70 II=IT6
      JJ=JT6
   80 I1 = II-1
      I2 = II+1
      J1 = JJ-1
      J2 = JJ+1
      AVEDX = (GRID1(I1,JJ)-GRID2(I1,JJ)+GRID1(I2,JJ)-GRID2(I2,JJ))*0.5
      AVEDY = (GRID1(II,J1)-GRID2(II,J1)+GRID1(II,J2)-GRID2(II,J2))*0.5
      GO TO (110,120,130,140,150,160),KK
  110 UCM1(NUV) = GRID1(IT1,JT1)/AVEDX
      VCM1(NUV) = GRID2(IT1,JT1)/AVEDY
      GO TO 10
```

```
120 UCM2(NUV) = GRID1(IT2,JT2)/AVEDX
    VCM2(NUV) = GRID2(IT2,JT2)/AVEDY
    GO TO 10
130 UCM3(NUV) = GRID1(IT3,JT3)/AVEDX
    VCM3(NUV) = GRID2(IT3,JT3)/AVEDY
    GO TO 10
140 UCM4(NUV) = GRID1(IT4,JT4)/AVEDX
    VCM4(NUV) = GRID2(IT4,JT4)/AVEDY
    GO TO 10
150 UCM5(NUV)=GRID1(IT5,JT5)/AVEDX
    VCM5(NUV)=GRID2(IT5,JT5)/AVEDY
    GO TO 10
160 UCM6(NUV)=GRID1(IT6,JT6)/AVEDX
    VCM6(NUV)=GRID2(IT6,JT6)/AVEDY
 10 CONTINUE
    RETURN
    END
    SUBROUTINE HUV
    COMMON/BLK1/GRID1(45,15),GRID2(45,15),           S(45,15),HYD1(30
   10),HYD2(300),HYD3(300),HYD4(300),UCM1(300),UCM2(300),UCM3(300),UCM
   24(300),VCM1(300),VCM2(300),VCM3(300),VCM4(300)
    COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
    COMMON/BLK3/          GRAV,              NMAX,IH1,JH1,IT1,JT1,IH2,
   1JH2,IT2,JT2,IH3,JH3,IT3,JT3,IH4,JH4,IT4,JT4,INC
    COMMON/BLK5/DSDXI(45),DTDET(15),HYD5(300),HYD6(300),UCM5(300),UCM6
   1(300),VCM5(300),VCM6(300)
    COMMON/BLK6/IH5,JH5,IT5,JT5,IH6,JH6,IT6,JT6
    COMMON/BLK7/HOBS1(67),HOBS2(67),HOBS3(67),HOBS4(67),HOBS5(67),HOBS
   16(67)
C
    WRITE (6,505) IH1,JH1,IH2,JH2,IH3,JH3,IH4,JH4,IH5,JH5,IH6,JH6
```

```
      WRITE (6,506) IT1,JT1,IT2,JT2,IT3,JT3,IT4,JT4,IT5,JT5,IT6,JT6
 505  FORMAT(1H1,41H  ADJUSTED-COMPUTED HYDROGRAPH (M)  AT     ,6(I2,1H.,
     6 I2,7X),/,30H  AND THE OBSERVED WATER LEVEL ,// )
 506 FORMAT(11X,34HSIMULATED CURRENT    (M/S) AT       ,6(I2,1H.,I2,7X),/
     1//)
      J=1
      K = 1
      NDEX= NMAX/INC+1
      DO 500 I=1,NDEX
      T = (K-1)*DELT/3600.
      MIN= (K-1)*DELT/60. +1.0E-05
C  CORRECT COMPUTED H FOR INITIAL OBSERVED WATER LEVEL CONDITIONS
      HYD1(I)= HYD1(I)+1.
C     HYD1(I)= HYD1(I)+HOBS1(1)
      HYD2(I)= HYD2(I)+HOBS2(1)
      HYD3(I)= HYD3(I)+HOBS3(1)
      HYD4(I)= HYD4(I)+HOBS4(1)
      HYD5(I)= HYD5(I)+HOBS5(1)
      HYD6(I)= HYD6(I)+HOBS6(1)
      WRITE (6,510) K,T,HYD1(I),HYD2(I),HYD3(I),HYD4(I),HYD5(I),HYD6(I)
      IF( MOD(MIN,60).EQ.0)WRITE(6,513)HOBS1(J),HOBS2(J),HOBS3(J),HOBS4(
     9J),HOBS5(J),HOBS6(J)
      WRITE (6,511) UCM1(I),UCM2(I),UCM3(I),UCM4(I),UCM5(I),UCM6(I)
      WRITE (6,512) VCM1(I),VCM2(I),VCM3(I),VCM4(I),VCM5(I),VCM6(I)
      K = K+INC
      IF(MOD(MIN,60).EQ.0) J=J+1
 500 CONTINUE
 510 FORMAT (/,13X,2HN=,I5,10H  T (HRS)=,F6.2,5H   H  ,6(F6.2,6X))
 511 FORMAT (39X,4HU   ,6(F7.2,5X))
 512 FORMAT (39X,4HV   ,6(F7.2,5X))
 513  FORMAT( 34X,7HOBS H    ,6(F6.2,6X))
```

```
      RETURN
      END
      SUBROUTINE WINCF
      COMMON/BLK2/C2,CC,C1XI,C1ETA,DXI,DETA,DELT,F,IM,JM,    IMM,JMM, N
      CCMMON/ TRANS/XX(45,15),YY(45,15),COSG(45,15),SING(45,15)
      COMMON /HURR/  TIM(50)   ,ROT(50)   ,RAD(50)   ,VRMAX(50)        ,
     1               PZRO(50)  ,TIMPOS(150),XPOS(150),YPOS(150)
      CCMMON /HURR1/ YRANGE    ,THIT      ,XHIT      ,YHIT      ,
     3                          C10       ,C11       ,PHI       ,
     4               NT1       ,NT2       ,
     5                                     PINF      ,IX        ,IY
      COMMON /EXTRA/ X(45,15) ,Y(45,15)
      CCMMON/ STCRM /NO,XEYE,YEYE,P(45,15),WIND(46,15)
C
      DATA IT1P1,IT2P1/2,2/
C
      NC=N
      TIME=FLCAT(N-1)*DELT/3600.
      DC 101 I=IT1P1,NT1
      IF(TIM(I).GE.TIME) GO TO 102
  101 CONTINUE
      I=NT1
  102 IT1=I-1
      DO 103 I=IT2P1,NT2
      IF(TIMPCS(I).GE.TIME)GC TC 104
  103 CONTINUE
      I=NT2
  104 IT2= I-1
      IT1P1=IT1+1
      IT2P1=IT2+1
      TFAC1=(TIME-TIM(IT1))/(TIM(IT1P1)-TIM(IT1))
```

```
      TFAC2=(TIME-TIMPOS(IT2))/(TIMPOS(IT2P1)-TIMPOS(IT2))
      DELT2=(TIMPOS(IT2P1)-TIMPOS(IT2))*3600.
C
      R=RAD(IT1)+TFAC1*(RAD(IT1P1)-RAD(IT1))
      VR=VRMAX(IT1)+TFAC1*(VRMAX(IT1P1)-VRMAX(IT1))
      THETA=ROT(IT1)+ TFAC1*(ROT(IT1P1)-ROT(IT1))
      PO=PZRO(IT1)+TFAC1*(PZRO(IT1P1)-PZRO(IT1))
      XEYE=XPOS(IT2)+TFAC2*(XPOS(IT2P1)-XPOS(IT2))
      YEYE=YPOS(IT2)+TFAC2*(YPOS(IT2P1)-YPOS(IT2))
      US=(XPOS(IT2P1)-XPOS(IT2))/DELT2
      VS=(YPOS(IT2P1)-YPOS(IT2))/DELT2
      R=R*.84167
      VR=VR*.515
      US=US*2201.6
      VS=VS*2201.6
      THETA=(90.-THETA+PHI)*.0174533
      CO=COS(-THETA)
      C1=SIN(-THETA)
C
      USR=US*CO  + VS*C1
      VSP=VS*CO  - US*C1
C
      DO 108  I=1,IX
      DO 107  J=1,IY
      XP=XX(I,J)
      YP=YY(I,J)
      XP1=XP-XEYE
      YP1=YP-YEYE
      RSML=SQRT(XP1**2 + YP1**2)
      IF(MOD((I+J),2).EQ.1)GO TO 109
      A=-YP1*C10 -XP1*C11
```

```
      B= XP1*C10 -YP1*C11
      IF(RSML.LT.1.0E-10) RSML= 1.0E-10
      IF(RSML.LE. R)GO TO 105
C
C     POINT IS OUTSIDE RADIUS TO MAX WINDS
C
      S1=R/(R+RSML)
      S2=(VR/RSML)*(R/RSML)**.45
      GO TO 106
C
C     POINT IS INSIDE RADIUS TO MAX WINDS
C
 105  S1=RSML/(R+RSML)
      S2=(VR/RSML)*((RSML/R)**1.5)
 106  X1=(USR*S1)+(A*S2)
      Y1=(VSR*S1)+(B*S2)
C
C     ROTATE VELOCITY FOR CURV GRID
C
      C=COSG(I,J)
      S=SING(I,J)
      XR=X1*C+Y1*S
      YR=Y1*C-X1*S
      X(I,J)=XR
      Y(I,J)=YR
      GO TO 107
  109 RDIST=22.*.84167
      PP=P0+(PINF-P0)*EXP(-RDIST/RSML)
      P(I,J)=(PINF-PP)*.01
 107  CONTINUE
 108  CONTINUE
```

```
      DO 110 J=1,IY
      DO 110 I=1,IX,2
      IF((J/2)*2.EQ.J)GO TO 112
      WIND(I,J)=X(I,J)
      WIND(I+1,J)=Y(I,J)
      GO TO 110
112   IF(I.EQ.IX)GO TO 110
      WIND(I,J)=X(I+1,J)
      WIND(I+1,J)=Y(I+1,J)
110   CONTINUE
      RETURN
      END
      FUNCTION YLAND(XD)
      DATA YRANGE/17./
      YLAND=ABS(XD-YRANGE)/7.
      RETURN
      END
```

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2 v. : ill. (Technical report - U.S. Coastal Engineering Research Center ; no. 76-3) (Contract - U.S. Coastal Engineering Research Center ; DACW72-73-C-0014)
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