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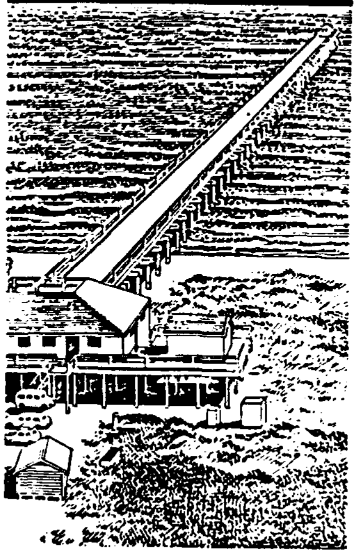

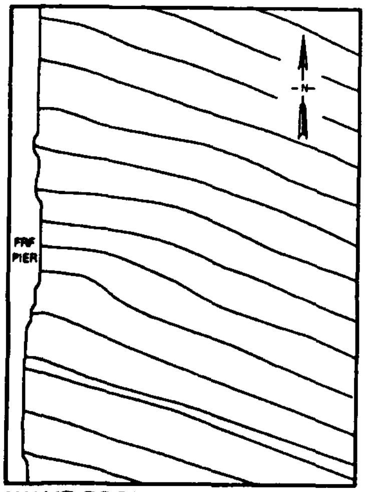

WAVE REFRACTION DIAGRAM
PERIOD 8 SECONDS ANGLE -35 DEGREES

INSTRUCTION REPORT CERC-91-1

COASTAL MODELING SYSTEM (CMS) USER'S MANUAL

by

Mary A. Cialone, David J. Mark, Lucia W. Chou, David A. Leenknecht
Jack E. Davis, Linda S. Lillycrop, Robert E. Jensen

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

August 1992

Supplement 1 to September 1991 Manual

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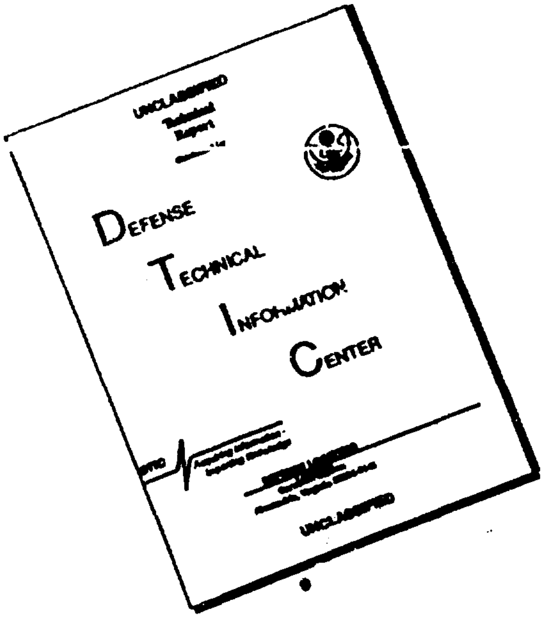

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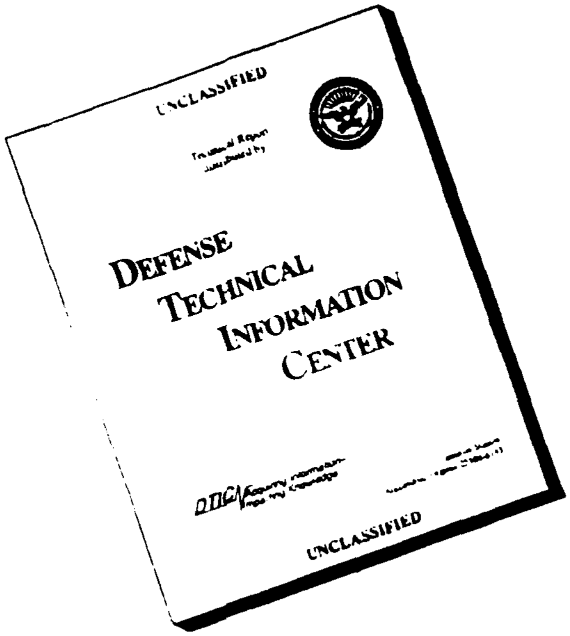

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THE COASTAL MODELING SYSTEM USER'S MANUAL
Supplement 1

Issued August 1992

Enclosed are additions and corrections to the *Coastal Modeling System (CMS) User's Manual*, which was originally published in September 1991 and sent to your office. If you do not have or cannot find the original publication, please contact Mary Cialone at (601) 634-2139 for another copy. Please note the following:

a. Chapters 1 and 2 have been modified because of additions to the CMS (models STWAVE and HARBD, and the CMSSAMP module).

b. Chapter 5, documenting model RCPWAVE, has been modified to reflect model updates to accommodate the input requirements of model GENESIS. (Model GENESIS will be published with the next release of the *CMS User's Manual*.)

c. Chapter 6 had one typographical error on page 19. The error has been corrected and is included in this release.

d. Chapters 8 and 9, documenting models STWAVE and HARBD, respectively, are additions to the *CMS User's Manual*.

e. Appendixes A, B, and C have been modified because of additions to the CMS. Appendix D (CMSSAMP) is a new feature of the CMS that contains sample input and output files for each of the models in the CMS.

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13. ABSTRACT (*Maximum 200 words*)

The Coastal Modeling System (CMS) is a software package aimed at organizing the Coastal Engineering Research Center's larger numerical models and their supporting software into a user-freindly system that is available to all Corps elements having a need to apply the supported modeling technology. Since some of the models share similar input requirements, output capability, and procedural implementation, efforts are made to standardize these portions of the models as much as possible. FORTRAN 77 programming language is used exclusively in the system software to ensure portability of the models and supporting programs to other computer systems. Graphics programs also make use of DISSPLA software. Models selected for inclusion in CMS are well advanced in their development and have been rigorously tested over a wide range of conditions. The models in CMS can be considered tested, reliable, and mature. The numerical models documented here include: SPH, WIFM, RCPWAVE, CLHYD, SHALWV, STWAVE and HARBD. Numerical model SPH is a parametric model for representing wind and atmospheric pressure fields generated by hurricanes. Numerical model WIFM solves the vertically integrated Navier-Stokes equations in stretched Cartesian coordinates. The model simulates

(Continued)

14. SUBJECT TERMS

CLHYD	HARBD	SPH
Coastal Modeling system (CMS)	RCPWAVE	STWAVE
CMS	SHALWV	WIFM

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shallow-water, long-wave hydrodynamics such as tidal circulation, storm surges, and tsunami propagation. Numerical model RCPWAVE is a short-wave model used to predict linear, plane wave propagation over an open coast region of arbitrary bathymetry. Numerical model CLHYD simulates shallow-water, long-wave hydrodynamics such as tidal circulation and storm surge propagation. CLHYD can simulate flow fields induced by wind fields, river inflows/outflows, and tidal forcing. Numerical model SHALWV is a time-dependent spectral wind-wave model for computing a time-history of wind-generated waves. STWAVE is a computationally efficient finite-difference model for near-coast time-independent spectral wave energy propagation simulations. HARBD is a harbor wave oscillation model for use in the design and modification of harbors.

PREFACE

This manual presents the documentation for several numerical models and supporting software that comprise the Coastal Modeling System. The system development documented here was authorized as part of the Civil Works Research and Development Program of Headquarters, US Army Corps of Engineers (HQUSACE). This work was funded under Work Unit 31675, "Development of a Coastal Modeling System," which is part of the Harbor Entrances and Coastal Channels Program. Messrs. John H. Lockhart, Jr.; John G. Housley; James E. Crews; and Robert H. Campbell were the HQUSACE Technical Monitors.

The system development was conducted under the direction of Dr. James R. Houston, Director, Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES); Mr. Charles C. Calhoun, Jr., Assistant Director, CERC; Mr. H. Lee Butler, Chief, Research Division (RD); and Mr. Bruce A. Ebersole, Chief, Coastal Processes Branch (CPB). Technical Editor for the *Coastal Modeling System User's Manual* was Ms. Mary A. Cialone, CPB, RD. The various chapters of the manual were authored by the following individuals:

Chapter 1	Mary A. Cialone
Chapter 2	Mary A. Cialone and Lucia W. Chou, CPB, RD
Chapter 3	Mary A. Cialone and David J. Mark, CPB, RD
Chapter 4	Mary A. Cialone
Chapter 5	Mary A. Cialone
Chapter 6	Mary A. Cialone
Chapter 7	Jack E. Davis, Coastal Oceanography Branch (COB), RD, and Robert E. Jensen, COB, RD
Chapter 8	Jack E. Davis and Robert E. Jensen
Chapter 9	Linda S. Lillycrop, COB, RD
Appendix A	Mary A. Cialone, David J. Mark, and David A. Leenknecht, Automated Coastal Engineering (ACES) Group, RD
Appendix B	Mary A. Cialone, David J. Mark, and David A. Leenknecht
Appendix C	Mary A. Cialone and Lucia W. Chou
Appendix D	Mary A. Cialone and Lucia W. Chou

This report was edited for publication by Ms. Janean C. Shirley, Information Technology Laboratory, WES. An extensive amount of word processing and figure preparation were provided by Ms. Dawn E. Abbe, CPB, RD.

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

CONTENTS

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

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

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
degrees (angle)	0.01745329	radians
fathoms	1.8288	meters
feet	0.3048	meters
inches	25.4	millimeters
knots (international)	0.5144444	meters per second
miles (US nautical)	1.852	kilometers
miles (US statute)	1.609347	kilometers
pounds (force) per square inch	6.894757	kilopascals

COASTAL MODELING SYSTEM (CMS) USER'S MANUAL

CHAPTER 1

COASTAL MODELING SYSTEM (CMS) OVERVIEW

PART I: INTRODUCTION

Background

1. Numerical modeling technology is increasingly being employed as a tool to study complex problems in many engineering disciplines. In the field of coastal engineering, processes studied with numerical models include: hydrodynamics and transport associated with astronomical tides, storm surges, and tsunamis; refraction, diffraction, shoaling and breaking of waves; wave-induced currents; shoreline change induced by littoral movement of sand; erosion caused by short-term severe storms; and the fate and stability of dredged material placed in open water.

2. Numerical models use sophisticated methodology to solve governing equations describing the physical processes of interest. When a physical process is well described by the specified equations, the numerical modeling technique is capable of providing accurate solutions to engineering problems. However, the model developer must take extreme care in implementing the equations in a numerical scheme, and the model must be thoroughly tested for a variety of conditions and compared with prototype measurements to ensure correct model operation. Of equal importance is the care the engineer must take in applying the model to a field problem by ensuring that the model's governing equations are appropriate for representing the dominant physical processes at the site. Also, errors in input specification could dramatically alter model results, and without diligent inspection of model output, the errors could go undetected.

3. The Coastal Engineering Research Center (CERC) has developed a number of numerical models that are used for studying a variety of coastal processes under existing and proposed configurations. Some of these models are large and complex and may require a substantial amount of input data and/or computing effort. The models usually have a battery of supporting software for creating computational grids, running the model on the host

computer, and evaluating large amounts of output from the simulations. Because of the complexity of the model software and the diversity of modifications to input data associated with individual applications, these models have required considerable effort to apply.

4. Traditionally, most of the models were developed by researchers as individual efforts to solve a specific problem. Consequently, models have used different input/output structures, have been sparsely documented, and have been frequently altered to accomplish application-specific tasks. In addition, each model had its own set of supporting utilities to plot results, reformat data, etc. Often code alterations resulted in several versions of the same model, each with specific or enhanced capabilities. This situation had the potential for introducing errors, either by engineers applying the wrong version of the model or by programmers inadvertently altering the operation of a previously tested portion of the model.

5. Because of these factors, some of the most useful models at CERC have also been the most difficult to apply; and in some cases, it was necessary for the model developer to oversee the specific application. This dependence on the model developer meant that he or she had less time to devote to providing improved models to solve Corps problems.

6. The condition of the models described above implied a need for:

a. Maintenance of a single version of each model.

b. Standardization of the model input/output processes.

c. A central location for using the models.

d. Versatile models capable of covering a wide range of problems at different sites by using model options.

e. Comprehensive model documentation in the form of a user's manual.

Objective

7. The Coastal Modeling System (CMS) is a software package aimed at organizing CERC's larger numerical models and their supporting software into a user-friendly system that is available to all Corps elements having a need to apply the supported modeling technology.

8. Several objectives are followed in developing and expanding CMS. Since some of the models share similar input requirements, output capability,

and procedural implementation, efforts are made to standardize these portions of the models as much as possible. This standardization promotes efficiency because coding effort is reduced, new users learn the models in the system more rapidly, and chances for errors in entering input or interpreting output are reduced because of user familiarity with the system structure.

9. Most numerical models are applied to specific areas by representing the spatial bathymetric and topographic features as depths or elevations on a matrix called a computational grid. In some instances, it is possible to share a common numerical grid between models. This commonality allows efficient application of several different models to the same site without additional effort in building new grids. Similarly, processing of model output data can proceed in the same manner for several different models. To the extent possible, models in CMS share the same numerical grids, utilities, plotting programs, post-processing routines, and job control files.

10. FORTRAN 77 programming language is used exclusively in the system software to ensure portability of the models and supporting programs to other computer systems. Graphics programs also make use of DISSPLA™ software. When appropriate, attempts are made to produce a code that is capable of being vectorized for efficient and economical use on vector array processing computers such as the CRAY Y-MP, where CMS resides.

11. Models selected for inclusion in CMS must be well advanced in their development, and they must have been rigorously tested over a wide range of conditions. In most cases, a selected model has already been applied to numerous field problems and, thus, has reached some level of maturity through careful application to the types of problems encountered by the Corps. Incorporation of these time-tested models into CMS involves modification to the input/output structure and, possibly, re-coding of sections to produce more efficient use of computer resources. Once included in CMS, the models are not expected to be modified unless errors are found or new features are added. Therefore, the models in CMS can be considered tested, reliable, and mature.

PART II: IMPLEMENTATION OF CMS

Organization

12. CMS software is organized into three major groups: models, supporting utilities, and procedure files that draw components together for execution. Several software elements use common algorithms, and efforts are made to place these software elements into shared libraries. This placement eliminates redundant software and reduces associated development costs.

13. Another level of organization concerns user interfaces to the software, which are arranged according to various activities encountered during a modeling endeavor. These major procedure files provide users access to the various CMS software elements on the available computers.

14. Although the models and supporting software are written in standard FORTRAN 77, library structures and procedure files are specific to the computer system hosting CMS. In addition, some plotting utilities rely on specific graphics software that resides on the host computer, and certain terminal/plotter configurations may be required to produce plots of the model output at the user's local site.

Host Computer System

15. Most models included in CMS, or targeted for addition to CMS, are both memory-intensive and computationally intensive, requiring use of large supercomputers for efficient operation. It is possible to run some of the models on smaller minicomputers, but double precision would probably be necessary to avoid accumulated round-off errors, and applications could take from several hours to several days of CPU time on the smaller machines.

16. To satisfy the objective of Corps-wide access to the models, initial installation of CMS was on a mainframe computer operated by Scientific Information Services (SIS), formerly CYBERNET, which provided Corps-wide mainframe and supercomputer service. Now, with the installation of a CRAY Y-MP at the US Army Engineer Waterways Experiment Station (WES), Corps-wide access is available, and CMS has been transferred to that system to take advantage of reduced costs and the likelihood of a permanent home for CMS.

17. Corps personnel have access to the CRAY Y-MP through several communication networks. Presently, the supercomputer can be accessed through INTERNET, MILNET, ARPANET, ASNET, SURANET, BITNET, NSFNET, through a 1200, 2400, or 9600 baud modem, dedicated line, or the "front end" VAX 8800 computer.

18. Generally, CMS users are not required to learn the operating system associated with the supercomputer (UNICOS) because most of the job control commands normally required to submit models and data files to the computer for execution are accomplished by the CMS procedure files. This setup reduces learning time appreciably and minimizes errors caused by improper commands. However, users must be able to manipulate files, create and edit ASCII files, and download output files to a printer or plotter. These functions are easily mastered, and manuals are available to all Corps users of the CRAY Y-MP at a nominal fee by contacting the Information Technology Laboratory (ITL) Research Library, Ms. Susan Hicks (601) 634-2296. Presently there are 26 CRAY manuals covering such topics as UNICOS User Commands, CFT77 Reference, UNICOS Support Tools, and UNICOS Symbolic Debugging.

Model Support

19. Including a model in CMS represents a technology transfer from CERC to the field. CERC will maintain the CMS on the WES CRAY Y-MP and will provide support services to Corps users of the system. Support includes correcting recognized flaws in the codes, updating the models with new capabilities and technology, improving the user interface to the models, improving graphics and visualization capabilities, updating the *User's Manual* to reflect changes to the models and/or CMS, conducting periodic workshops for Corps personnel, and providing telephone support services.

20. Additionally, CERC staff can assist Corps personnel in applications of the CMS via "one-stop services" or by direct participation in site-specific studies. One-stop service is intended to address questions or problems that arise during field application of a model in CMS. Usually, these questions can be satisfactorily resolved in a short time over the telephone. More involved questions requiring a substantial effort by CERC engineers or scientists may require reimbursement. Experience at CERC indicates that field

application of these models usually requires a significant initial consulting effort by CERC engineers until experience has been gained by the field user.

Coastal Modeling System (CMS) User's Manual

21. The *Coastal Modeling System (CMS) User's Manual* is intended to be an evolving document, and it is structured in a modular fashion, much like the modeling system itself. Individual numerical models and major supporting utility software are documented in separate chapters. Attempts are made to structure all chapters in a similar format to facilitate learning the system models.

22. The unbound format of the user's manual allows efficient and cost-effective updating of the manual as models are added to CMS, and it allows users to remove chapters for convenient reference during model applications. The documentation for each new model will be an added chapter to the *CMS User's Manual*. Updates will also include additions of (or alterations to) utilities and procedures.

23. Initial distribution of the *CMS User's Manual* will be to all Corps Divisions and Districts with coastal interests. A register of all manuals distributed within the Corps of Engineers will be maintained by CERC, and updates will be provided for all Corps-registered copies of the manual.

24. Training on the usage of CMS and on application of specific models within CMS is accomplished during periodic workshops. Workshop participants, especially new users, will be introduced to CMS. Each workshop will demonstrate sign-on procedures, building input data files, file transfer methods, accessing CMS, running workshop-specific models, and post-processing model results. Technical presentations of workshop specific models will also be given. More intensive training can be provided at CERC as part of joint field applications between CERC and personnel from a field activity.

Point of Contact

25. Each model residing in CMS has a CERC point of contact (POC). Most often that person is the model developer or someone with extensive experience in applying the model. Table 1-1 provides POC's for models presently included in CMS. This table will be updated periodically to assure that it continues

to be a useful reference for CMS users. The modules listed in column 1 of Table 1-1 are briefly described in Part III of this chapter and are extensively documented in later chapters.

Table 1-1

CERC Points of Contact

Subject	Point of Contact	Office Symbol	Phone Number
CMS general inquiries	Ms. Mary A. Cialone	CEWES-CR-P	601-634-2139
Using CMS	Ms. Lucy W. Chou	CEWES-CR-P	601-634-2843
SPH	Mr. Dave J. Mark	CEWES-CR-O	601-634-2094
WIFM	Ms. Mary A. Cialone	CEWES-CR-P	601-634-2139
RCPWAVE	Mr. Steven M. Bratos	CEWES-CR-O	601-634-4230
CLHYD	Ms. Mary A. Cialone	CEWES-CR-P	601-634-2139
SHALWV	Dr. Robert E. Jensen	CEWES-CR	601-634-2101
STWAVE	Ms. Robin D. Reinhard	CEWES-CR-O	601-634-3492
HARBD	Dr. Edward F. Thompson	CEWES-CR-O	601-634-2027
CMSGRID	Ms. Mary A. Cialone	CEWES-CR-P	601-634-2139
CMSUTIL	Ms. Lucy W. Chou	CEWES-CR-P	601-634-2843
CMSPOST	Ms. Lucy W. Chou	CEWES-CR-P	601-634-2843
CMSSAMP	Ms. Lucy W. Chou	CEWES-CR-P	601-634-2843

PART III: PRESENT CMS COMPONENTS

26. The following briefly describes the numerical models, major utility software, and major procedures currently in the Coastal Modeling System.

Chapter 2: Using the Coastal Modeling System

27. This chapter provides information on execution of the CMS on the WES CRAY Y-MP. The new user should refer to this chapter to learn to compile or run a model for a specific application. Once the user becomes familiar with the system, this chapter can be used as a quick reference.

Chapter 3: Standard Project Hurricane (SPH)

28. The numerical model SPH is a parametric model for representing wind and atmospheric pressure fields generated by hurricanes. It is based on the Standard Project Hurricane criteria developed by the National Oceanic and Atmospheric Administration (NOAA 1979), and the model's primary output are hurricane-generated wind fields that can be used in storm surge modeling. It can be run separately, or it can be invoked from within the WES Implicit Flooding Model (WIFM).

Chapter 4: WES Implicit Flooding Model (WIFM)

29. The numerical model WIFM solves the vertically integrated Navier-Stokes equations in stretched Cartesian coordinates. The model simulates shallow-water, long-wave hydrodynamics such as tidal circulation, storm surges, and tsunami propagation. WIFM contains may useful features for studying these phenomena, such as moving boundaries to simulate flooding/drying of low-lying areas and subgrid flow boundaries to simulate small barrier islands, jetties, dunes, or other structural features. The model may be driven at the outer boundary by tide elevations, flow velocities, specification of uniform flux, or inverted barometer effects. WIFM also accepts wind fields for including the effects of wind stress during hurricanes or other strong storm systems.

Chapter 5: Regional Coastal Processes Wave Propagation Model (RCPWAVE)

30. The numerical model RCPWAVE is a short-wave model used to predict linear, plane wave propagation over an open coast region of arbitrary bathymetry. RCPWAVE uses linear wave theory because it has been shown to yield fairly accurate first-order solutions to wave propagation problems at a relatively low cost. Refractive and bottom-induced diffractive effects are included in the model; however, the model cannot treat diffraction caused by surface-piercing structures. This model does not include nonlinear wave effects or a spectral representation of irregular waves.

Chapter 6: Curvilinear Long-Wave Hydrodynamic Model (CLHYD)

31. The numerical model CLHYD simulates shallow-water, long-wave hydrodynamics such as tidal circulation and storm surge propagation. CLHYD can simulate flow fields induced by wind fields, river inflows/outflows, and tidal forcing. CLHYD is similar to WIFM, with the added feature of operating on a boundary-fitted (curvilinear) grid system. However, CLHYD cannot simulate flooding/drying of low-lying areas as WIFM can. This feature will be incorporated in a later release of CLHYD.

Chapter 7: Spectral Wave Modeling Module: Model SHALWV

32. The numerical model SHALWV is a time-dependent spectral wind-wave model for computing a time-history of wind-generated waves. The model solves the inhomogeneous energy balance equation using finite-difference methods. It simulates the growth, decay, and transformation of a wave field over a spatial area (i.e., an ocean basin, bay, or lake) for a given time period. SHALWV can simulate the wave climate for a specific storm or idealized events, such as a standard project hurricane.

Chapter 8: Spectral Wave Modeling Module: Model STWAVE

33. The numerical model STWAVE is a near-coast, time-independent spectral wave energy propagation model. The model solves the spectral energy balance equation (including refraction, shoaling, and wave breaking) using

finite-difference methods. This steady-state model simulates wave propagation over a spatial area assuming wave conditions vary sufficiently slowly. The variation of waves at a given point may be neglected relative to the time required for waves to pass across the computational grid if the model is limited to near-coast applications in which waves move quickly across the grid (within 30 minutes).

Chapter 9: Harbor Wave Oscillation Model (HARBD)

34. The numerical model HARBD is a finite element model for predicting wave oscillations in harbors. HARBD is a steady-state, linear monochromatic wave model that assumes bathymetric gradients are small and neglects wave-wave interaction, wave-current interaction, wave breaking, and wave transmission and overtopping of structures. The model has been used in the design and modification of numerous harbors, the study of dredging effects on wave propagation, and in the design and planning of wave protection structures for existing harbors.

Appendix A: CMSGRID

35. Grid development is a major part of successfully applying a numerical model to a specific site. Module CMSGRID contains software used in the generation of stretched coordinate, rectilinear computational grids for several models in CMS. The software employs sophisticated techniques that allow concentration of grid cells in regions of interest, or where geographic features are irregular, and wider spacing of grid cells in areas where conditions are not expected to change rapidly. The ability to generate variably spaced grids provides economy in computational time and costs. Generated grids can be plotted to scale on Mylar for overlaying bathymetric charts to obtain depths and elevations.

Appendix B: CMSUTIL

36. Module CMSUTIL contains useful programs that supplement numerical models in CMS. Presently, there are two programs in this module: a program to determine tidal constituents from a time-history of tidal elevations, and a

program to generate a time series of water elevations from tidal constituent input.

Appendix C: CMSPOST

37. Most numerical models generate large output files containing results saved at user-specified grid cells and time-steps during the simulation. Module CMSPOST contains post-processing plotting packages that plot the model output for comparison and analysis purposes. Four basic types of plotting are available: (a) time-histories of field arrays such as water surface elevation or velocity at selected grid points, (b) "snapshots" of the entire flow field at a given instant in time, (c) wave ray plots, and (d) profile plots that show the spatial variation of a model variable at an instant in time.

Appendix D: CMSSAMP

38. Module CMSSAMP is used to access sample input files for each of the models in the CMS. This provides the user with the required format of input data, and can also be used as a template for generating the user's own input file(s). In addition, sample files can be used to run a particular model in the CMS to help the user gain familiarity with the model. Appendix D contains a table of sample input file names and the procedure for accessing these files from within the CMS.

REFERENCE

National Oceanic and Atmospheric Administration. 1979. "Meteorological Criteria for Standard Project Hurricane and Probable Maximum Hurricane Wind Fields, Gulf and East Coasts of the United States," Technical Report NWS 23, National Weather Service, Washington, DC.

CHAPTER 2

USING THE COASTAL MODELING SYSTEM

PART I: ACCESS TO THE VAX 8800 AND CRAY Y-MP

Introduction

1. The Coastal Modeling System (CMS) is available to all Corps elements through the CRAY Y-MP supercomputer that resides at the Information Technology Laboratory (ITL), U.S. Army Waterways Experiments Station (WES). This chapter provides a detailed description of the steps necessary to use the CMS. In addition, sample runs of several models in the CMS are given for illustration.

Computer Account Information

2. A computer account for both the VAX 8800 and CRAY Y-MP can be obtained by calling the Customer Assistance Center (CAC) at WES (601) 634-4400. Although it is no longer necessary to have a VAX 8800 account to access the CRAY Y-MP, it is recommended that the user obtain a VAX 8800 account for data manipulation purposes. Cost for usage of the CRAY is $500/hr (CPU time) and $100/hr (CPU time) for the VAX 8800. Disk storage will be billed at the rate of $1.60/megaword-day (1 megaword = 8 megabytes) on both systems. A DA 448 - Military Interagency Purchasing Request (MIPR) or a DA 2544 funding document must be sent to WES-CAC before computer accounts can be set up on the CRAY or VAX.

Login Procedure for the VAX 8800 and CRAY Y-MP

3. A user can log onto the VAX 8800 through the INTERNET network or a modem. (INTERNET is a national collection of networks including MILNET, NSFNET, ARPANET, ASNET, SURANET, and BITNET.) The login procedure is as follows:

a. To log onto the ITL VAX 8800 through the INTERNET network, type in the following command at your remote workstation.

```
telnet wesim3.wes.army.mil      <cr>
```

or

telnet 134.164.4.1 <ret>

where 134.164.4.1 is the INTERNET address for the ITL VAX 8800.

b. To log onto the ITL VAX 8800 through a 1200 or 2400 modem:

(1) Dial (601) 634-4458 or FTS 542-4458 to connect to the terminal server.

(2) Press the RETURN key twice after the terminal server is connected.

(3) Type in the command:

c wesim3 <ret>

A 9600 baud modem can also be used. The telephone number for the 9600 baud rate is (601) 634-4426 or FTS 542-4426.

4. Once connected to the ITL VAX 8800, a user can log onto the CRAY Y-MP from the VAX 8800. The user can also connect directly to the CRAY Y-MP, if so desired. It should be noted that the UNICOS operating system is case sensitive; therefore, terminal keyboard CAPS LOCK should remain "off" for all CRAY Y-MP sessions.

a. To log onto the CRAY Y-MP through the VAX 8800, type:

telnet larry <ret>

b. To log onto the CRAY Y-MP through the INTERNET network, type:

telnet larry.wes.army.mil <ret>

or

telnet 134.164.8.2 <ret>

where 134.164.8.2 is the INTERNET address of the WES CRAY Y-MP.

c. To log onto the CRAY Y-MP through a modem:

(1) Dial (601) 634-4458 or FTS 542-4458 to connect to the terminal server.

(2) Press the RETURN key twice after the terminal server is connected.

(3) Type in the command:

telnet larry <ret>

The computer will then prompt the user for the username and password for his/her account.

PART II: ACCESSING THE CMS

5. CMS is a command procedure file or "shell script" for using models in CMS. The script serves two purposes: (a) it builds the necessary preprocessor file and compiled source code of the desired model, and (b) it loads, links, and executes the model. The steps necessary to use CMS are as follows:

a. To access CMS, type in the command:

```
/u3/h2crplc0/cms
```

Note that CMS resides on the CRAY Y-MP account **/u3/h2crplc0**; therefore, the user must provide this path name when accessing CMS. The computer will then prompt the user with a series of questions, in menu form, concerning:

(1) The desired model name.

(2) The model procedure name, which is either **BUILD** (or **build**), **RUN** (or **run**), or **EXIT** (or **exit**) where "**build**" is used for compiling and linking the model, "**run**" is used for model execution, and "**exit**" is used to terminate the CMS session.

(3) The input and output filenames. Filenames should be limited to 8 digits with 3-digit extensions if they are to be transferred to a personal computer (PC). It is recommended that input files be created and edited on the VAX 8800 or on the user's PC and transferred to the CRAY Y-MP for CMS simulations.

Following the entry of all output filenames, CMS launches a batch job to the CRAY Y-MP, for example:

```
Request 1234.larry submitted to queue:prime
```

where 1234 is the job number assigned by the CRAY Y-MP for the particular run. The batch queue selected by the system, in this case "prime," is based on the estimated execution time of the job.

b. To check the job status after it is submitted to the CRAY Y-MP, the user can type in the UNICOS command:

```
qstat -a          <ret>
```

where -a indicates status of the current user's batch jobs only. If the batch job is still in the batch queue, the computer will respond:

```
1234.larry   wifm_build.com  h2crpmc0  primea@larry
no pipe queue entries
no device queue entries
```

indicating that the job is still in the batch queue. If the job is completed (compiled or executed), the computer will respond:

```
no batch queue entries
no pipe queue entries
no device queue entries
```

6. To save computing time and expenses, CMS is divided into two parts: (a) compilation and (b) execution. The user can change certain values in the input data set without recompiling the model. However, changing certain crucial values will require recompilation. After the job's completion, system output files will be generated and will reside in the user's working directory. The two files generated after model compilation are named **Model_bu.exxxx** and **Model_bu.oxxxx**, and the two system output files generated after model execution are **Model_ru.exxxx** and **Model_ru.oxxxx**. The **xxxx** is the 4 or 5-digit job number assigned by the system (depending on the CRAY Y-MP schedule) for the particular run. The .e file contains compiling or execution error messages while the .o file contains a summary report of the job accounting information. Example filenames are given in Table 2-1.

Table 2-1

Example Filenames

Example Procedure	Example File Produced
Build WIFM	WIFM_BU.E1234 WIFM_BU.O1234
Run WIFM	WIFM_RU.E5678 WIFM_RU.O5678

7. To read the error messages or the accounting report, the user can type the UNICOS command

pg file_name <ret>

where "file_name" is a filename in the form mentioned previously and in Table 2-1. The pg command displays the text file on a terminal, one screenful at a time. The user can press the return key to view another screenful or q to terminate viewing of the particular file. The UNICOS command cat is not recommended for this purpose because the entire file will scroll onto the terminal screen and it is difficult to terminate the scrolling process.

PART III: ILLUSTRATIONS OF THE CMS

Compilation

8. For illustrative purposes, model WIFM was selected for compilation. Compilation of any of the other models in the CMS is identical to the procedure given below. The user:

   a. Invokes CMS.

   b. Selects the name of the desired model.

   c. Selects "BUILD" to compile and link the desired model.

   d. Enters the input filename to be used for the subsequent model run.

9. CMS resides on the CRAY Y-MP account **/u3/h2crplc0**; therefore, the user must provide this path name when accessing CMS. To compile model WIFM, the user (h2crplcl for the following examples) invokes CMS by entering the information shaded below (step a). It should be noted that user entries are shown as shaded and CMS response "screens" are shaded boxes. The information preceding the shaded command in step a (h2crplcl:larry$) is a system prompt.

   a. h2crplcl:larry$/u3/h2crplc0/cms

The CMS responds:

```
      W E L C O M E   T O . . .

   XXXXX        X     X       XXXXX
  X     X       XX   XX      X     X
  X             X X X X      X
  X             X  X  X       XXXXX
  X             X     X            X
  X     X       X     X      X     X
   XXXXX        X     X       XXXXX

            Return for more...
```

```
**********************************************************************
*                        C M S   COMPONENTS                          *
**********************************************************************
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1  *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                 numerical models)  ------------------------> 2    *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  -----------------> 3    *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  -----------------> 4    *
*                                                                    *
*  CMSSAMP (Sample input files for each model)  -------------> 5    *
*                                                                    *
*  Exit CMS  ------------------------------------------------> q    *
**********************************************************************
```

```
Enter option number  ------------------------>  2
```

The CMS responds:

```
   CCCCC   M     M   SSSSS   M     M    OO    DDDDD    EEEEE  L
  C        MM   MM  S        MM   MM   O  O   D    D   E      L
 C         M M M M  S        M M M M  O    O  D     D  E      L
 C         M  M  M   SSSS    M  M  M  O    O  D     D  EEE    L
 C         M     M       S   M     M  O    O  D     D  E      L
  C        M     M       S   M     M   O  O   D    D   E      L
   CCCCC   M     M  SSSSS    M     M    OO    DDDDD    EEEEE  LLLLL


                     Return for more. . .
```

```
*********************************************************************
*                                                                   *
*                  USING THE COASTAL MODELING SYSTEM                *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ------------------------------------------> 1   *
*                                                                   *
*    Enter CMSMODEL Module  ---------------------------------> 2   *
*                                                                   *
*    Return to Main Menu  -----------------------------------> 3   *
*                                                                   *
*********************************************************************
```

```
Enter option number  ----------------->  2
```

The CMS responds:

```
*************************************************************
*                                                           *
*                Models Presently in System                 *
*************************************************************

   CLHYD:      Curvilinear Hydrodynamic 2-Dimensional Model

   HARBD:      Harbor Wave Oscillation Model

   RCPWAVE:    Regional Coastal Processes Wave Model

   SPH:        Standard Project Hurricane Wind Model

   SWM:        SPECTRAL WAVE MODELING
               SHALWV:  Time Dependent Wave Model
               STWAVE:  Time Independent Wave Model

   WIFM:       WES Implicit Flooding Model

   EXIT:       Terminate computer session
```

The user is prompted to enter the name of the model desired:

b. Enter name of model wifm

The CMS responds:

```
W       W       I       FFFFFF      M       M
W       W       I       F           MM     MM
W       W       I       F           M M M M
W   W   W       I       FFFF        M   M   M
W W W W         I       F           M       M
WW     WW       I       F           M       M
W       W       I       F           M       M


              Return for more...
```

```
Select Model Procedure:

    BUILD - compile and link model
    RUN   - execute model
    EXIT  - terminate computer session
```

For this example WIFM is compiled and linked by responding to the CMS prompt with:

c. Enter procedure name **build**

The user is prompted for the input data set as follows:

d. Enter name of input data file **/u3/h2crplcl/wifm/test/mock.inpl**

Note that the name of the user's input data file (/wifm/test/mock.inpl) may be different from that given in step d. The system responds:

```
Request 2710.larry submitted to queue: prime.
**** END OF CMS PROCEDURE
```

This procedure launches a batch job (number 2710) to the CRAY Y-MP. The user then has the option of continuing to use the CMS or exiting from the CMS:

```
e.   Do you want to continue the computer session ?
     Enter y[es] or [n]o to continue n
```

The system responds with the interactive job accounting summary as follows:

```
Job Accounting - Summary Report
_______________________________

Job Accounting File Name          : /tmp/jtmp.001818a/.jacct1818
Operating System                  : sn1022 larry 6.1 gar.28 CRAY Y-MP
User Name (ID)                    : h2crplcl (1432)
Group Name (ID)                   : CERC (105)
Account Name (ID)                 : A-cerc (200)
Job Name (ID)                     : 1818
Report Starts                     : 06/15/92 10:35:47
Report Ends                       : 06/15/92 10:36:33
Elapsed Time                      :            46      Seconds
User CPU Time                     :             0.3736 Seconds
System CPU Time                   :             0.1831 Seconds
I/O Wait Time (Locked)            :             0.2748 Seconds
I/O Wait Time (Unlocked)          :             0.4207 Seconds
CPU Time Memory Integral          :             0.0318 Mword-seconds
SDS Time Memory Integral          :             0.0000 Mword-seconds
I/O Wait Time Memory Integral     :             0.0110 Mword-seconds
Data Transferred                  :             0.0762 Mwords
Logical I/O Requests              :           244
Physical I/O Requests             :           121
Number of Commands                :            11
Billing Units                     :             0.0000
```

Interactive CPU costs are the sum of 'User CPU Time' and 'System CPU Time' listed above, multiplied by the CPU cost per hour (see Part I). For this example, the interactive costs were .5567 sec multipled by $500/hr or 7.7 cents.

10. To check the status of the batch job, the user types:

```
h2crplcl:larry$ qstat -a
```

When the system responds:

```
no batch queue entries
no pipe queue entries
no device queue entries
```

then the batch job is completed.

11. To check the status of files produced by the batch job, the user types the following to check the status of the error file:

```
h2crplcl:larry$ ls -l *.e*
-rw-------    1 h2crplcl CERC              0 Aug 13 12:54 wifm_bu.e2710
```

and the following to check the status of the output files:

```
h2crplcl:larry$ ls -l *.o*
-rw-------    1 h2crplcl CERC           1556 Aug 13 12:54 wifm_bu.o2710
-rw-------    1 h2crplcl CERC         450504 Aug 13 12:54 wifmall.o
```

The .e2710 file contains compiling error messages, and the .o2710 file contains a summary report of the job accounting information. Similar to the interactive CPU costs, batch job CPU costs are given in the summary report as the sum of 'User CPU Time' and 'System CPU Time,' multiplied by the CPU cost per hour.

12. To view the compiling error message, the user types:

```
h2crplcl:larry$ pg wifm_bu.e2710
```

In this case, there are no error messages. If the user encounters compilation errors, he or she should call the Coastal Engineering Research Center (CERC) CMS representative.

13. To view the summary report of the job accounting information, the user types:

```
h2crplcl:larry$ pg wifm_bu.o2710
```

The system responds:

```
             USAEWES Information Technology Laboratory
                   CRAY Y-MP 8/6128  (UNICOS 5.1)

Questions/problems/comments --> call Customer Assistance at
(601)634-4400 or send mail to cag@wesim3

%% Use 'bull' for information on tapes, printer, and other news. %%



Job Accounting - Summary Report
_______________________________

Job Accounting File Name          : /tmp/nqs.+++++0+eL/.jacct1166
Operating System                  : sn1022 larry 5.1 1022.15 CRAY Y-MP
User Name (ID)                    : h2crplcl (1458)
Group Name (ID)                   : CERC (105)
Account Name (ID)                 : A-00000 (0)
Job Name (ID)                     : wifm_build.com (1166)
Report Starts                     : 08/13/90 12:53:20
Report Ends                       : 08/13/90 12:54:02
Elapsed Time                      :          42      Seconds
User CPU Time                     :          36.2225 Seconds
System CPU Time                   :           0.8803 Seconds
I/O Wait Time (Locked)            :           0.1809 Seconds
I/O Wait Time (Unlocked)          :           0.6861 Seconds
CPU Time Memory Integral          :          35.9472 Mword-seconds
SDS Time Memory Integral          :           0.0000 Mword-seconds
I/O Wait Time Memory Integral     :           0.2086 Mword-seconds
Data Transferred                  :           2.1089 Mbytes
Logical I/O Requests              :         518
Physical I/O Requests             :         454
Number of Commands                :          16
Billing Units                     :           0.0000
```

In this example, the cost of running a batch job to compile model WIFM was 37.1028 sec multipled by $500/hr or $5.15.

Execution

14. Models WIFM, SPH, RCPWAVE, and CLHYD were selected for execution. The user is referred to Chapters 7 and above for illustrations of other models in the CMS. To execute model WIFM, the user types:

a. h2crplcl:larry$ [redacted]

The CMS responds:

```
          W E L C O M E   T O . . .


   XXXXX          X     X          XXXXX
  X     X         XX   XX         X     X
  X               X X X X         X
  X               X  X  X          XXXXX
  X               X     X               X
  X     X         X     X         X     X
   XXXXX          X     X          XXXXX



              Return for more...
```

```
**********************************************************************
*                           C M S   COMPONENTS                       *
**********************************************************************
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------->  1 *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                 numerical models)  ------------------------->  2 *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  ------------------->  3 *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  ------------------->  4 *
*                                                                    *
*  CMSSAMP (Sample input files for each model)  --------------->  5 *
*                                                                    *
*  Exit CMS  ------------------------------------------------->  q *
**********************************************************************
```

Enter option number ------------------------->

The CMS responds:

```
  CCCCC   M     M    SSSSS   M     M     OO     DDDDD    EEEEE  L
 C        MM   MM   S        MM   MM    O  O    D    D   E      L
C         M M M M   S        M M M M   O    O   D     D  E      L
C         M  M  M    SSSS    M  M  M   O    O   D     D  EEE    L
C         M     M        S   M     M   O    O   D     D  E      L
 C        M     M        S   M     M    O  O    D    D   E      L
  CCCCC   M     M   SSSSS    M     M     OO     DDDDD    EEEEE  LLLLL



                          Return for more. . .
```

```
*********************************************************************
*                                                                   *
*                 USING THE COASTAL MODELING SYSTEM                 *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ------------------------------------------->  1  *
*                                                                   *
*    Enter CMSMODEL Module  ---------------------------------->  2  *
*                                                                   *
*    Return to Main Menu  ------------------------------------>  3  *
*                                                                   *
*********************************************************************
```

```
Enter option number  ----------------->
```

The CMS responds:

```
************************************************************
*             Models Presently in System                   *
************************************************************
   CLHYD:     Curvilinear Hydrodynamic 2-Dimensional Model

   HARBD:     Harbor Wave Oscillation Model

   RCPWAVE:   Regional Coastal Processes Wave Model

   SPH:       Standard Project Hurricane Wind Model

   SWM:       SPECTRAL WAVE MODELING
              SHALWV:  Time Dependent Wave Model
              STWAVE:  Time Independent Wave Model

   WIFM:      WES Implicit Flooding Model

   EXIT:      Terminate computer session
```

The user is prompted to enter the name of the model desired:

b. Enter name of model wifm

The CMS responds:

```
W     W     I     FFFFFF    M     M
W     W     I     F         MM   MM
W     W     I     F         M M M M
W  W  W     I     FFFF      M  M  M
W W W W     I     F         M     M
WW   WW     I     F         M     M
W     W     I     F         M     M


           Return for more...
```

```
Select Model Procedure:

    BUILD - compile and link model
    RUN   - execute model
    EXIT  - terminate computer session
```

For this example WIFM is executed by responding to the CMS prompt with:

c. Enter procedure name run

The user is prompted for the input and output data sets as follows. Note that the names of the user's input and output files may differ from those given in steps d, f, g, and h. Example input and output files can be found in Chapter 4 (WIFM) or accessed on-line using CMSSAMP (see Appendix D).

d. Enter name of input data file /u3/h2crplcl/wifm/test/mock.inp1

A hotstart simulation indicates that model results (water surface elevations and velocities) have been saved from a previous simulation and are to be used as initial conditions for the present simulation:

```
e. Is this a HOTSTART simulation?
   Enter y[es] or n[o] to continue n
```

```
f. Enter the name of the output data file mock.out
   outdeck = mock.out
```

Hydrograph data are time-histories of model results (i.e., water surface elevations and velocities) at selected (gage) points in the computational domain.

```
g. Do you want to save hydrographic data?
   Enter y[es] or n[o] to continue y
   Enter the name of the hydrograph data file mock.hyd1
```

A snapshot is a "picture" of the flow field for the entire grid or a portion of the grid at a given instant in time.

```
h. Do you want to save snapshots?
   Enter y[es] or n[o] to continue y
   Enter the name of the snapshot data file mock.snp1
```

Hotstart data (water surface elevations and velocities) can be saved for the entire computational domain for use in a subsequent simulation.

```
i. Do you want to save hotstart data?
   Enter y[es] or n[o] to continue n
```

The system responds:

```
Request 2713.larry submitted to queue: prime.
**** END OF CMS PROCEDURE
```

This procedure launches a batch job (number 2713) to the CRAY Y-MP. The user then has the option of continuing to use the CMS or exiting from the CMS:

e. Do you want to continue the computer session ?
Enter y[es] or [n]o to continue n

The system responds with the interactive job accounting summary as follows:

```
Job Accounting - Summary Report
_______________________________

Job Accounting File Name         : /tmp/jtmp.001818a/.jacct1818
Operating System                 : sn1022 larry 6.1 gar.28 CRAY Y-MP
User Name (ID)                   : h2crplcl (1432)
Group Name (ID)                  : CERC (105)
Account Name (ID)                : A-cerc (200)
Job Name (ID)                    : 1818
Report Starts                    : 06/15/92 10:35:47
Report Ends                      : 06/15/92 10:36:33
Elapsed Time                     :       46      Seconds
User CPU Time                    :        0.3736 Seconds
System CPU Time                  :        0.1831 Seconds
I/O Wait Time (Locked)           :        0.2748 Seconds
I/O Wait Time (Unlocked)         :        0.4207 Seconds
CPU Time Memory Integral         :        0.0318 Mword-seconds
SDS Time Memory Integral         :        0.0000 Mword-seconds
I/O Wait Time Memory Integral    :        0.0110 Mword-seconds
Data Transferred                 :        0.0762 Mwords
Logical I/O Requests             :      244
Physical I/O Requests            :      121
Number of Commands               :       11
Billing Units                    :        0.0000
```

15. In order to check the status of the batch job, the user types:

h2crplcl:larry$ qstat -a

If the job is still in the batch queue, the computer responds:

```
2713.larry wifm_run.com h2crpmc0 prime@larry
no pipe queues entries
no device queue entries
```

When the system responds:

```
no batch queue entries
no pipe queue entries
no device queue entries
```

then the batch job is completed.

16. To check the status of files produced by the batch job, the user types:

```
h2crplcl:larry$ ls -l *.e*
-rw-------   1 h2crplcl CERC          0 Aug 13 12:54 wifm_bu.e2710
-rw-------   1 h2crplcl CERC         73 Aug 13 13:01 wifm_ru.e2713
```

and

```
h2crp.cl:larry$ ls -l *.o*
-rw-------   1 h2crplcl CERC     140567 Aug 13 13:01 mock.out
-rw-------   1 h2crplcl CERC          0 Aug 13 13:01 wifm.out
-rw-------   1 h2crplcl CERC       1556 Aug 13 12:54 wifm_bu.o2710
-rw-------   1 h2crplcl CERC       1554 Aug 13 13:01 wifm_ru.o2713
-rw-------   1 h2crplcl CERC     450504 Aug 13 12:54 wifmall.o
```

The .e file contains compiling error messages, and the .o file contains a summary report of the job accounting information.

17. To view the system error messages, the user types:

```
h2crplcl:larry$ pg wifm_ru.e2713
```

The system responds:

```
STOP
CP:  7.886s, Wallclock:  7.987s,   16.5% of 6-CPU Machine
```

In this case, there are no error messages. Types of errors one might encounter include:

```
Floating exception
TB001 - BEGINNING OF TRACEBACK
      - $TRBK    WAS CALLED BY f_sig    AT 234471a (LINE NUMBER  235)
      - f_sig    WAS CALLED BY CALLFUNC AT 204414c
      - CALLFUNC WAS CALLED BY WIFMXY   AT  31402a
      - WIFMXY   WAS CALLED BY WIFM     AT    664c (LINE NUMBER  236)
      - WIFM     WAS CALLED BY $START$  AT    136d
TB002 - END OF TRACEBACK
```

which indicates that a "floating divide by zero" or a dimensioning problem was encountered during the simulation. If this occurs, call the CERC CMS representative. Input errors would not be indicated in the system error file (**wifm_ru.e2713**), but can be found in the model output file (**mock.out**). A sample output file with errors should be examined as shown in Table 2-2. The underlined information in Table 2-2 is typed by the user, making use of the CRAY line editor (see UNICOS primer SG-2010 C).

Table 2-2

Example of an Input Error

```
ed mock.out
$                    to go to the end of the file
***** PROGRAM ABORTING !!!!!
n                    to determine the line number at the end of file
242  ***** PROGRAM ABORTING !!!!!
230,$p               to type lines 230 to the end of file
*** FATAL ERRORS =    2      WARNINGS =  0
***** SYSTEM SPECIFICATION -- "FNGLISH  " NOT RECOGNIZED !!!!!
***** PROGRAM ABORTING !!!!!
```

18. To view the summary report of the job accounting information, the user types:

h2crp1c1:larry$ pg wifm_ru.o2713

The system responds:

```
              USAEWES Information Technology Laboratory
                     CRAY Y-MP 8/6128  (UNICOS 5.1)

Questions/problems/comments --> call Customer Assistance at
(601)634-4400 or send mail to cag@wesim3

%% Use 'bull' for information on tapes, printer, and other news. %%

Job Accounting - Summary Report
________________________________

Job Accounting File Name           : /tmp/nqs.+++++0+e0/.jacct1181
Operating System                   : sn1022 larry 5.1 1022.15 CRAY Y-MP
User Name (ID)                     : h2crplcl (1458)
Group Name (ID)                    : CERC (105)
Account Name (ID)                  : A-00000 (0)
Job Name (ID)                      : wifm_run.com (1181)
Report Starts                      : 08/13/90 13:01:40
Report Ends                        : 08/13/90 13:01:51
Elapsed Time                       :          11      Seconds
User CPU Time                      :           8.3513 Seconds
System CPU Time                    :           0.1963 Seconds
I/O Wait Time (Locked)             :           1.3230 Seconds
I/O Wait Time (Unlocked)           :           1.0556 Seconds
CPU Time Memory Integral           :           2.8742 Mword-seconds
SDS Time Memory Integral           :           0.0000 Mword-seconds
I/O Wait Time Memory Integral      :           0.3517 Mword-seconds
Data Transferred                   :           4.5823 Mbytes
Logical I/O Requests               :         189
Physical I/O Requests              :         260
Number of Commands                 :          11
Billing Units                      :           0.0000
```

19. To execute model SPH, the user types:

a. h2crplcl:larry$ /u3/h2crplc0/cms

The CMS responds:

```
           W E L C O M E   T O . . .


      XXXXX         X     X        XXXXX
     X     X        XX   XX       X     X
     X              X X X X       X
     X              X  X  X        XXXXX
     X              X     X             X
     X     X        X     X       X     X
      XXXXX         X     X        XXXXX



               Return for more...
```

```
*********************************************************************
*                          C M S   COMPONENTS                       *
*********************************************************************
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid) ------->  1 *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                 numerical models) ------------------------->  2 *
*                                                                   *
*  CMSPOST (Plots and lists model outputs) ------------------->  3 *
*                                                                   *
*  CMSUTIL (Additional "utility" programs) ------------------->  4 *
*                                                                   *
*  CMSSAMP  (Sample input files for each model) -------------->  5 *
*                                                                   *
*  Exit CMS ------------------------------------------------->  q *
*********************************************************************
```

Enter option number ----------------> 2

The CMS responds:

```
  CCCCC   M     M   SSSSS   M     M    OO    DDDDD   EEEEE L
 C        MM   MM  S        MM   MM   O  O   D    D  E     L
C         M M M M  S        M M M M  O    O  D     D E     L
C         M  M  M   SSSS    M  M  M  O    O  D     D EEE   L
C         M     M       S   M     M  O    O  D     D E     L
 C        M     M       S   M     M   O  O   D    D  E     L
  CCCCC   M     M  SSSSS    M     M    OO    DDDDD   EEEEE LLLLL


                      Return for more. . .
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ------------------------------------------> 1     *
*                                                                   *
*    Enter CMSMODEL Module ---------------------------------> 2     *
*                                                                   *
*    Return to Main Menu -----------------------------------> 3     *
*                                                                   *
*********************************************************************
```

Enter option number ----------------> 2

The CMS responds:

```
**************************************************************
*                 Models Presently in System                 *
**************************************************************
   CLHYD:      Curvilinear Hydrodynamic 2-Dimensional Model

   HARBD:      Harbor Wave Oscillation Model

   RCPWAVE:    Regional Coastal Processes Wave Model

   SPH:        Standard Project Hurricane Wind Model

   SWM:        SPECTRAL WAVE MODELING
               SHALWV:  Time Dependent Wave Model
               STWAVE:  Time Independent Wave Model

   WIFM:       WES Implicit Flooding Model

   EXIT:       Terminate computer session
```

The user is prompted to enter the name of the model desired:

b. Enter name of model sph

The CMS responds:

```
  SSSSS      PPPPP      H     H
 S     S     P    P     H     H
 S           P    P     H     H
  SSSSS      PPPPP      HHHHHHH
       S     P          H     H
 S     S     P          H     H
  SSSSS      P          H     H


        Return for more...
```

```
Select Model Procedure:

    BUILD - compile and link model
    RUN   - execute model
    EXIT  - terminate computer session
```

For this example SPH is executed by responding to the CMS prompt with:

c. Enter procedure name [redacted]

The user is prompted for the input and output data sets as follows. Note that the names of the users input and output files may differ from those given in steps d, e, and f. Example input and output files can be found in Chapter 3 (SPH) or accessed on-line using CMSSAMP (see Appendix D).

d. Enter the name of the input data file
[redacted]

e. Enter the name of the output data file [redacted]

Hydrograph data are time-histories of model results (i.e., wind velocities) at selected (gage) points in the computational domain.

f. Do you want to save hydrographic data?
Enter y[es] or n[o] to continue [redacted]
Enter the name of the hydrograph data file [redacted]

A snapshot is a "picture" of the flow field for the entire grid or a portion of the grid at a given instant in time.

g. Do you want to save snapshots?
Enter y[es] or n[o] to continue [redacted]

The system responds:

```
Request 8640.larry subfitted to queue: prime.
**** END OF CMS PROCEDURE
```

This procedure launches a batch job (number 8640) to the CRAY Y-MP. The user then has the option of continuing to use the CMS or exiting from the CMS:

h. Do you want to continue the computer session ?
Enter y[es] or [n]o to continue [redacted]

The system responds with the interactive job accounting summary as follows:

```
Job Accounting - Summary Report
===============================

Job Accounting File Name          : /tmp/jtmp.001818a/.jacct1818
Operating System                  : sn1022 larry 6.1 gar.28 CRAY Y-MP
User Name (ID)                    : h2crplc1 (1432)
Group Name (ID)                   : CERC (105)
Account Name (ID)                 : A-cerc (200)
Job Name (ID)                     : 1818
Report Starts                     : 06/15/92 10:35:47
Report Ends                       : 06/15/92 10:36:33
Elapsed Time                      :        46      Seconds
User CPU Time                     :         0.3736 Seconds
System CPU Time                   :         0.1831 Seconds
I/O Wait Time (Locked)            :         0.2748 Seconds
I/O Wait Time (Unlocked)          :         0.4207 Seconds
CPU Time Memory Integral          :         0.0318 Mword-seconds
SDS Time Memory Integral          :         0.0000 Mword-seconds
I/O Wait Time Memory Integral     :         0.0110 Mword-seconds
Data Transferred                  :         0.0762 Mwords
Logical I/O Requests              :       244
Physical I/O Requests             :       121
Number of Commands                :        11
Billing Units                     :         0.0000
```

20. To excute model RCPWAVE, the user types:

<u>a</u>. **h2crplc1:larry$ /u3/h2crplc0/cms**

The CMS responds:

```
                 W E L C O M E   T O . . .

        XXXXX              X     X           XXXXX
       X     X             XX   X           X     X
       X                   X X X X          X
       X                   X  X  X           XXXXX
       X                   X     X                X
       X     X             X     X          X     X
        XXXXX              X     X           XXXXX


                     Return for more...
```

```
**************************************************************************
*                          C M S   COMPONENTS                            *
**************************************************************************
*  Options:                                                              *
*                                                                        *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------->  1    *
*                                                                        *
*  CMSMODEL (Compiles, links, loads, and executes                       *
*                  numerical models)  ------------------------->  2     *
*                                                                        *
*  CMSPOST (Plots and lists model outputs)  ------------------->  3     *
*                                                                        *
*  CMSUTIL (Additional "utility" programs)  ------------------->  4     *
*                                                                        *
*  CMSSAMP  (Sample input files for each model)  -------------->  5     *
*                                                                        *
*  Exit CMS  -------------------------------------------------->  q     *
**************************************************************************
```

Enter option number ------------------------> ▓

The CMS responds:

```
  CCCCC   M     M   SSSSS   M     M     OO     DDDDD    EEEEE  L
 C        MM   MM  S        MM   MM    O  O    D    D   E      L
C         M M M M  S        M M M M   O    O   D     D  E      L
C         M  M  M   SSSS    M  M  M   O    O   D     D  EEE    L
C         M     M       S   M     M   O    O   D     D  E      L
 C        M     M       S   M     M    O  O    D    D   E      L
  CCCCC   M     M  SSSSS    M     M     OO     DDDDD    EEEEE  LLLLL


                        Return for more. . .
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ------------------------------------------> 1    *
*                                                                   *
*    Enter CMSMODEL Module  ---------------------------------> 2    *
*                                                                   *
*    Return to Main Menu  -----------------------------------> 3    *
*                                                                   *
*********************************************************************
```

```
Enter option number  ---------------> 2
```

The CMS responds:

```
*************************************************************
*                Models Presently in System                 *
*************************************************************
   CLHYD:      Curvilinear Hydrodynamic 2-Dimensional Model

   HARBD:      Harbor Wave Oscillation Model

   RCPWAVE:    Regional Coastal Processes Wave Model

   SPH:        Standard Project Hurricane Wind Model

   SWM:        SPECTRAL WAVE MODELING
               SHALWV:  Time Dependent Wave Model
               STWAVE:  Time Independent Wave Model

   WIFM:       WES Implicit Flooding Model

   EXIT:       Terminate computer session
```

The user is prompted to enter the name of the model desired:

b. Enter name of model [redacted]

The CMS responds:

```
RRRRR      CCCCC    PPPPP    W     W      A      V   V    EEEEEE
R    R    C     C   P    P   W     W     A A     V   V    E
R    R    C         P    P   W     W    A   A    V   V    E
RRRRR     C         PPPPP    W  W  W   AAAAAAA   V   V    EEEE
R  R      C         P        W W W W   A     A   V   V    E
R   R     C     C   P        WW   WW   A     A    V V     E
R    R     CCCCC    P        W     W   A     A     V      EEEEEE

                     Return for more...
```

```
Select Model Procedure:

    BUILD - compile and link model
    RUN   - execute model
    EXIT  - terminate computer session
```

For this example RCPWAVE is executed by responding to the CMS prompt with:

c. Enter procedure name **run**

The user is prompted for the input and output data sets as follows. Note that the names of the user's input and output files may differ from those given in steps d, e, f, and g. Example input and output file can be found in Chapter 5 (RCPWAVE) or can be accessed on-line using CMSSAMP (see Appendix D).

d. Enter name of input data file **/u3/h2crplc0/cms/sph/exm/rcp.inp**

The general output file can be given a default filename:

e. Enter the name of the output data file **<ret>**
Default output filename is rcpwave.out

The ray plot data are used to produce wave ray plots of model results using the CMSPOST program RAYPLT (see Appendix C).

f. Enter the name of the output file for ray plot data **<ret>**
Default output filename for ray plot data is rcpwave.ang

The shoreline data are also used with program RAYPLT:

g. Enter the name of the output file for shoreline data **<ret>**
Default output filename for shoreline data is rcpwave.shl

The system responds:

```
Request 7280.larry submitted to queue: prime.
**** END OF CMS PROCEDURE
```

This procedure launches a batch job (number 7280) to the CRAY Y-MP. The user then has the option of continuing to use the CMS or exiting from the CMS:

h. Do you want to continue the computer session ?
Enter y[es] or [n]o to continue **n**

The system responds with the interactive job accounting summary as follows:

```
Job Accounting - Summary Report
_______________________________

Job Accounting File Name       : /tmp/jtmp.001818a/.jacct1818
Operating System               : sn1022 larry 6.1 gar.28 CRAY Y-MP
User Name (ID)                 : h2crplcl (1432)
Group Name (ID)                : CERC (105)
Account Name (ID)              : A-cerc (200)
Job Name (ID)                  : 1818
Report Starts                  : 06/15/92 10:35:47
Report Ends                    : 06/15/92 10:36:33
Elapsed Time                   :        46      Seconds
User CPU Time                  :         0.3736 Seconds
System CPU Time                :         0.1831 Seconds
I/O Wait Time (Locked)         :         0.2748 Seconds
I/O Wait Time (Unlocked)       :         0.4207 Seconds
CPU Time Memory Integral       :         0.0318 Mword-seconds
SDS Time Memory Integral       :         0.0000 Mword-seconds
I/O Wait Time Memory Integral  :         0.0110 Mword-seconds
Data Transferred               :         0.0762 Mwords
Logical I/O Requests           :       244
Physical I/O Requests          :       121
Number of Commands             :        11
Billing Units                  :         0.0000
```

To execute model CLHYD, the user types:

a. h2crplcl:larry$ /u3/h2crplc0/cms

The CMS responds:

```
        W E L C O M E   T O . . .

     XXXXX        X     X       XXXXX
    X     X       XX   XX      X     X
    X             X X X X      X
    X             X  X  X       XXXXX
    X             X     X            X
    X     X       X     X      X     X
     XXXXX        X     X       XXXXX


            Return for more...
```

```
*********************************************************************
*                        C M S   COMPONENTS                         *
*********************************************************************
* Options:                                                          *
*                                                                   *
* CMSGRID (Maps, plots, and lists the numerical grid) -------> 1    *
*                                                                   *
* CMSMODEL (Compiles, links, loads, and executes                    *
*                  numerical models) -----------------------> 2     *
*                                                                   *
* CMSPOST (Plots and lists model outputs) -----------------> 3      *
*                                                                   *
* CMSUTIL (Additional "utility" programs) -----------------> 4      *
*                                                                   *
* CMSSAMP (Sample input files for each model) -------------> 5      *
*                                                                   *
* Exit CMS ----------------------------------------------> q        *
*********************************************************************
```

```
Enter option number ---------------->
```

The CMS responds:

```
  CCCCC   M     M   SSSSS   M     M     OO     DDDDD    EEEEE  L
 C        MM   MM  S        MM   MM    O  O    D    D   E      L
C         M M M M  S        M M M M   O    O   D     D  E      L
C         M  M  M   SSSS    M  M  M   O    O   D     D  EEE    L
C         M     M       S   M     M   O    O   D     D  E      L
 C        M     M       S   M     M    O  O    D    D   E      L
  CCCCC   M     M  SSSSS    M     M     OO     DDDDD    EEEEE  LLLLL


                         Return for more. . .
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ---------------------------------------------> 1  *
*                                                                   *
*    Enter CMSMODEL Module ------------------------------------> 2  *
*                                                                   *
*    Return to Main Menu --------------------------------------> 3  *
*                                                                   *
*********************************************************************
```

Enter option number ----------------->

The CMS responds:

```
**************************************************************
*                Models Presently in System                  *
**************************************************************
   CLHYD:      Curvilinear Hydrodynamic 2-Dimensional Model

   HARBD:      Harbor Wave Oscillation Model

   RCPWAVE:    Regional Coastal Processes Wave Model

   SPH:        Standard Project Hurricane Wind Model

   SWM:        SPECTRAL WAVE MODELING
               SHALWV:  Time Dependent Wave Model
               STWAVE:  Time Independent Wave Model

   WIFM:       WES Implicit Flooding Model

   EXIT:       Terminate computer session
```

The user is prompted to enter the name of the model desired:

b. Enter name of model clhyd

The CMS responds:

```
   CCCCC    L        H     H     Y     Y    DDDDDD
  C     C   L        H     H      Y   Y     D     D
  C         L        H     H       Y Y      D      D
  C         L        HHHHHHH        Y       D      D
  C         L        H     H        Y       D      D
  C     C   L        H     H        Y       D     D
   CCCCC    LLLLLL   H     H        Y       DDDDDD

                  Return for more...
```

```
Select Model Procedure:

    BUILD  - compile and link model
    RUN    - execute model
    EXIT   - terminate computer session
```

For this example CLHYD is executed by responding to the CMS prompt with:

> c. **Enter procedure name run**

The user is prompted for the input and output data sets as follows. Note that the names of the user's input and output files may differ from those given in steps d, f, and g. Example input and output files can be found in Chapter 6 (CLHYD) or can be accessed on-line using CMSSAMP (see Appendix D).

> d. **Enter name of input data file**
> **/u3/h2crplcl/wifm/test/indian_nl.inp**

A hotstart simulation indicates that model results (water surface elevations and velocities) have been saved from a previous simulation and are to be used as initial conditions for the present simulation:

> e. **Is this a HOTSTART simulation?**
> **Enter y[es] or n[o] to continue** [illegible]

> f. **Enter the name of the output data file indian.out**

Hydrograph data are time-histories of model results (i.e., water surface elevations and velocities) at selected (gage) points in the computational domain.

> g. **Do you want to save hydrographic data?**
> **Enter y[es] or n[o] to continue** [illegible]
> **Enter the name of the hydrograph data file indian.hyd**

> h. **Do you wand to save discharge range data?**
> **Enter y[es] or n[o] to continue** [illegible]

A snapshot is a "picture" of the flow field for the entire grid or a portion of the grid at a given instant in time.

> i. **Do you want to save snapshots?**
> **Enter y[es] or n[o] to continue** [illegible]

The system responds:

```
Request 7528.larry submitted to queue: prime.
**** END OF CMS PROCEDURE
```

This procedure launches a batch job (number 7528) to the CRAY Y-MP. The user then has the option of continuing to use the CMS or exiting from the CMS:

> h. **Do you want to continue the computer session ?**
> **Enter y[es] or [n]o to continue** [illegible]

The system responds with the interactive job accounting summary as follows:

```
Job Accounting - Summary Report
________________________________

Job Accounting File Name          : /tmp/jtmp.001818a/.jacctl818
Operating System                  : sn1022 larry 6.1 gar.28 CRAY Y-MP
User Name (ID)                    : h2crplcl (1432)
Group Name (ID)                   : CERC (105)
Account Name (ID)                 : A-cerc (200)
Job Name (ID)                     : 1818
Report Starts                     : 06/15/92 10:35:47
Report Ends                       : 06/15/92 10:36:33
Elapsed Time                      :          46      Seconds
User CPU Time                     :           0.3736 Seconds
System CPU Time                   :           0.1831 Seconds
I/O Wait Time (Locked)            :           0.2748 Seconds
I/O Wait Time (Unlocked)          :           0.4207 Seconds
CPU Time Memory Integral          :           0.0318 Mword-seconds
SDS Time Memory Integral          :           0.0000 Mword-seconds
I/O Wait Time Memory Integral     :           0.0110 Mword-seconds
Data Transferred                  :           0.0762 Mwords
Logical I/O Requests              :         244
Physical I/O Requests             :         121
Number of Commands                :          11
Billing Units                     :           0.0000
```

PART IV: CREATING AND EDITING INPUT FILES TO THE CMS

21. It is recommended that input files to the CMS be created and edited on the VAX 8800 or the user's PC, rather than the CRAY Y-MP. The user will be more familiar with his or her own PC, and in addition, PC editing is cost-free. The input files can then be transferred to the CRAY Y-MP for use with the CMS (see Part V). However, PC's place an end-of-file marker (^M) when saving a file and this must be removed using the CRAY Y-MP VI editor as follows. To enter the VI editor the user types:

```
            vi filename <ret>, then
                  G     <ret>         : to move to the end of the file
                  $     <ret>         : to move to the end of the current line
      CTRL h or Backspace <ret>       : to move left one character
         l or Spacebar <ret>          : to move right one character
                  x                   : to delete the current character
                 wq!                  : to save the file and leave the editor
```

22. An input file for a given model must conform to the specifications outlined in the individual model chapters. For example, model WIFM requires a TIMESPECS card to conform to the following specifications:

```
TIMESPECS       30.     SECONDS         0.      86400.          360.
```

where each variable occupies 8, 16, 24, or 32 columns. It is recommended that the user refer to Chapters 3 and above for specific model input requirements. A portion of a WIFM input file is given in Figure 2-1.

```
GENSPECS    WIFM SIMULATION NO. 1:  TIDE WITHOUT FEATHERING        ENGLISH
TIMESPEC    30. SECONDS     0.  86400.    360.
GRIDSPEC        ENGLISH     75      30    500.   1000.     0.      0.0
PRWINDOW                                 3600.                      EV
RECGAGE       19      16       INLET GAGE
XBOUNDRYCONSTELV      75     1      30      1          BDRYX
YBOUNDRYINTRPELV       1    17      75      2        1 BDRY1
YBOUNDRYINTRPELV      30    17      75      2        1 BDRY2
FUNCTION       1HARMCNST
CNRECORD     0.0    1981     6       1     2.5
CONSTIT       M2    3.97  199.02
```

Figure 2-1. Sample WIFM input file

PART V: FILE TRANSFER PROCEDURE BETWEEN THE VAX 8800 and CRAY Y-MP

23. When logged onto the VAX 8800, files can be transferred to and from the VAX 8800 as follows:

a. Log onto the VAX 8800

b. Type:

```
ftp larry        <ret>
```

The computer will prompt the user to enter the user's account and password for the CRAY Y-MP.

c. To send a file from the VAX 8800 to the CRAY Y-MP, type in the command:

```
put VAX_file_name CRAY_file_name        <ret>
```

d. To get a file from the CRAY Y-MP and send it to VAX 8800, type in the command:

```
get CRAY_file_name  VAX_file_name        <ret>
```

Note that file transfer is to the main or root directory at the receiving end. If the second filename is omitted, then the filename will remain unchanged on the receiving system.

24. When logged onto the CRAY Y-MP, files can be transferred to and from the CRAY Y-MP as follows:

a. Log onto the CRAY Y-MP

b. Type:

```
ftp wesla3        <ret>
```

The computer will prompt the user to enter the user's account and password for the VAX 8800.

c. To send a file from the CRAY Y-MP to the VAX 8800, type in the command:

```
put CRAY_file_name  VAX_file_name        <ret>
```

d. To get a file from the VAX 8800 to the CRAY Y-MP, type in the command:

```
get VAX_file_name  CRAY_file_name        <ret>
```

CHAPTER 5

REGIONAL COASTAL PROCESSES WAVE PROPAGATION MODEL THEORY AND PROGRAM DOCUMENTATION

PART I: INTRODUCTION

1. This chapter documents the Regional Coastal Processes Wave (RCPWAVE) Propagation Model. RCPWAVE is a short-wave numerical model used to predict linear, plane wave propagation over an open coast region of arbitrary bathymetry. The goal of regional modeling is to determine coastal changes resulting from natural forces and man-made structures over an extensive length of coastline. RCPWAVE uses linear wave theory because it has been shown to yield fairly accurate first-order solutions to wave propagation problems and at a relatively low cost. Refractive and bottom-induced diffractive effects are included in the model; however, the model cannot treat diffraction caused by surface-piercing structures. Application of this model does not include nonlinear effects nor a spectral representation of irregular waves.

2. RCPWAVE has evolved as it has been applied to wave propagation problems (Ebersole, Cialone, Prater 1986). The model results can be used as a forcing function to drive models that calculate longshore and cross-shore sediment transport (Hanson and Kraus 1989). For example, RCPWAVE has been used in conjunction with the shoreline change model, GENESIS, for mission support projects at Homer Spit, Alaska (Chu et al. 1987); Sea Bright to Ocean Township, New Jersey (Kraus et al. 1988); and Asbury Park to Manasquan, New Jersey (Gravens et al. 1989).

3. Berkhoff (1972, 1976) derived an elliptical equation to approximate the complete wave transformation process for linear waves over arbitrary bathymetry with the restriction of a mild bottom slope. By substituting the velocity potential into the elliptic mild slope equation and solving the real and imaginary parts separately, two equations are derived. RCPWAVE solves finite difference approximations of these equations along with the equation specifying irrotationality of the wave phase function gradient and the dispersion relation. These equations describe the combined refraction and diffraction process for linear plane waves subject to the restrictions of a small bottom slope. Wave reflections are assumed to be negligible, and any

energy losses are assumed to be small and can be neglected. These equations are valid outside the surf zone.

4. The model also contains an algorithm that estimates wave conditions inside the surf zone. This wave breaking model is an extension of the work of Dally, Dean, and Dalrymple (1984) to two horizontal dimensions. The importance of predicting wave transformation within the surf zone cannot be overemphasized. Wave action within the surf zone initiates sediment movement, and prediction of this movement is a frequent goal of coastal modelers.

Report Organization

5. This chapter is divided into five sections: Part II presents the theoretical development, Part III defines the input data formats, Part IV discusses the model's input data requirements, and Part V contains two illustrative examples.

PART II: THEORETICAL DEVELOPMENT

Assumptions and Limitations

6. Proper application of any model requires a clear understanding of the physical processes occurring in a study area and a comprehension of the capabilities of a given model to simulate those processes. Model results should provide a realistic representation of the physical system being modeled.

7. The limitations of a model define its range of applicability. In particular, RCPWAVE is a linear, monochromatic, short wave model. Therefore, nonlinear effects and irregular waves cannot be modeled. RCPWAVE is a steady-state model; therefore, time-dependent effects are not modeled. Refractive and bottom-induced diffractive effects are included in the model; however, structure-induced diffraction is not. Model applications are restricted to a mild bottom slope. Wave reflection and energy losses outside the surf zone are assumed negligible.

8. A thorough comprehension of the physical processes simulated by the model is necessary to ensure that the model is applied to appropriate problems, that it is applied correctly, and that accurate results are produced. A discussior ✓ the governing equations used in RCPWAVE is provided in the following section. It is recommended that the reader refer to Horikawa (1988) or Dean and Dalrymple (1984) for a detailed discussion of coastal hydrodynamics, particularly linear wave propagation.

Governing Equations Outside the Surf Zone

9. Berkhoff (1972, 1976) derived an elliptical equation to approximate the complete wave transformation process for linear waves over an arbitrary bathymetry with the restriction of a mild bottom slope. Berkhoff's "mild slope" equation is:

$$\frac{\partial}{\partial x}\left(cc_g\frac{\partial\phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(cc_g\frac{\partial\phi}{\partial y}\right) + \sigma^2\frac{c_g}{c}\phi = 0 \qquad (5\text{-}1)$$

where

x, y = two orthogonal horizontal coordinate directions

(x,y) = wave celerity ($= \sigma/k$)

σ = angular wave frequency (defined to be $2\pi/T$)

$k(x,y)$ = wave number given by the dispersion relation $\sigma^2 = gk \tanh(kh)$

T = wave period

$c_g(x,y)$ = group velocity ($\partial\sigma/\partial k$)

$\phi(x,y)$ = complex velocity potential

g = acceleration due to gravity

$h(x,y)$ = still-water depth

10. If one considers only the forward scattered wave field and neglects wave reflection, the velocity potential function for linear, monochromatic plane waves can be given as:

$$\phi = ae^{is} \tag{5-2}$$

where

$a(x,y)$ = wave amplitude function $[gH(x,y)/2\sigma]$

$H(x,y)$ = wave height

$s(x,y)$ = wave phase function

11. By substituting Equation 5-2 into Equation 5-1 and solving the real and imaginary parts separately, two equations can be derived:

$$\frac{1}{a}\left\{\frac{\partial^2 a}{\partial x^2} + \frac{\partial^2 a}{\partial y^2} + \frac{1}{cc_g}\left[\nabla a \bullet \nabla(cc_g)\right]\right\} + k^2 - |\nabla s|^2 = 0 \tag{5-3}$$

$$\nabla \bullet (a^2 cc_g \nabla s) = 0 \tag{5-4}$$

where the symbol ∇ denotes the horizontal gradient operation. These equations describe the combined refractive-diffractive process.

12. Linear wave theory assumes irrotationality of the wave phase function gradient. This property can be expressed mathematically as:

$$\nabla x(\nabla s) = 0 \tag{5-5}$$

The phase function gradient, ∇s, can be written in vector notation as

$$\nabla s = |\nabla s| \cos\theta \, \vec{i} + |\nabla s| \sin\theta \, \vec{j} \tag{5-6}$$

where

- $\vec{i}, \vec{j}$ = unit vectors in the x- and y-directions, respectively
- $|\nabla s|$ = magnitude of the phase function gradient
- θ = local wave direction

Equations 5-5 and 5-6 can be combined to yield the following expression:

$$\frac{\partial}{\partial x}(|\nabla s| \sin\theta) - \frac{\partial}{\partial y}(|\nabla s| \sin\theta) = 0 \tag{5-7}$$

If the magnitude of the wave phase function gradient is known, local wave angles can be calculated from Equation 5-7. Similarly, Equation 5-4 can be expressed as:

$$\frac{\partial}{\partial x}(a^2 cc_g |\nabla s| \cos\theta) + \frac{\partial}{\partial y}(a^2 cc_g |\nabla s| \sin\theta) = 0 \tag{5-8}$$

Equation 5-3 is solved for the magnitude of the wave phase function gradient, $|\nabla s|$; Equation 5-7 is solved for the wave angle, θ ; and Equation 5-8 is solved for the wave amplitude function, a . Equations 5-3, 5-7, and 5-8 along with the dispersion relation describe the combined refractive-diffractive process for linear plane wave propagation over a mild slope with negligible wave reflection and energy losses.

Numerical solution

13. Numerical methods are used to solve the three governing equations described previously. Analytical solutions of the governing equations may exist for idealized situations. However, it is generally necessary to use numerical approximations of the governing equations to provide a more general solution. This is accomplished by approximating the partial derivatives with finite difference operators (i.e. resolving the continuous domain of interest with discrete spatial increments). Finite difference solution methods operate on a computational grid system. Solution accuracy is directly related to resolution within the grid system.

14. The coordinate system convention adopted by RCPWAVE is oriented with the x-axis in the on-offshore direction and the y-axis alongshore (Figure 5-1). The grid cells have constant lengths of DX and DY in the x- and

y-directions, respectively. The cell counter in the x-direction, i, ranges from 1 to a maximum value of XCELLS. The cell counter in the y-direction, j, ranges from 1 to a maximum value of YCELLS.

15. As previously stated, the partial derivatives in the governing equations are approximated with finite difference operators. The first and second derivatives of ar arbitrary dependent variable, say F, are approximated with the following finite difference operators:

$$\frac{\partial^2 F}{\partial x^2} = \frac{2F_{i,j} - 5F_{i+1,j} + 4F_{i+2,j} - F_{i+3,j}}{(\Delta x)^2} \tag{5-9}$$

$$\frac{\partial^2 F}{\partial y^2} = \frac{F_{i,j+1} - 2F_{i,j} + F_{i,j-1}}{(\Delta y)^2} \tag{5-10}$$

$$\frac{\partial F}{\partial x} = \frac{-3F_{i,j} + 4F_{i+1,j} - F_{i+2,j}}{2\Delta x} \tag{5-11}$$

$$\frac{\partial F}{\partial y} = \frac{F_{i,j+1} - F_{i,j-1}}{2\Delta y} \tag{5-12}$$

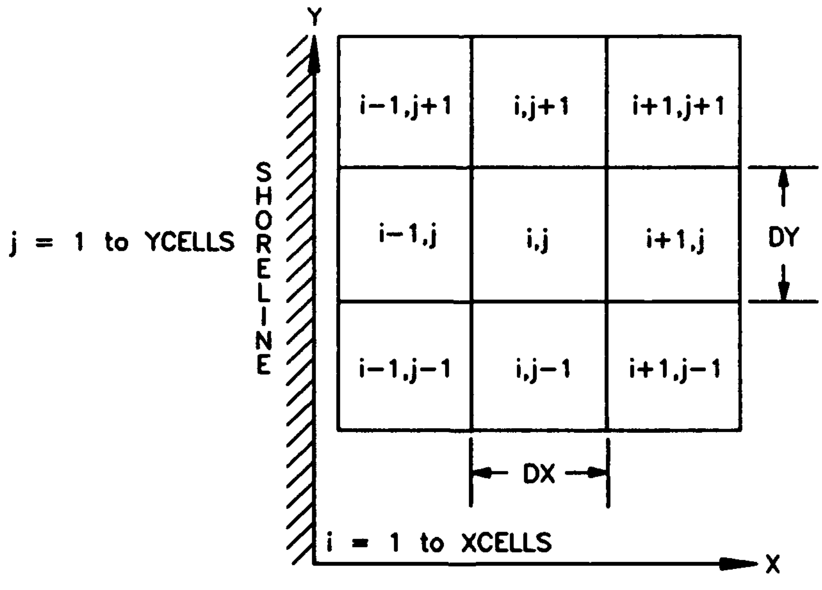

Figure 5-1. Definition of coordinate system and grid cell convention

16. Equations 5-10 and 5-12 are central differences, and Equations 5-9 and 5-11 are backward differences of the same order of accuracy. Backwards differences are used to approximate the derivatives in the x-direction because of the forward (-x-direction) marching scheme used in the model.

17. These difference equations can be used to approximate the partial derivatives in Equation 5-3:

$$|\nabla s|^2_{i,j} = k^2_{i,j} + \frac{1}{a_{i,j}}\Bigg\{\left[\frac{2a_{i,j} - 5a_{i+1,j} + 4a_{i+2,j} - a_{i+3,j}}{(\Delta x)^2}\right] \tag{5-13}$$

$$+ \left[\frac{a_{i,j+1} - 2a_{i,j} + a_{i,j-1}}{(\Delta y)^2}\right] + \frac{1}{cc_{g_{i,j}}}\left[\left(\frac{-3a_{i,j} + 4a_{i+1,j} - a_{i+2,j}}{2\Delta x}\right)\right.$$

$$\left.* \left(\frac{-3cc_{g_{i,j}} + 4cc_{g_{i+1,j}} - cc_{g_{i+2,j}}}{(2\Delta x)}\right) + \left(\frac{a_{i,j+1} - a_{i,j-1}}{2\Delta y}\right)\left(\frac{cc_{g_{i,j+1}} - cc_{g_{i,j-1}}}{(2\Delta y)}\right)\right]\Bigg\}$$

The remaining two governing equations, 5-7 and 5-8, have the general form:

$$\frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = 0 \tag{5-14}$$

The partial derivatives in equation 5-14 can be approximated using central differences about the point $(i\text{-}1/2,j)$. The final form of Equations 5-7 and 5-8 are:

$$\sin\theta_{i-1,j} = \frac{1}{|\nabla s|_{i-1,j}}\Big[\big(\alpha|\nabla s|_{i,j+1}\sin\theta_{i,j+1} + (1 - 2\alpha)\,|\nabla s|_{i,j}\sin\theta_{i,j}$$

$$+ \alpha|\nabla s|_{i,j-1}\sin\theta_{i,j-1}\big) - \frac{W\Delta x}{2\Delta y}\big(|\nabla s|_{i-1,j+1}\cos\theta_{i-1,j+1} \tag{5-15}$$

$$- |\nabla s|_{i-1,j-1}\cos\theta_{i-1,j-1}\big) - \frac{(1 - W)\Delta x}{2\Delta y}\big(|\nabla s|_{i,j+1}\cos\theta_{i,j+1}$$

$$- |\nabla s|_{i,j-1}\cos\theta_{i,j-1})\Big]$$

and

$$a^2_{i-1,j} = \frac{1}{A_{i-1,j}}\Big[\left(\alpha a^2_{i,j+1} A_{i,j+1} + (1-2\alpha) a^2_{i,j} A_{i,j} + \alpha a^2_{i,j-1} A_{i,j-1}\right) \tag{5-16}$$

$$+ \frac{W\Delta x}{2\Delta y}\left(a^2_{i-1,j+1} B_{i-1,j+1} - a^2_{i-1,j-1} B_{i-1,j-1}\right) + \frac{(1-W)\Delta x}{2\Delta y}\left(a^2_{i,j+1} B_{i,j+1} - a^2_{i,j-1} B_{i,j-1}\right)\Big]$$

where

A = $cc_g |\nabla s| \cos \theta$,

B = $cc_g |\nabla s| \sin \theta$,

W, α = weighting factors

The parameter W weights information between the known row, i, and the solution row, i-1. If W is 1.0, then an implicit solution of the equation is performed. If W is 0.0, then an explicit solution of the equation is performed. The weighting parameter α reflects use of a dissipative interface to enhance the stability of the numerical scheme (Abbott 1975).

Solution procedure

18. The following procedure is implemented in the model to solve finite difference Equations 5-13, 5-15, and 5-16:

a. Model input includes values of the deepwater wave height, H_o, direction, θ_o, and period, T, of the waves to be simulated along with bathymetric data for every grid cell.

b. The wave number, k, is computed using the dispersion relation and is used as an initial guess for the magnitude of the wave phase function gradient, $|\nabla s|$, at every grid cell.

c. The wave celerity, c, and the group velocity, c_g, are functions of the wave period and wave number and can, therefore, be calculated at each grid cell.

d. An estimate of the local wave angle, θ, can be calculated throughout the grid using this information and Snell's law,

$$\frac{\sin\theta}{c} = \frac{\sin\theta_o}{c_o} \tag{5-17}$$

where c_o is the deepwater wave celerity ($gT/2\pi$). This estimate assumes that the bottom contours are parallel to the y-axis. If the bottom bathymetric contours make a known nonzero angle, θ_c, with the y-axis (Figure 5-2), a better first guess for the wave angles can be computed using the following approximation:

$$\theta = \pi - \sin^{-1}\left(\frac{\sin(\theta_o - \theta_c)}{\frac{C_o}{C}}\right) + \theta_c \qquad (5\text{-}18)$$

e. Wave heights at each cell are estimated as the product of the deepwater wave height, H_o , the shoaling coefficient, κ_s , and the refraction coefficient, κ_r , where

$$\kappa_s = \left[\frac{1}{\left(1 + \frac{2kh}{\sinh(2kh)}\right)\tanh(kh)}\right]^{1/2} \qquad (5\text{-}19)$$

and

$$\kappa_r = \left(\frac{\cos(\theta_o - \theta_c)}{\cos(\theta - \theta_c)}\right)^{1/2} \qquad (5\text{-}20)$$

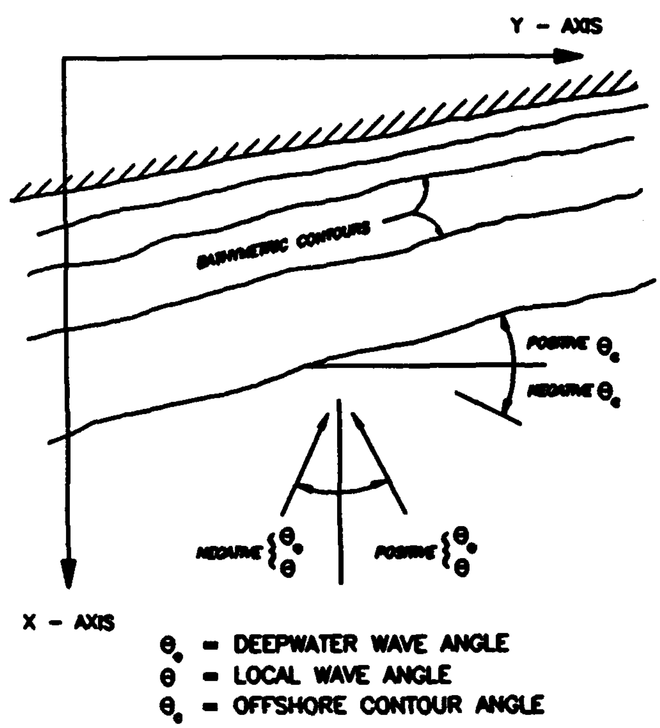

Figure 5-2. Definition of angle conventions used in the model

19. Following the determination of the initial guess for the variables of interest, a row-by-row marching scheme is implemented. Computations begin at the offshore row designated (i=XCELLS-3), where a solution for wave angles, heights, and numbers is determined for cells j=2 to j=YCELLS-1.

20. The implicit differencing formulation used in Equations 5-15 and 5-16 requires an iterative procedure to determine values of wave height and angle. Calculations are repeated until a convergence criterion is met. Convergence for wave height is achieved when the difference between the wave height computed from one iteration to the next iteration is less than a small value (0.0005 ft). Similarly, convergence for wave angle is achieved when the difference between the wave angle computed from one iteration to the next iteration is less than a small value (0.00025 rad). The third governing equation (5-13) is used to compute the wave phase gradient that accounts for the effects of diffraction.

21. Equations 5-15 and 5-16 are solved again with the new values of the wave phase function gradient. This procedure is repeated along the row under consideration until the phase functions satisfy a convergence criterion (i.e., the difference in the phase functions between consecutive iterations is less than 0.5 percent). This condition must be met at each cell along the row. Row by row marching proceeds until a solution is computed along row i=2.

Boundary conditions

22. Lateral boundary conditions for a row are specified upon completion of calculations for that row. The values of all variables at cells j=YCELLS and j=1 are set equal to the values at cells j=YCELLS-1 and j=2, respectively. This boundary condition implies that there is no change in wave properties in the y-direction. This condition is most valid when the grid y-axis parallels the bathymetric contours.

23. The seaward boundary condition (deepwater wave parameters) are used to initiate the shoreward marching procedure. Values along the seaward boundary are computed from deepwater wave input, assuming Snell's law is valid (i.e., the bottom contours are straight and parallel from the grid boundary to deep water). No inshore boundary condition (row $i = 1$) is necessary because of the forward marching scheme implemented in the model.

Wave transformation inside the surf zone

24. Since linear wave theory does not allow for the prediction of the breaker location nor for wave transformation across the surf zone, empirical and approximate methods must be used to describe incipient wave breaking and the subsequent decay of energy. Many empirical methods give reasonable approximations of incipient breaking wave height. RCPWAVE uses Weggel's (1972) criterion, which was developed by fitting an empirical relationship to field data on breaking waves:

$$H_b = \frac{\bar{b}h_b}{1 + \frac{\bar{a}h_b}{gT^2}} \tag{5-21}$$

where

$\bar{a}$ = $43.75\ [\ 1 - e^{(-19m)}\ ]$

$\bar{b}$ = $1.56\ /\ [\ 1 + e^{(-19.5m)}\ ]$

m = bottom slope

H_b = breaking wave height

h_b = water depth at breaking

25. After defining the incipient breaking point, a means of transforming the waves across the surf zone is needed. Dally, Dean, and Dalrymple (1984) developed an algorithm to approximate energy loss across the entire surf zone based on energy loss in a hydraulic jump.

$$\frac{\partial(Ec_g)}{\partial x} = \frac{-\kappa}{h}\,[Ec_g - (Ec_g)_s] \tag{5-22}$$

where

κ = energy dissipation coefficient (set to 0.2 in RCPWAVE)

(Ec_g) = energy flux associated with a breaking wave

$(Ec_g)_s$ = stable level of energy flux that the transformation process seeks to attain

The right-hand side of Equation 5-22 is simply a dissipative term. Substituting the linear wave theory estimate for E ($E = 1/8\ \rho g H^2$) into Equation 5-22 results in the following expression:

$$\frac{\partial(H^2 c_g)}{\partial x} = \frac{-\kappa}{h}\left[H^2 c_g - (H^2 c_g)_s\right] = D \tag{5-23}$$

26. It has been observed in field (Thornton and Guza 1982) and laboratory (Horikawa and Kuo 1966) experiments that, well into the surf zone, the wave height tends toward a stable value that is proportional to the local water depth:

$$H_s = \gamma h \tag{5-24}$$

where

H_s - stable wave height

γ - proportionality coefficient (set equal to 0.4 in RCPWAVE)

Equation 5-23 can now be written as

$$\frac{\partial(H^2 c_g)}{\partial x} = \frac{-\kappa}{h}\left[H^2 c_g - (\gamma^2 h^2 c_g)_s\right] = D \tag{5-25}$$

27. This surf zone wave transformation model can be incorporated into the conservation of wave energy equation (Equation 5-4) by simply adding the dissipation term D to the right-hand side. The function D must now represent dissipation in the direction of wave propagation. Also for dimensional consistency, the term D must be multiplied by the wave celerity and the magnitude of the wave phase gradient, and the wave height must be replaced by the wave amplitude function. In vector notation, the energy equation becomes

$$\nabla\bullet(a^2 c c_g \nabla s) = \frac{-\kappa}{h}\left\{a^2 c c_g|\nabla s| - \left[\left(\frac{g}{2\sigma}\right)^2 \gamma^2 h^2 c c_g|\nabla s|\right]_s\right\} \tag{5-26}$$

This equation can be thought of as being valid both inside and outside the surf zone. Outside, the coefficient κ is zero, and the equation reduces to Equation 5-4.

28. Discussion relating to wave transformation within the surf zone has addressed the problem of determining wave heights. The problem of wave phase must also be addressed. Diffractive effects are assumed to be negligible inside the surf zone. Therefore, the wave number, k , is assumed to accurately represent the wave phase function gradient in the surf zone.

29. Lastly, the linear wave theory assumption of irrotationality also will be assumed to remain valid inside the surf zone. Consequently, wave angles inside the surf zone are computed in the same manner that is used outside the surf zone.

Numerical solution

30. The numerical procedure for computing wave angles inside and outside the surf zone is the same. This section documents the solution scheme used to determine breaking wave heights. The finite difference form of the wave energy equation outside the surf zone (Equation 5-16) can be expressed in the following form:

$$a_{i-1,j}^2 = \frac{\bar{F} + \Delta x \bar{G}}{A_{i-1,j}} \tag{5-27}$$

where

$$\bar{F} = \alpha a_{i,j+1}^2 A_{i,j+1} + (1 - 2\alpha) a_{i,j}^2 A_{i,j} + \alpha a_{i,j-1}^2 A_{i,j-1} ,$$

$$\bar{G} = (1 - W)\left(\frac{a_{i,j+1}^2 B_{i,j+1} - a_{i,j-1}^2 B_{i,j-1}}{2\Delta y}\right),$$

$$B = cc_g |\nabla s| \sin\theta , \text{ and}$$

$$A = cc_g |\nabla s| \cos\theta .$$

With the inclusion of the dissipative term, Equation 5-27 becomes

$$a_{i-1,j}^2 = \frac{\bar{F} + \Delta x \bar{G}}{A_{i-1,j}} + \frac{\Delta x D^*}{A_{i-1,j}} \tag{5-28}$$

where D^* represents the finite difference form of the dissipation term on the right-hand of Equation 5-26. Reiterating, the dissipation term represents an average value along the wave path (direction of propagation). The wave path is determined by the local wave angle at the position *i-1,j* which has already been computed. Therefore, the average along the path is an average of information at cell *i-1,j* and another cell whose position is denoted by *ikey,jkey*. The procedure used for determining the location of this cell will be presented later.

31. The term D can be written in finite difference form as

$$D^* = \frac{k}{\bar{h}}\left\{\left[\frac{(a^2 cc_g|\nabla s|)_{ikey,jkey} + (a^2 cc_g|\nabla s|)_{i-1,j}}{2}\right]\right. \tag{5-29}$$

$$\left. - \left(\frac{g}{2\sigma}\right)^2 \left(\frac{\gamma^2 h^2 cc_g|\nabla s|_{ikey,jkey} + \gamma^2 h^2 cc_g|\nabla s|_{i-1,j}}{2}\right)\right\}$$

where

$$\bar{h} = \frac{h_{i-1,j} + h_{ikey,jkey}}{2}$$

With some algebra, Equation 5-28 can be reorganized so that the amplitude function at the position *i-1,j* appears only on the left-hand side of the equation. Therefore, the energy equation inside the surf zone can be numerically solved using the same procedure used to solve it outside the surf zone.

32. The location of the cell denoted *ikey,jkey* is found using the following procedure. "Areas of influence" are determined by extending lines from the center of the cell *i-1,j* to the midpoints between the surrounding cell centers (Figure 5-3). Angles are computed from the x-axis to these radial lines. The local wave angle calculated at cell *i-1,j* is compared with each of these angles in order to determine the nearest, prior cell (in row *i*) along the wave path. For example (refer to Figure 5-3), if the local wave angle is greater than θ_2 but less than θ_1, then cell *i,j+1* is the cell of influence and *ikey* = *i* and *jkey* = *j+1*.

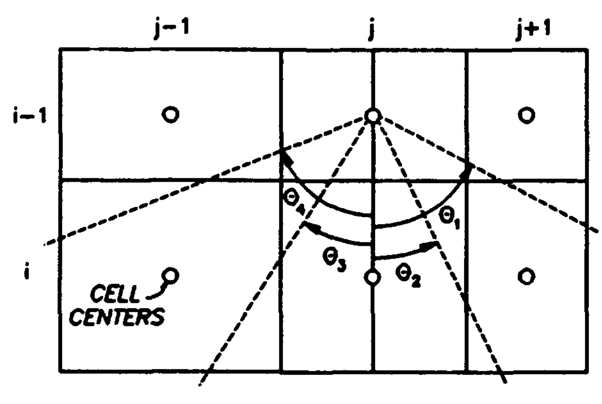

Figure 5-3. Cells of influence used in wave breaking scheme

33. A flowchart describing the wave height computation is shown in Figure 5-4. The wave amplitude function is computed from the energy equation assuming no dissipation. The amplitude function is converted to wave height and compared with the stable wave height γh . If the wave is less than or equal to this stable level, the wave has broken and attained a stable height, or it is outside the surf zone and unbroken. In either case, no consideration of dissipation is needed. If the wave height is greater than γh , the cell of influence is located and tested to determine whether or not the wave is breaking. If the wave is breaking in the cell of influence, it continues to decay in height. If the wave in the cell of influence is not breaking, the local wave height is checked against the incipient breaking height criterion. If the height exceeds the allowable value, wave dissipation begins. The accuracy of the surf zone wave transformation model has been verified using laboratory data of Horikawa and Kuo (1966) and Izumiya (1984). Results of the comparisons can be found in Ebersole, Cialone, and Prater (1986).

Computational stability

34. In applying RCPWAVE, it has been determined that the aspect ratio, $\Delta y/\Delta x$, plays an important role in determining the computational stability of the numerical solution scheme. The maximum allowable local wave angle is defined as the inverse tangent of the ratio $\Delta y/\Delta x$. Therefore, larger wave angles can be resolved by the model as this ratio increases (Figure 5-5).

35. Computational instability occurs when no energy reaches a cell in the computational domain, implying a zero wave height. This instability may occur when a cell (i,j) passes energy to cell $(i-1,j+1)$ while cell $(i,j-1)$ passes energy to cell $(i-1,j+1)$ (Figure 5-6a). Cell $(i-1,j)$ receives no energy and therefore is assigned a zero wave height. The diffractive portion of the model cannot recover from this situation. For irregular bathymetry, stability problems can occur when large bathymetry gradients cause strong wave refraction and local wave angles become large. Strongly oblique wave incidence is not a problem for plane beach simulations because every cell, $j=1$ to $j=YCELLS$, in a given row, i , behaves identically; therefore, energy is uniformly passed to every cell in row $i-1$ (Figure 5-6b).

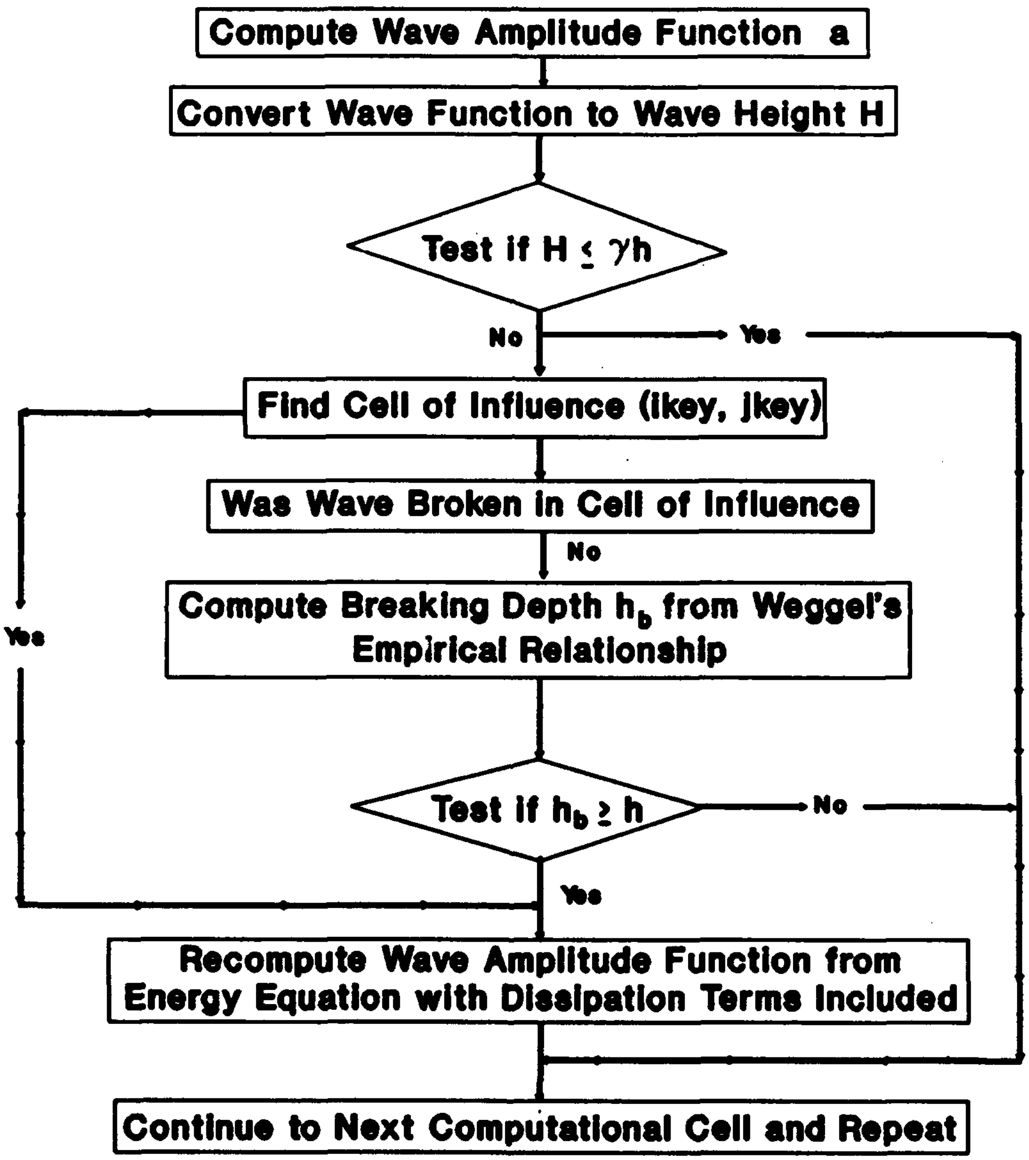

Figure 5-4. Flowchart of the wave breaking scheme

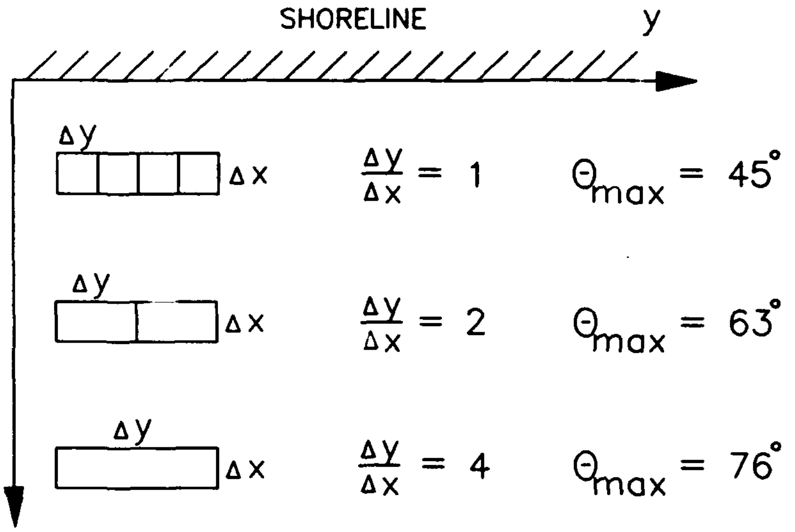

Figure 5-5. Aspect ratios and maximum allowable local wave angles

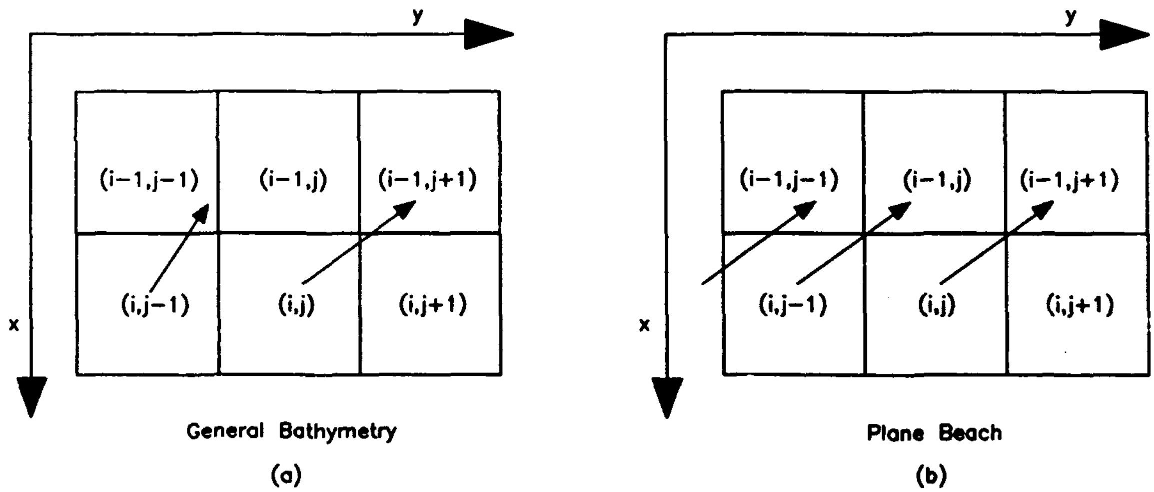

Figure 5-6. Schematic of wave energy passing from row *i* to row *i-1*

PART III: DEFINITION OF INPUT DATA FORMAT

36. The input data set format was designed to resemble the format required by the series of models released by the USAE Hydrologic Engineering Center. It is the intent that this structure, being familiar to Corps personnel, will reduce the time needed to learn this system. The general format of the input data set records, where a record refers to one line of data, is presented below:

- a. Each record is divided into 10 fields containing 8 columns each.
- b. Field 1, columns 1 through 8, contains a mnemonic identification label that describes the purpose or function of each record.
- c. Fields 2 through 10 contain data that may be real, integer, or character in type. Integers must be right justified. Real numbers must also be right-justified if the decimal point is omitted. Character data does not need to be right- or left-justified.
- d. Array data, such as depths, are read with DO or Implied DO loops. No label is required for each record containing array data. However, a general specification record, such as BATHSPEC which defines bathymetric attributes, must precede that array.

37. Spelling of record identification labels and alphanumeric variables is important. Misspelled entries will result in either recognized error conditions that force the model to abort execution, or bypassing of desired user-defined operations, such as bathymetric changes.

38. Certain records and variables have been assigned default values in the model for minimizing input data and computer resources. Thus, not all input data records will be needed for each application, and only those records pertinent to the simulation or required by the model should be included. Default values are representative of those chosen in previous studies performed by Coastal Engineering Research Center (CERC) staff. Although these quantities may not be applicable to all studies, they can serve as a guide when selecting replacement values.

39. Default values are processed when the record field corresponding to that variable is blank. Hence, the user must be careful when leaving fields blank in a record; blank fields will not necessarily result in a variable

being assigned a value of zero. These variables and their respective default values are noted in Appendix 5-A. The following discussion pertains to the general format of the input records given in Appendix 5-A.

40. Each record is presented in a standardized tabular format and has as its heading the mnemonic identification label or name with a brief description of its function. Following its name, the record has an abbreviated note documenting whether it is required for a simulation. These abbreviations have the following definitions:

(Req)	Record or variable is required for each simulation.
(Opt)	Record or variable is optional. Omitting this item results in either the default value being used or the defined operation not being performed.

For example, record BATHSPEC, presented in Appendix 5-A, contains the note (Req) meaning that this record must reside in the input data set for each simulation. Record CHNGBATH contains the note (Opt) meaning this record is optional and is only used when changes to the bathymetric data are desired.

41. Input variables, presented in column 2 of each table, are referenced to their respective record fields shown in column 1. Generally, data for each variable occupy a single 8-column data field. However, variables assigned titling or formatting information can occupy several fields.

42. Variable attributes are presented in columns 3 through 6 of each table. Valid data types are listed in column 3 and can be real, integer, or alphanumeric. Abbreviations presented in this column are described below:

Char*16	Alphanumeric character string containing up to 16 characters
Char*8	Alphanumeric character string containing up to 8 characters
Integer	Integer data
Real	Real (floating point) data

43. Column 4 of each table defines whether the respective variable must be assigned a value. Abbreviations listed in this column have identical meanings as those for the records. Default values are listed in column 5. A blank entry in this column denotes that the respective variable is not assigned a default value.

44. Column 6 of each table lists the variables' permitted data type or all valid character strings. Variables having integer or real data types are specified with the following notation:

A	Alphanumeric values
+R	Positive real values
R	Positive, zero, or negative real values
+I	Positive integer values
I	Positive, zero, or negative integer values

45. Variable definitions are listed in table column 7 of each table. Variables whose quantities are unit-dependent contain a reference to that variable designating its system of units. For example, variable WDATUM is assigned a value having units defined by variable BUNITS. Variables defining input data units and the record on which they reside are presented below.

Variable	Record	Definition
BUNITS	BATHSPEC	bathymetry/topography data
GUNITS	GRIDSPEC	numerical grid data
SUNITS	GENSPECS	model computations and output

Part IV: DISCUSSION OF THE INPUT DATA REQUIREMENTS

46. The types of data processed by RCPWAVE are not extremely extensive. However, since each application is unique, the type of input data required for each study will vary. In this discussion of model input, data have been divided into four categories to present model capabilities and data requirements. These categories are:

a. Model control specifications.
b. Grid description.
c. Physical characteristics.
d. Output specifications.

47. Table 5-1 presents RCPWAVE input data records pertaining to each category. A record refers to one line of data, and each record begins with a mnemonic character string to identify one record type from another. Record format and detailed specification for each record are presented in this chapter. While reading Part IV, the user will find it beneficial to refer to Appendix 5-A.

Model Control Parameters

48. The only data record contained in this category is the GENSPECS record. Record GENSPECS is used to specify the general title of the simulation (TITLE) and the system of units (SUNITS) used for model computations and displaying model results. Variable names are given in parentheses. Additional titles may be selected for specific input data records. Although this information is optional, it can be very helpful when reviewing a series of simulations. A title should specifically state data attributes, such as data source or collection date, to differentiate from data used in other simulations.

49. Model output is displayed in either English or metric units. However, the user can specify a different system of units for the input data. For example, the user can supply bathymetry data having units of feet or meters. RCPWAVE will convert the input data into the necessary system of units.

Table 5-1

Input Data Set Records

Category	Record Name
Model control specifications	GENSPECS
Grid description	GRIDSPEC
Physical characteristics	BATHSPEC CHNGBATH WAVCOND WAVMOD CONVERG
Output specifications	PRWINDOW PLOTREC SAVESPEC

Grid Description

50. The study area is defined in the model via a computational grid. The grid is composed of rectilinear cells, where each cell is assigned a two-dimensional index. The first index, i , corresponds to the x-coordinate, and the second index, j , corresponds to the y-coordinate. The grid index system was presented in Figure 5-1. All wave data, such as wave heights, are assigned and referenced to their respective grid cells with this system. Guidelines for developing grids are discussed in Appendix A of the *CMS User's Manual*.

51. Selection of a grid coordinate system is controlled by variable GRTYPE on record GRIDSPEC. RCPWAVE permits a rectilinear uniform grid coordinate system only. A uniform, or constant grid cell size is selected by assigning the character string RECTANG to variable GRTYPE.

52. Variable GUNITS on record GRIDSPEC controls the system of units for the computational grid. Valid units are feet ",d meters. RCPWAVE will convert the data to the system of units for computations (SUNITS) internally. Variables XCELLS and YCELLS specify the number of grid cells in the x- and y-directions, respectively. Variables DX and DY on record GRIDSPEC specify the grid's cell size in the x- and y-directions, respectively.

Physical Characteristics

Topography/bathymetry

53. Each grid cell must be assigned a water depth or land elevation. Topography/bathymetry data are referenced relative to an arbitrary datum. Typically, the map datum from which the depths are taken is used. Water cells are designated by negative values, whereas land cells have positive values.

54. One BATHSPEC record is required for defining the general characteristics of the topography/bathymetry array and must precede this array. Variable BUNITS defines the units of topography/bathymetry data. Valid units are feet, meters, or fathoms. The input sequence for reading this array is controlled by variable BSEQ. Eight options for the input sequence are available for reading the array data and are documented in Table 5-2. As an example, for the first input sequence (Figure 5-7), the depths are read along the x-direction, then y is incremented to a value of 2, and again the sweep in the x-direction takes place. This procedure is repeated until the entire array is read. The input format for reading this array can be selected by the user with variable BFORM.

55. The maximum water depth is specified with variable DLIMIT and any array values deeper than DLIMIT are set to DLIMIT (in BUNITS). Grid-wide adjustments to land elevations contained in the topography/bathymetry array can be made with variable LDATUM. The value assigned to this variable is added to all land cells in the grid. Positive LDATUM values will increase land elevations, whereas negative values will decrease land elevations. Similarly, grid-wide adjustments to water depths can be made with variable WDATUM. The value assigned to this variable is added to all water cells. Since these cells have negative values, positive WDATUM values produce shallower depths.

56. Changes to the topography/bathymetry array can also be made to individual cells or a group of cells with record CHNGBATH. This record allows the user to quickly change values assigned to the bathymetry array (using variable BATH) without editing the array itself. It should be noted that (a) values of the variable BATH on the CHNGBATH record are assumed to have units consistent with those selected for bathymetry/topography (i.e., variable BUNITS on record BATHSPEC), and (b) LDATUM and WDATUM are not applied

Table 5-2

Input Sequence for Array Data

No	Sequence	Description
1	XY	DO 1 J=1,YCELLS 1 READ(LUN,FORM) (VAR(I,J),I=1,XCELLS)
2	-XY	DO 2 J=1,YCELLS 2 READ(LUN,FORM) (VAR(I,J),I=XCELLS,1,-1)
3	X-Y	DO 3 J=YCELLS,1,-1 3 READ(LUN,FORM) (VAR(I,J),I=1,XCELLS)
4	-X-Y	DO 4 J=YCELLS,1,-1 4 READ(LUN,FORM) (VAR(I,J),I=XCELLS,1,-1)
5	YX	DO 5 I=1,XCELLS 5 READ(LUN,FORM) (VAR(I,J),J=1,YCELLS)
6	-YX	DO 6 I=1,XCELLS 6 READ(LUN,FORM) (VAR(I,J),J=YCELLS,1,-1)
7	Y-X	DO 7 I=XCELLS,1,-1 7 READ(LUN,FORM) (VAR(I,J),J=1,YCELLS)
8	-Y-X	DO 8 I=XCELLS,1,-1 8 READ(LUN,FORM) (VAR(I,J),J=YCELLS,1,-1)

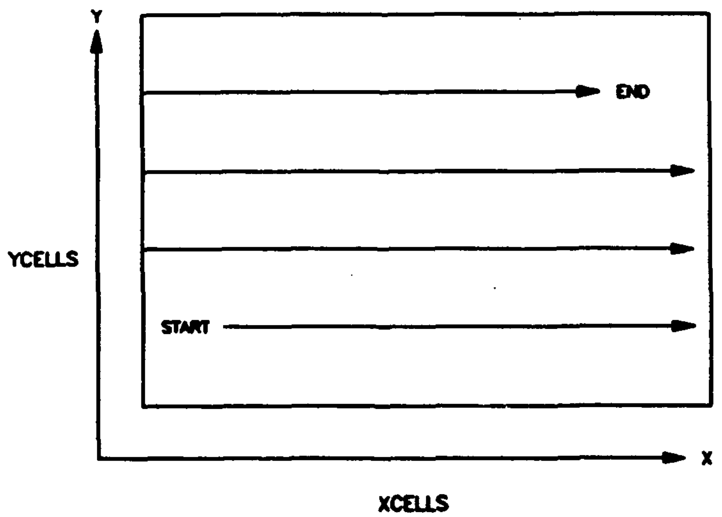

Figure 5-7. Input sequence - option 1

to cells specified with record CHNGBATH; therefore, the effect of nonzero LDATUM and WDATUM must be included in the value of variable BATH.

57. Variables X1INDX and X2INDX on the CHNGBATH record specify the minimum and maximum cell numbers in the x-direction, respectively, where the topography/bathymetry value will change. Similarly, variables Y1INDX and Y2INDX on the CHNGBATH record specify the minimum and maximum cell numbers in the y-direction, respectively, where the topography/bathymetry value will change. More than one CHNGBATH record is permitted.

Wave conditions

58. Each simulation requires wave information in deep water (i.e., the deepwater wave height, direction, and period). The angle which the offshore contour makes with the grid y-axis is also needed (see Figure 5-4 for the angle definition/sign convention).

59. A WAVCOND record is required to define each of the deepwater wave conditions to be simulated. This information is also used to come up with an initial "guess" for the wave height and angle at each point on the computational grid using Snell's Law. One WAVCOND record is required for each wave condition to be simulated, and multiple wave conditions are permitted for a single simulation. Simulations are usually limited, however, to 5 to 10 wave conditions grouped together in a logical manner. Diffractive effects can be included or excluded for any given simulation by specification on the WAVCOND record. Variables HDEEP, TDEEP, and ZDEEP specify the deepwater wave height, period, and deepwater wave angle, respectively. Variable CNTRNG is used to define the offshore contour angle. The inclusion of topography-induced diffractive effects is accomplished by setting DIFFR equal to YES.

60. The WAVMOD record is used to explicitly specify wave characteristics along the offshore boundary. If a WAVMOD record is selected for one wave condition (WAVCOND record), then WAVMOD records are required for the remaining wave conditions in a given simulation. Variables HUTIL1 and HUTIL2 are used to specify the wave height at the first (J=1) and last (J=YCELLS) cells on the offshore boundary (I=XCELLS), respectively. If HUTIL1 and HUTIL2 have different values assigned to them, then values of wave height along the offshore boundary will be linearly interpolated between the two specified end values (HUTIL1 and HUTIL2). Similarly, variables ZUTIL1 and ZUTIL2 are used to specify the wave angle at the first (J=1) and last (J=YCELLS) cells on the offshore boundary (I=XCELLS), respectively. If ZUTIL1 and ZUTIL2 have

different values assigned to them, then values of wave angle along the offshore boundary will be linearly interpolated between the two specified end values (ZUTIL1 and ZUTIL2).

Convergence criteria

61. Certain model parameters can be modified to alter how quickly the model converges toward a solution to the governing equations. When the change in a given variable from iteration to iteration is less than a specified value, the model has "converged" on a solution. The change in the variable from iteration to iteration is called the convergence criterion. Variables HCONVR and SCONVR on record CONVERG are convergence criteria for wave heights and wave angles, respectively. ITAMX and IDIFF are the maximum number of iterations for wave heights/angles and diffraction computations, respectively. Default values for the convergence criteria have been developed based on experience. Users should not change these values arbitrarily.

62. Certain model parameters are used to specify the stable wave height and rate of wave height decay through the surf zone. Variables STABL and DECAY on record CONVERG are used to set the stability and decay coefficients used in surf zone computations. For more information on the selection of these values, refer to Dally, Dean, and Dalrymple (1984).

Output Specifications

63. RCPWAVE generates an output listing containing a summary of the input data set for every simulation. Error and warning diagnostic messages are also contained in this listing. A sample output listing containing a summary of the input dataset is presented in Figure 5-8. Each record is summarized in tabular form with a heading containing its record identification label followed by a brief description of that record's function. The table is composed of each variable's name, a description of that variable (including its units, when applicable), and an error diagnostic note.

64. RCPWAVE contains error diagnostic features that inspect an input data set for possible errors. These features include: (a) comparing an inputted value against a range of quantities that are representative for that variable, (b) checking for misspelled character data, and (c) checking for missing data. The error diagnostic note can be assigned one of three character strings, which are (a) "FATAL" for errors where the model cannot execute

```
                    C O A S T A L   M O D E L I N G   S Y S T E M   ( C M S ) :   R C P W A V ,   V E R S I O N   1 . 0

                                   ----                    PLANE BEACH EXAMPLE                    ----

***** GENSPECS CARD:  SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE  DESCRIPTION OF USAGE:             VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:             VALUE:    NOTES:
--------  --------------------------------  --------  ------- * --------  --------------------------------  --------  -------
SUNITS    UNITS SYSTEM USED IN COMPUTATIONS  ENGLISH           *

***** GRIDSPEC CARD:  SPECIFICATION OF THE TYPE OF FINITE-DIFFERENCE GRID USED

VARIABLE  DESCRIPTION OF USAGE:             VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:             VALUE:    NOTES:
--------  --------------------------------  --------  ------- * --------  --------------------------------  --------  -------
GRTYPE    TYPE OF FINITE-DIFFERENCE GRID    RECTANG           * GUNITS    SYSTEM OF UNITS USED FOR THE GRID  ENGLISH
XCELL     NUMBER OF GRID CELLS, X DIRECTION       48          * YCELL     NUMBER OF GRID CELLS, Y DIRECTION        5
DX        SPATIAL STEPSIZE IN X DIRECTION      10.00          * DY        SPATIAL STEPSIZE IN Y DIRECTION      10.00

***** PRINTING OF FIELD ARRAY VARIABLES:   1 AREAS

       AREA  *  STARTING  ENDING   STARTING  ENDING           *                                      *   VARIABLE FIELD
     NUMBER  *   X CELL   X CELL    Y CELL   Y CELL  NOTES:   * START AT  END AT    INTERVAL NOTES:  *  ARRAYS TO PRINT:  NOTES:
     ------  *  --------  ------  --------  ------  -------  * --------  --------  -------- ------- *  ----------------  -------
          1  *   X=   1   X=  48   Y=   1   Y=   5            *                                      *  DANB

***** WAVCOND CARD:  NUMBER OF WAVE CONDITIONS:   2
```

Figure 5-8. Sample output listing

given the value supplied, (b) "WARN" for data that are outside the range of values typically selected for that variable, and (c) a null string for instances where an error condition has not been identified. Although this model contains error diagnostic capabilities, the user should thoroughly inspect the input data summary to ensure that the data are correct.

65. Field arrays (e.g., bathymetry, wave heights, angle, numbers, breaker indices) are printed along with the input data summary by including one or more PRWINDOW records. Variable WPRVAR on record PRWINDOW is used to specify which field arrays are to be printed (e.g. WPRVAR = B for breaker indices). The breaker index is a flag to distinguish cells where wave breaking occurs (indicated with a B), from cells where wave breaking does not occur (indicated with a .). The user can snecify printing of subgrid regions as opposed to the entire grid, if they so choose. This is done by specifying the x- and y-boundaries of a subgrid region with variables WXCEL1, WXCEL2, WYCEL1, and WYCEL2.

66. Plotting wave rays is facilitated by adding a PLOTREC record to the input data set. With this record, wave angles are saved for every grid cell in the computational domain for any number of wave conditions. The wave angle data are then used by program RAYPLOT in CMSPOST to generate wave ray plots.

67. The SAVESPEC record is used for saving wave conditions along the nearshore reference line as input to model GENESIS (Gravens, Kraus, and Hanson 1989). Nearshore wave data requirements of GENESIS are prebreaking wave height and angle and water depth at each alongshore cell on the reference line and the associated wave period (which is constant over the entire grid for a given RCPWAVE simulation). Input to model RCPWAVE is a SAVESPEC record followed by a 1-D array containing the x-cell designation of the nearshore reference line for each of the y-direction (alongshore) cells. Therefore, the total number of values entered is YCELLS. Variable FILOUT on the SAVESPEC record is used to specify the output file name for wave heights and angles along the nearshore reference line.

PART V: ILLUSTRATIVE EXAMPLES

68. Two examples are included in this section to demonstrate RCPWAVE's capabilities. The model was used to simulate wave conditions at the CERC's Field Research Facility (FRF) in Duck, North Carolina, and at Homer Spit, Alaska.

Duck, North Carolina

69. The FRF is located on the northern North Carolina coast. The selected study area measured 900 m in the x- (on-offshore) direction and 1,200 m in the y- (longshore) direction. The grid was composed of 75 cells in the x-direction and 50 cells in the y-direction, with a cell size of 12 by 24 m, respectively. Bathymetry contours off the Duck, North Carolina, coast are generally straight and parallel to the coastline, except in the immediate vicinity of the FRF pier (Figure 5-9). The pier's presence has caused the formation of a deep scour hole along much of its length. Actual depth values (relative to mean sea level (msl)) were provided for each cell in the study grid. The total water depth matrix was computed by simply adding half of the mean tide range (0.5 m) to each depth value. Two wave conditions were considered: (a) $H_o = 2$ m, $T = 12$ sec, and $\theta_o = 20$ deg and (b) $H_o = 1.5$ m, $T = 8$ sec, and $\theta_o = -35$ deg. The input data set is given in Appendix 5-B for details of each record.

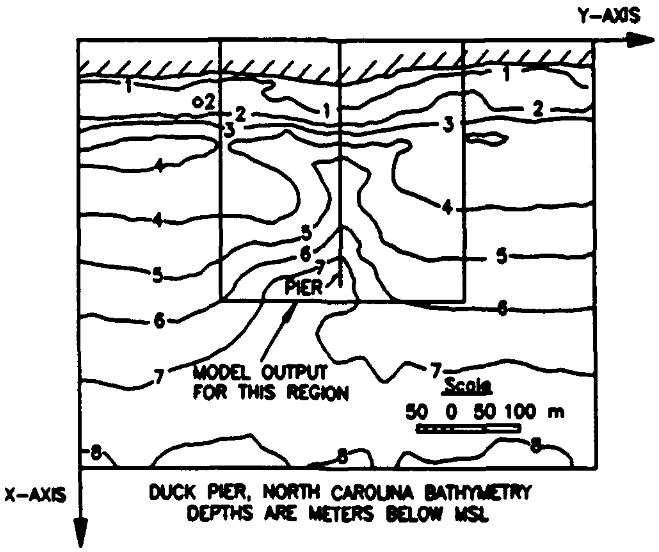

Figure 5-9. Bathymetric contours at Duck, North Carolina

70. A wave ray plot for each of the two wave conditions is given in Figures 5-10 and 5-11 for the entire computational domain. The wave rays tend to diverge from the scour hole along the pier and converge on the adjacent shoals, as expected. Model results (wave angles, heights, and breaker indices only) were also printed (Table 5-3) for the subgrid region shown in Figure 5-9. The breaker indices show wave breaking on the shoals and farther shoreward in the vicinity of the pier.

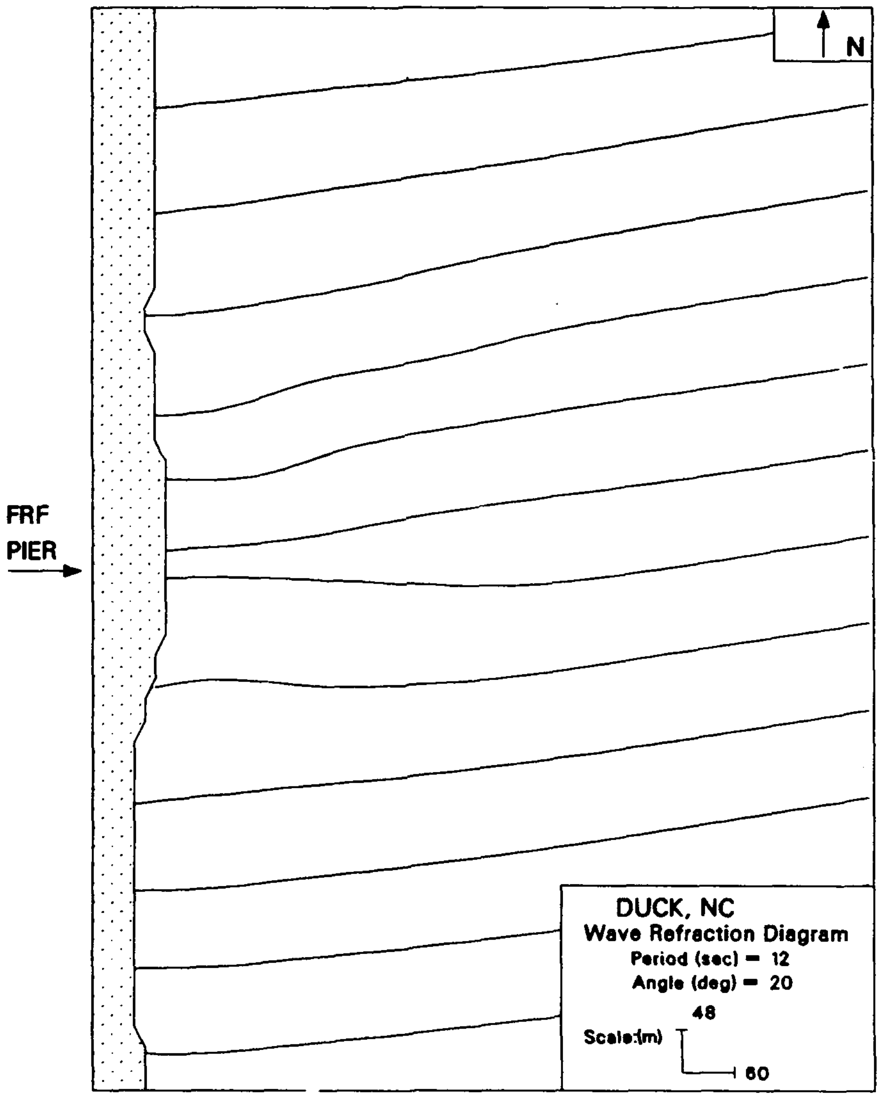

Figure 5-10. Wave rays for wave condition 1 at Duck, North Carolina

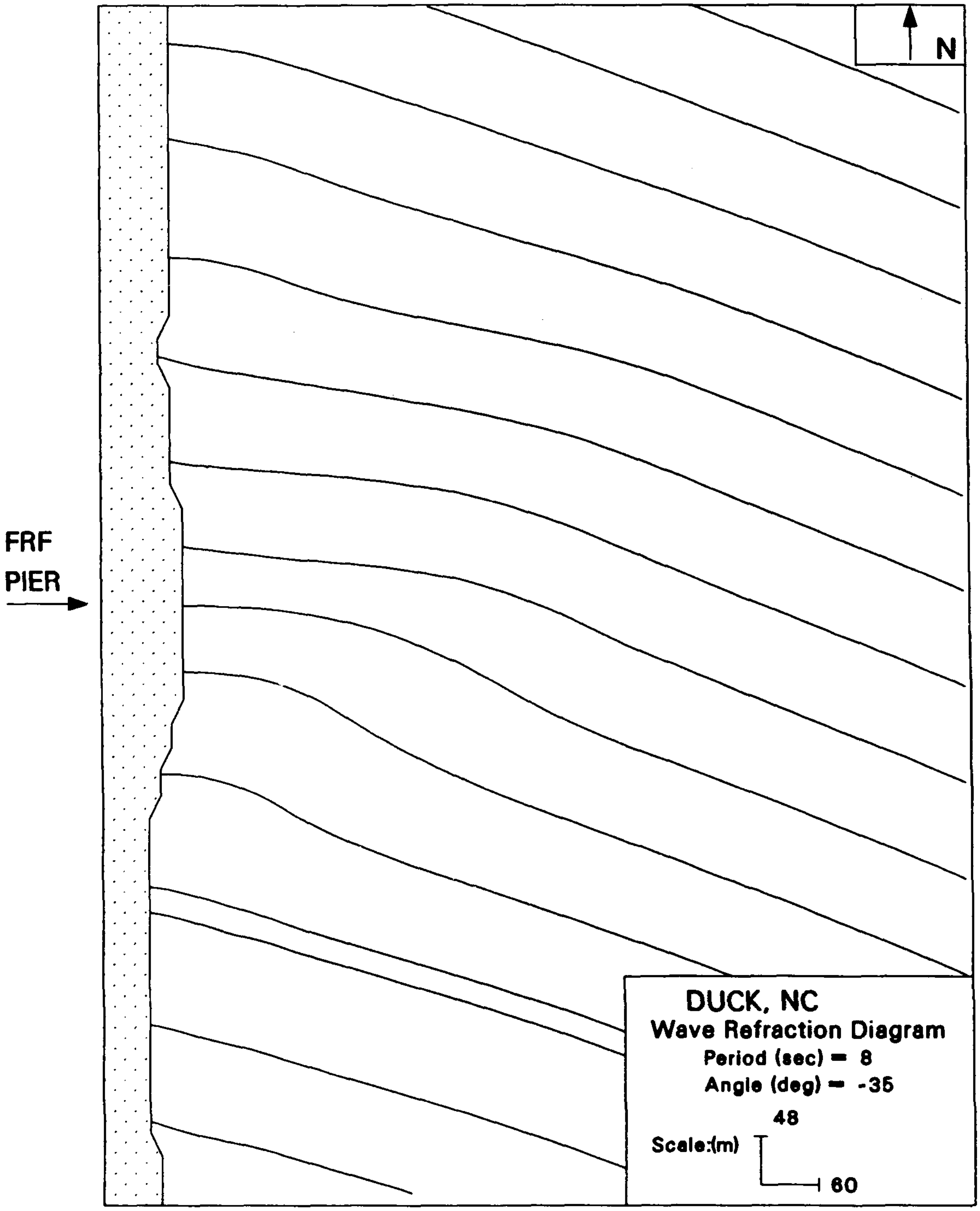

Figure 5-11. Wave rays for wave condition 2 at Duck, North Carolina

Table 5-3

Output Summary for Duck, North Carolina, Simulation

COASTAL MODELING SYSTEM (CMS): RCPWAV, VERSION 1.0

---- FIELD RESEARCH FACILITY (DUCK, NC) EXAMPLE ----

***** GENSPECS CARD: SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	*	VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
SUNITS	UNITS SYSTEM USED IN COMPUTATIONS	METRIC		*				

***** GRIDSPEC CARD: SPECIFICATION OF THE TYPE OF FINITE-DIFFERENCE GRID USED

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	*	VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
GRTYPE	TYPE OF FINITE-DIFFERENCE GRID	RECTANG		*	GUNITS	SYSTEM OF UNITS USED FOR THE GRID	METRIC	
XCELL	NUMBER OF GRID CELLS, X DIRECTION	75		*	YCELL	NUMBER OF GRID CELLS, Y DIRECTION	50	
DX	SPATIAL STEPSIZE IN X DIRECTION	12.00		*	DY	SPATIAL STEPSIZE IN Y DIRECTION	24.00	

***** PRINTING OF FIELD ARRAY VARIABLES: 1 AREAS

AREA NUMBER	*	STARTING X CELL	ENDING X CELL	STARTING Y CELL	ENDING Y CELL	NOTES:	*	START AT	END AT	INTERVAL	NOTES:	*	VARIABLE FIELD ARRAYS TO PRINT:	NOTES:
1	*	X= 1	X= 50	Y= 11	Y= 41		*					*	DAMB	

***** WAVCOND CARD: NUMBER OF WAVE CONDITIONS: 2

BREAKING INDEX

	I= 13	14	15	16	17	18	19	20	21	22	23	24
J= 41	B	.	.	.	.	.	.	.	.	.	.	.
J= 40	B	.	.	.	.	.	.	.	.	.	.	.
J= 39	B	.	.	.	.	.	.	.	.	.	.	.
J= 38	B	.	.	.	.	.	.	.	.	.	.	.
J= 37	B	.	.	.	.	.	.	.	.	.	.	.
J= 36	B	B	.	.	.	.	.	.	.	.	.	.
J= 35	B	B	.	.	.	.	.	.	.	.	.	.
J= 34	B	B	.	.	.	.	.	.	.	.	.	.
J= 33	B	B	.	.	.	.	.	.	.	.	.	.
J= 32	B	B	.	.	.	.	.	.	.	.	.	.
J= 31	B	B	B	.	.	.	.	.	.	.	.	.
J= 30	B	B	B	.	.	.	.	.	.	.	.	.
J= 29	B	B	B	.	.	.	.	.	.	.	.	.
J= 28	B	B	B	.	.	.	.	.	.	.	.	.
J= 27	B	B	.	.	.	.	.	.	.	.	.	.
J= 26	B	B	.	.	.	.	.	.	.	.	.	.
J= 25	B	B	.	.	.	.	.	.	.	.	.	.
J= 24	B	B	B	.	.	.	.	.	.	.	.	.
J= 23	B	B	.	.	.	.	.	.	.	.	.	.
J= 22	B	B	.	.	.	.	.	.	.	.	.	.
J= 21	B	.	.	.	.	.	.	.	.	.	.	.
J= 20	B	B	.	.	.	.	.	.	.	.	.	.
J= 19	B	B	.	.	.	.	.	.	.	.	.	.
J= 18	B	B	.	.	.	.	.	.	.	.	.	.
J= 17	B	B	B	.	.	.	.	.	.	.	.	.
J= 16	B	B	B	.	.	.	.	.	.	.	.	.
J= 15	B	B	B	.	.	.	.	.	.	.	.	.
J= 14	B	B	.	.	.	.	.	.	.	.	.	.
J= 13	B	B	.	.	.	.	.	.	.	.	.	.
J= 12	B	.	.	.	.	.	.	.	.	.	.	.
J= 11	B	.	.	.	.	.	.	.	.	.	.	.
	I= 13	14	15	16	17	18	19	20	21	22	23	24

Homer Spit, Alaska

71. Homer Spit is a narrow peninsula 300 to 1,500 feet wide, extending approximately 4-1/2 miles from northwest to southeast into Kachemak Bay, an appendage of lower Cook Inlet in southcentral Alaska (Figure 5-12). The selected study area measured 7.5 miles in the x- (on-offshore) direction and 13 miles in the y- (longshore) direction. The grid was composed of 96 cells in the x-direction and 83 cells in the y-direction, with a cell size of 416.7 by 833.3 ft. Bathymetry in the vicinity of Homer Spit is complicated (Figure 5-13). Actual depth values (relative to mean lower low water (mllw)) were provided for each cell in the study grid. One wave condition was considered: H_0 = 8 ft, T = 10 sec, and θ_0 = -45 deg. The input data set is given in Appendix 5-C for details of each record.

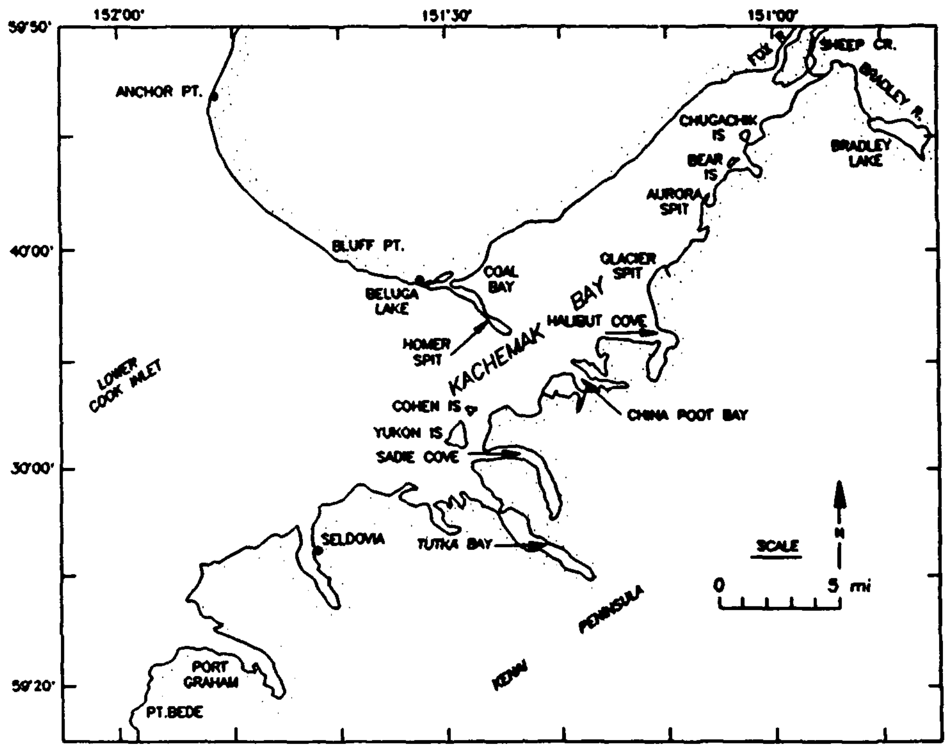

Figure 5-12. Map of Homer Spit, Alaska

72. A wave ray plot of model results is given in Figure 5-14 for the entire grid. The wave rays bend towards the shoals, as expected. Model results (wave heights, angles, numbers, and breaker indices) were also printed for cells I=1 to I=50 and J=25 to J=55 (Table 5-4).

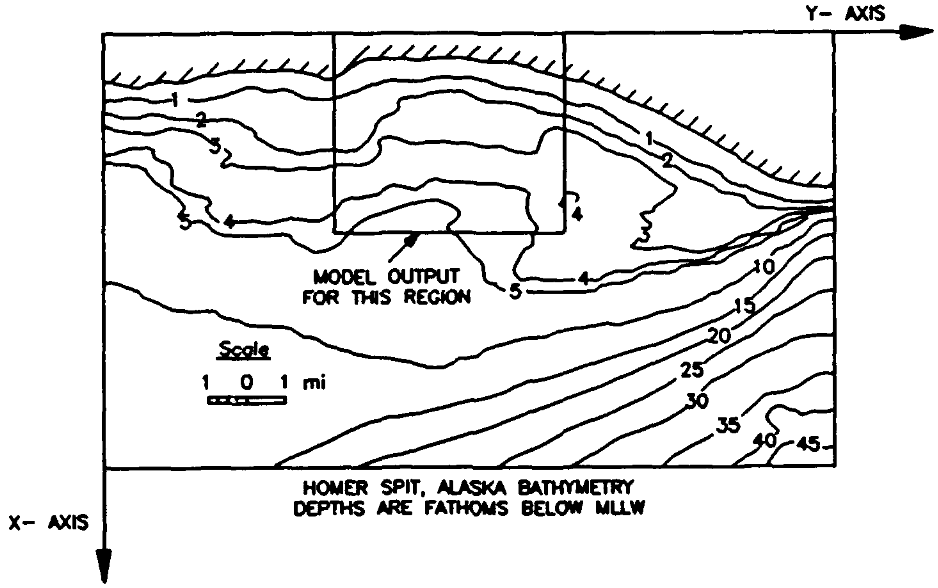

Figure 5-13. Bathymetric contours at Homer Spit, Alaska

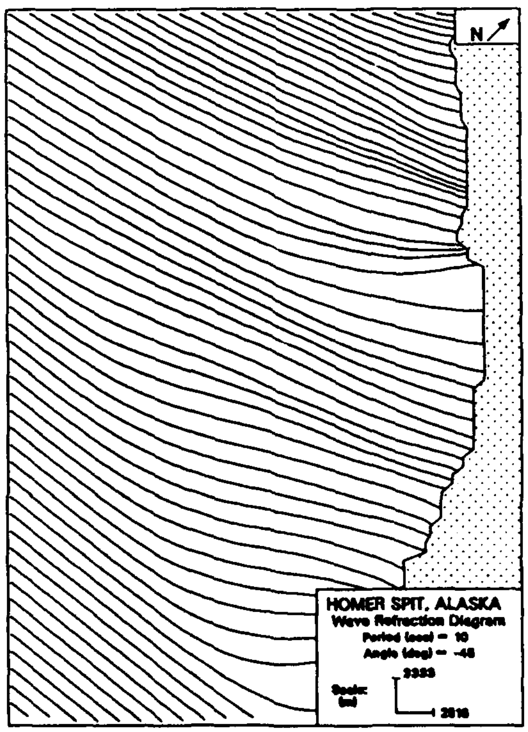

Figure 5-14. Wave rays for wave condition 1 at Homer Spit, Alaska

Table 5-4

Output Summary for Homer Spit, Alaska, Simulation

```
COASTAL MODELING SYSTEM (CMS): RCPWAV, VERSION 1.0

     ----          HOMER SPIT, ALASKA EXAMPLE          ----

***** GENSPECS CARD:  SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES: * VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES:
-------- ---------------------------------- -------- ------- * -------- ---------------------------------- -------- -------
SUNITS   UNITS SYSTEM USED IN COMPUTATIONS  ENGLISH          *

***** GRIDSPEC CARD:  SPECIFICATION OF THE TYPE OF FINITE-DIFFERENCE GRID USED

VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES: * VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES:
-------- ---------------------------------- -------- ------- * -------- ---------------------------------- -------- -------
GRTYPE   TYPE OF FINITE-DIFFERENCE GRID     RECTANG          * GUNITS   SYSTEM OF UNITS USED FOR THE GRID  ENGLISH
XCELL    NUMBER OF GRID CELLS, X DIRECTION        96         * YCELL    NUMBER OF GRID CELLS, Y DIRECTION        83
DX       SPATIAL STEPSIZE IN X DIRECTION      416.70         * DY       SPATIAL STEPSIZE IN Y DIRECTION      833.30

***** PRINTING OF FIELD ARRAY VARIABLES:   1 AREAS

      AREA  * STARTING  ENDING   STARTING  ENDING          *                                      *  VARIABLE FIELD
     NUMBER *  X CELL   X CELL    Y CELL   Y CELL  NOTES:  * START AT  END AT   INTERVAL NOTES:   * ARRAYS TO PRINT: NOTES:
     ------ * -------- ------    -------- ------  ------- * -------- -------- -------- -------   * ---------------- -------
        1   *  X=   1  X=  96     Y=   1  Y=  83          *                                      * DANB

***** WAVCOND CARD:  NUMBER OF WAVE CONDITIONS:   1


    WAVE CONDITION NUMBER:   1

VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES: * VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES:
-------- ---------------------------------- -------- ------- * -------- ---------------------------------- -------- -------
HDEEP    DEEPWATER WAVE HEIGHT                  8.00         * TDEEP    WAVE PERIOD                           10.00
ZDEEP    DEEPWATER WAVE ANGLE                 -45.00         * DIFFR    DIFFRACTION SIMULATED              YES
CNTRANG  OFFSHORE CONTOUR ANGLE                 0.00         *

COASTAL MODELING SYSTEM (CMS): RCPWAV, VERSION 1.0

**** BATHSPEC CARD: SPECIFICATION OF BATHYMETRY/TOPOGRAPHY -

VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES: * VARIABLE DESCRIPTION OF USAGE:              VALUE:   NOTES:
-------- ---------------------------------- -------- ------- * -------- ---------------------------------- -------- -------
BUNITS   SYSTEM OF UNITS FOR DEPTH DATA     FEET             * BSEQ     READ SEQUENCE FOR DEPTH DECK             YX
WDATUM   DATUM FOR WATER DEPTHS                0.000         * LDATUM   DATUM FOR LAND ELEVATIONS             0.000
DLIMIT   MAXIMUM DEPTH ALLOWED               -6000.0         * BFORM    FORMAT OF DEPTH DATA               (10F8.0)

         NUMBER OF ELEVATION CHANGES =    0


  ******************************************
  *** INPUT PROCESSING COMPLETED:
      FATAL ERRORS=   0     WARNINGS =   0
  ******************************************
```

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APPENDIX 5-A: RCPWAVE DATA SPECIFICATION RECORDS

RCPWAVE: RECORD FUNCTION INDEX

Model Control Specifications

(Req)	GENSPECS	Specify general title and system of units

Grid Description

(Req)	GRIDSPEC	Specify general grid characteristics

Physical Characteristics

(Req)	BATHSPEC	Specify characteristics of bathymetry/topography
(Req)	--	Two-dimensional array of bathymetric/topographic data
(Opt)	CHNGBATH	Specify changes to the bathymetric data
(Req)	WAVCOND	Specify deepwater wave conditions
(Opt)	WAVMOD	Specify wave conditions on the offshore boundary
(Opt)	CONVERG	Specify changes to the convergence criteria

Output Specifications

(Req)	PRWINDOW	Specify location of a print window
(Opt)	PLOTREC	Specify saving data for wave ray plot
(Opt)	SAVESPEC	Save wave conditions along the nearshore reference line

CMS Data Specification: GENSPECS Record: (Req)
Purpose: Specify general title and system of units.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		GENSPECS	Record identifier.
2-9	TITLE	Char *64	(Opt)		A*	General title for simulation.
10	SUNITS	Char *8	(Opt)	ENGLISH	ENGLISH METRIC	Declares the system of units for model computations and results.

UNIT	ENGLISH (SI)	METRIC (British)
Length	ft	m
Time	sec	sec

CMS Data Specification: GRIDSPEC Record: (Req)
Purpose: Specify general computational grid characteristics.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		GRIDSPEC	Record identifier.
2	GRTYPE	Char *8	(Opt)	RECTANG	RECTANG	Cartesian system with constant-spaced grid cells.
3	GUNITS	Char *8	(Opt)	ENGLISH	ENGLISH METRIC	System of units for grid data.
4	XCELLS	Integer	(Req)		+I*	Number of grid cells in x-direction.
5	YCELLS	Integer	(Req)		+I*	Number of grid cells in y-direction.
6	DX	Real	(Req)		+R*	Spatial stepsize in x-direction (in GUNITS).
7	DY	Real	(Req)		+R*	Spatial stepsize in y-direction (in GUNITS).

CMS Data Specification: BATHSPEC Record: (Req)
Purpose: Specify general characteristics of the bathymetry/topography data.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		BATHSPEC	Record identifier.
2	BUNITS	Char *8	(Opt)	FEET	FEET METERS FATHOMS	Declares the units for the following bathymetry/topograghy data.
3	WDATUM	Real	(Opt)	0.	R*	Negative values of bathymetry (depths) are added to this datum value (in BUNITS)
4	LDATUM	Real	(Opt)	0.	R*	Positive values of topography are added to this datum (in BUNITS).
5	DLIMIT	Real	(Opt)	-6000. ft	R*	A limiting water depth (deeper values are set to this value in BUNITS).
6	BSEQ	Char *8	(Opt)	XY	XY -XY X-Y -X-Y YX -YX Y-X -Y-X	The 2-D array of bathymetry/topography which follows this record is read in a sequence specified by this mnemonic code (see notes for the conventions represented by these mnemonics).
7-8	BFORM	Char *16	(Opt)	(8G10.3)	A*	Format used to read the following 2-D array of bathymetry/topography values.
9-10	BNAME	Char *16	(Opt)		A*	Name of bathymetry/topography set.

(Continued)

BATHSPEC Record (Concluded)

NOTES:
(1) The actual 2-D array of bathymetry/topography data follows this record.
(2) Conventions for 2-D array read sequence mnemonics:

```
***************** SEQ = XY ******************
      DO 1 J=1,YCELLS
 1    READ(LUN,FORM) (VAR(I,J),I=1,XCELLS)

***************** SEQ = -XY ******************
      DO 2 J=1,YCELLS
 2    READ(LUN,FORM) (VAR(I,J),I=XCELLS,1,-1)

***************** SEQ = X-Y ******************
      DO 3 J=YCELLS,1,-1
 3    READ(LUN,FORM) (VAR(I,J),I=1,XCELLS)

***************** SEQ =-X-Y ******************
      DO 4 J=YCELLS,1,-1
 4    READ(LUN,FORM) (VAR(I,J),I=XCELLS,1,-1)

***************** SEQ = YX *******************
      DO 5 I=1,XCELLS
 5    READ(LUN,FORM) (VAR(I,J),J=1,YCELLS)

***************** SEQ = -YX ******************
      DO 6 I=1,XCELLS
 6    READ(LUN,FORM) (VAR(I,J),J=YCELLS,1,-1)

***************** SEQ = Y-X ******************
      DO 7 I=XCELLS,1,-1
 7    READ(LUN,FORM) (VAR(I,J),J=1,YCELLS)

**************** SEQ = -Y-X ******************
      DO 8 I=XCELLS,1,-1
 8    READ(LUN,FORM) (VAR(I,J),J=YCELLS,1,-1)
```

CMS Data Specification: CHNGBATH Record: (Opt)
Purpose: Specify changes to the bathymetry data.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		CHNGBATH	Record identifier.
2	BATH	Real	(Req)		R*	New bathymetry/topography value (in BUNITS ... the two datum shift values LDATUM and WDATUM will not be applied to this value).
3	X1INDX	Integer	(Req)		I*	Declares the location of the bathymetry /topography value as a point, line, or a rectangular patch in the grid.
4	Y1INDX	Integer	(Req)		I*	
5	X2INDX	Integer	(Opt)	0	I*	
6	Y2INDX	Integer	(Opt)	0	I*	

NOTE:
(1) Use one CHNGBATH record per value (no changes if this record is omitted).
(2) All CHNGBATH records must follow two-dimensional bathymetry array.

CMS Data Specification: WAVCOND Record: (Req)
Purpose: Specify deepwater wave conditions

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		WAVCOND	Record identifier.
2	HDEEP	Real	(Req)		+R*	Deepwater wave height
3	TDEEP	Real	(Req)		+R*	Wave period
4	ZDEEP	Real	(Req)		+R*	Deepwater wave angle
5	CNTRANG	Real	(Opt)	0.0	R*	Offshore contour angle
6	DIFFR	Char *8	(Opt)	YES	YES NO	Determine if diffractive effects are included

CMS Data Specification: WAVMOD Record: (Opt)
Purpose: Specify wave conditions on the offshore boundary

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		WAVMOD	Record identifier.
2	HUTIL1	Real	(Req)		+R*	Wave height at I=XCELLS, J=1
3	HUTIL2	Real	(Req)		+R*	Wave height at I=XCELLS, J=YCELLS
4	ZUTIL1	Real	(Req)		+R*	Wave angle at I=XCELLS, J=1
5	ZUTIL2	Real	(Req)		+R*	Wave angle at I=XCELLS, J=YCELLS

CMS Data Specification: CONVERG Record: (Opt)
Purpose: Specify changes to convergence criteria

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		CONVERG	Record identifier.
2	HCONVR	Real	(Opt)	0.0005 ft	+R*	Wave height convergence criteria
3	SCONVR	Real	(Opt)	0.00025 rad	+R*	Wave angle convergence criteria
4	ITAMX	Integer	(Opt)	50	+I*	Maximum number of iterations for height/angle calculations
5	IDIFF	Integer	(Opt)	15	+I*	Maximum number of iterations for diffraction
6	STABL	Real	(Opt)	0.4	+R*	Stability factor
7	DECAY	Real	(opt)	0.2	+R*	Decay factor

CMS Data Specificaiton: PRWINDOW Record: (Opt)
Purpose: Specify location of a print window.

Field	Varaiable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRWINDOW	Record identifier.
2	WXCEL1	Integer	(Opt)	1	+I*	Cell indices declaring the grid subregion or window for printing the selected variables. The window will be bounded by (and include) the region from (WXCEL1,WYCEL1) to (WXCEL2,WYCEL2).
3	WXCEL2	Integer	(Opt)	XCELLS	+I*	
4	WYCEL1	Integer	(Opt)	1	+I*	
5	WYCEL2	Integer	(Opt)	YCELLS	+I*	
9-10	WPRVAR	Char *16	(Opt)	DAHKB	D	Bathymetry value.
					A	Wave angle.
					H	Wave height.
					K	Wave number
					B	Breaking index

Note: Use 1 PRWINDOW record/window (in space).

CMS Data Specification: PLOTREC Record: (Opt)
Purpose: Specify saving data for wave ray plot

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PLOTREC	Record identifier.

CMS Data Specification: SAVESPEC Record: (Opt)
Purpose: Specify saving wave conditions along the nearshore reference line

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		SAVESPEC	Record identifier.
2	FILOUT	Char *16	(Req)	NSRF.OUT	A*	Output file name (for waveheights and angles along the nearshore reference line.

ξ-Continuity

$$\frac{S_{i,j}^{*} - S_{i,j}^{n}}{\Delta t} + \theta \frac{|g_u|}{|g_s|}\left(\frac{U_{i+1,j}^{*} - U_{i,j}^{*}}{\Delta \xi}\right) + (1-\theta)\frac{|g_u|}{|g_s|}\left(\frac{U_{i+1,j}^{n} - U_{i,j}^{n}}{\Delta \xi}\right) + \tag{6-33}$$

$$\frac{|g_v|}{|g_s|}\left(\frac{V_{i,j+1}^{n} - V_{i,j}^{n}}{\Delta \eta}\right) = 0$$

η-Continuity

$$\frac{S_{i,j}^{n+1} - S_{i,j}^{*}}{\Delta t} + \theta \frac{|g_v|}{|g_s|}\left(\frac{V_{i,j+1}^{n+1} - V_{i,j}^{n+1}}{\Delta \eta}\right) + (1-\theta)\frac{|g_v|}{|g_s|}\left(\frac{V_{i,j+1}^{n} - V_{i,j}^{n}}{\Delta \eta}\right) - \tag{6-34}$$

$$\frac{|g_v|}{|g_s|}\left(\frac{V_{i,j+1}^{n} - V_{i,j}^{n}}{\Delta \eta}\right) = 0$$

Rearranging the terms in Equations 6-31 through 6-34 yields:

ξ-Momentum

$$\theta\left(-gHg^{11}\frac{\Delta t}{\Delta \xi}\right)S_{i-1,j}^{*} + (1 + \theta(FRIC)\Delta t)\, U_{i,j}^{*} + \theta\left(gHg^{11}\frac{\Delta t}{\Delta \xi}\right)S_{i,j}^{*} = B_4 \tag{6-35}$$

B_1 B_2 B_3

where: B_4 represents all known quantities

η-Momentum

$$\theta\left(-gHg^{22}\frac{\Delta t}{\Delta \eta}\right)S_{i,j-1}^{n+1} + (1 + \theta(FRIC)\Delta t)\, V_{i,j}^{n+1} + \theta\left(gHg^{22}\frac{\Delta t}{\Delta \eta}\right)S_{i,j}^{n+1} = B_4 \tag{6-36}$$

B_1 B_2 B_3

ξ-Continuity

$$\theta\left(\frac{-|g_u|}{|g_s|}\frac{\Delta t}{\Delta \xi}\right)U_{i,j}^{*} + [1]\, S_{i,j}^{*} + \theta\left(\frac{|g_u|}{|g_s|}\frac{\Delta t}{\Delta \xi}\right)U_{i+1,j}^{*} = A_4 \tag{6-37}$$

A_1 A_2 A_3

where: A_4 represents all known quantities

η-Continuity

$$\underbrace{\theta\left(\frac{-|g_v|}{|g_s|}\frac{\Delta t}{\Delta\eta}\right)}_{A_1} V^{n+1}_{i,j} + \underbrace{[1]}_{A_2} S^{n+1}_{i,j} + \underbrace{\theta\left(\frac{|g_v|}{|g_s|}\frac{\Delta t}{\Delta\eta}\right)}_{A_3} V^{n+1}_{i,j+1} = A_4 \qquad (6\text{-}38)$$

Computational Theory

36. The computational procedure used in CLHYD is based on an Alternating Direction Implicit (ADI) scheme (Roache 1976). Using this method, the ξ- and η-momentum equations are solved separately, and each calculation in time is made in two stages (Figure 6-9). In the first stage, the ξ-continuity and ξ-momentum equations are solved along each row of the grid to progress from time level n to an intermediate time level $*$. The ξ-direction unit flow rate components and water surface fluctuations are solved implicitly, and the η-direction unit flow rate components are supplied from time level n. The ξ-direction unit flow rates from this step represent those at time level $n+1$, whereas the water surface fluctuations are only an approximation to those at time level $n+1$. The η-direction unit flow rate components remain at time level n. In the second stage, the η-continuity and η-momentum equations are solved along each column for the η-direction unit flow rates and the water surface fluctuations at time level $n+1$. ξ-direction unit flow rate components are supplied from the first stage calculations.

37. As shown in the finite difference approximations to the governing equations, a weighting factor, θ, is used to place the water surface slope and bottom friction terms between time levels n and $n+1$. When the weighting factor equals 0.0, these terms are evaluated at the previous time level n (explicit treatment), whereas when the weighting factor equals 1.0, they are evaluated at the new time level $n+1$ (implicit treatment). Usually a value between 0.0 and 1.0 is used. Tests have shown that a value of 0.55 produces a stable solution with less damping of the solution than occurs with a value of 1.0.

CHAPTER 8

STWAVE THEORY AND PROGRAM DOCUMENTATION

PART I: INTRODUCTION

1. The STWAVE program in the Coastal Modeling System (CMS) is a computationally efficient finite-difference model for near-coast time-independent spectral wave energy propagation simulations. The program was developed by Dr. Donald T. Resio of Ocean and Coastal Technology, Inc., and was implemented in the CMS by the Coastal Engineering Research Center (CERC) at the US Army Engineer Waterways Experiment Station. The efficiency of the program is due to the assumption that only wave energy directed into the computational grid is significant, i.e., wave energy not directed into the grid is neglected. The program also assumes that wave conditions vary slowly enough that the variation of waves at a given point over time may be neglected relative to the time required for waves to pass across the computational grid. While these assumptions minimize computations, they also limit the model to near-coast applications in which waves are generally directed into the grid and move quickly across it (within 30 min).

2. The following sections briefly describe the theoretical background of STWAVE. Also, the operations of the STWAVE portion of the CMS Spectral Wave Modeling module are described, including the structure of the module, organizational procedures for an STWAVE simulation, and the required data for a successful STWAVE simulation.

Theoretical Foundation

3. STWAVE is based on a simplified form of the following spectral balance equation where it is noted that the variables are functions of space and time although not explicitly written as such:

$$\frac{\partial E(f,\theta)}{\partial t} + \frac{\partial cc_g E(f,\theta)}{\partial x} + \frac{\partial cc_g E(f,\theta)}{\partial y} = S_{at} + S_{nl} + S_{ds} + S_{wb} + S_{br} \qquad (8\text{-}1)$$

where

E = spectral energy density

f - frequency of spectral component

θ - propagation direction of spectral component

t - time

c - phase speed of spectral component

c_g - group velocity of spectral component

x,y - plan-view spatial coordinates

S - energy source/sink quantity described below

The first term on the left-hand side (LHS) of Equation 8-1 is the rate of change of a spectral energy component with respect to time for a given location. The second and third terms on the LHS of Equation 8-1 represent the advection of a spectral energy component. The remaining source/sink terms on the right-hand side of Equation 8-1 represent physical mechanisms that add to, or subtract from, energy in the wave field. The source/sink terms, in order from left to right are the atmospheric energy input, nonlinear wave-wave interactions, wave energy dissipation within the wave field (e.g., white capping), energy dissipation due to wave-bottom interactions, and surf-zone breaking.

4. Under the assumption that the simulated waves are independent of time, the first term on the LHS of Equation 8-1 is zero. Additionally, since the implementation of STWAVE in CMS is for wave propagation only, it neglects wind-wave generation, nonlinear energy transfer, and wave field and wave-bottom dissipation. Therefore, all of the source terms in Equation 8-1 are zero, except for S_{br}, which accounts for surf-zone breaking of the wave-energy spectrum. Equation 8-1 may then be reduced to:

$$\frac{\partial c c_g E(f,\theta)}{\partial x} + \frac{\partial c c_g E(f,\theta)}{\partial y} - S_{br} = 0 \qquad (8\text{-}2)$$

5. In general, S_{br} is zero except when surf-zone breaking is important. Hence, the equation solved in STWAVE is:

$$\frac{\partial c c_g E(f,\theta)}{\partial x} + \frac{\partial c c_g E(f,\theta)}{\partial y} = 0 \qquad (8\text{-}3)$$

Solution Method

6. All STWAVE simulations require a wave energy spectrum specified for the input boundary of the computational grid. STWAVE then transforms that spectrum across the grid. Considering the computational grid presented in Figure 8-1, the spectrum is transformed from one column to the next starting at the input boundary. The transformation of each spectral component includes refraction and shoaling effects. Each spectral component along a given column is then modified to include the effects of bottom diffraction and the convergence/divergence of energy within the spectrum influenced by the local bathymetry. When the propagation of the entire spectrum to the new column is complete, it is evaluated for breaking conditions. When a spectrum is considered breaking, the energy levels within the spectrum are limited to levels defined by Davis, Smith, and Vincent (1991). The spectra along the new column are then propagated to the next column. When a land point within the

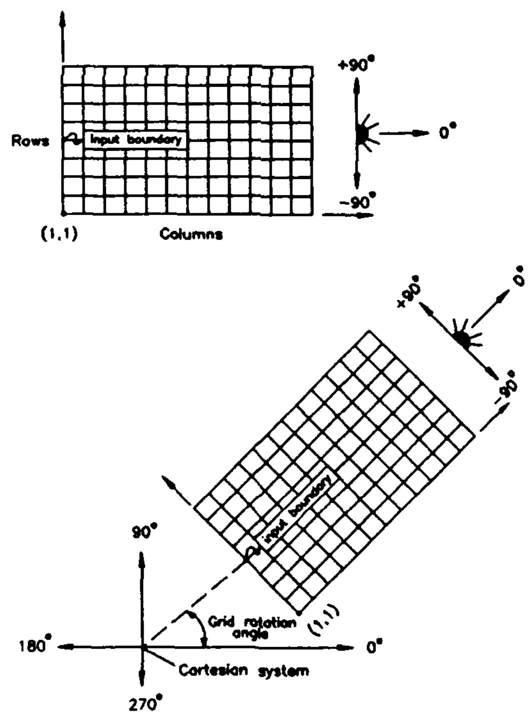

Figure 8-1. Orientation and coordinate systems for an STWAVE simulation

grid is encountered, the total spectral energy for that point is set to zero. Also, the energy levels for spectra on the boundaries of the grid are set to the values of the spectra on the rows or columns adjacent to the boundaries.

7. The user is provided with great flexibility in specifying the input boundary spectrum. Note that the input boundary spectrum is applied to all points on the boundary except land points that are assigned zero spectral energy values. The STWAVE module can be used to generate an input boundary spectrum from a given total energy-based wave height, peak spectral period, and mean spectral propagation direction. Based on these wave characteristics, a JONSWAP/TMA spectrum (Bouws et al. 1985) is generated with a symmetric directional distribution. The user specifies the amount of directional spread of energy within the spectrum, which may range from unidirectional to extremely wide spread in direction. The user may also specify the input boundary spectrum by entering the JONSWAP/TMA spectral parameters directly, by entering the complete frequency spectrum, or by entering the complete frequency-direction spectrum.

8. The input boundary condition spectra may be provided as a single spectrum or as a series of spectra for a given STWAVE simulation. For example, if several design wave conditions are to be evaluated by the user, all of the design conditions may be simulated during a single STWAVE run. The ability to enter multiple wave conditions during a single STWAVE execution also allows the user to represent a time-dependent simulation by modeling a series of time-independent wave conditions in sequence. By the inherent assumptions in STWAVE, each wave condition simulated is independent of time, but the variation from one simulated wave condition to the next could represent the variation of wave conditions over time.

9. Another method available in the STWAVE module for specifying input boundary conditions is through a subgrid simulation for a preceding SHALWV simulation. The STWAVE module is designed to easily incorporate wave energy spectra saved from a previous SHALWV run at the location of the input boundary of the STWAVE simulation. Hence, a record of wave spectra may be simulated during a single STWAVE simulation. Each input spectrum within the STWAVE simulation would be independent of time, but the simulation of the sequence of spectra would represent the time-variation of the spectra. This approach is only valid when the computational grid is small, such that the smallest

spectra in the record can propagate across the grid quickly; for example, in less than 30 min. If the grid is too large, then the subgrid simulation should be conducted with the subgrid option within the SHALWV module (Chapter 7).

PART II: STRUCTURE OF THE SPECTRAL WAVE MODELING MODULE

Introduction: Operational Structure of the STWAVE Branch

10. The operational functions of the STWAVE branch of the Spectral Wave Modeling module are illustrated in Figure 8-2. In general, the file-building function must be used prior to the function to run programs, and the function to run programs must be used prior to the function to post-process the model results. Figures 8-3 through 8-5 indicate the coordination between files created and used by each routine within each function of the STWAVE module. The coordination between the functions and the routines within each function can be followed by observing which routines create files, and which routines use those files. Each file has an associated letter and number. Files that are required for input are identified with the letter "R." Files that are automatically created by routines are identified with the letter "A," and files that are optionally created or required by routines are identified with the letter "O." The contents and format of data within each file are described in Part IV, Spectral Wave Modeling Module File Descriptions.

Organizational Procedures for Common Simulations

11. The organizational procedures for common types of simulations are presented below:

Simulation #1: Simulate the transformation of a wave energy spectrum across a region of interest, but not as a subgrid computation for a previous SHALWV run.

Procedure: Run General File-Building Routine.

Run Boundary Condition File-Building Routine.

Run Boundary Condition Generator (BCGEN) program.

Run STWAVE.

Notes: The General File-Building Routine allows the user to specify characteristics of the computational grid, discretization of the wave energy spectrum, number of wave conditions that will be simulated, and specific locations at which model results should be output. The Boundary Condition File-Building Routine allows the user to specify the type of wave

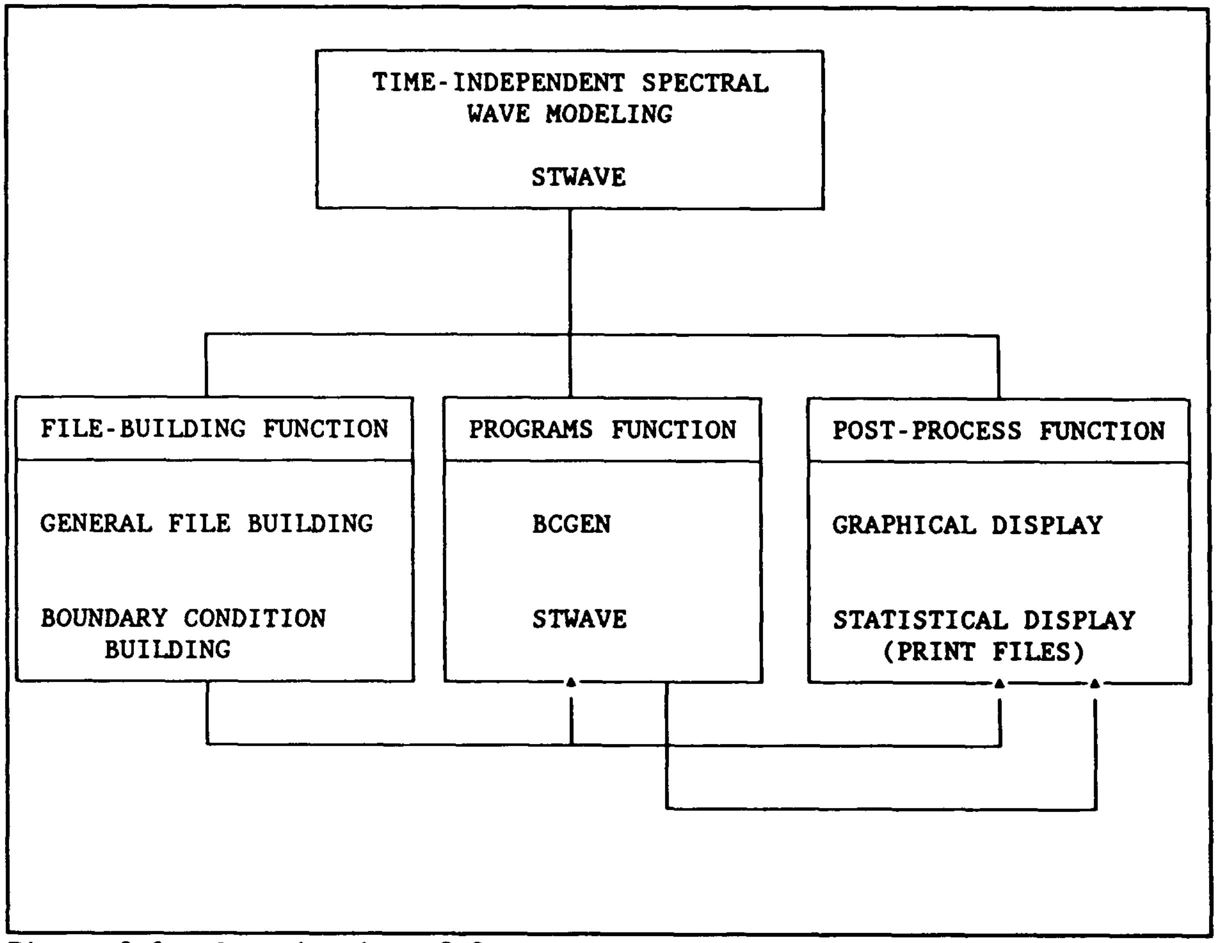

Figure 8-2. Organization of functions and routines within the STWAVE branch of the Spectral Wave Modeling Module

conditions to simulate. The BCGEN program is run to generate the input boundary condition spectrum for the STWAVE simulation, and STWAVE is run to compute the transformation of those input spectral wave conditions across the region of interest (computational grid).

<u>Simulation #2:</u> Simulate the transformation of a wave energy spectrum across a region of interest as a subgrid computation for a previous SHALWV run.

<u>Procedure:</u> Run General File-Building Routine.

Run STWAVE.

<u>Notes:</u> The General File-Building Routine is used as described in Simulation #1. However, the boundary condition data saved from the previous SHALWV run are formatted by the General File-Building Routine for the subsequent STWAVE subgrid run. STWAVE is then run to compute the transformation of those input spectral wave conditions across the subgrid.

OPTION *	FILE #	FILE-BUILDING FUNCTION: INPUT FILES	ROUTINE	OUTPUT FILES	OPTION *	FILE #
0	X	OLD SHALWV GENERAL INPUT FILE (SHALWVIN.SWV)	GENERAL FILE-BUILDING	GENERAL INPUT FILE (STWAVEIN.SWV)	A	2
0	X	OLD SHALWV BOUNDARY CONDITION FILE (*.BND)		BATHYMETRY FILE (USER-SPECIFIED)	A	1
0	1	BATHYMETRY FILE (USER-SPECIFIED)		BOUNDARY CONDITION FILE (BOUNDOUT.SWV)	0	3
				PARAMETER FILE (FILE1.SWV)	A	4
				MAIN FILE NAME FILE (FILENMI.SWV)	A	5
R	2	GENERAL INPUT FILE (STWAVEIN.SWV)	BOUNDARY CONDITION FILE-BUILDING	BCCEN INPUT FILE (BOUNDIN.SWV)	A	8
R	1	BATHYMETRY FILE (USER-SPECIFIED)				
0	6	WAVE CHARACTERISTICS INPUT FILE (USER-SPECIFIED)				
0	7	SPECTRAL DATA FILE (USER-SPECIFIED)				
R	4	PARAMETER FILE (FILE1.SWV)				
R	5	MAIN FILE NAME FILE (FILENMI.SWV)				

X = See SHALWV User's Guide (Chapter 7).
*A = Automatically created output file.
0 = Optionally created or required file.
R = Required File

Figure 8-3. File-Building Function

OPTION *	FILE #	RUN PROGRAMS FUNCTION: INPUT FILES	ROUTINE	OUTPUT FILES	OPTION *	FILE #
R	8	BCGEN INPUT FILE (BOUNDIN.SWV)	RUN BCGEN	BOUNDARY CONDITION FILE (BOUNDOUT.SWV)	A	3
R	4	PARAMETER FILE (FILE1.SWV)				
R	2	GENERAL INPUT FILE (STWAVEIN.SWV)	RUN STWAVE	WAVE FIELD OUTPUT FILE (USER-SPECIFIED + .MTX)	A	9
R	3	BOUNDARY CONDITION FILE (BOUNDOUT.SWV)		WAVE SPECTRA OUTPUT FILE (USER-SPECIFIED + .SPE)	A	10
R	1	BATHYMETRY FILE (USER-SPECIFIED)		WAVE CHARACTERISTICS OUTPUT FILE (USER-SPECIFIED + .SEA)	A	11
R	4	PARAMETER FILE (FILE1.SWV)		POST-PROCESSING FILE NAME FILE (FILENMPST.SWV)	A	12

*A = Automatically created output file.
0 = Optionally created or required file.
R = Required File.

Figure 8-4. Run Programs Function

OPTION *	FILE #	POST-PROCESSING FUNCTION			OPTION *	FILE #
R	5	MAIN FILE NAME FILE (FILENMI.SWV)	GRAPHICS	SCREEN DISPLAYS NO FILES		
R	2	GENERAL INPUT FILE (STWAVEIN.SWV)				
R	1	BATHYMETRY FILE (USER-SPECIFIED)				
R	4	PARAMETER FILE (FILE1.SWV)				
R	9	WAVE FIELD FILE (USER-SPECIFIED + .MTX)				
R	10	WAVE SPECTRA FILE (USER-SPECIFIED + .SPE)				
R	11	WAVE CHARACTERISTICS FILE (USER-SPECIFIED + .SEA)				
R	12	POST-PROCESSING FILE NAME FILE (FILENMPST.SWV)	STATISTICS	WAVE CHARACTERISTICS FILE (USER-SPECIFIED)	0	NA
R	5	MAIN FILE NAME FILE (FILENMI.SWV)		GENERAL STATISTICS FILE (USER-SPECIFIED)	0	NA
R	2	GENERAL INPUT FILE (STWAVEIN.SWV)		WAVE FIELD OUTPUT FILE (USER-SPECIFIED)	0	NA
R	9	WAVE FIELD FILE (USER-SPECIFIED + .MTX)				
R	10	WAVE SPECTRA FILE (USER-SPECIFIED + .SPE)				
R	11	WAVE CHARACTERISTICS FILE (USER-SPECIFIED + .SEA)				

*A = Automatically created output file.
0 = Optionally created or required file.
R = Required input file.

Figure 8-5. Post-Processing Function

PART III: MODULE FUNCTIONS AND ROUTINES

STWAVE Module Functions and Routines

12. The first function of the STWAVE branch of the Spectral Wave Modeling module of CMS is to build most or all of the necessary input files for the user's application. The second function is to run the BCGEN and STWAVE programs. The third function is to display graphically or statistically the results of the user's most recent STWAVE run. Descriptions of the operation of each function and routine, and the specific information required by each function and routine, are presented in the following sections.

File-Building Functions

13. The first function of the STWAVE module is to assist users in building the input files required by STWAVE. Users are prompted for input through a series of menu selections and question-answer sessions. It is recommended that the file-building function routines be used at all times to organize data and files for an STWAVE run. This will minimize potential file format and organization errors. Note, however, that some files may be easier to build on a word processor (e.g., large bathymetry files). For such cases, the proper data definitions and data formats for the files may be found in Part IV, Spectral Wave Modeling Module File Descriptions.

14. Two routines can be used to build the necessary input files for STWAVE. The first is the General File-Building Routine which builds up to five of the input files required for an STWAVE run. The second file-building routine is called the Boundary Condition File-Building Routine, which constructs the BCGEN input file. (The BCGEN program generates boundary conditions for STWAVE.)

General File-Building Routine

15. The General File-Building Routine is used to construct the required General Input File, Bathymetry File, Parameter File, Main File Name File, and

optionally, the Boundary Condition File. The General Input File contains the following information:

a. Program flow control parameters.

b. Discretization specifications for the wave energy spectra.

c. Computational grid specifications.

d. Specifications of locations at which model results are desired.

16. The Bathymetry File contains a water depth for each node in the computational grid. The user may build the Bathymetry File interactively through the General File-Building Routine, in which case the user is prompted for a water depth at each node, or, when water depth is constant, the user is prompted for the constant depth value. The user may also build the Bathymetry File with another editor (word processor), transfer it to the user's CRAY Y-MP account, and then specify the name of the file during the General File-Building Routine. In such a case, since the Bathymetry File already exists, the General File-Building Routine will simply record the name of the file for later use by STWAVE.

17. The Boundary Condition File is used by STWAVE for input boundary conditions. The only instance in which the General File-Building Routine creates this file is when STWAVE is being run as a subgrid of a previous SHALWV run. In such cases, the boundary condition data saved by SHALWV at the boundary of the STWAVE grid are read by the General File-Building Routine and processed appropriately for the subsequent STWAVE run. In essence, the General File-Building Routine eliminates the portion of the wave energy spectrum that is not directed into the STWAVE grid. Figure 8-6 illustrates this "spectral energy filtering" process. The processed (filtered) spectra are then written to the Boundary Condition File for input to STWAVE.

Data descriptions for General File-Building Routine

18. Descriptions of the data requested by the General File-Building Routine are provided below. The descriptions have the following format: the prompts that the user will see during the interactive General File-Building session are provided by "Question:" as they would appear on the user's terminal during the interactive file-building session, along with an identifying number for reference (e.g., GF-1, which stands for General File-Building question number 1). A list of "Options:" is provided, which may be

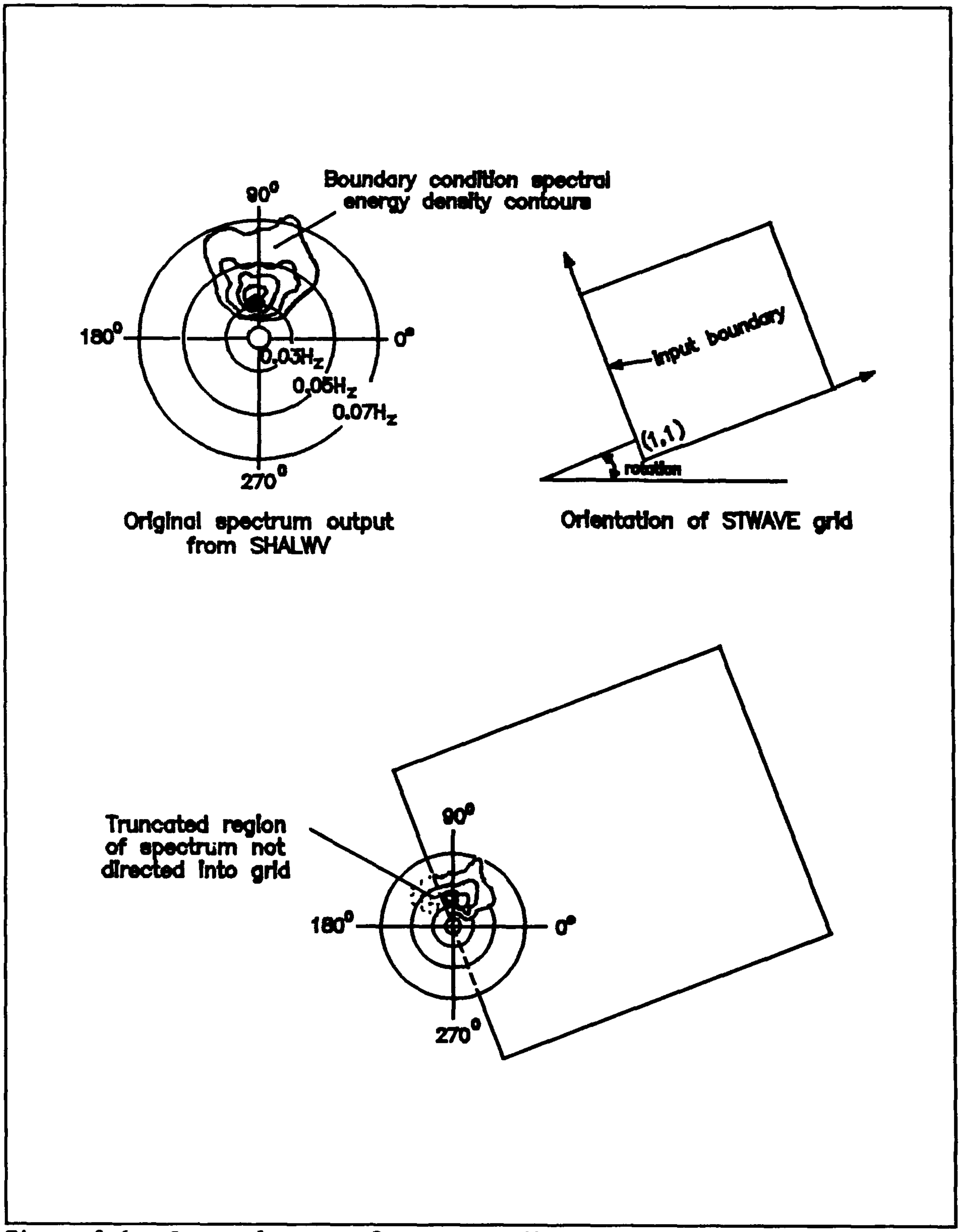

Figure 8-6. Spectral energy from a preceding SHALWV simulation is truncated for a subsequent STWAVE subgrid simulation

used to answer the question. If the question requires a limited response, then the permitted range of values is given. A list of previous questions and their corresponding answers that determine whether the current question is asked are presented under "Preselect:." For example, question GF-8 will not be asked unless the user previously selected option 1 for question GF-2. Each question is explained under the "Define:" section, and a "Caution:" is provided when appropriate to alert users to special requirements of the module. When necessary, a "PATH:" is provided, which indicates the next question based on the user's answers to previous questions. While all of the questions that could be asked by the module are listed below, no one simulation will ever require answers to all of the questions.

GF-1 Question : **Enter SCREEN WIDTH OPTION >**

Options : 1 = 80 Characters.

2 = 132 Characters.

Preselect: None.

Define : The setup for the display width of the user's screen is necessary to keep matrices from "wrapping" around on the screen or from being truncated on the screen during the review of data at the terminal following the General File-Building Routine.

Caution : If the user selects a 132-character screen width when the screen is only 80 characters, matrices displayed during the data review at the end of the General File-Building session will be "wrapped" around on the screen or truncated by the edge of the screen. This will only affect data viewing and not the data itself.

GF-2 Question : **Enter the SUB-GRID OPTION >**

Options : 1 = No subgrid.

2 = Subgrid to SHALWV run.

Preselect: None.

Define : If this STWAVE simulation is intended to be a subgrid simulation for a previous SHALWV simulation, then the user selects option 2. If not, the user selects option 1. See the discussion in Part II, Structure of the Spectral Wave Modeling Module, regarding subgrid simulations for preceding SHALWV simulations.

Caution : A subgrid simulation requires that the General Input File and the Subgrid Boundary Condition File exist from the preceding SHALWV simulation. Both files are automatically retrieved during the General File-Building session for STWAVE and are used to reformat the Boundary Condition File for the subsequent STWAVE subgrid simulation. The user may be unaware of many of the files that are being built and used by SHALWV and STWAVE, and therefore, he may not know whether the required files from the original SHALWV simulation exist. However, if prior to this subgrid simulation the user specified that the output boundary conditions be saved during the original SHALWV simulation, and he conducted no other simulations in between, and if the user did not delete or remove any files from his directory, then he can be assured that the necessary files exist.

GF-3 Question : **Enter number of COLUMNS in Grid >**

Options : Range 3 - 200.

Preselect: None.

Define : Figure 8-1 defines the columns of the computational grid.

Caution : None.

GF-4 Question : **Enter number of ROWS in the Grid >**

Options : Range 3 - 200.

Preselect: None.

Define : Figure 8-1 defines the rows of the computational grid.

Caution : None.

GF-5 Question : **Enter CELL-SIZE OF COLUMNS (m) >**

Options : > 0.

Preselect: None.

Define : The user must input the cell width of a column of the grid.

Caution : Units must be in meters (m).

GF-6 Question : **Enter CELL-SIZE OF ROW (m) >**

Options : > 0.

Preselect: None.

Define : The user must input the cell width of a row of the grid.

Caution : Units must be in meters (m).

GF-7 Question : **Enter ROTATION ANGLE FOR GRID (deg) >**

Options : $0 \leq$ ROTATION ANGLE < 360.

Preselect: None.

Define : All calculations performed by STWAVE are referenced to the STWAVE grid. That is, the reference frame for the program is attached to the grid and not the real world. To relate a Cartesian reference to input and output for STWAVE, the rotation of the grid relative to the Cartesian system shown in Figure 8-1 must be given. A counterclockwise rotation of the STWAVE grid is positive. A clockwise rotation is negative.

Caution : Units must be in degrees (deg) using the Cartesian reference system shown in Figure 8-1.

PATH: o **IF SUBGRID SIMULATION (Option 2, question GF-2), GO TO QUESTION GF-11.**

GF-8 Question : **Enter number of FREQUENCY BANDS >**

Options : Range 5 - 20.

Preselect: GF-2, option 1.

Define : A wave energy spectrum is defined over frequency and direction. Although a wave energy spectrum is actually a continuum, the spectrum can only be represented numerically by discretizing it over frequency and direction. The user must select the number of frequency bands with which to discretize the wave energy spectrum.

Caution : A value of 20 frequency bands is recommended. Both the spectral resolution and simulation computation time vary directly with the number of frequency bands.

GF-9 Question : **Enter the FIRST FREQUENCY BAND VALUE (Hz) >**

Options : > 0.

Preselect: GF-2, option 1.

Define : The user must provide a starting frequency value to which the module will add frequency increments to derive all of the frequency band values. (The size of the frequency increment is specified in question GF-10.)

The user should provide for a range of frequency values that span the expected range of frequencies that contain significant wave energy for the simulation. A reasonable range of values is from one-fourth to four times the peak frequency (inverse of the peak spectral period). For example, if the spectral wave conditions to be simulated by STWAVE have a peak period of 10 sec, then the peak frequency would be 0.1 Hz. The recommended frequency band values should then range between 0.025 and 0.4 Hz. Therefore, the first frequency band value would be 0.025 Hz.

Caution : First frequency band value must be greater than zero. Units must be in Hertz (Hz).

GF-10 Question : **Enter the FREQUENCY BAND INTERVAL (Hz) >**

Options : > 0.

Preselect: GF-2, option 1.

Define : The user must provide the frequency increment value for computing the frequency band values. The increment value is cumulatively added to the first frequency value specified in question GF-9. The increment value must be such that when it is added to the first frequency value, the resulting frequency band values will cover the necessary range of frequencies. For the example given in question GF-9, assuming 20 frequency bands were specified in question GF-8, the increment needed is about 0.02 Hz to get 20 equally spaced frequency bands between 0.025 and 0.4 Hz.

Caution : Units must be in Hertz (Hz).

GF-11 Question : **Enter the number of ANGLE BANDS >**

Options : Range 5 - 36.

Preselect: None.

Define : This is the same as question GF-8, except that direction bands are considered instead of frequency bands. The directional bands encompass a 180° arc, less two small extreme angle bands, which are described in question GF-12. The equation to determine the size of each angle band is

$$\Theta=(180^\circ-2\epsilon)/(N_a-1) \tag{8-4}$$

where

Θ - spectral angle band width
ϵ - spectral angle band width excluded at edge of the 180° arc (see question GF-12)
N_a - number of angle bands

For example, if ϵ is 5° and N_a is 18, then Θ is 10°.

Caution : A value of 18 frequency bands is recommended for most simulations. Both the spectral resolution and simulation computation time vary as the number of angle bands.

GF-12 Question : **Enter the size of EXTREME ANGLE EXCLUSION (deg) >**

Options : > 0.

Preselect: None.

Define : The extreme angle exclusion should be approximately one-half the width of an angle band as defined by Equation 8-4.

Caution : None.

GF-13 Question : **Enter WATER DEPTH INPUT OPTION >**

Options : 1 - Spatially constant water depth.

2 - Spatially variable water depth.

Preselect: None.

Define : The bathymetry of the model area may be specified either as constant or variable. If constant depth is selected, the user will be prompted for the depth to be used for all points on the computational grid. If variable depth is selected, the user will have the option to input the depth data interactively, or through a file, for every point on the computational grid.

Caution : None.

GF-14 Question : **Enter DEPTH CONVERSION FACTOR >**

Options : Variable.

Preselect: None.

Define : The depths that STWAVE uses must be in units of meters with positive values indicating depth below mean sea level. A conversion factor must be entered, which allows STWAVE to convert depth information to meters. For example, if depth data are given in feet, then a conversion factor of 0.3048 (m/ft) must be entered.

Caution : If bathymetry data are given in meters, the user enters a value of 1.0 as a conversion factor. Note: if bathymetry data are provided such that negative values indicate depths below a mean sea level, then a negative depth conversion factor will convert those values to the positive values that are required by STWAVE. Depth values of zero are considered land.

PATH: o **IF WATER DEPTHS ARE CONSTANT (Option 1, question GF-13), GO TO GF-19.**

GF-15 Question : **Are WATER DEPTHS in a file? (yes or no) >**

Options : y (or Y) - water depths are in a file.

n (or N) - water depths will be entered interactively.

Preselect: GF-13, option 2.

Define : Water depths may be entered from a file. If water depths are entered from a file, then the user is prompted for the file name. If water depths are not entered from a file, the user must enter them interactively during the General File-Building session. Water depth values are required for each point on the computational grid.

Caution : None.

PATH: o **IF NO WATER DEPTH FILE (Option 'no', question GF-15), GO TO GF-17.**

GF-16 Question : **Enter the WATER DEPTH FILE name >**

Options : Variable.

Preselect: GF-13, option 2; GF-15, option "yes."

Define : The water depth file contains the water depth values for each point in the computational grid. The format for the Bathymetry File is provided in Part IV, Spectral Wave Modeling Module File Descriptions. Figure 8-1 shows the orientation of the grid and the corresponding orientation of the water depth data. Water depths must be entered as positive numbers, while land points are zero.

Caution : The water depth file name must conform to the file-naming conventions of the UNIX operating system (only the first 14 characters are significant). The units of the water depth data must be consistent with the conversion factor entered in question GF-14. The number of depth data values must be identical to the number of grid points (questions GF-3 and GF-4).

PATH: o **IF WATER DEPTH FILE (Option 'yes', question GF-15), GO TO GF-20.**

GF-17 Question : **Build the water depth file? (yes or no) >**

Options : y (or Y) - water depth values entered interactively.

n (or N) - water depth values not entered interactively.

Preselect: GF-13, option 2; GF-15, option "no."

Define : The user indicates whether he is ready to begin building the water depth file. If he indicates yes, the module will prompt him for water depth values for each point on the computational grid.

Caution : If the user indicates that the water depth file will not be built interactively, then the General File-Building session will end, and no information will be saved. The user will be required to rerun the General File-Building Routine.

GF-18 Question : **Enter the WATER DEPTH MATRIX >**

Enter the value for ROW = ##, COL = ##:

Options : Variable.

Preselect: GF-13, option 2; GF-15, option "no"; GF-17, option "yes."

Define : The user begins entering the water depth values for the specified grid points. Figure 8-1 shows the orientation of the grid and the corresponding orientation of the water depth data. While building the water depth file, the user should keep in mind that land should be identified by a value equal to zero (0.0).

Caution : The water depth values must be consistent with the depth conversion factor entered in question GF-14.

PATH: o **IF VARIABLE WATER DEPTHS (Option 2, question GF-13), GO TO GF-20.**

GF-19 Question : **Enter CONSTANT WATER DEPTH >**

Options : > 0.

Preselect: GF-13, option 1.

Define : Enter the single water depth value to be used for all points on the computational grid.

Caution : The depth value must be consistent with the depth conversion factor entered in question GF-14.

GF-20 Question : **Enter NUMBER OF HOURS BETWEEN INPUT CONDITIONS >**

Options : ≥ 1.

Preselect: GF-2, option 1.

Define : If input boundary conditions are intended to represent the time variation of wave conditions, the user must specify the number of hours represented by each input condition. If input boundary conditions are unrelated to one another, for example, a series of design wave conditions, the user enters "1." The answer to this question does not influence the simulation, it is simply used to increment time during the simulation.

Caution : None.

GF-21 Question : **Enter NUMBER OF INPUT CONDITIONS >**

Options : ≥ 1.

Preselect: GF-2, option 1.

Define : The user enters the number of input data sets (boundary conditions) that will be simulated during this STWAVE run.

Caution : None.

GF-22 Question : **Enter NUMBER OF OUTPUT LOCATIONS >**

Options : Range 0 - 100.

Preselect: None.

Define : The output locations are those points on the computational grid at which model results should be saved to files. The model results saved include the energy-based wave height, peak spectral period, mean spectral propagation direction, and both the one-dimensional (frequency) and two-dimensional (frequency-direction) spectra.

Caution : If the user selects 0, no data will be saved from the STWAVE run except wave field data (energy-based wave heights, peak spectral periods, and mean spectral propagation directions for each node, for each input condition). If the user selects a value between 1 and 100, he will be prompted for the ROW and COLUMN values for each output location in question GF-23.

PATH: o **IF NO SPECIAL OUTPUT LOCATIONS (answer 0, question GF-21), END THE FILE-BUILDING SESSION.**

GF-23 Question : **Enter the OUTPUT LOCATIONS (COLUMN and ROW) >**

COLUMN and ROW for point ###:

Options : Variable.

Preselect: GF-22, $0 < \text{VALUE} \leq 100$.

Define : The column and row values must conform to the orientation of the grid as defined in Figure 8-1.

Caution : Separate the entered values with a comma (,) or a space ( ).

PATH: o **END GENERAL FILE-BUILDING SESSION.**

Boundary Condition File-Building Routine

19. The user must provide an input wave-energy spectrum (called a boundary condition) for any STWAVE simulation. This boundary condition spectrum may be specified in several ways. One method for generating the input boundary condition spectrum is by specifying the energy-based wave height, peak spectral period, and mean spectral propagation direction for the spectrum. The BCGEN program then translates those characteristics into a spectrum with a JONSWAP/TMA spectral shape (Bouws et al. 1985) with a symmetric spread in direction defined by the user. Another method for entering the boundary condition spectrum is by entering the JONSWAP/TMA spectral description parameters with a user-defined directional spread. Another method is to enter the frequency spectrum directly, in which case only a directional spread is applied to the spectrum. The user may also enter the complete frequency-direction spectrum, in which case the spectrum is merely reformatted for use in STWAVE. When STWAVE is used for a subgrid simulation for a preceding SHALWV run, the input boundary condition spectra are obtained from the spectral data saved from the preceding SHALWV simulation. Hence, the user does not have to specify the input boundary conditions, i.e., in this case the Boundary Condition File-Building Routine does not have to be used.

20. A feature of the STWAVE module is the capability to simulate multiple wave conditions during a single execution of the STWAVE program. Using this capability, multiple design wave conditions, or a pseudo time-varying simulation, may be run in a single execution of STWAVE. If a series of boundary conditions are entered, the user will be prompted for a wave spectrum (or its "characteristics") for each input interval specified in question GF-21.

21. An important assumption about STWAVE's boundary conditions is that the boundary condition spectra specified are assumed to apply across the entire input boundary of the grid (Figure 8-1) except for land points, which have no spectral energy associated with them. In some cases, this is a reasonable assumption. However, in cases where the depths along the input boundary vary considerably, one would not expect the wave conditions to be the same across the boundary. Therefore, the user must evaluate the grid boundary and use the most appropriate wave condition.

22. The descriptions below outline the questions with which the module prompts the user to gather information for generating the input boundary conditions. The module will build a data file, and then the BCGEN must be run to generate the boundary condition spectrum.

<u>Input descriptions</u>

BC-1 Question : **General File-Building Routine has been run? (yes / no) >**

Options : y (or Y) - General File-Building Routine has been run.

n (or N) - General File-Building Routine has not been run.

Preselect: None.

Define : Some of the files generated by the General File-Building Routine must exist prior to using this Boundary Condition File-Building Routine.

Caution : If the General File-Building Routine has not been run, but the user answers yes, an error will occur when the Boundary Condition File-Building Routine searches for the existence of files created by the General File-Building Routine. The Boundary Condition File-Building Routine will end.

PATH: o IF GENERAL FILE-BUILDING ROUTINE HAS NOT BEEN RUN (Option 'no', question BC-1), END THE BOUNDARY CONDITION FILE-BUILDING ROUTINE.

BC-2 Question : **Enter TIME VARIATION OPTIONS >**

Options : 1 - Constant spectra over time.

2 - Variable spectra over time.

Preselect: None.

Define : If time-invariant boundary conditions are selected, the user will be prompted for a single set of boundary condition data, which will be used for the entire simulation period.

If time-varying boundary conditions are selected, the user will be prompted for boundary conditions for every input interval of the simulation as specified in question GF-21. The time-varying option would be used if the user were going to simulate several design wave conditions during a single execution of STWAVE, or if he is simulating the time-variation of wave conditions by a series of time-independent wave conditions.

Caution : None.

BC-3 Question : **Enter BOUNDARY CONDITION OPTION >**

Options : 1 - Input wave characteristics.

2 - Input spectral characteristics.

3 - Input one-dimensional frequency spectrum.

4 - Input two-dimensional frequency-direction spectrum.

Preselect: None.

Define : The user must specify the method for creating the boundary condition spectrum. Option 1 will require him to enter an energy-based wave height, peak spectral period, and mean spectral propagation direction for each boundary condition. Option 2 will require the user to enter the peak spectral frequency, Phillips' Equilibrium constant, spectral peakedness factor, and the spectral peak-width factors. [See question GF-27, Chapter 7.] Options 3 and 4 will require the user to enter the frequency and frequency-direction spectrum, respectively.

Caution : None.

PATH: o **IF ONE-DIMENSIONAL SPECTRUM IS ENTERED (Option 3, question BC-3), GO TO BC-5.**

o **IF TWO-DIMENSIONAL SPECTRUM IS ENTERED (Option 4, question BC-3), GO TO BC-9.**

BC-4 Question : **Enter FREQUENCY SPECTRAL SHAPE OPTION >**

Options : 1 - Kittigoradski, deep and shallow.

2 - Pierson-Moskowitz, deep only.

3 - JONSWAP, deepwater with mean values.

4 - JONSWAP/TMA, computed alpha and gamma.

Preselect: BC-3, options 1 or 2.

Define : When the input boundary conditions will not be given as an explicit spectrum (i.e., frequency or frequency-direction spectrum), then the user must specify the type of frequency spectrum that should be generated based on the wave or spectral characteristics he will be entering later. The BCGEN converts the wave and spectral characteristics into a one-dimensional spectrum based on the spectral shape selected here. Option 4 is recommended.

Caution : None.

BC-5 Question : **Enter DIRECTION DISTRIBUTION SHAPE OPTION >**

Options : 1 - $\cos^{nn}\theta$

2 - $\cos^{2p}(\frac{\theta}{2})$

Preselect: BC-3, option 1, 2, or 3.

Define : As with the spectral shape discussed in question BC-4, the shape of the spread of the spectrum across the direction domain must be specified. The user will be asked later to enter the value for nn , or possibly p , depending on the option that is selected. The shape of the directional spreading will be applied to any type of input boundary condition to generate a two-dimensional spectrum, except when a two-dimensional spectrum is entered explicitly. Option 1 is recommended.

Caution : None.

PATH: o IF $\cos^{2p}(\theta/2)$ SPREADING FUNCTION SELECTED (Option 2, question BC-5), GO TO BC-7.

BC-6 Question : **Enter SPECTRAL SPREADING FUNCTION EXPONENT nn >**

Options : Variable.

Preselect: BC-3, options 1, 2, or 3; BC-5, option 1.

Define : The spreading function exponent is the value of nn in the expression $\cos^{nn}\theta$ provided in question BC-5. A low value of nn will provide a wide spread in direction about the principal propagation direction of the spectrum. Higher values for nn provide a spectrum with an extremely small directional spread. In general, a value of 4 may be used for a wind-sea spectrum and a value of 8 for a swell spectrum.

Caution : None.

PATH: o IF $\cos^{nn}\theta$ SPREADING FUNCTION SELECTED (Option 1, question BC-5), GO TO BC-9.

BC-7 Question : **Enter p COMPUTATION OPTION >**

Options : 1 - p value computed.

2 - p value entered interactively.

Preselect: BC-3, option 1, 2, or 3; BC-5, option 2.

Define : The value for p in the term $\cos^{2p}(\theta/2)$ provided in question BC-5 may be entered interactively, or it may be computed by the module. The derivation of p is based on the work of Mitsuyasu (1981).

Caution : None.

PATH: o IF p VALUE IS COMPUTED (Option 1, question BC-7), GO TO BC-9.

BC-8 Question : **Enter SPREAD PARAMETER p >**

Options : Variable.

Preselect: BC-3, options 1, 2, 3; BC-5, option 2; BC-7, option 2.

Define : Low values for p provide spectra with large directional distributions about the principal direction of propagation. High values for p provide spectra with small directional distributions about the principal direction of propagation. Recommended values are 8 for a wind-sea spectrum or 16 for a swell spectrum.

Caution : None.

BC-9 Question : **Enter the start date for spectral input >**

Options : 0 ≤ VALUE ≤ 99999999.

Preselect: None.

Define : If STWAVE is being used to simulate time-varying wave conditions, then the date for the first input boundary condition must be specified. The module automatically computes the dates for the remaining input boundary condition data based on the input interval which is specified in question GF-20.

If STWAVE is being used to simulate a series of design wave conditions, enter 1. This will force the date to act as a counter for each wave condition. That is, the first design wave condition would be associated with "date 00000001," the second condition with "date 00000002," and so on.

Caution : None.

PATH:

- **IF SPECTRAL WAVE CHARACTERISTICS ARE ENTERED (Option 2, question BC-3), GO TO BC-17.**
- **IF ONE-DIMENSIONAL SPECTRAL DATA ARE ENTERED (Option 3, question BC-3), GO TO BC-25.**
- **IF TWO-DIMENSIONAL SPECTRAL DATA ARE ENTERED (Option 4, question BC-3), GO TO BC-31.**

BC-10 Question : **WAVE CHARACTERISTICS INPUT OPTION >**

Options : 1 - Read data from file with dates.

2 - Read data from file without dates.

3 - Enter data from keyboard.

Preselect: BC-3, option 1.

Define : Select the desired method for entering wave characteristics.

Caution : If option 1 or 2 is selected, a file containing the wave characteristics data must be available and specified in question BC-11. The formats for the files are provided in Part IV, Spectral Wave Modeling Module File Descriptions.

PATH:

- **IF DATA ARE ENTERED FROM KEYBOARD (Option 3, question BC-10,) GO TO BC-12.**

BC-11 Question : **Enter WAVE CHARACTERISTICS filename >**

Option : ≤ 14 significant characters.

Preselect: BC-3, option 1; BC-10, option 1 or 2.

Define : Since the user indicated in question BC-10 that the wave characteristics data are to be read from a file, he must provide the file name. If no valid file name is provided, the Boundary Condition File-Building Routine will be terminated.

Caution : The file name must conform to the UNIX file-naming conventions of the UNIX operating system, i.e., only 14 characters are significant.

PATH: o IF WAVE CHARACTERISTIC DATA ARE ENTERED VIA A FILE (Option 1 or 2, Question BC-10) THEN END.

BC-12 Question : **Enter WAVE TYPE OPTION >**

Options : 1 = Wind-sea conditions.

2 = Swell conditions.

Preselect: BC-3, option 1; BC-10, option 3.

Define : The user must specify whether the input boundary conditions that he is entering represent locally generated wind-sea or swell. The BCGEN will convert the wave characteristics that the user enters into a two-dimensional spectrum (frequency-direction spectrum). The method of conversion depends on whether the waves are specified as sea or swell. This question will be repeated for each input interval that is specified in question GF-21, unless constant input boundary conditions are specified in question BC-2.

Caution : None.

BC-13 Question : **Enter the WAVE HEIGHT (m) >**

Options : Variable.

Preselect: BC-3, option 1; BC-10, option 3.

Define : The user must enter the energy-based wave height to be used as an input boundary condition.

Caution : Units must be in meters (m).

BC-14 Question : **Enter PEAK SPECTRAL WAVE PERIOD (sec) >**

Options : Variable.

Preselect: BC-3, option 1; BC-10, option 3.

Define : The user must enter the peak spectral wave period associated with the wave height identified in question BC-13.

Caution : Units must be in seconds (sec).

BC-15 Question : **Enter MEAN PROPAGATION DIRECTION (deg) >**

Options : $0 \le$ VALUE < 360.

Preselect: BC-3, option 1; BC-10, option 3.

Define : The user must enter the mean propagation direction of the wave spectrum to be used as an input boundary condition.

Caution : Units must be in degrees (deg) using the Cartesian reference system shown in Figure 8-1.

BC-16 Question : **Enter WATER DEPTH (m) >**

Options : Variable.

Preselect: BC-3, option 1; BC-10, option 3.

Define : The user must enter the water depth associated with the spectral wave boundary condition described in questions BC-13 through BC-15. It is recommended that the average depth along the input boundary of the grid be used. The input wave energy spectrum applied along the input boundary of the grid is derived based on this water depth.

Caution : Units must be in meters (m).

PATH :

- **IF BOUNDARY CONDITIONS ARE CONSTANT (option 1, question BC-2), THEN END.**
- **IF BOUNDARY CONDITIONS ARE NOT CONSTANT (option 2, question BC-2), THEN REPEAT QUESTIONS BC-12 THROUGH BC-16 UNTIL ALL BOUNDARY CONDITIONS ARE ENTERED, THEN END.**

BC-17 Question : **Enter WAVE TYPE OPTION >**

Options : 1 = Wind-sea conditions.

2 = Swell conditions.

Preselect: BC-3, option 2.

Define : See description in BC-12.

Caution : None.

BC-18 Question : **Enter the PEAK SPECTRAL FREQUENCY (Hz) >**

Options : > 0.

Preselect: BC-3, option 2.

Define : The peak frequency (f_m) of the spectrum must be specified.

[See question GF-27, Chapter 7.]

Caution : Units must be in Hertz (Hz).

BC-19 Question : **Enter the PHILLIPS' EQUILIBRIUM CONSTANT >**

Options : 0 < VALUE $\le$ 0.1.

Preselect: BC-3, option 2.

Define : The Phillips' Equilibrium constant for the spectrum must be specified. [See question GF-27, Chapter 7.]

Caution : None.

BC-20 Question : **Enter the SPECTRAL PEAKEDNESS FACTOR >**

Options : $1 < VALUE \leq 20$.

Preselect: BC-3, option 2.

Define : The "peakedness" factor for the spectrum must be specified. [See question GF-27, Chapter 7.]

Caution : None.

BC-21 Question : **Enter the SPECTRAL WIDTH FACTOR >**

Options : $0 < VALUE \leq 0.2$.

Preselect: BC-3, option 2.

Define : The spectral peak width factor for frequencies below the peak spectral frequency must be specified. [See question GF-27, Chapter 7.]

Caution : None.

BC-22 Question : **Enter the SPECTRAL WIDTH FACTOR >**

Options : $0 < VALUE \leq 0.2$.

Preselect: BC-3, option 2.

Define : The spectral peak width factor for frequencies above the peak spectral frequency must be specified. [See question GF-27, Chapter 7.]

Caution : None.

BC-23 Question : **Enter the MEAN SPECTRAL PROPAGATION DIRECTION (deg) >**

Options : $0 \leq VALUE < 360$.

Preselect: BC-3, option 2.

Define : The mean propagation direction of the spectrum must be specified. The directional distribution specified in question BC-5 will be applied about the mean propagation direction.

Caution : Units must be in degrees (deg) using the Cartesian reference system shown in Figure 8-1.

BC-24 Question : **Enter the WATER DEPTH (m) >**

Options : Variable.

Preselect: BC-3, option 2.

Define : See question BC-15 above.

Caution : Units must be in meters (m).

PATH : o IF BOUNDARY CONDITIONS ARE CONSTANT (option 1, question BC-2), THEN END.

- o **IF BOUNDARY CONDITIONS ARE NOT CONSTANT (option 2, question BC-2), THEN REPEAT QUESTIONS BC-17 THROUGH BC-24 UNTIL ALL BOUNDARY CONDITIONS ARE ENTERED, THEN END.**

BC-25 Question : **Enter 1-D SPECTRA INPUT OPTION >**

Options : 1 - Read headers and spectra from a file.

2 - Enter headers and spectra.

3 - Enter headers, read spectra from a file.

Preselect: BC-3, option 3.

Define : The method for entering the one-dimensional spectra must be specified. The header contains the following information: the wave-type option (question BC-27), the mean spectral propagation direction (question BC-28), and the water depth for the input boundary conditions (question BC-29). If the headers are read from a file, then questions BC-27 through BC-29 will not be asked.

Caution : If option 2 is selected, the user will be required to input the headers and the spectra interactively. The spectra must contain energy density values for each frequency band (question GF-8) for each input interval (question GF-20), unless constant boundary conditions are selected in question BC-2.

PATH: o IF SPECTRAL DATA ARE ENTERED INTERACTIVELY (Option 2, question BC-25), GO TO BC-27.

BC-26 Question : **Enter the name of the SPECTRAL DATA FILE >**

Options : ≤ 14 significant characters.

Preselect: BC-3, option 3; BC-25, option 1 or 3.

Define : The name of the file containing the one-dimensional frequency spectral data must be entered.

Caution : If the file name entered is improper, or if an error occurs while the module reads the file, the Boundary Condition File-Building session will terminate. No information will be saved. The user will have to correct the file before rerunning the Boundary Condition File-Building Routine.

The file name must conform to the file-naming conventions of the UNIX operating system, i.e., 14 significant characters.

PATH: o IF SPECTRAL DATA AND HEADERS ARE ENTERED BY FILE (Option 1, question BC-25), END BOUNDARY CONDITION FILE-BUILDING ROUTINE.

BC-27 Question : **Enter WAVE TYPE OPTION >**

Options : 1 - Wind-sea conditions.

2 - Swell conditions.

3 - Sea and swell conditions.

Preselect: BC-3, option 3; BC-25, option 2 or 3.

Define : See question BC-12 above.

Caution : None.

BC-28 Question : **Enter MEAN SPECTRAL PROPAGATION DIRECTION (deg) >**

Options : $0 \leq$ VALUE < 360.

Preselect: BC-3, option 3; BC-25, option 2 or 3.

Define : The mean direction of propagation of the spectra must be specified. The module will apply the specified directional distribution shape selected in question BC-5 about the mean direction.

Caution : Units must be in degrees (deg) using the Cartesian reference system illustrated in Figure 8-1.

BC-29 Question : **Enter WATER DEPTH (m) >**

Options : Variable.

Preselect: BC-3, option 3; BC-25, option 2 or 3.

Define : The user must enter the water depth associated with the spectra entered. It is recommended that an average depth be used for the input boundary of the grid.

Caution : Units must be in meters (m).

PATH: o IF SPECTRAL DATA ARE ENTERED BY FILE (Option 3, question BC-25), END BOUNDARY *CONDITION FILE-BUILDING* ROUTINE.

BC-30 Question : **Enter the 1-D FREQUENCY SPECTRA (m^2/Hz) >**

Spectral Energy Value ##:

Options : Variable.

Preselect: BC-3, option 3; BC-25, option 3.

Define : The spectral energy density values must be entered for each frequency band in the spectrum (question GF-8).

Caution : The first spectral energy value corresponds to the lowest frequency. Units must be in m^2/Hz.

PATH: o END BOUNDARY CONDITION FILE-BUILDING ROUTINE.

BC-31 Question : **Enter 2-D SPECTRA INPUT OPTION >**

Options : 1 - Read headers and spectra from a file.

2 - Enter headers, read spectra from a file.

Preselect: BC-3, option 4.

Define : The method for entering the two-dimensional spectra must be specified. The header includes the values for the wave type option, the water depth, the wind speed, and wind direction (questions BC-33 through BC-36).

Caution : None.

BC-32 Question : **Enter the name of the SPECTRAL DATA FILE >**

Options : ≤ 14 significant characters.

Preselect: BC-3, option 4.

Define : The spectral data file name must be provided. This file contains the two-dimensional wave energy spectra information in the format described in Part IV, Spectral Wave Modeling Module File Descriptions.

Caution : The file name must conform to the file-naming conventions of the UNIX operating system, i.e., up to 14 significant characters. If no file name is provided or an error is encountered when the module reads the file, the Boundary Condition File-Building Routine will end. No information will be saved. The user must correct the file before the Boundary Condition File-Building Routine can be rerun.

PATH: o IF HEADERS ARE ENTERED BY FILE (Option 1, question BC-31), END BOUNDARY CONDITION FILE-BUILDING ROUTINE.

BC-33 Question : **Enter WAVE TYPE OPTION >**

Options : 1 = Wind-sea conditions.

2 = Swell conditions.

3 = Sea and swell conditions.

Preselect: BC-3, option 4; BC-31, option 2.

Define : See question BC-12 above.

Caution : None.

BC-34 Question : **Enter WATER DEPTH (m) >**

Options : Variable.

Preselect: BC-3, option 4; BC-31, option 2.

Define : The user must enter the water depth associated with the spectra entered. The water depth will be assumed to be valid at every point along the input boundary of the grid (question BC-16). It is recommended that an average depth be used for the input boundary of the grid.

Caution : Units must be in meters (m).

BC-35 Question : **Enter WIND SPEED (knots) >**

Options : 0 < VALUE < 100.

Preselect: BC-3, option 4; BC-31, option 2.

Define : The wind speed is used to separate the spectrum into wind-sea spectra and swell spectra. It is assumed that energies in spectral frequencies with phase speeds greater than the wind speed are part of the swell spectrum. Those energies in spectral frequencies with phase speeds less than the wind speed are part of the wind-sea spectrum.

Caution : The wind speed must be given in knots and must represent the equivalent overwater, 10-m elevation, neutrally stable value. If the user selected option 1 or 2 in question BC-33, then the spectrum has already been identified as wind-sea or swell, and the wind speed entered here will be ignored.

BC-36 Question : **Enter WIND DIRECTION (deg) >**

Options : 0 ≤ VALUE < 360.

Preselect: BC-3, option 4; BC-31, option 2.

Define : Wind direction associated with wind speed entered on question BC-35.

Caution : The units must be in degrees (deg) using the Cartesian reference system shown in Figure 8-1.

PATH: o END BOUNDARY CONDITION FILE-BUILDING ROUTINE

Function to Run Programs

23. If a user is ready to run the module programs for a particular application, then the task of composing and formatting all of the necessary input data into the proper files has been completed. Running the programs simply entails specifying which program should be run. In most cases, the BCGEN program will be run first to create input boundary conditions for STWAVE, and then STWAVE will be run to simulate the transformation of the boundary conditions across the computational grid. The only exception is when STWAVE is used to conduct a subgrid simulation of a preceding SHALWV simulation.

Running BCGEN

24. The Boundary Condition File-Building Routine must be used to build the input file for the BCGEN prior to running the program. The BCGEN program is then run to generate the input boundary conditions for STWAVE. When an STWAVE simulation is a subgrid computation for a previous SHALWV run, then the BCGEN is not used because the boundary conditions for STWAVE will be obtained from the preceding SHALWV simulation (described in Part II).

Running STWAVE

25. When the STWAVE program is selected, the user is asked to specify a reference name under which the STWAVE output data will be stored. The reference name must conform to the file-naming conventions of the UNIX operating system and should NOT have a file name extension, like ".dat" or ".out." (The UNIX file-naming convention allows up to 14 significant characters, including the extension.) The module uses the reference name to create three output files (described in Part IV). Each file has the user-specified reference name with a unique extension.

26. The first output file created by STWAVE is the Wave Field File (given the ".mtx" extension), which contains the energy-based wave height, peak spectral period, and mean spectral propagation direction for each grid point for each output interval (specified in question GF-21) of the simulation. The second output file is the Wave Spectra File (given the ".spe" extension), which contains the frequency and frequency-direction spectra for each specified output location (questions GF-22 & GF-23) and for each output interval. The third output file is the Wave Characteristics File (given the extension ".sea"), which contains the energy-based wave height, peak spectral period, and mean spectral propagation direction for each specified output location and for each output interval.

Function to Plot/Print STWAVE Output

27. The graphical and statistical post-processing features of the module for STWAVE are identical to those for SHALWV. Hence, the user may refer to Chapter 7 for more information.

PART IV: SPECTRAL WAVE MODELING MODULE FILE DESCRIPTIONS

STWAVE Files

28. The organization of the files used in the STWAVE branch of the Spectral Wave Modeling module is shown in Figures 8-3 through 8-5. A list of all of the files (and related file numbers) used by the STWAVE branch of the CMS Spectral Wave Modeling module is provided in Table 8-1. The reference numbers in Table 8-1 match the numbers given in Figures 8-3 and 8-4. In general, the creation, organization, and usage of almost all of the files in the CMS Spectral Wave Modeling module are transparent to the user. That is, the module creates and organizes the files, prompting the user for information only when necessary. For reference, however, a brief description of the data and data format required by each file is provided below.

Table 8-1

STWAVE Files

File Title	Name	Reference Number
General Input File	stwavein.swv	2
Bathymetry File	user-specified	1
Spectral Data File	user-specified	7
BCGEN Input File	boundin.swv	8
Boundary Condition File (for STWAVE)	boundout.swv	3
Wave Field Output File	user-specified + .mtx	9
Wave Spectra Output File	user-specified + .spe	10
Wave Characteristics Output File	user-specified + .sea	11
Parameter File	file1.swv	4
Main File Name File	filenmi.swv	5
Post-Processing File Name File	filenmpst.swv	12
Wave Characteristics Input File	user-specified	6

File Descriptions and Data Formats

General Input File

29. The General Input File is one of the files built by the General File-Building Routine. The General Input File contains program flow control parameters for STWAVE, spectral frequency and direction discretization parameters, computational grid parameters, and node locations for output of model results.

a. RECORD 1, Format (2I5, 3F10.2).

    Field 1 - Number of columns in grid (Figure 8-1).
    Field 2 - Number of rows in grid (Figure 8-1).
    Field 3 - Length dimension of grid column (m).
    Field 4 - Length dimension of grid row (m).
    Field 5 - Grid rotation angle (Figure 8-1).

b. RECORD 2, Format (I5, 2F10.3).

    Field 1 - Number of spectral frequency bands.
    Field 2 - First frequency band value (Hz).
    Field 3 - Frequency band increment (Hz).

c. RECORD 3, Format (I5, F10.2).

    Field 1 - Number of spectral direction bands.
    Field 2 - Extreme exclusion angle (deg).

d. RECORD 4, Format (I5).

    Field 1 - 1

e. RECORD 5, Format (11I5, F10.2).

    Fields 1-4 - 0
    Field 5 - Number of special output locations.
    Fields 6-8 - 0
    Field 9 - 3
    Field 10 - Number of hours between input boundary conditions.
    Field 11 - Number of input boundary conditions.
    Field 12 - Depth unit conversion factor.

f. RECORD 6, Format (2I5). (Repeated for each special output location.)

    Field 1 - Column for special output location.

Field 2 - Row for special output location.

Bathymetry File

30. The Bathymetry File can be built during operation of the General File-Building Routine. However, because the number of bathymetry data is usually large, it is recommended that users build this file using the most convenient editor available to them. The Bathymetry File is a matrix of numbers indicating the depth at each point on the computational grid (see questions GF-13 through GF-19). Depth values may be entered in any units desired, but they must all have the SAME units. A depth-unit conversion factor must be entered during the General File-Building Routine (question GF-14) to convert the user's depth units to meters.

a. If Field 6 on RECORD 2 of the General Input File is 1, then Format (F6.0).

Field 1 - Uniform (constant) water depth value.

b. If Field 6 on RECORD 2 of the General Input File is 2, then Format (21F6.0).

Fields 1-21 - Matrix of depth values for each point on the computational grid. Values equal to zero (0.0) are considered land.

Note: Only 21 values are allowed per row. If the computational grid has more than 21 values on a row, then 21 values are entered on the first record and the remaining numbers are placed on additional records until the entire row of values has been entered. The second and subsequent rows of the computational grid begin on a new record.

BCGEN Input File

31. The BCGEN Input File is generated by the Boundary Condition File-Building routine to be used as input to the BCGEN program. The BCGEN Input File contains the program control parameters and necessary information for generating boundary conditions for the STWAVE simulation. It is recommended that this file be created and modified only through the Boundary Condition File-Building Routine, so that consistency can be maintained in file organization and program control parameters.

a. RECORD 1, Format (2I5).

Field 1 - 1 = Boundary conditions are constant.

2 = Boundary conditions are time-varying.

Field 2 - 1 = Wave characteristics are specified.

2 = Wave spectral parameters are specified.

3 = One-dimensional spectra are specified.

4 = Two-dimensional spectra are specified.

b. RECORD 2, Format (2F10.2).

Field 1 - Extreme angle exclusion (deg).

Field 2 - Rotation angle for grid (deg Cartesian).

c. RECORD 3, Format (8I5).

Field 1 - Number of spectral frequency bands.

Field 2 - Number of spectral direction bands.

Field 3 - 0 = frequency band values are computed.

Field 4 - Spectral shape criteria where:

4 = TMA

Field 5 - Spectral spreading function where:

1 = $\cos^{nn\theta}$

2 = $\cos^{2p}(\theta/2)$ (Gamma Function)

Field 6 - 3

Field 7 - 0

Field 8 - Specifies method for determining p in spectral spreading function specified in Field 5 where:

0 = p computed.

1 = p entered.

d. RECORD 4, Format (I5). If Field 5 on RECORD 3 is 1, then this record is used.

Field 1 - nn, the spectral spreading exponent.

e. RECORD 5, Format (F5.1). If Field 5 on RECORD 3 is 2, and Field 8 on RECORD 3 is 1, then this record is used.

Field 1 - p, the spectral spreading exponent.

f. RECORD 6, Format (10F7.4). If Field 3 on RECORD 3 is 1, then this record is used.

Fields 1-10 - frequency band values (Hz). An additional record may be used.

g. RECORD 7, Format (2F7.4). If Field 3 on RECORD 3 is 0, then this record is used.

Field 1 - Initial frequency band value (Hz).

Field 2 - Frequency band value interval (Hz).

h. RECORD 8, Format (I5).

Field 1 - Maximum number of input intervals.

i. RECORD 9, Format (I5).

Field 1 - Number of input boundary condition locations.

j. RECORD 10, Format (3I5, F8.2).

Field 1 - 0 = Main input side.

Field 2 - Input boundary condition column location.

Field 3 - Input boundary condition row location.

Field 4 - Depth at input boundary condition location.

This record is repeated for each input boundary condition location.

k. RECORD 11, Format (I5, 4F6.1, I10). If Field 2 of RECORD 1 is 1, then this record is used. A record is required for each input time interval.

Field 1 - Wave type option.

Field 2 - Wave height (m).

Field 3 - Wave period (sec).

Field 4 - Wave propagation direction (deg Cartesian).

Field 5 - Water depth (m).

Field 6 - Date/time for input (yymmddhh).

l. RECORD 12, Format (I5, 2F6.4, 2F6.1, F6.1, F7.2, I10). If Field 2 of RECORD 1 is 2, then this record is used. A record is required for each input time interval.

Field 1 - Wave type option.

Field 2 - Peak spectral frequency (Hz), f_m.

Field 3 - Phillips' Equilibrium Constant, α.

Field 4 - Spectral peakedness factor, γ.

Field 5 - Frequency shape factor, σ_a.

Field 6 - Frequency shape factor, σ_b.

Field 7 - Mean propagation direction (deg Cartesian).

Field 8 - Water depth (m).

Field 9 - Date/time for input (yymmddhh).

m. RECORD 13, Format (I5, 2F6.1, I10). If Field 2 of RECORD 1 is 3, then RECORDS 13 and 14 are used. A set of records is required for each input time interval.

Field 1 - Wave type option.

Field 2 - Mean propagation direction (deg Cartesian).

Field 3 - Water depth (m).

Field 4 - Date/time for input (yymmddhh).

n. RECORD 14, Format (6G12.5).

Fields 1-10 - Spectral energy values for each frequency band in m^2/Hz. Values must be provided from lowest to highest frequency band.

An additional record may be used for more frequency bands.

o. RECORD 15, Format (I5, 3F6.1, I10). If Field 2 of RECORD 1 is 4, then RECORDS 15 and 16 are used. A set of records is required for each input time interval.

Field 1 - Wave type option.

Field 2 - Water depth (m).

Field 3 - Wind speed (knots).

Field 4 - Wind direction (deg Cartesian).

Field 5 - Date/time for input (yymmddhh).

p. RECORD 16, Format (6G12.5).

Fields 1-10 - Spectral energy values for each direction band for a given frequency band (units are $m^2/(Hz \cdot rad)$). Values must be provided starting with the 0-deg band and the lowest frequency band.

Additional records may be used for more frequency bands.

Spectral Data File

32. The Spectral Data File contains wave energy spectra which the BCGEN program uses to generate boundary conditions for STWAVE. The Spectral Data File may contain either one- or two-dimensional spectral information for each input interval specified in question GF-21. If time-invariant boundary conditions are specified during the Boundary Condition File-Building Routine, then only one spectrum is required for each input station. Descriptions for the question numbers provided with the file data format below can be found in Part III, Module Functions and Routines.

One-Dimensional Input Boundary Condition Spectra

a. RECORD 1, Free Format.

This record is only used if Headers are specified as being read from a file during the Boundary Condition File-Building Routine.

Field 1 - Wave type option (question BC-27).

Field 2 - Mean propagation direction (question BC-28).

Field 3 - Water depth (question BC-29).

b. RECORD 2, Free Format.

The fields on this record are filled with spectral values (up to 132 characters/record). Several records may be used to enter all of the spectral values. The energy values associated with each frequency should be in units of m^2/Hz. The values should be provided from the lowest to the highest frequency band.

RECORDS 1 and 2 are repeated for each data input interval.

Two-Dimensional Input Boundary Condition Spectra

a. RECORD 1, Free Format.

This record is only used if headers are specified as being read from a file during the Boundary Condition File-Building Routine.

Field 1 - Wave type option (question BC-33).

Field 2 - Water depth (question BC-34).

Field 3 - Wind speed (question BC-35).

Field 4 - Wind direction (question BC-36).

b. RECORD 2, Free Format.

The fields on this record are filled (up to 132 characters/record) until all of the spectral values for a given frequency are entered. Several records may be used. The spectral energy is entered for each direction band for a given frequency, beginning with the band at 0 deg in a Cartesian coordinate system (see Figure 8-1). After the values for each direction in a frequency band have been entered, a new frequency band is selected and a new record must be used. Several records may be used. The energy values associated with each frequency should be in units of $m^2/(Hz \cdot rad)$. The data should be provided from the lowest to the highest frequency band.

RECORDS 1 and 2 are repeated for each data input interval.

Boundary Condition File (for STWAVE)

33. The Boundary Condition File (for STWAVE) is output from the BCGEN program. The data for this file are written in binary form and, therefore, the format is not described.

Subgrid Boundary Condition File

34. The Subgrid Boundary Condition File is created by SHALWV for use by STWAVE. SHALWV fills the file with boundary condition information for a subsequent STWAVE subgrid simulation. The data are written to the file in binary form. Therefore, format and data within the file are not described.

Wave Field Output File

35. The Wave Field Output File contains the energy-based significant wave height, the peak spectral period, and the mean spectral propagation direction for each point on the computational grid for each output interval specified in question GF-21. The data are oriented in the file for a given output interval with the matrix of energy-based wave heights provided first, followed by the peak spectral wave periods, and then the mean spectral propagation directions.

Wave Spectra Output File

36. The Wave Spectra Output File contains the frequency and frequency-direction wave energy spectra for each output location specified in questions GF-22 and GF-23 for each output time interval specified in question GF-21. The first record contains (from left to right) the date, the column and row for the output location, and an assigned station number.

37. The matrix of numbers that follows the first record contains both the frequency and frequency-direction spectrum for the specified location and date. The first column contains the frequency spectrum (in square centimeters). The top of the column corresponds to the lowest frequency. The frequency values associated with the energy values in the first column were specified through questions GF-9 and GF-10. The other columns contain the frequency-direction spectrum (in square centimeters). Each row corresponds to the same frequency in the adjacent frequency spectrum. The first column of the frequency-direction spectrum corresponds to the direction band at $-90° + \epsilon$ where ϵ is defined in question GF-12, and the reference system is defined in Figure 8-1. The width of each direction band is defined in question GF-11.

Wave Characteristics Output File

38. The Wave Characteristics Output File contains the energy-based wave height, peak spectral period, and mean spectral propagation direction for the total energy spectrum for each specified output location (questions GF-22 and GF-23) and each output interval (question GF-21). The values in each record have the following definitions: (from left to right)

1. The date (yymmddhhmm).
2. The column of the output location.
3. The row of the output location.
4. The location identification number (station number).

5. The energy-based wave height of the spectrum (m).

6. The peak spectral period (sec).

7. The mean spectral propagation direction (see Figure 8-1).

8.-15. 0.

Parameter File

39. The Parameter File is created by the General File-Building Routine. The values in the Parameter File are used to dimension variables in STWAVE and its supporting programs. The programs use the FORTRAN command "INCLUDE" to include the Parameter File in the programs during compilation. The Parameter File contains a FORTRAN "PARAMETER" statement. The variables in the "PARAMETER" statement are defined below:

IDMN = Number of columns in the computational grid.

JDMN = Number of rows in the computational grid.

IF = Number of spectral frequency bands.

IA = Number of spectral direction bands.

KSST = 0

MKST = 0

NBPS = 0

NDIF = 0

ITDM = Number of output intervals.

NDMN = Number of special output locations.

MODEL = 2, specifies STWAVE model.

INDM = Number of input data sets.

Main File Name File

40. The Main File Name File contains the names of the General Input File and the Bathymetry File. The format for the Main File Name File is provided below.

a. RECORD 1, Free Format.

Field 1 - Blank.

b. RECORD 2, Free Format.

Field 1 - General Input File Name.

c. RECORD 3, Free Format.

Field 1 - Bathymetry Data File Name.

d. RECORD 4, Free Format.

Field 1 - Boundary Condition Option Number.

Boundary Condition File Name File

41. The Boundary Condition File Name File contains the name of the Boundary Condition File generated by the BCGEN, or by the General File-Building Routine (when conducting a subgrid simulation) for STWAVE. The format for the Boundary Condition File Name File is provided below.

a. RECORD 1, Free Format.

Field 1 - Boundary Condition File Name.

Post-Processing File Name File

42. The Post-Processing File Name File contains the names of the data output files generated by STWAVE. The files include the Wave Field Output File, the Wave Characteristics Output File, and the Wave Spectra File. The format for the Post-Processing File Name File is provided below.

a. RECORD 1, Free format.

Field 1 - Name of the ".sea" file.

Field 2 - Name of the ".spe" file.

Field 3 - Name of the ".mtx" file.

(See Part III, "Function to Run Programs," for description.)

REFERENCES

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Chapter 9

HARBOR WAVE OSCILLATION MODEL (HARBD) THEORY AND PROGRAM DOCUMENTATION

PART I: INTRODUCTION

Background

1. Excessive wave action in harbors is caused by resonance or inadequate protection from structures such as breakwaters or jetties. Harbor resonance is the phenomenon that occurs when the natural period of a harbor is equal or close to an incident wave period. The effects of this wave activity should be avoided or minimized in harbor planning and operation, since the impact on navigation or mooring of vessels will be adverse or will result in sediment deposition or erosion within the harbor. This chapter documents the harbor wave oscillation model (HARBD) developed at the US Army Engineer Waterways Experiment Station (WES) Coastal Engineering Research Center (CERC) for use in the design and modification of harbors. The theoretical basis of the model is described in Chen (1984, 1986), and the numerical scheme of the model is described in Chen and Mei (1974). A description of the theoretical basis of the finite element method, which is used in HARBD, is beyond the scope of this chapter. It is recommended that the user refer to an introductory text pertaining to the finite element method for a better understanding of the numerical techniques used in the model (Mori 1983).

2. A number of numerical models have been used to investigate the effects of harbor resonance. For example, Lee 1969; Chen and Mei 1974; Yue, Chen, and Mei 1976; Berkoff 1976; Houston 1981; Lepelletier 1981; Ganaba, Welford, and Lee 1982; Behrendt and Jonsson 1984; Skovgaard, Behrendt, and Jonsson 1984; Yoshida, Ijima, and Okuzono 1984; Matsoukis 1985; and Chen 1986 implement various numerical techniques including the ray method, Green's function method, eigen-function method, finite difference method, finite element method, and hybrid element method (Crawford and Chen 1988). HARBD uses a hybrid element method in this steady-state model, based on linear wave theory. The model is used in the study of wave oscillations in harbors and wave scattering in the water domain with boundaries of arbitrary configuration

and variable bathymetry. The effects of bottom friction and boundary reflection are included. The bottom friction is assumed to be proportional to flow velocity with a phase difference. The boundary reflection is formulated similar to the impedance condition in acoustics, and is expressed in terms of the wave number ($2\pi/L$ where L is the wavelength) and the reflection coefficient of the boundary. A hybrid element method based on a variational principal is used for the numerical solution (Chen and Houston 1987). The model was originally developed for harbor oscillations (long-period waves), and the general formulation was adapted for wind waves (short-period waves) by Houston (1981).

3. HARBD has been tested and compared with known analytical solutions for a number of cases and the results are excellent (Chen 1984; Chen and Houston 1987). It has been applied in the design or modification of Agat Harbor, Guam (Farrar and Chen 1987); Kawaihae Harbor, Hawaii (Lillycrop, Bratos, and Thompson 1990); Barbers Point Harbor, Oahu, Hawaii (Durham 1978); and has been recently applied to Maalaea Harbor, Maui, Hawaii. The model was instrumental in studying the effects of entrance channel dredging at Morro Bay Harbor, California (Kaihatu, Lillycrop, and Thompson 1989), and analyzing harbor resonance at Los Angeles-Long Beach Harbor, California (Sargent 1989). The model was used to plan wave protection at Fisherman's Wharf, San Francisco, CA (Bottin, Sargent, and Mize 1985); Green Harbor, Massachusetts (Weishar and Aubrey 1986); Los Angeles-Long Beach Harbor, California (Houston 1976); and to estimate the wave conditions in Indiana Harbor, Indiana (Clausner and Abel 1986). HARBD was compared to laboratory data collected from the physical model study of Barcelona Harbor, Buffalo, NY (Crawford and Chen 1988) with encouraging results. The predictions of HARBD are currently under further comparison with prototype and physical model data collected from recent studies of Barbers Point Harbor, Oahu, Hawaii.

Report Organization

4. This chapter is divided into five sections; Part II presents the mathematical formulations, assumptions, and limitations, Part III defines the input data format, Part IV discusses the model's input data requirements and finite element grid generation, and Part V contains two illustrative examples.

PART II: MATHEMATICAL FORMULATION

Assumptions and Limitations

5. Proper application of any model requires a clear understanding of the physical processes occurring and a comprehension of the capabilities for a given model to simulate those processes. Model results should provide a realistic representation of the physical system being modeled.

6. The limitations of a model define its range of applicability. Assumptions in applying HARBD include: (a) steady-state (or time-independent) conditions, (b) linear monochromatic waves, (c) small gradients in bathymetry, (d) neglect of wave-wave or wave-current interaction, (e) neglect of wave breaking, (f) neglect of wave transmission or overtopping of structures such as breakwaters and jetties, and (g) representation of diffraction around tips of structures by diffraction around a blunt vertical wall with specified reflection coefficients. HARBD is also limited by the radial extent of the open-water boundary surrounding the harbor. The offshore area beyond the open-water boundary is assumed to have a constant water depth and no bottom friction; therefore, prototype bathymetry and shoreline configuration beyond the open-water boundary cannot be modeled exactly.

7. It is crucial that the user follow all specifications required of the HARBD model in generation of the finite element grid used as input. The input grid to the HARBD model is unique from other finite element models in that specific grid constraints are required for proper application. Additional information regarding grid generation is given in Part IV of this chapter.

Boundary Value Problem

8. HARBD uses a hybrid element method in which a finite-element solution in the interior region of the harbor is matched to an analytical solution in the exterior region. In the interior region, HARBD allows arbitrary depth (i.e., shallow, intermediate, and deepwater waves), variable geometry, and consideration for the effects of bottom friction and boundary reflection.

9. In model formulation for arbitrary depth water waves, the entire water domain is divided into near and semi-infinite regions, A and B , respectively. The two regions are separated by an artificial 180-deg* semicircular boundary ∂A as shown in Figure 9-1. The near region A is bounded by a wall boundary ∂C and should include the harbor and all marine structures and bathymetry of interest. The semi-infinite region B is a 180-deg semicircular ring shape which is bounded by ∂A and the straight horizontal coastlines along the x-axis. The region extends to infinity in all directions, as shown in Figure 9-1. The semi-infinite region B is assumed to have a constant water depth and no bottom friction (Chen and Houston 1987).

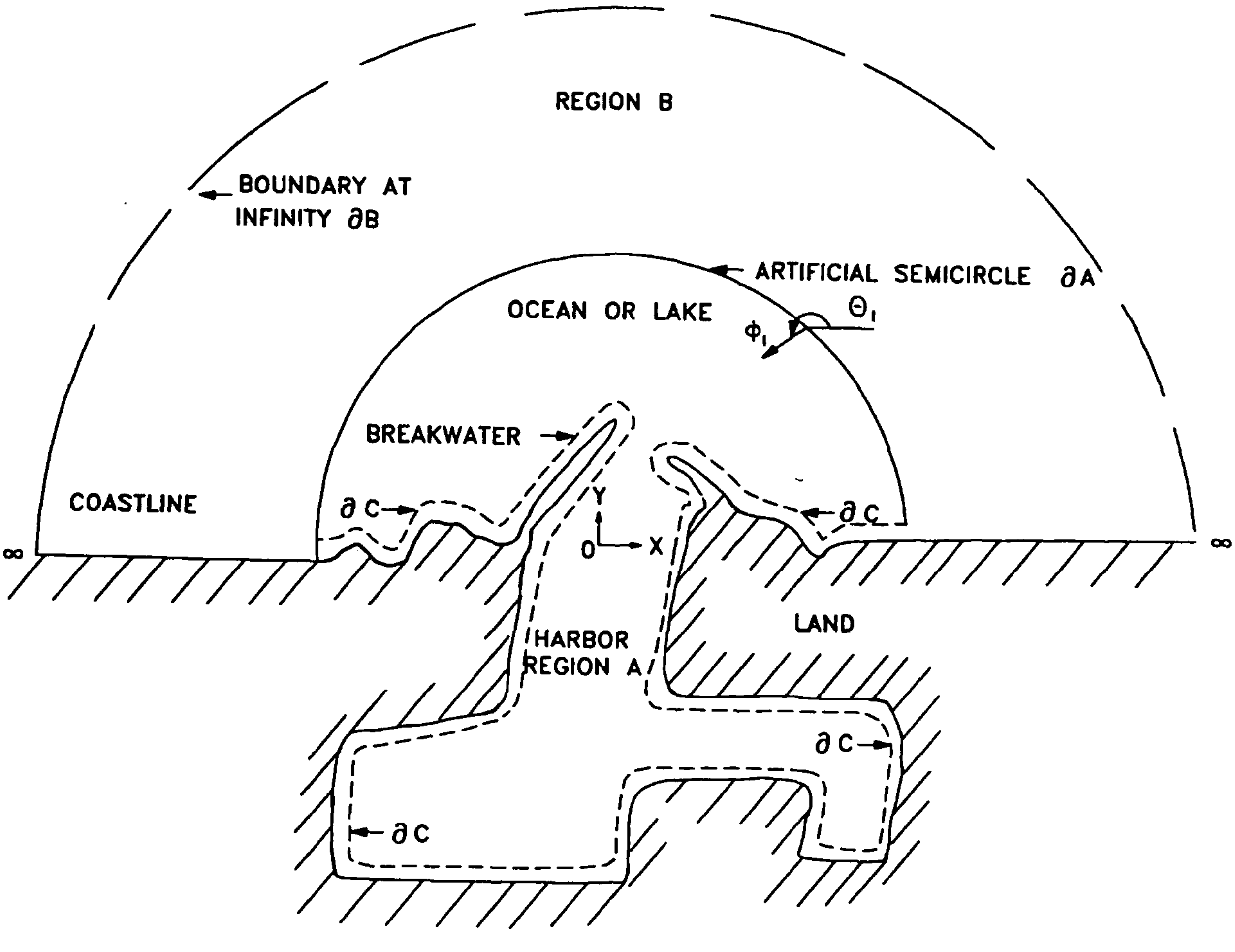

Figure 9-1. Definition sketch of a harbor

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

10. The governing partial differential equation is derived through application of linear wave theory to the continuity and momentum equations. This also assumes all dependent variables are periodic in time with angular frequency ω. These steps yield the following generalized Helmholtz equation (Chen 1986):

$$\nabla\cdot(\lambda c c_g \nabla\phi) + \frac{c c_g}{c}\omega^2\phi = 0 \qquad (9\text{-}1)$$

where ∇ = horizontal gradient operator

λ = complex bottom friction factor

c = wave phase velocity = (ω/κ)

c_g = wave group velocity = $[c/2\{1 + (2\kappa h/\sinh 2\kappa h)\}]$

κ = wave number, $(2\pi/L)$, where L = wavelength

h = water depth

ϕ = velocity potential

ω = angular frequency

The wave number is obtained from the dispersion relation

$$\omega^2 = g\kappa \tanh(\kappa h) \qquad (9\text{-}2)$$

where g = acceleration due to gravity

11. The complex bottom friction factor λ is assumed proportional to the maximum velocity at the bottom and is defined as:

$$\lambda = \frac{1}{1 + \dfrac{i\beta a_o}{h \sinh \kappa h}\exp(i\gamma)} \qquad (9\text{-}3)$$

where i = $(-1)^{1/2}$

β = dimensionless bottom friction coefficient that varies spatially

a_o = incident wave amplitude

h = water depth

κ = wave number $2\pi/L$, where L = wavelength

γ = phase shift between stress and flow velocity

The effects of bottom friction do not necessarily need to be included in the general solution. This is accomplished by setting $\beta = 0$, which results in $\lambda = 1$, and Equation 9-1 reduces to an expression which excludes bottom friction.

12. Equation 9-1 is the field equation that is solved for the velocity potential ϕ . In order to solve for ϕ , the boundary conditions must first be established. Since the field is separated into the two regions, A and B , there are two boundary conditions to establish. The two boundary conditions are: (a) along the interface between the solid harbor boundaries ∂C and near region A , and (b) along the interface between the ocean boundary ∂A and the semi-infinite region B . The goal is to solve for the velocity potential ϕ in regions A and B with the assumptions governing these regions.

13. The velocity potential does not have a physical meaning in engineering practice. However, if ϕ is obtained through Equation 9-1, it can be related to physical quantities such as velocities, pressures, or free surface displacement. The user is referenced to Dean and Dalrymple (1984) for the theoretical development of the velocity potential ϕ .

14. The horizontal flow velocities u and v in the x- and y-directions, respectively, the hydrodynamic pressure P_d , and the free surface displacement ζ are related to the velocity potential ϕ by:

$$u(x,y,z,t) = \lambda f \frac{\partial \phi}{\partial x} e^{-i\omega t} \tag{9-4}$$

$$v(x,y,z,t) = \lambda f \frac{\partial \phi}{\partial y} e^{-i\omega t} \tag{9-5}$$

$$P_d(x,y,z,t) = \rho i \omega f \phi e^{-i\omega t} \tag{9-6}$$

$$\zeta(x,y,t) = \frac{i\omega}{g} \phi e^{-i\omega t} \tag{9-7}$$

where z = vertical coordinate with the origin at the still-water surface

t = temporal variable

ρ = water density

f = vertical dependency of the wave field given as:

$$f = \frac{\cosh \kappa(z + h)}{\cosh \kappa h} \tag{9-8}$$

15. The objective is to solve Equation 9-1 for the velocity potential ϕ . To accomplish this, the two boundary conditions along ∂A and ∂C are needed. For the boundary condition along the solid harbor boundaries ∂C (Figure 9-1), the model uses the impedance condition used in acoustics which relates the flow velocity u , hydrodynamic pressure P_d , and free surface displacement ζ to the velocity potential ϕ , and is expressed as:

$$\frac{\partial \phi}{\partial n} - \alpha \phi = 0 \tag{9-9}$$

and

$$\alpha = i\kappa \frac{1 - K_r}{1 + K_r} \tag{9-10}$$

where n = unit-normal vector directed outward from the fluid domain

α = dimensional coefficient related to the boundary reflection

K_r = reflection coefficient of the boundary

Similar to the friction coefficient, when $K_r = 1$, then $\alpha = 0$, and Equation 9-9 reduces to a zero velocity potential normal to the boundary (Sargent 1989). This infers a perfectly reflecting boundary condition.

16. After the field equation and the boundary condition along the solid harbor boundaries ∂C have been specified, attention must be given to solving the "open ocean" boundary ∂A . The "hybrid" nature of the solution method is used to solve Equation 9-1 for ϕ . Basically, the velocity potential ϕ can be separated into several components. Once each component is determined, its relationship to the others is used to solve for ϕ .

17. For a harbor in a semi-infinite ocean with a straight coastline, there are incident, reflected, and scattered waves. The sum of the velocity

potentials of these waves is the velocity potential of the total wave ϕ . An incident wave is assumed to arrive from infinity. Water depth is assumed to be constant in the semi-infinite region B , and along the open ocean boundary ∂A . It is important to characterize the incident angle of approach θ_I relative to the x-axis (Figure 9-1). The velocity potential of the incident wave ϕ_I can be expressed in general terms as:

$$\Phi_I = \phi_I e^{-i\omega t}, \qquad \phi_I = -\frac{iga_o}{\omega} e^{i\kappa r \cos(\theta - \theta_I)} \tag{9-11}$$

where θ is the wave angle of the total wave.

18. As shown in Equation 9-11, a wave of amplitude a_o , angular frequency ω , and wave number κ can be expressed in terms of the velocity potential of the incident wave. If the water depth is constant, the reflected wave ϕ_A which originates in the near region A can easily be obtained for a given incident wave and a straight perfectly reflecting coastline. The reflected wave ϕ is equal to the incident wave ϕ_I . The scattered wave, which occurs in the semi-infinite region B , is the total wave less the incident and reflected wave, i.e.,

$$\phi_B = \phi - \phi_I - \phi_A \tag{9-12}$$

The scattered wave has a velocity potential ϕ_B given by:

$$\phi_B = \sum_{n=0}^{\infty} \alpha_n H_n(\kappa r) \cos(n\theta) \tag{9-13}$$

where α_n = unknown coefficients

$H_n(\kappa r)$ = Hankel functions of the first order n

r, θ = radial and angular variables in polar coordinates

19. Since the fluid domain in the semi-infinite region B is assumed to extend to infinity, the radiation condition that all scattered waves must behave as outgoing waves at infinity must be imposed. The velocity potential of the scattered wave satisfies this radiation condition. This condition is

known as the Sommerfeld radiation condition and is expressed mathematically as follows (Houston 1981):

$$\lim_{r \to \infty} \sqrt{r} \left(\frac{\partial}{\partial r} - i\kappa \right) \phi_B = 0 \qquad (9\text{-}14)$$

Solution Method

20. A method of solving the boundary value problem must be established. The field equation (Equation 9-1) and the variable to be solved for (velocity potential ϕ) have been identified. The two boundary conditions in the near and semi-infinite regions, A and B , respectively, have been established. In order to solve for the total velocity potential ϕ , the components of ϕ have been identified as the velocity potentials of the incident wave ϕ_I , the reflected wave ϕ_A in the near region, and the scattered wave ϕ_B in the semi-infinite region. Since the incident wave is known, the reflected and scattered waves must be solved for with the hybrid element method described in the following section.

Hybrid Element Solution Method

21. The hybrid element method (so named because the method involves the combination of analytical and finite element numerical solutions) is used to solve the aforementioned boundary value problem (Equation 9-1). In this solution, a conventional finite element approximation is used in the near region A , while an analytical solution with unknown coefficients is used to describe the semi-infinite region B . To solve the boundary value problem, a linear functional must be established and minimized. The objective is to construct an approximate solution to the boundary value problem in terms of the functional. A variation-of-principles approach is used to minimize the functional. Once the first and second variations of the functional are calculated, it is a necessary condition that the functional attain its stationary point. That is, when the functional is minimized, the first variation must vanish (Mori 1983). A Euler-Lagrange formulation is used to match the boundary value problem between regions A and B . The following

functional was constructed with the property that it is stationary with respect to the first variation of the velocity potential:

$$F(\phi) = \iint_A \frac{1}{2}\left[\frac{\lambda c c_g}{g}(\nabla\phi)^2 - \frac{\omega^2 c_g}{g\,c}\phi^2\right] dA + \int_{\partial B_\infty} \frac{i\kappa\lambda c c_g}{2\,g}(\phi - \phi_I)^2\, dL - \int_{\partial B_\infty} \frac{\lambda c c_g}{g}\frac{\partial\phi_I}{\partial n}\phi\, dL \qquad (9\text{-}15)$$

where ϕ_I is the incident wave velocity potential, n is a unit normal, and the last two integrals are line integrals at infinity. This functional (Equation 9-15) can be rewritten as follows:

$$\begin{aligned} F(\phi) = {} & \iint_A \frac{1}{2}\left[\frac{\lambda c c_g}{g}(\nabla\phi_A)^2 - \frac{\omega^2 c_g}{g\,c}\phi_A^2\right] dA + \\ & \int_{\partial A} \frac{1}{2}\frac{\lambda c c_g}{2\,g}(\phi_B - \phi_I)\frac{\partial(\phi_B - \phi_I)}{n_A} \int_{\partial A} \frac{\lambda c c_g}{g}\,\partial\phi_A \frac{\partial(\phi_B - \phi_I) -}{\partial n_A} \\ & \int_{\partial A} \frac{\lambda c c_g}{g}\phi_A \bigg| \frac{\partial\phi_I}{\partial n_A} + \\ & \int_{\partial A} \frac{\lambda c c_g}{g}\phi_I \frac{\partial(\phi_B - \phi_I)}{\partial n_A} + \int_{\partial A} \frac{\lambda c c_g}{g}\phi_I \frac{\partial\phi_I}{\partial n_A} \end{aligned} \qquad (9\text{-}16)$$

22. In the near region A the finite element method is used to solve the integral equation obtained from minimizing the functional. Basically, this is a numerical approximation technique that divides the near region A within the bounding semicircular domain ∂A into a finite element mesh or finite number of nonoverlapping triangular sub-domains which are called elements (Houston, Carver, and Markle 1977).

23. The objective is to approximate the solution within each element by suitable interpolation functions in terms of a finite number of unknown parameters. The unknown parameters are the values of field variable ϕ at a finite number of coordinate pairs called nodes. These nodes are related to adjacent nodes by element connectivity (three nodes per triangular element). The relationships for individual elements are combined into a system of equations for all unknown parameters. The local water depth h and bottom friction factor β are defined at the element centers. The reflection coefficients K_r are specified at boundary elements, which are defined as a

subset of the element data. Once the physical geometry of the finite element mesh is defined, a series of values for wave period T, wave direction θ, and wave amplitude a_o can be supplied as input to the model (Sargent 1989).

24. In the semi-infinite region B outside the basin, the velocity potentials are solved analytically in terms of unknown coefficients α_n. The region is considered to be a single super-element with a shape function given by Equation 9-13, the velocity potential of the scattered wave ϕ_B. The shape functions are used to evaluate the integrals in Equation 9-16 and the functional is extremized with respect to the unknowns. A set of linear algebraic equations is then obtained. The infinite series given by Equation 9-13 must be truncated at some finite extent. The number of terms to maintain is dependent on the incident wavelength such that the addition of further terms is no longer sensitive to the solution for ϕ_B. The solution of the boundary value problem is now reduced to the solution of N linear algebraic equations for N unknowns (where N is the sum of the number of nodes in the finite element mesh of the near region A plus the number of unknowns in the truncated series in Equation 9-13) (Houston 1981).

25. Upon solving the system of linear algebraic equations, the conditions between the regular elements in the near region A and the super-element in the semi-infinite region B will be matched. To solve the system of linear algebraic equations, the equations are assembled into element matrices:

$$\underset{NxN}{[K]}\ \underset{Nx1}{\{\psi\}} = \underset{Nx1}{\{Q\}} \tag{9-17}$$

where [K] = the complex coefficient matrix, or [K] is referred to the element stiffness matrix in structural mechanics, $\{\psi\}$ = the combination of nodal and coefficient unknowns which define a total unknown vector, and {Q} = the load vector. The coefficient matrix [K] is symmetric. The numbering of the nodes in the finite element mesh of the near region A and the arrangement of the unknown coefficients in $\{\psi\}$ determine the bandwidth of the matrix [K]. The bandwidth is the largest difference in node numbers between two nodes of the same element (Chen and Mei 1974).

26. Computer capabilities often limit solving a large system of algebraic equations which arise from using the finite element method. The

symmetric complex coefficient matrix $[K]_{NxN}$ is, in general, large, sparse, and banded. Therefore, it is stored and manipulated in the computer in a packed form. This saves a substantial amount of storage and computer processing time. The packed form is chosen to be a rectangular array $[K]_{NxB}$ (N variables in length and the semi-band in width, B) as shown in Figure 9-2. Only the elements of $[K]_{NxN}$ on and above the diagonal, and within the bandwidth need to be stored in the rectangular packed matrix $[K]_{NxB}$, which contains zeros in its lower triangular part as shown in Figure 9-2. The rectangular packed matrix is solved using Gaussian elimination. The solution time is proportional to the number of unknowns (nodes) multiplied by the bandwidth squared.

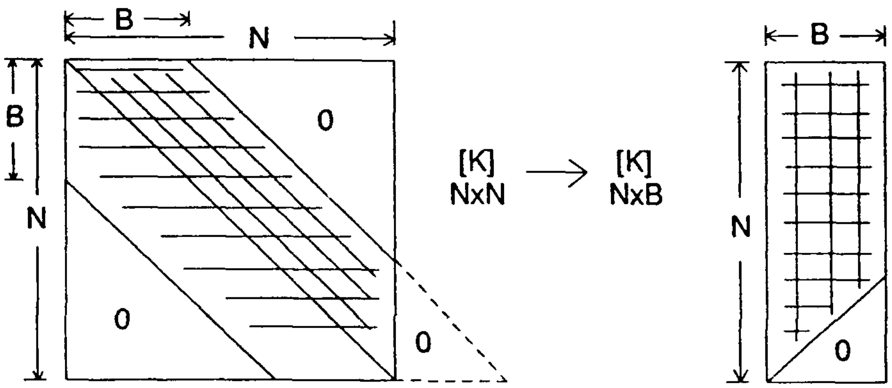

Figure 9-2. Rectangular packed form of storage for $[K]_{NxN}$

27. With the solution for the velocity potentials of the reflected and scattered waves ϕ_A and ϕ_B , respectively, accomplished, and knowing the incident wave ϕ_I , the total velocity potential ϕ can be solved for and substituted into the governing field equation, Equation 9-1. The solution is normalized with respect to an incident wave of unit amplitude. The absolute value of the resulting complex velocity potential ϕ at each node is represented as an amplification factor (i.e., the ratio of wave height at a particular node to incident wave height) and corresponding phase angle.

28. The hybrid element method is a steady-state solution of the boundary value problem. The response of a harbor to an arbitrary forcing function can be determined within the framework of linear wave theory. For example, an arbitrary incident wave in the semi-infinite region can be Fourier decomposed as follows:

$$a_o(t) = \int_{-\infty}^{\infty} a(\omega)\, e^{-i[\omega t + \rho(\omega)]}\, d\omega \tag{9-18}$$

where a_o = incident wave amplitude

$a(\omega)$ = amplitude of frequency component ω

$\rho(\omega)$ = phase angle

If η is the response amplitude at any point inside the harbor due to an incident plane wave of unit amplitude and frequency ω, then the response of the harbor to the arbitrary incident wave $a_o(t)$ is given by

$$\xi = R_e\left[\int_{-\infty}^{\infty} a(\omega)\, \eta\, e^{i[\omega t + \rho(\omega)]}\, d\omega\right] \tag{9-19}$$

where the operation $R_e[\,]$ takes the real part of the bracketed quantity. Therefore, as soon as η is known for all phase angles ω, the harbor response to an arbitrary incident wave can be calculated (Houston, Carver, and Markle 1977).

PART III: DEFINITION OF INPUT DATA FORMAT

29. The input data set format was designed to resemble the format required by the series of computer models released by the US Army Engineer (USAE) Hydrologic Engineering Center. Since Corps of Engineers personnel are familiar with this structure, it was chosen in an effort to reduce the amount of time necessary to learn this system. The general format of the input data set records, where a record refers to one line of data, is presented below:

a. Each record is divided into 10 fields containing 8 columns each.

b. Field 1, columns 1 through 8, contains a mnemonic identification label that describes the purpose or function of each record.

c. Fields 2 through 10 contain data that may be real, integer, or character in type. Integers must be right-justified. Real numbers must also be right-justified if the decimal point is omitted. Character data do not need to be right- or left-justified.

d. Array data, such as depths, are read with a group of statements that is performed repeatedly (DO), or Implied DO loops. A label is not required for each record containing array data. However, a general specification record, such as BATHSPEC, which defines bathymetric attributes, must precede that array.

30. Spelling of record identification labels and alphanumeric variables is important. Misspelled entries will result in either recognized error conditions that force the model to abort execution, or bypassing of desired user-defined operations, such as bathymetric changes.

31. Certain records and variables have been assigned default values in the model for minimizing input data and computer resources. Thus, not all input data records will be needed for each application, and only those records pertinent to the simulation or required by the model should be included. Default values are representative of those chosen in previous studies performed by the WES/CERC staff. Although these quantities may not be applicable to all studies, they can serve as a guide when selecting replacement values.

32. Default values are processed when the record field corresponding to that variable is blank. Hence, the user must be careful when leaving fields blank in a record; blank fields will not necessarily result in a

variable being assigned a value of zero. These variables and their respective default values are noted in Appendix 9-A. The following discussion pertains to the general format of the input records given in Appendix 9-A.

33. Each record is presented in a standardized tabular format and has as its heading the mnemonic identification label or name, with a brief description of its function. Following its name, the record has an abbreviated note documenting whether it is required for a simulation. These abbreviations have the following definitions:

(Req)	Record or variable is required for each simulation.
(Opt)	Record or variable is optional. Omitting this item results in either the default value being used or the defined operation not being performed.

For example, record BATHSPEC, presented in Appendix 9-A, contains the note (Req), meaning that this record must reside in the input data set for each simulation. Record CHNGBATH contains the note (Opt), meaning this record is optional and is only used when changes to the bathymetric data are desired.

34. Input variables, presented in column 2 of each table, are referenced to their respective record fields shown in column 1. Generally, data for each variable occupy a single 8-column data field. However, variables assigned titling or formatting information can occupy several fields.

35. Variable attributes are presented in columns 3 through 6 of each table. Valid data types are listed in column 3, and can be real, integer, or alphanumeric. Abbreviations presented in this column are described below:

Char*16	Alphanumeric character string containing up to 16 characters
Char*8	Alphanumeric character string containing up to 8 characters
Integer	Integer data
Real	Real (floating point) data

36. Column 4 of each table defines whether the respective variable must be assigned a value. Abbreviations listed in this column have meanings identical to those for the records. Default values are listed in column 5. A blank entry in this column denotes that the respective variable is not assigned a default value.

37. Column 6 of each table lists the variables' permitted data type or all valid character strings. Variables having integer or real data types are specified with the following notation:

A	Alphanumeric values
+R	Positive real values
R	Positive, zero, or negative real values
+I	Positive integer values
I	Positive, zero, or negative integer values

38. Variable definitions are listed in column 7 of each table. Variables whose quantities are unit-dependent contain a reference to that variable designating its system of units. For example, variable WDATUM is assigned a value having units defined by variable BUNITS. Variables defining input data units, and on which record they reside, are presented below.

Variable	Record	Definition
BUNITS	BATHSPEC	Bathymetry/topography data
GUNITS	GRIDSPEC	Numerical grid data
SUNITS	GENSPECS	Model computations and output

PART IV: DISCUSSION OF THE INPUT DATA REQUIREMENTS

39. Considerable effort is required by the user to prepare HARBD for execution. Care should be taken to prepare all required information to minimize any syntax, compilation, or other errors during execution of this code. Since each application to a site-specific project is unique, the type of input data required for each study will vary. In this discussion of model input, data have been divided into four categories to present model capabilities and data requirements. These categories are:

a. Model control specifications.

b. Grid description.

c. Physical characteristics.

d. Output specifications.

40. Table 9-1 presents HARBD input data records pertaining to each category. A record refers to one line of data, and each record begins with a mnemonic character string to identify one record type from another. Record format and detailed specification for each record are presented in this chapter. While reading Part IV, the user will find it beneficial to refer to Appendix 9-A.

Model Control Specifications

41. The model control parameters are contained in the GENSPECS record. Record GENSPECS is used to specify the general title of the simulation (TITLE) and the system of units (SUNITS) used for model computations and displaying model results. Variable names are given in parentheses. Additional titles may be selected for specific input data records. Although this information is optional, it can be very helpful when reviewing a series of simulations. A title should specifically state data attributes, such as data source or collection date, to differentiate it from data used in other simulations.

42. Model output is displayed in either English or metric units. However, the user can specify a different system of units for the input data. For example, the user can supply bathymetry data in units of feet or meters. HARBD will convert the input data into the necessary system of units.

Table 9-1

Input Data Set Records

Category	Record Name
Model Control Specifications	GENSPECS
Grid Description	GRIDSPEC GRIDFORM
Physical Characteristics	BATHSPEC CHNGBATH WAVCOND CONVERG
Output Specifications	PRWINDOW PRNODE PRNODNUM PRBASIN PRBNELEM

Finite Element Grid Description

43. The most difficult and time-consuming procedure in preparing HARBD for a simulation is generating the finite element grid. The model is extremely sensitive to inaccuracies in the specific requirements of the unique HARBD finite element grid. Great care should be taken in generation and application of the input grid to HARBD. Guidelines for correctly generating the finite element grid are given in this section. For clarity, the case of a simple rectangular harbor with a finite element mesh overlay, as shown in Figure 9-3, will serve as an example.

44. In generating a finite element mesh for the harbor, the x-axis is selected to generally follow the coastline of the semi-infinite region B. The origin is placed at the harbor entrance and the positive y-axis is defined pointing offshore. A 180-deg semicircular ocean boundary ∂A is drawn on the positive y-plane to divide the water domain into the semi-infinite region B and the near region A. The near region must include the harbor and all bathymetry of interest, marine structures, and the coastline.

45. A mesh of triangular elements is then used to subdivide the region N. For the most accurate results, the mesh spacing, although arbitrary, should not change too rapidly and should not be greater than one-sixth of the wavelength inside the harbor. The wavelength can be determined from linear

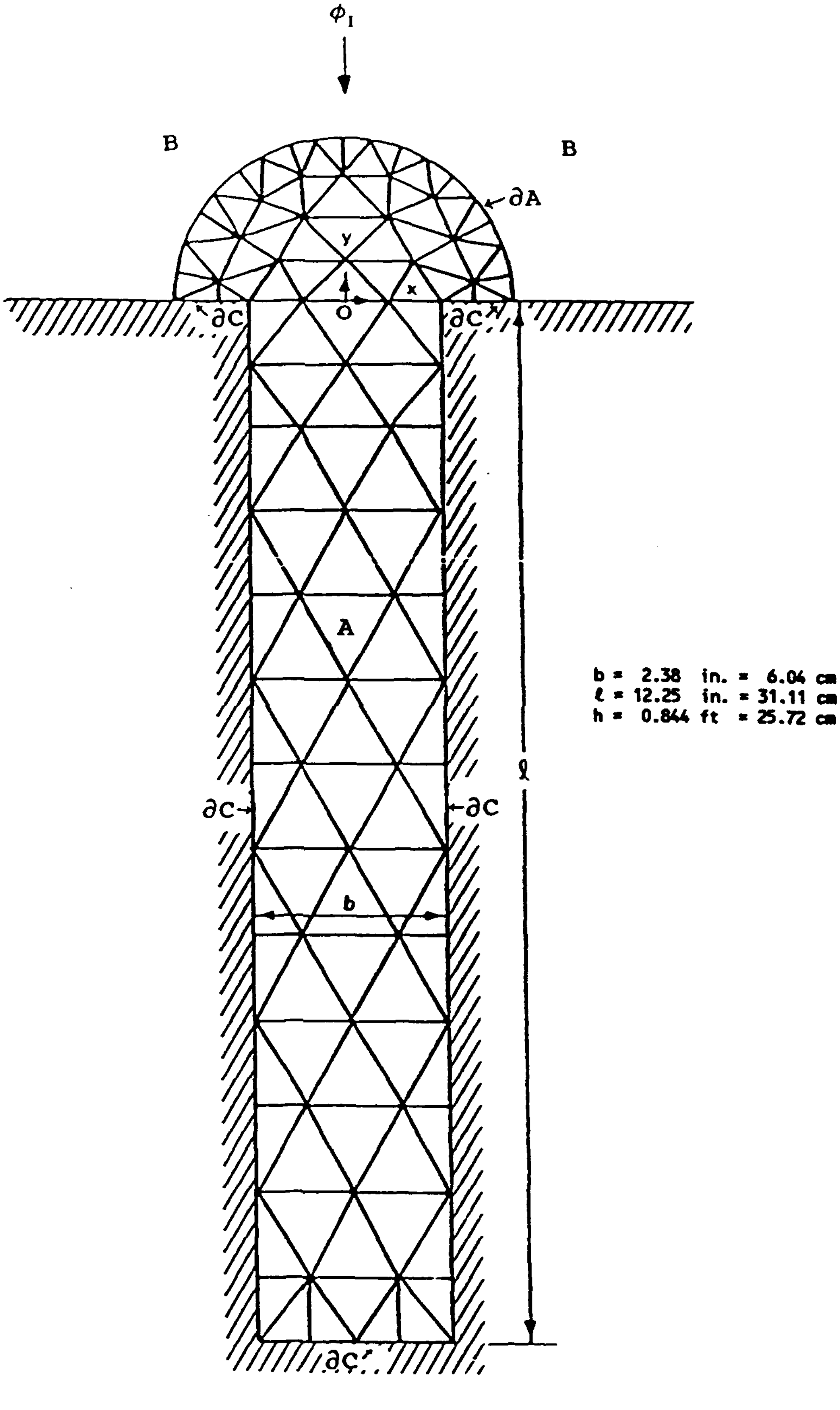

Figure 9-3. A simple rectangular harbor and finite element mesh

wave theory based on the minimum wave period to be tested and the depth inside the harbor basin. The method is given in the Shore Protection Manual (SPM 1984). It is also required that the elements along ∂A have equal spacing and that each element along the boundaries ∂C in near region A have only one side on the boundary.

46. The user should refer to Figure 9-4 to further clarify the following explanation of the required numbering schemes for HARBD finite element grids. A listing of the input data set of Figure 9-4 is given in Appendix 9-B. Node numbering is required. Each node is assigned an integer value ranging from one to NNOD, where NNOD is the total number of nodes. The largest node numbers must be located along the semicircular boundary ∂A in a specified sequence. The largest node, NNOD, must be located at the intersection of the semicircular boundary ∂A and the negative x-axis. The nodes along ∂A must sequentially decrease by one from NNOD advancing to the next node in a clockwise direction (Figure 9-4). The total number of nodes along the semicircular boundary ∂A defines variable NODR. For the nodes which do not lie along ∂A, the nodal numbering, although arbitrary, should minimize the matrix bandwidth, which is the incremental difference of values assigned to adjacent nodes. This is accomplished by numbering the nodes in a semicircular manner, starting from the back of the harbor. The computational time required by HARBD is strongly dependent upon the bandwidth of the grid.

47. Along with the assignment of a node number are the corresponding x- and y- coordinates of each node. The coordinate system must be in compliance with the requirement that the origin be located at the harbor entrance and at the center of the 180-deg semicircular boundary (Figure 9-3). The y-axis is positive offshore.

48. Each triangular element is also assigned a sequential number. Element numbering is arbitrary and bears no relationship to the nodal numbering. Each element is assigned a unique integer value ranging from one to NELE, where NELE is the total number of elements.

49. The three nodes which define a triangular element, or nodal connectivity, must also be recorded. Nodal numbers for each element must be recorded in a counterclockwise order. In addition, those elements that are located along a boundary must meet the specification that the first two nodes on the boundary be recorded first, in a counterclockwise order. A depth and bottom friction coefficient are also assigned to each element.

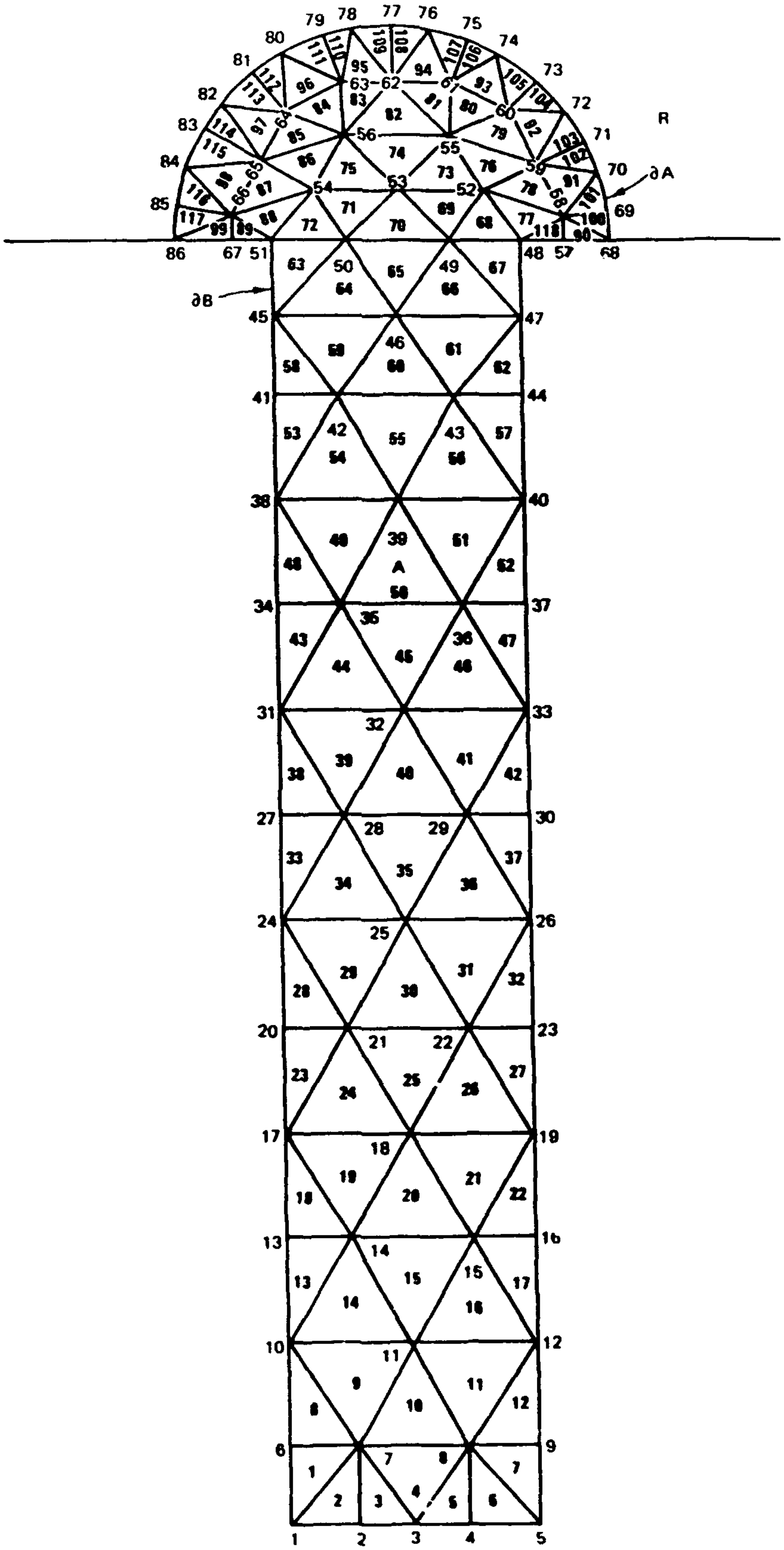

Figure 9-4. Node and element numbering for the finite element mesh

50. The elements located along the boundary in near region A (boundary elements) are then recorded in the following manner. The required information includes sequential number, boundary element number, and reflection coefficient of the boundary at that location. Boundary reflection coefficients are chosen through methods given in the SPM (1984).

51. Records in Appendix 9-A which control the finite element grid are GRIDSPEC and GRIDFORM. Selection of the finite element grid type is controlled by variable GRTYPE on record GRIDSPEC. HARBD permits an x- y- Cartesian system with triangular elements only (GRTYPE = TRIANG).

52. Variable GUNITS on record GRIDSPEC controls the system of units for the finite element grid. Valid units are feet and meters. HARBD will convert the data to the system of units for computations (SUNITS) internally. Variables NNOD and NELE specify the number of nodes and elements on the numerical grid, respectively. Variables NODR and NELB specify the number of nodes along the semicircular boundary ∂A and the number of boundary elements in near region A , respectively. NBAND specifies the grid bandwidth, or largest incremental difference of two adjacent nodes. The file name containing the input data is specified with variable GRNAME.

53. The GRIDFORM record is used to specify formats for reading in the input grid. GFORM1 specifies the format for reading the node and corresponding x- and y- coordinates. GFORM2 specifies the format for reading the element, nodal connectivity (node-1, node-2, node-3), depth, and friction coefficients. Finally, GFORM3 specifies the format for reading the sequential number of the boundary element, boundary element number, and reflection coefficient. The default formats are documented in Table 9-2.

54. Various methods to generate an appropriate and accurate grid have been investigated. Early methods centered around manual generation, which was extremely laborious, inefficient, and economically inadequate. For a given harbor and accompanying bathymetric chart, the finite element mesh was drafted over the entire water domain inside the harbor and extended seaward of the harbor entrance. Each node and element was hand numbered in sequential order and the x- and y- coordinates of each nodal point were then digitized. For each element, the element number, nodal connectivity, depth, and bottom friction coefficient were entered into a file. The elements which lay along the harbor boundaries were also recorded and assigned a boundary reflection coefficient. Errors in numbering schemes were corrected through countless

Table 9-2

Input Sequence for Array Data

Sequence	Description
node, x-coor., y-coor.	READ(LUIN*,GFORM1)(J,X(J),Y(J),J=1,NNOD) GFORM1= (3(I6,2F10.2))
element, node1, node2, node3, depth, friction coef.	READ(LUIN,GFORM2)(J,(ICON(K,J),K=1,3), D(J),FRIC(J),J=1,NELE) GFORM2= (2(4I6,F8.2,F8.4))
sequential boundary element, element, reflection coef.	READ(LUIN,GFORM3)(J,IELB(J),REFL(J),J=1,NELB) GFORM3= (5(2I5,F5.2))

*LUIN is the logical unit number for reading input data.

iterations of plotting the entire grid. The time required to perform grid generation for a 10,000-element grid was approximately 6 months.

55. Several attempts were made to automate finite element grid generation for HARBD. These codes were developed for various systems such as a mainframe VAX, personal computers, and workstations using Computer-Aided Drafting and Design software. Although these methods alleviated some of the manual labor, none were satisfactory for use with HARBD. Several automated finite element grid generation codes have been developed in recent years. CERC currently implements a finite element grid generation code developed at the Oregon Graduate Institute by Dr. Antonio Baptista and Mr. Paul Turner. The code is workstation-based and has resolved most of the intensive labor in grid generation for HARBD.

Physical Characteristics

Bathymetry

56. Each element must be assigned a water depth and bottom friction coefficient. Bathymetry data are referenced relative to an arbitrary datum. Typically, the map datum from which the depths are taken is used. Water depths are input as positive values.

57. One BATHSPEC record is required for defining tide level changes and the constant water depth in the semi-infinite region B . Variable BUNITS defines the units for bathymetric data. Valid units are feet or meters.

58. Grid-wide adjustments to water depths can be made with variable WDATUM. The value assigned to this variable is added to all element depths. Since these elements have positive values, positive WDATUM values produce deeper depths.

59. The constant depth value in the semi-infinite region B must be specified with variable FARD. In a prototype situation, the water depth in the semi-infinite region is spatially variable. For HARBD implementation, FARD should be chosen as the maximum water depth along the semicircular boundary ∂N .

60. Changes to the bathymetry can also be made to individual elements, or a group of elements with record CHNGBATH. This record allows the user to quickly change values assigned to element depths (using variable BATH) without editing the grid file itself. It should be noted that (a) values of the variable BATH on the CHNGBATH record are assumed to have units consistent with those selected for bathymetry (i.e., variable BUNITS on record BATHSPEC), and (b) WDATUM is not applied to variable BATH. Variables NELSTR and NELEND specify the starting and ending element numbers whose depth value should change to BATH, respectively. More than one CHNGBATH record is permitted.

Wave conditions

61. Each simulation requires wave information in deep water (i.e., the deepwater wave amplitude, direction, and period).

62. A WAVCOND record is required to define each of the deepwater wave conditions to be simulated. One WAVCOND record is required for each wave condition to be simulated, and multiple wave conditions can be processed in one simulation. Simulations are usually limited, however, to 5-10 wave conditions grouped together in a logical manner.

63. Variables HDEEP, TDEEP, and ZDEEP specify the deepwater wave amplitude, period, and angle, respectively. HDEEP is used only to calculate friction terms. If HDEEP is set to 0, HARBD will generate a value for HDEEP for each wave to be simulated. It is suggested that HDEEP be set to 0. TDEEP is the incident wave period in seconds. ZDEEP is the angle in degrees measured counterclockwise from the positive x-axis. For example, if an incident wave propagates from the negative to positive x-axis, the incident

wave angle is 0 deg. If the wave propagates from the positive to negative y-axis, the incident wave angle is 270 deg.

Convergence record

64. The only variable on record CONVERG is REFLEC. REFLEC is the reflection coefficient specified along the infinite coastlines in the region B.

Output Specifications

65. HARBD generates an output listing containing a summary of the input data set for every simulation. Error and warning diagnostic messages are also contained in this listing. A sample output listing containing a summary of the input data set is presented in Figure 9-5.

66. Each record is summarized in tabular form with a heading containing its record identification label followed by a brief description of that record's function. A table is composed of each variable's name, a description of that variable (including its units, when applicable), and an error diagnostic note.

67. HARBD contains error diagnostic features that inspect an input data set for possible errors. These features include (a) comparing an input value against a range of quantities that are representative for that variable, (b) checking for misspelled character data, and (c) checking for missing data. The error diagnostic note can be assigned one of three character strings: (a) "FATAL" for errors where the model cannot execute given the value supplied, (b) "WARN" for data that are outside the range of values typically selected for that variable, and (c) a null string for instances where an error condition has not been identified. Although this model contains error diagnostic capabilities, the user should thoroughly inspect the input data summary to insure that the data are correct.

68. The PRWINDOW record is used to specify the amount of information to be printed from a simulation. Variable WPRGRD specifies printing of the entire input grid. The options are YES or NO. The default value is NO. It should be noted that HARBD grid files can be extremely large. Once the input grid has been checked, it is unnecessary to print the file repeatedly.

69. Variable WPRNOD on record PRWINDOW is used to select printing of the solution at node locations throughout the harbor. The options are to print ALL (solution over the entire grid), SELECT specific nodes of interest,

```
                  C O A S T A L   M O D E L I N G   S Y S T E M   ( C M S ) :  HARD    ,  V E R S I O N   1 . 0

                         ----     HARD - HARBD MANUAL EXAMPLE PROBLEM                         ----

***** GENSPECS CARD:  SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
SUNITS    UNITS SYSTEM USED IN COMPUTATIONS   METRIC             *

***** GRIDSPEC CARD:  SPECIFICATION OF THE FINITE-ELEMENT GRID -  SAMPLE.DAT

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
GRTYPE    TYPE OF FINITE-ELEMENT GRID         TRIANG             * GUNITS    SYSTEM OF UNITS USED FOR THE GRID    METRIC

NNOD      NUMBER OF GRID NODES                      86           * NELE      NUMBER OF GRID ELEMENTS                   118

NODR      NUMBER OF NODES ON SEMICIRCULAR BOUN      19           * NELB      NUMBER OF BOUNDARY ELEMENTS                34

NBAND     BANDWIDTH OF GRID                         21           * RADIUS    RADIUS OF SEMICIRCLE                     2.00

***** PRWINDOW CARD:  SPECIFICATION OF THE MODEL OUTPUT

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
UPRNOD    PRINTING OF NODAL SOLUTIONS         SELECT             * MAXNOD    SPECIFIED MAX NUMBER OF OUTPUT NODES       3

NODOUT    NUMBER OF NODES SELECTED FOR OUTPUT       3            * UPRBSN    NUMBER OF SPECIFIED BASINS                 2

MAXBSN    SPECIFIED MAXIMUM NUMBER OF BASINS        2            * MAXELE    SPECIFIED MAX ELEMENTS IN ANY BASIN        3

UPRCOF    PRINTING OF COEFFICIENT SOLUTIONS   YES                * UPRGRD    PRINTING OF FINITE ELEMENT GRID      YES


BASIN   * NUMBER OF ELEMENTS                                     * BASIN   * NUMBER OF ELEMENTS
------- * ------------------                                     * ------- * ------------------
    1                   1                                              2                    3

***** WAVCOND CARD:  NUMBER OF WAVE CONDITIONS:   1


     WAVE CONDITION NUMBER:   1

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
HDEEP     DEEPWATER WAVE HEIGHT                   0.05           * TDEEP     WAVE PERIOD                              4.29

ZDEEP     DEEPWATER WAVE ANGLE                  270.00           *
                C O A S T A L   M O D E L I N G   S Y S T E M   ( C M S ) :  HARD    ,  V E R S I O N   1 . 0

***** BATHSPEC CARD: SPECIFICATION O  BATHYMETRY/TOPOGRAPHY -

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
BUNITS    SYSTEM OF UNITS FOR DEPTH DATA      METERS             * WDATUM    DATUM FOR WATER DEPTHS                   0.00
FARD      WATER DEPTH OF FAR REGION             10.128

          NUMBER OF ELEVATION CHANGES =    0

-***** CONVERGENCE CRITERIA ARE AS FOLLOWS:

VARIABLE  DESCRIPTION OF USAGE:               VALUE:     NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                   VALUE:    NOTES:
--------  ----------------------------------  --------   ------- * --------  -----------------------------------  --------  -------
REFLEC    REFL. COEFF. ALONG OPEN COAST BNDRY  1.00000


   ****************************************
   *** INPUT PROCESSING COMPLETED:
       FATAL ERRORS=  0     WARNINGS=  0
   ****************************************
```

Figure 9-5. Sample output listing

or print NONE of the nodal information. The default value is ALL. Again, file sizes may be extremely large for printing the solution over the entire grid. If the SELECT option is specified, a PRNODE record must follow the PRWINDOW record. Variable NODOUT on record PRNODE is used to specify the number of specified nodes for output. An array of the specific node numbers for output, OUTNOD, is then read from PRNODNUM records following the PRNODE record.

70. Variable WPRCOF on record PRWINDOW is used to select printing of the unknown coefficients which were solved for in the calculation of the velocity potential of the scattered wave ϕ_B in Equation 9-14. The options are YES or NO. The default value is YES.

71. Variable WPRBSN on record PRWINDOW is used to select calculation and printing of the solution at specified output "basins" throughout the harbor, rather than the entire grid. A basin is defined as an area comprised of a specified number of elements in which the mean value of the velocity potential for the elements is calculated. The total number of output basins selected define variable WPRBSN. Obtaining mean values for various output locations throughout the harbor is useful in investigating the wave response in specific locations of interest. If WPRBSN is greater than zero, a PRBASIN record must follow the PRWINDOW record or PRNODE record if the SELECT option was chosen for WPRNOD. Variable NELBSN on record PRBASIN is the number of elements in a particular output basin. An array of the specific element numbers in the basin, BSNELE, is then read from PRBNELEM records following the PRBASIN record. The number of PRBASIN records must equal the value specified in WPRBSN.

PART V: ILLUSTRATIVE EXAMPLES

72. Two examples are included in this section to demonstrate HARBD's capabilities. The model was used to simulate the harbor wave response of Agat Harbor, Guam and Maalaea Harbor, Maui, Hawaii.

Agat Harbor, Guam

73. Agat Harbor is located on the west coast of the island of Guam which is part of the Marianas Islands in the South Pacific Ocean. The design plan of the harbor (Figure 9-6) consists of a 930-ft-long, 120-ft-wide, and

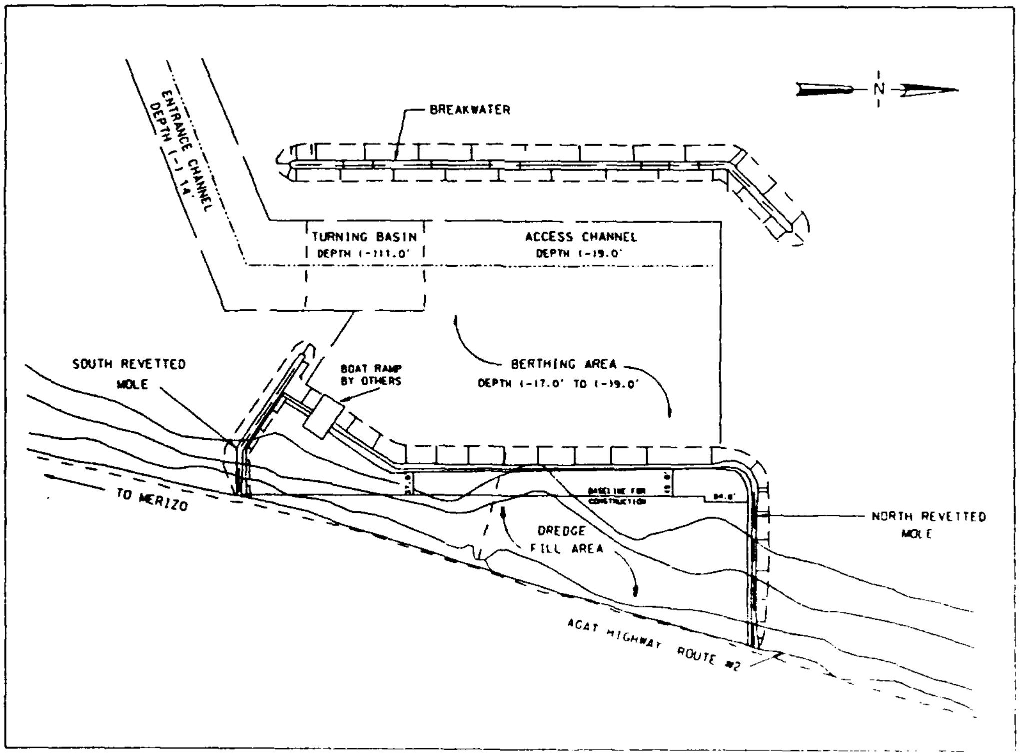

Figure 9-6. Design plan of Agat Harbor, Guam

14-ft-deep entrance channel; a 150-ft-wide, 120-ft-long, and 14-ft-deep turning basin; a 600-ft-long, 75-ft-wide, and 9-ft-deep access channel; and a 600-ft-long, 300-ft-wide, and 9-ft-deep berthing area. Protective structures include revetments along the shore; a 180-ft-long stub breakwater and revetment at the south end of the harbor; and an 885-ft-long detached breakwater seaward of the harbor basin.

74. The HARBD finite element grid generated for the harbor is shown in Figure 9-7. At the time of this study, a grid resolution of four elements per wavelength was sufficient. It was later determined that accuracy increased with a resolution no larger than six elements per wavelength. The bathymetry was obtained from hydrographic surveys prepared by the US Army Engineer Division, Pacific Ocean (POD). The grid consists of 1,334 nodes, 2,421 elements, 84 elements along the semicircular boundary, 164 boundary elements in the near region, and a matrix bandwidth of 88. Boundary reflection coefficients were 0.2 for the shoreline outside the harbor (beaches), 0.45 for the revetment inside the harbor and outside the detached breakwater, and 0.5 for the stub breakwater, the north face of the shoreline revetment, and inside the detached breakwater. A bottom friction coefficient of 0.0 was used for all elements.

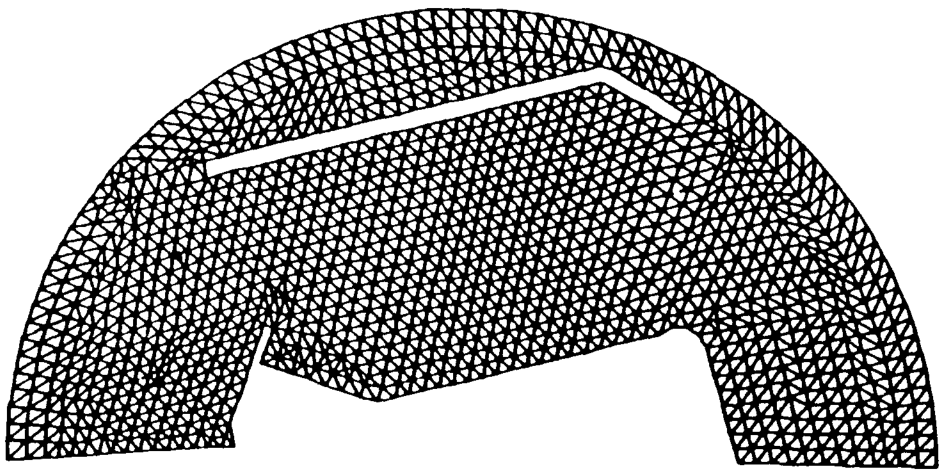

Figure 9-7. HARBD finite element grid of Agat Harbor, Guam

75. Two wave conditions were tested, an 8-sec wave and an 11-sec wave from a 248.1-deg azmith (329.7-deg model coordinates). As recommended, a value of 0.0 was used for the incident wave amplitude. Thirty-two output basins were selected for output and are listed in the output summary in Table 9-4 (shown in Figure 9-8). The input data set is given in Appendix 9-C for details of each record. The complete output listing is given in Appendix 9-D.

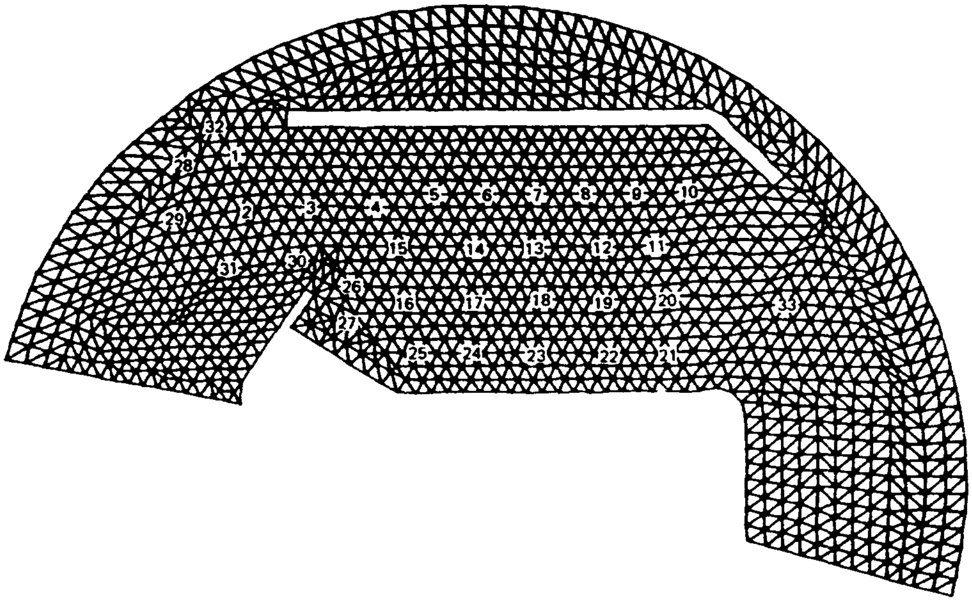

Figure 9-8. Output basin locations for Agat Harbor, Guam

76. The goal of the study was to develop a design plan that would provide the harbor with adequate protection from the incident wave climate. The US Army Corps of Engineers criteria for adequate harbor protection is that wave heights must be less than 1 ft in harbor berthing areas and less than 2 ft in the entrance channel and turning basin for a period less than 10 percent of the time per year. The design plan tested failed to meet the criterion for adequate harbor protection. Wave heights exceeded the criteria in output basins 19 and 22, which are located near the shore in the northeast corner of the harbor. Modifications to the design plan were tested to determine an optimal design to adequately protect the harbor.

Table 9-3

Output Summary for Agat Harbor, Guam Simulation

```
                     C O A S T A L   M O D E L I N G   S Y S T E M   ( C M S ) :  HARD   ,  V E R S I O N   1 . 0

                    ----      HARD - HARBD MANUAL EXAMPLE PROBLEM                          ----

***** GENSPECS CARD:  SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
SUNITS    UNITS SYSTEM USED IN COMPUTATIONS     METRIC            *

***** GRIDSPEC CARD:  SPECIFICATION OF THE FINITE-ELEMENT GRID -  SAMPLE.DAT

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
GRTYPE    TYPE OF FINITE-ELEMENT GRID           TRIANG            * GUNITS    SYSTEM OF UNITS USED FOR THE GRID     METRIC

NNOD      NUMBER OF GRID NODES                        86          * NELE      NUMBER OF GRID ELEMENTS                    118

NODR      NUMBER OF NODES ON SEMICIRCULAR BOUN        19          * NELB      NUMBER OF BOUNDARY ELEMENTS                 34

NBAND     BANDWIDTH OF GRID                           21          * RADIUS    RADIUS OF SEMICIRCLE                  .   2.00

***** PRWINDOW CARD:  SPECIFICATION OF THE MODEL OUTPUT

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
IPRNOD    PRINTING OF NODAL SOLUTIONS           SELECT            * MAXNOD    SPECIFIED MAX NUMBER OF OUTPUT NODES       3

NODOUT    NUMBER OF NODES SELECTED FOR OUTPUT          3          * IPRBSN    NUMBER OF SPECIFIED BASINS                 2

MAXBSN    SPECIFIED MAXIMUM NUMBER OF BASINS           2          * MAXELE    SPECIFIED MAX ELEMENTS IN ANY BASIN        3

IPRCOF    PRINTING OF COEFFICIENT SOLUTIONS     YES               * IPRGRD    PRINTING OF FINITE ELEMENT GRID       YES


BASIN   * NUMBER OF ELEMENTS                                      * BASIN   * NUMBER OF ELEMENTS
------- * -----------------                                       * ------- * -----------------
     1                    1                                             2                    3

***** WAVCOND CARD:  NUMBER OF WAVE CONDITIONS:   1


      WAVE CONDITION NUMBER:   1

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
HDEEP     DEEPWATER WAVE HEIGHT                     0.05          * TDEEP     WAVE PERIOD                                4.29

ZDEEP     DEEPWATER WAVE ANGLE                    270.00          *
                     C O A S T A L   M O D E L I N G   S Y S T E M   ( C M S ) :  HARD   ,  V E R S I O N   1 . 0

***** BATHSPEC CARD: SPECIFICATION OF BATHYMETRY/TOPOGRAPHY -

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
BUNITS    SYSTEM OF UNITS FOR DEPTH DATA        METERS            * WDATUM    DATUM FOR WATER DEPTHS                     0.00
FARD      WATER DEPTH OF FAR REGION               10.128

          NUMBER OF ELEVATION CHANGES =    0

***** CONVERGENCE CRITERIA ARE AS FOLLOWS:

VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:  * VARIABLE  DESCRIPTION OF USAGE:                 VALUE:    NOTES:
--------  ------------------------------------  --------  ------- * --------  ------------------------------------  --------  -------
REFLEC    REFL. COEFF. ALONG OPEN COAST BNDRY   1.00000


     ****************************************
     *** INPUT PROCESSING COMPLETED:
         FATAL ERRORS=  0     WARNINGS=  0
     ****************************************
```

77. In the Hawaiian Island chain, Maalaea Harbor is located on the southwest coast of the island of Maui. The shoreline of Maalaea Bay is part of an isthmus connecting two inactive volcanos which form west and east Maui (Figure 9-9). Maalaea Harbor currently experiences adverse conditions that affect navigation and mooring of vessels. This study is an effort to develop a design plan of improvement to alleviate the current problems occurring in the harbor. The existing harbor configuration and one alternate design plan are presented. Due to large file sizes, only the input and output listings of the existing harbor configuration will be presented in this chapter.

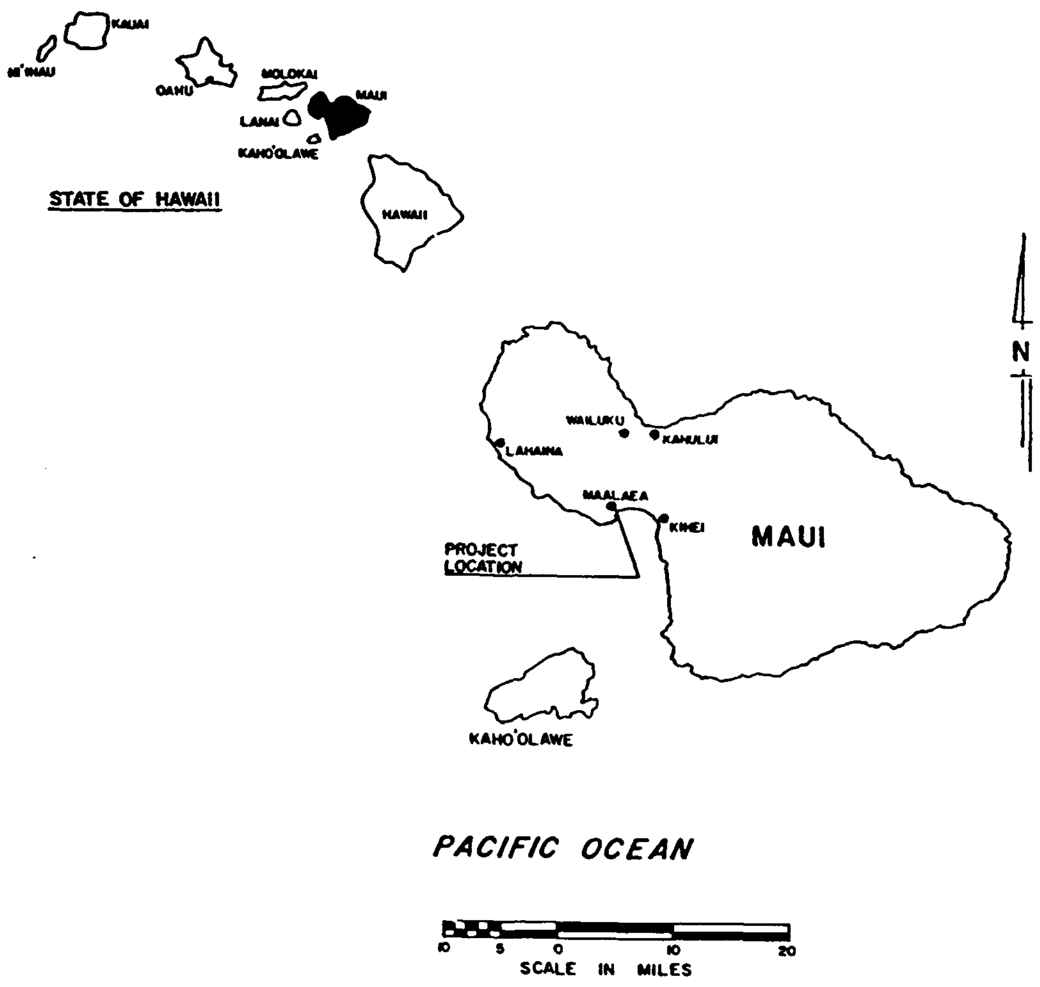

Figure 9-9. Project location, Maalaea Harbor, Maui, Hawaii

78. The existing harbor configuration (Figure 9-10) consists of a 90-ft-wide, 12-ft-deep entrance channel; a 1,000-ft-long, 90-ft-wide breakwater on the south side of the basin; an 870-ft-long breakwater on the east side of the basin; and a 300-ft-long, 50-ft-wide paved wharf on the north side of the basin. The dredged basin area is 11.3 acres.

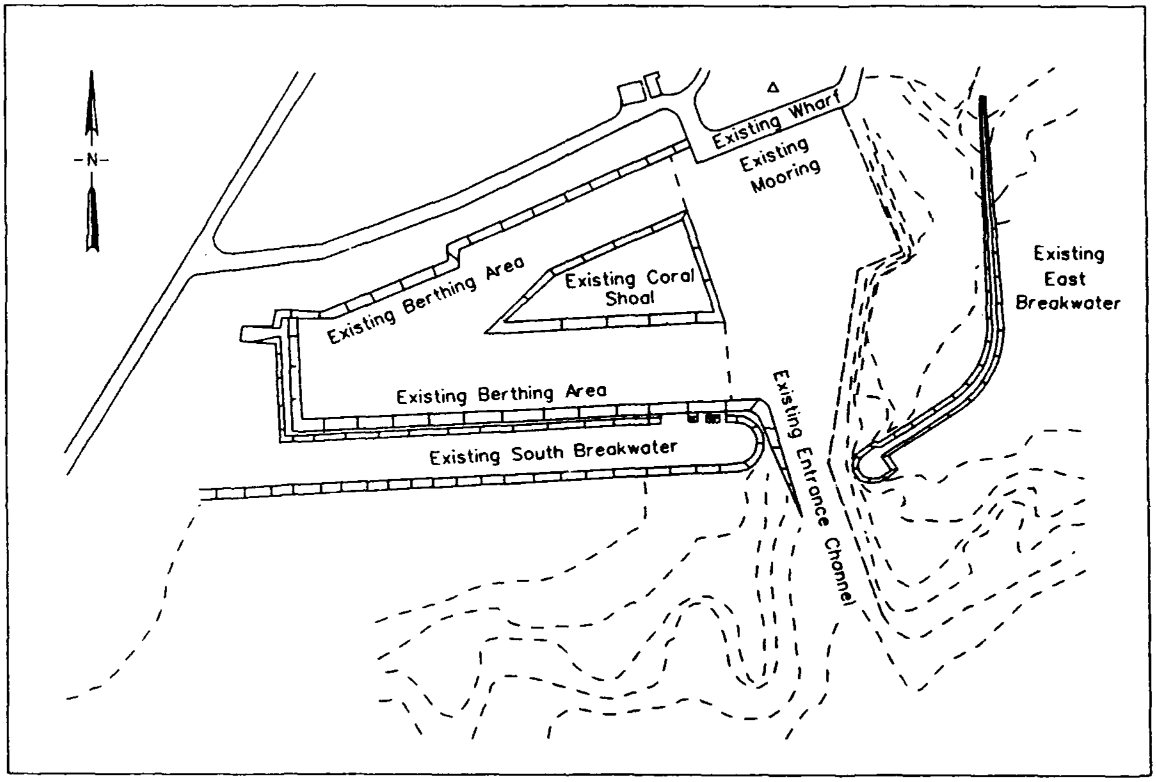

Figure 9-10. Existing configuration of Maalaea Harbor, Maui, Hawaii

79. The HARBD finite element grid generated for the existing configuration is shown in Figure 9-11. The grid was designed with a grid resolution of six elements per wavelength based on an 8-sec wave and a basin depth of 8 ft. The bathymetry was obtained from hydrographic surveys prepared by the POD. The grid consists of 7,146 elements, 3,752 nodes, 105 nodes on the semicircular boundary, 252 boundary elements in near region A, and a matrix bandwidth of 107. The radius of the semicircular ocean boundary ∂A is approximately 800 ft. Boundary reflection coefficients were 0.4 for the

seaward and harbor sides of the south breakwater and along the west and north walls of the basin, 1.0 for the paved wharf, and 0.35 for the seaward and harbor sides of the east breakwater. A bottom friction coefficient of 0.05 was used for all elements.

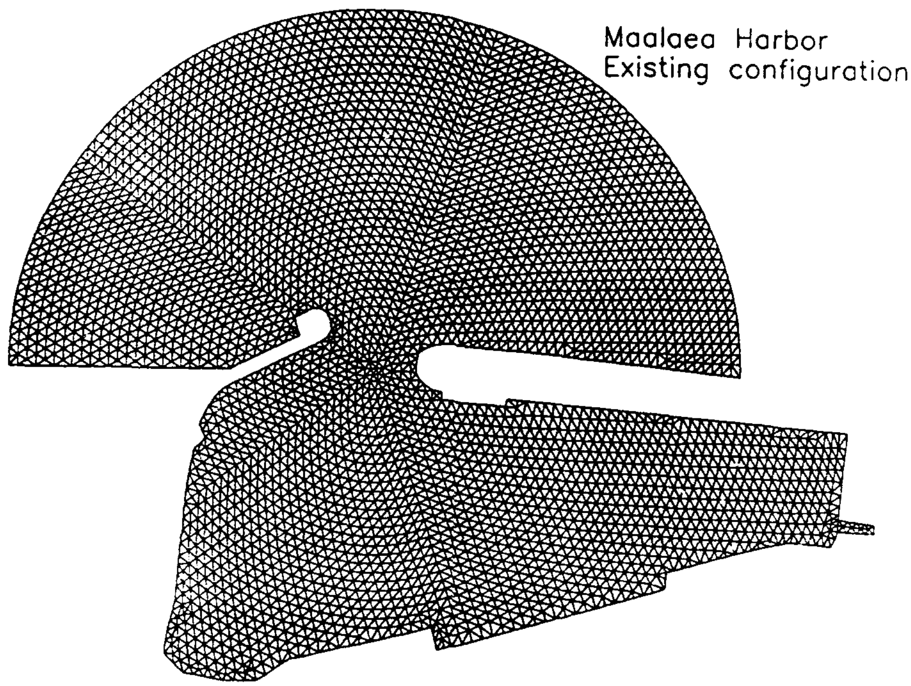

Figure 9-11. HARBD finite element grid of the existing configuration of Maalaea Harbor, Maui, Hawaii

80. The results from a 20-sec wave arriving from 175 deg (265-deg model coordinates) are presented. As recommended, a value of 0.0 was used for the incident wave amplitude. Sixteen output basins were selected throughout the harbor. The locations of the output basins are shown in Figure 9-12 and are listed in the output summary in Table 9-4. The input data set is given in Appendix 9-E for details of each record. The complete output listing is given in Appendix 9-F.

81. The goal of the study was to develop a design plan that would provide the harbor with adequate protection from the incident wave climate. The USAE criteria for adequate harbor protection are that wave heights must be

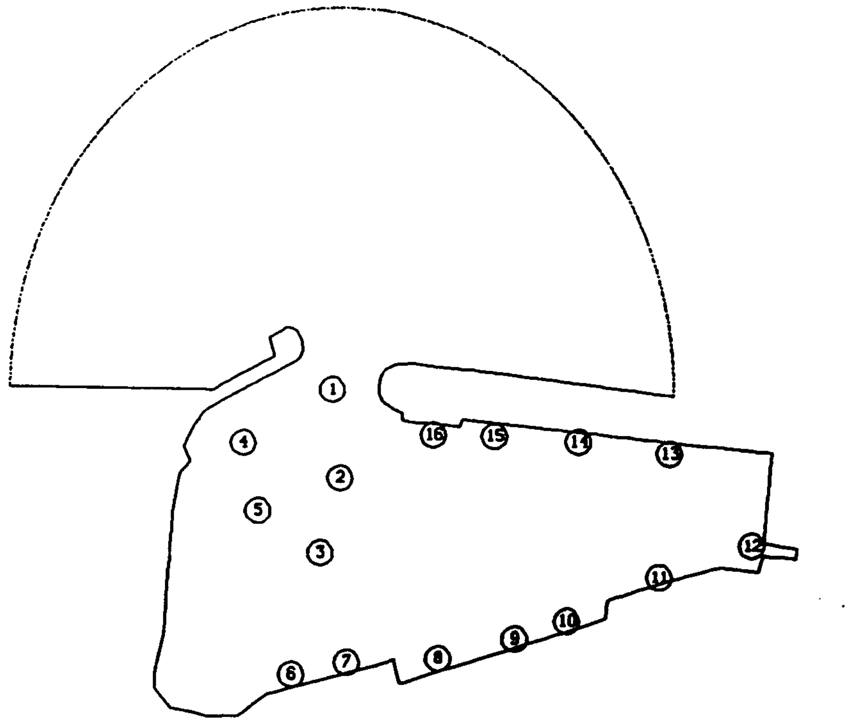

Figure 9-12. Output basin locations for existing configuration

less than 1 ft in harbor berthing areas and less than 2 ft in the entrance channel and turning basin for a period of less than 10 percent of the year. As expected, the existing configuration failed to meet the criteria for adequate harbor protection. Wave heights exceeded the criteria in all output basins except those located along the west wall and in the turning basin.

82. Alternate design plans were developed and tested. Alternate Design Plan I (Figure 9-13) includes the following modifications: (a) a 620-ft-long extension to the existing south breakwater, (b) an additional 400-ft-long revetment on the seaward side of the existing south breakwater, (c) a 610-ft-long entrance channel, varying in width from 105 to 180 ft, and varying in depth from 12 to 15 ft; and (d) a 1.7-acre, 12-ft-deep turning basin. About 80 ft of the existing east breakwater head would be removed, and a 50-ft-wide, 720-ft-long interior revetment will be added to the interior of the east breakwater. An 8-ft-deep berthing area adjacent to the east breakwater and a center revetment for a fuel station are included.

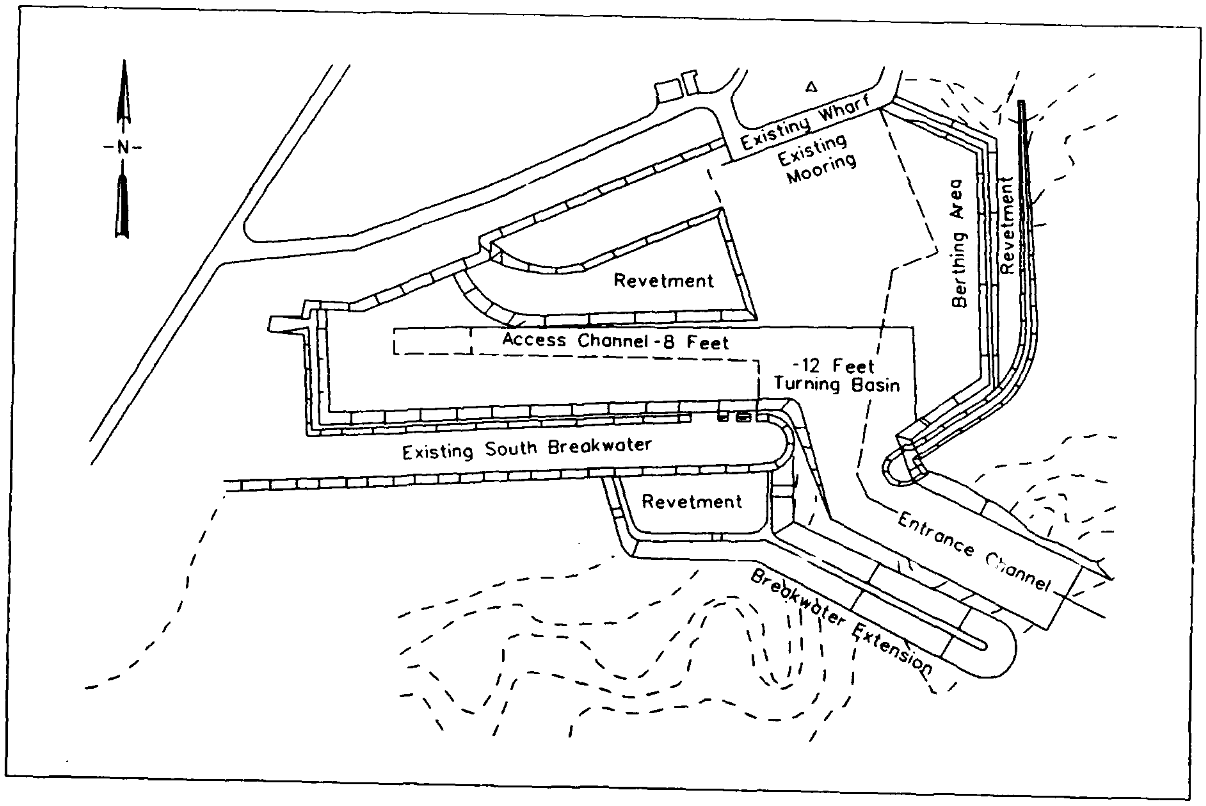

Figure 9-13. Alternate Design Plan I, Maalaea, Maui, Hawaii

83. The HARBD finite element grid generated for Alternate Design Plan I is shown in Figure 9-14. The grid resolution was also six elements per

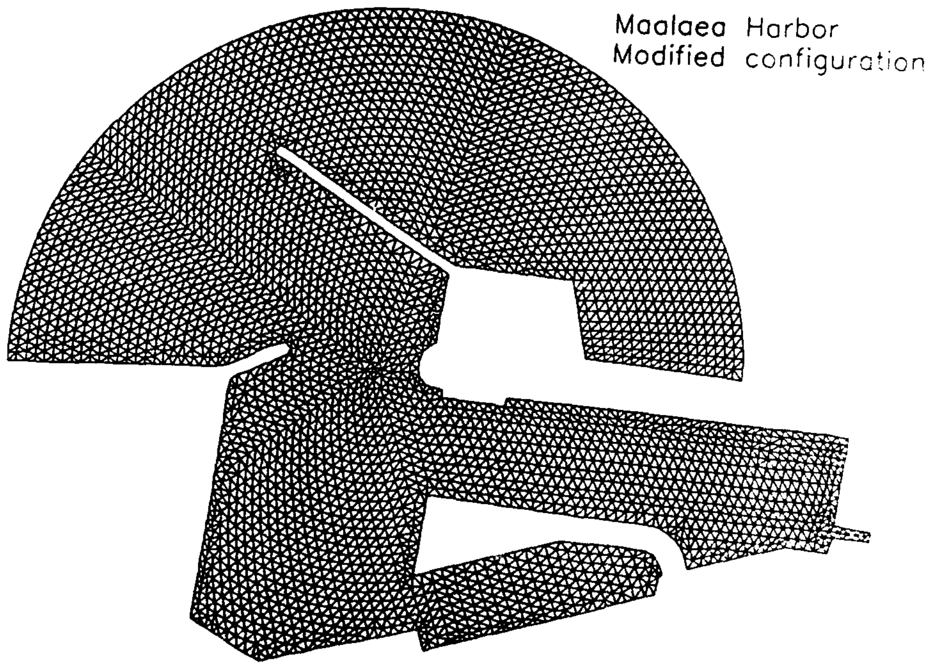

Figure 9-14. HARBD finite element grid of Alternate Design Plan I

wave-length. The grid consists of 6,764 elements and 3,613 nodes (105 nodes on the semicircular boundary, 356 boundary elements in near region A), and the matrix bandwidth is 107. The radius of the semicircular ocean boundary, ∂A , is approximately 800 ft. Boundary reflection coefficients of the existing structures remained unchanged. However, the reflection coefficients for the modifications are as follows: 0.25 for the extension and additional revetment to the existing south breakwater and 0.35 for the center and additional revetment to the east breakwater. A bottom friction coefficient of 0.0 was used for all elements. Twenty-three output basins were selected and the locations are shown in Figure 9-15. Wave heights exceeded the 1-ft criterion in output basin 6, just inside the entrance, and output basin 11, at the wharf along the north wall. However, these waves did not occur more than 10 percent of the time per year.

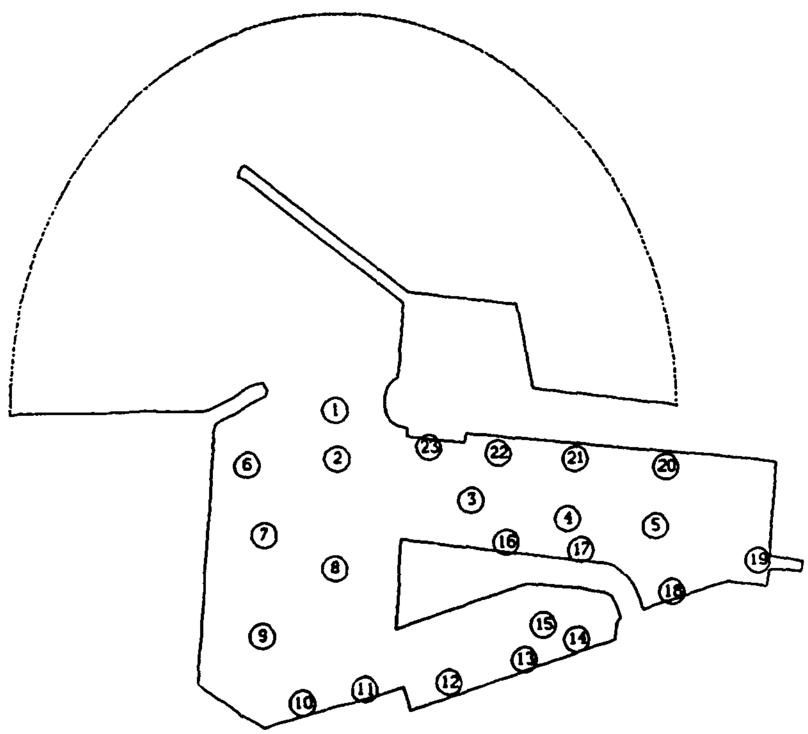

Figure 9-15. Output basin locations for Alternate Design Plan I

Table 9-4

Output Summary for Maalaea Harbor, Maui, HI Simulation

C O A S T A L   M O D E L I N G   S Y S T E M   (C M S) :   HARBD   ,   V E R S I O N   1 . 0

---- HARBD MAALAEA HARBOR, MAUI, HI - EXISTING CONFIGURATION ----

***** GENSPECS CARD: SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
SUNITS	UNITS SYSTEM USED IN COMPUTATIONS	ENGLISH		*			

***** GRIDSPEC CARD: SPECIFICATION OF THE FINITE-ELEMENT GRID - MAALAEA.INP

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
GRTYPE	TYPE OF FINITE-ELEMENT GRID	TRIANG		* GUNITS	SYSTEM OF UNITS USED FOR THE GRID	ENGLISH	
NNOD	NUMBER OF GRID NODES	3752		* NELE	NUMBER OF GRID ELEMENTS	7146	
NODR	NUMBER OF NODES ON SEMICIRCULAR BOUN	105		* NELB	NUMBER OF BOUNDARY ELEMENTS	252	
NBAND	BANDWIDTH OF GRID	107		* RADIUS	RADIUS OF SEMICIRCLE	786.03	

***** PRWINDOW CARD: SPECIFICATION OF THE MODEL OUTPUT

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
UPRNOD	PRINTING OF NODAL SOLUTIONS	NONE		* MAXNOD	SPECIFIED MAX NUMBER OF OUTPUT NODES	1	
NODOUT	NUMBER OF NODES SELECTED FOR OUTPUT	0		* UPRBSN	NUMBER OF SPECIFIED BASINS	16	
MAXBSN	SPECIFIED MAXIMUM NUMBER OF BASINS	16		* MAXELE	SPECIFIED MAX ELEMENTS IN ANY BASIN	7	
UPRCOF	PRINTING OF COEFFICIENT SOLUTIONS	NO		* UPRGRD	PRINTING OF FINITE ELEMENT GRID	NO	

BASIN	* NUMBER OF ELEMENTS	* BASIN	* NUMBER OF ELEMENTS
1	7	2	6
3	6	4	6
5	6	6	6
7	7	8	6
9	6	10	7
11	7	12	7
13	6	14	6
15	6	16	6

***** WAVCOND CARD: NUMBER OF WAVE CONDITIONS: 1

WAVE CONDITION NUMBER: 1

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
HDEEP	DEEPWATER WAVE HEIGHT	0.00		* TDEEP	WAVE PERIOD	20.00	
ZDEEP	DEEPWATER WAVE ANGLE	265.00		*			

C O A S T A L   M O D E L I N G   S Y S T E M   (C M S) :   HARBD   ,   V E R S I O N   1 . 0

***** BATHSPEC CARD: SPECIFICATION OF BATHYMETRY/TOPOGRAPHY -

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
BUNITS	SYSTEM OF UNITS FOR DEPTH DATA	FEET		* WDATUM	DATUM FOR WATER DEPTHS	0.00	
FARD	WATER DEPTH OF FAR REGION	25.000					

NUMBER OF ELEVATION CHANGES = 0

***** CONVERGENCE CRITERIA ARE AS FOLLOWS:

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
REFLEC	REFL. COEFF. ALONG OPEN COAST BNDRY	0.10000					

****
*** INPUT PROCESSING COMPLETED:
FATAL ERRORS= 0 WARNINGS= 0
****

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APPENDIX 9-A: HARBD FUNCTION INDEX

HARBD FUNCTION INDEX

Model Control Specifications

(Req)	GENSPECS	Specify general title and system of units

Grid Description

(Req)	GRIDSPEC	Specify general grid characteristics
(Opt)	GRIDFORM	Specify grid formats

Physical Characteristics

(Req)	BATHSPEC	Specify characteristics of bathymetry
(Opt)	CHNGBATH	Specify changes to the bathymetric data
(Req)	WAVCOND	Specify deepwater wave conditions
(Opt)	CONVERG	Specify reflection coefficient of infinite coastlines

Output Specifications

(Opt)	PRWINDOW	Specify printing of input and output window
(Opt)	PRNODE	Specify nodes and printing of nodal output
(Opt)	PRNODNUM	Selected node numbers to print
(Opt)	PRBASIN	Specify basins and printing of basin output
(Opt)	PRBNELEM	Element numbers in a basin

CMS Data Specification: GENSPECS Record: (Req)
Purpose: Specify general title and system of units.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		GENSPECS	Record identifier.
2	SUNITS	Char *8	(Opt)	ENGLISH	ENGLISH METRIC	Declares the system of units for model computations and results.
3-10	TITLE	Char *64	(Opt)		A*	General title for simulation.

UNIT	ENGLISH (SI)	METRIC (British)
Length	ft	m
Time	sec	sec

CMS Data Specification: GRIDSPEC Record: (Req)
Purpose: Specify general computational grid characteristics.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		GRIDSPEC	Record identifier.
2	GRTYPE	Char *8	(Opt)	NONE	TRIANG	Cartesian system with finite element grid elements.
3	GUNITS	Char *8	(Opt)	ENGLISH	ENGLISH METRIC	System of units for grid data.
4	NNOD	Integer	(Req)		+I*	Number of grid nodes.
5	NELE	Integer	(Req)		+I*	Number of grid elements.
6	NODR	Integer	(Req)		+I*	Number of nodes along semcircular boundary.
7	NELB	Integer	(Req)		+I*	Number of boundary elements in near region.
8	NBAND	Integer	(Req)		+I*	Largest incremental distance of two adjacent nodes.
9	CRNAME	Char*16	(Req)	NONE	+C*	Name of file containing input grid data.

CMS Data Specification: GRIDFORM Record: (Opt)
Purpose: Specify grid formats

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		GRIDFORM	Record identifier.
2	GFORM1	Char*16	(OPT)	(3(I6,2F10.2)	A*	Format for (node, x-coordinate,y-coordinate).
3	GFORM2	Char*18	(OPT)	(2(4I6,F8.2,F8.4))	A*	Format for (element, node1,node2, node3, depth,friction coefficient).
4	GFORM3	Char*16	(OPT)	(5(2I5,F5.2))	A*	Format for (sequential bound element number, element number, reflection coefficient).

CMS Data Specification: BATHSPEC Record: (Req)
Purpose: Specify general characteristics of the bathymetry/topography data.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		BATHSPEC	Record identifier.
2	BUNITS	Char *8	(Opt)	FEET	FEET METERS	Declares the units for the following bathymetry/topography data.
3	WDATUM	Real	(Opt)	0.	R*	Values of bathymetry (depths) are added to this datum value (in BUNITS).
4	FARD	Real	(Opt)	0.	R*	Depth value at semicircular boundary.

CMS Data Specification: CHNGBATH Record: (Opt)
Purpose: Specify changes to the bathymetry data.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		CHNGBATH	Record identifier.
2	BATH	Real	(Req)		R*	New bathymetry/topography value.
3	NELSTR	Integer	(Req)	1	I*	Starting element number for changes.
4	NELEND	Integer	(Req)	1	I*	Ending element number for changes.

CMS Data Specification: WAVCOND Record: (Req)
Purpose: Specify deepwater wave conditions

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		WAVCOND	Record identifier.
2	HDEEP	Real	(Req)		+R*	Incident wave height.
3	TDEEP	Real	(Req)		+R*	Incident wave period.
4	ZDEEP	Real	(Req)		+R*	Incident wave angle.

CMS Data Specification: CONVERG Record: (Opt)
Purpose: Specify changes to convergence criteria

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		CONVERG	Record identifier.
2	REFLECT	Real	(Opt)	0.09	+R*	Reflection coefficient along open coastlines.

CMS Data Specification: PRWINDOW Record: (Opt)
Purpose: Specify print windows.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRWINDOW	Record identifier.
2	WPRGRD	Char *8	(Opt)	NO	YES NO	Printing of input grid.
3	WPRNOD	Char *8	(Opt)	ALL	ALL NONE SELECT	Printing of nodal output data.
4	WPRCOF	Char *8	(Opt)	YES	YES NO	Printing of coefficients.
5	WPRBSN	Integer	(Opt)		+I*	Printing of selected output basins. Specify number of output basins.

Note: Use 1 PRWINDOW record/window (in space).

CMS Data Specification: PRNODE Record: (Opt)
Purpose: Specify number of nodes for output.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRNODE	Record identifier.
2	NODOUT	Integer	(Opt)	0	+I*	Number of specified nodes for output.

Note: Use 1 PRNODE record/window (in space).

CMS Data Specification: PRNODNUM Record: (C-Opt)
Purpose: Specify nodes for output.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRNODNUM	Record identifier.
2-10	OUTNOD	Integer	(Req)	0	+I*	Specific node numbers for output.

Note: Use 1 PRNODNUM record/window (in space).

CMS Data Specification: PRBASIN Record: (Opt)
Purpose: Specify number of elements in output basin.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRBASIN	Record identifier.
2	NELBSN	Integer	(Opt)	0	+I*	Number of elements in output basin.

Note: Use 1 PRBASIN record/window (in space).

CMS Data Specification: PRBNELEM Record: (C-Opt)
Purpose: Specify elements in output basin.

Field	Variable	Type	Status	Default	Permitted Data	Variable Definition
1	CARDID	Char *8	(Req)		PRBNELEM	Record identifier.
2-10	BSNELE	Integer	(Req)	0	+I*	Element numbers in output basin.

Note: Use 1 PRBNELEM record/window (in space).

APPENDIX 9-B: INPUT DATA SET
FOR FINITE ELEMENT GRID

```
GENSPECS  METRIC    HARD - HARBD MANUAL EXAMPLE PROBLEM
GRIDSPEC  TRIANG  METRIC      86      118       19       34       21  SAMPLE.DAT
CONVERG      1.0
WAVCOND     0.05    4.29   270.0
PRWINDOW     YES  SELECT     YES        2
PRNODE         3
PRNODNUM       3      32      53
PRBASIN        1
PRBNELEM       4
PRBASIN        3
PRBNELEM      15      16      20
GRIDFORM  (3(I6,2F10.2))(2(4I6,F8.2,F8.4))   (5(2I5,F5.2))
     1     -1.19    -12.25     2     -0.50    -12.25     3      0.00    -12.25
     4      0.50    -12.25     5      1.19    -12.25     6     -1.19    -11.50
     7     -0.50    -11.50     8      0.50    -11.50     9      1.19    -11.50
    10     -1.19    -10.50    11      0.00    -10.50    12      1.19    -10.50
    13     -1.19     -9.50    14     -0.50     -9.50    15      0.50     -9.50
    16      1.19     -9.50    17     -1.19     -8.50    18      0.00     -8.50
    19      1.19     -8.50    20     -1.19     -7.50    21     -0.50     -7.50
    22      0.50     -7.50    23      1.19     -7.50    24     -1.19     -6.50
    25      0.00     -6.50    26      1.19     -6.50    27     -1.19     -5.50
    28     -0.50     -5.50    29      0.50     -5.50    30      1.19     -5.50
    31     -1.19     -4.50    32      0.00     -4.50    33      1.19     -4.50
    34     -1.19     -3.50    35     -0.50     -3.50    36      0.50     -3.50
    37      1.19     -3.50    38     -1.19     -2.50    39      0.00     -2.50
    40      1.19     -2.50    41     -1.19     -1.50    42     -0.50     -1.50
    43      0.50     -1.50    44      1.19     -1.50    45     -1.19     -0.75
    46      0.00     -0.75    47      1.19     -0.75    48      1.19      0.00
    49      0.50      0.00    50     -0.50      0.00    51     -1.19      0.00
    52      0.75      0.50    53      0.00      0.50    54     -0.75      0.50
    55      0.50      1.00    56     -0.50      1.00    57      1.50      0.00
    58      1.50      0.25    59      1.25      0.75    60      1.00      1.25
    61      0.50      1.50    62      0.00      1.50    63     -0.50      1.50
    64     -1.00      1.25    65     -1.25      0.75    66     -1.50      0.25
    67     -1.50      0.00    68      2.00      0.00    69      1.97      0.35
    70      1.88      0.68    71      1.73      1.00    72      1.53      1.29
    73      1.29      1.53    74      1.00      1.73    75      0.68      1.88
    76      0.35      1.97    77      0.00      2.00    78     -0.35      1.97
    79     -0.68      1.88    80     -1.00      1.73    81     -1.29      1.53
    82     -1.53      1.29    83     -1.73      1.00    84     -1.88      0.68
    85     -1.97      0.35    86     -2.00      0.00
     1     6     1     7   10.13  0.0000     2     1     2     7   10.13  0.0000
     3     2     3     7   10.13  0.0000     4     8     7     3   10.13  0.0000
     5     3     4     8   10.13  0.0000     6     4     5     8   10.13  0.0000
     7     5     9     8   10.13  0.0000     8    10     6     7   10.13  0.0000
     9    11    10     7   10.13  0.0000    10    11     7     8   10.13  0.0000
    11    12    11     8   10.13  0.0000    12     9    12     8   10.13  0.0000
    13    13    10    14   10.13  0.0000    14    14    10    11   10.13  0.0000
    15    15    14    11   10.13  0.0000    16    15    11    12   10.13  0.0000
    17    12    16    15   10.13  0.0000    18    17    13    14   10.13  0.0000
    19    18    17    14   10.13  0.0000    20    18    14    15   10.13  0.0000
    21    19    18    15   10.13  0.0000    22    16    19    15   10.13  0.0000
    23    20    17    21   10.13  0.0000    24    21    17    18   10.13  0.0000
    25    22    21    18   10.13  0.0000    26    22    18    19   10.13  0.0000
```

```
   27    19    23    22   10.13  0.0000    28    24    20    21   10.13  0.0000
   29    25    24    21   10.13  0.0000    30    25    21    22   10.13  0.0000
   31    26    25    22   10.13  0.0000    32    23    26    22   10.13  0.0000
   33    27    24    28   10.13  0.0000    34    28    24    25   10.13  0.0000
   35    29    28    25   10.13  0.0000    36    29    25    26   10.13  0.0000
   37    26    30    29   10.13  0.0000    38    31    27    28   10.13  0.0000
   39    32    31    28   10.13  0.0000    40    32    28    29   10.13  0.0000
   41    33    32    29   10.13  0.0000    42    30    33    29   10.13  0.0000
   43    34    31    35   10.13  0.0000    44    35    31    32   10.13  0.0000
   45    36    35    32   10.13  0.0000    46    36    32    33   10.13  0.0000
   47    33    37    36   10.13  0.0000    48    38    34    35   10.13  0.0000
   49    39    38    35   10.13  0.0000    50    39    35    36   10.13  0.0000
   51    40    39    36   10.13  0.0000    52    37    40    36   10.13  0.0000
   53    41    38    42   10.13  0.0000    54    42    38    39   10.13  0.0000
   55    43    42    39   10.13  0.0000    56    43    39    40   10.13  0.0000
   57    40    44    43   10.13  0.0000    58    45    41    42   10.13  0.0000
   59    46    45    42   10.13  0.0000    60    46    42    43   10.13  0.0000
   61    47    46    43   10.13  0.0000    62    44    47    43   10.13  0.0000
   63    51    45    50   10.13  0.0000    64    50    45    46   10.13  0.0000
   65    49    50    46   10.13  0.0000    66    49    46    47   10.13  0.0000
   67    47    48    49   10.13  0.0000    68    52    49    48   10.13  0.0000
   69    52    53    49   10.13  0.0000    70    53    50    49   10.13  0.0000
   71    53    54    50   10.13  0.0000    72    54    51    50   10.13  0.0000
   73    55    53    52   10.13  0.0000    74    55    56    53   10.13  0.0000
   75    56    54    53   10.13  0.0000    76    55    52    59   10.13  0.0000
   77    52    48    58   10.13  0.0000    78    59    52    58   10.13  0.0000
   79    60    55    59   10.13  0.0000    80    61    55    60   10.13  0.0000
   81    61    62    55   10.13  0.0000    82    62    56    55   10.13  0.0000
   83    62    63    56   10.13  0.0000    84    63    64    56   10.13  0.0000
   85    64    65    56   10.13  0.0000    86    56    65    54   10.13  0.0000
   87    65    66    54   10.13  0.0000    88    54    66    51   10.13  0.0000
   89    67    51    66   10.13  0.0000    90    57    68    58   10.13  0.0000
   91    59    58    70   10.13  0.0000    92    72    60    59   10.13  0.0000
   93    74    61    60   10.13  0.0000    94    76    62    61   10.13  0.0000
   95    78    63    62   10.13  0.0000    96    80    64    63   10.13  0.0000
   97    82    65    64   10.13  0.0000    98    65    84    66   10.13  0.0000
   99    86    67    66   10.13  0.0000   100    68    69    58   10.13  0.0000
  101    69    70    58   10.13  0.0000   102    70    71    59   10.13  0.0000
  103    71    72    59   10.13  0.0000   104    72    73    60   10.13  0.0000
  105    73    74    60   10.13  0.0000   106    74    75    61   10.13  0.0000
  107    75    76    61   10.13  0.0000   108    76    77    62   10.13  0.0000
  109    77    78    62   10.13  0.0000   110    78    79    63   10.13  0.0000
  111    79    80    63   10.13  0.0000   112    80    81    64   10.13  0.0000
  113    81    82    64   10.13  0.0000   114    82    83    65   10.13  0.0000
  115    83    84    65   10.13  0.0000   116    84    85    66   10.13  0.0000
  117    85    86    66   10.13  0.0000   118    48    57    58   10.13  0.0000
    1   99 1.00     2    89 1.00     3    63 1.00     4    58 1.00     5    53 1.00
    6   48 1.00     7    43 1.00     8    38 1.00     9    33 1.00    10    28 1.00
   11   23 1.00    12    18 1.00    13    13 1.00    14     8 1.00    15     1 1.00
   16    2 1.00    17     3 1.00    18     5 1.00    19     6 1.00    20     7 1.00
   21   12 1.00    22    17 1.00    23    22 1.00    24    27 1.00    25    32 1.00
   26   37 1.00    27    42 1.00    28    47 1.00    29    52 1.00    30    57 1.00
   31   62 1.00    32    67 1.00    33   118 1.00    34    90 1.00
BATHSPEC  METERS      0.0   10.128
```

APPENDIX 9-C: INPUT DATA SET FOR
AGAT HARBOR, GUAM EXAMPLE

```
GENSPECS ENGLISH    HARD AGAT HARBOR WES  PLAN
GRIDSPEC  TRIANG ENGLISH     1334    2421       84      164       88  AGAT.DAT
CONVERG     0.0
WAVCOND     0.00     8.0   329.7
WAVCOND     0.00    11.0   329.7
PRWINDOW      NO  SELECT     YES       32
PRNODE        10
PRNODNUM       1     100     200      300      400      500      600      700      800
PRNODNUM     900
PRBASIN        6
PRBNELEM    1752    1753    1754     1756     1607     1606
PRBASIN       13
PRBNELEM    1191    1336    1337     1466     1467     1340     1339     1338     1193
PRBNELEM    1192    1196    1195     1194
PRBASIN       13
PRBNELEM    1187    1186    1046     1045      909     1049     1048     1047      911
PRBNELEM     910     912     913      914
PRBASIN       13
PRBNELEM     907     906     905      904      775      780      779      778      777
PRBNELEM     776     657     656      655
PRBASIN        6
PRBNELEM     769     768     767      770      646      645
PRBASIN        6
PRBNELEM     761     762     763      641      640      639
PRBASIN        6
PRBNELEM     757     882     881      756      755      754
PRBASIN        6
PRBNELEM     877    1009    1008      876      875      874
PRBASIN        6
PRBNELEM    1001    1002    1003     1004     1140     1139
PRBASIN        6
PRBNELEM    1135    1276    1275     1274     1133     1134
PRBASIN       13
PRBNELEM     860     861     862      737      736      735      738      618      617
PRBNELEM     616     615     614      734
PRBASIN       13
PRBNELEM     622     623     528      529      530      441      440      527      526
PRBNELEM     525     437     438      439
PRBASIN       13
PRBNELEM     446     447     448      449      450      384      383      382      381
PRBNELEM     445     380     315      316
PRBASIN       13
PRBNELEM     389     390     391      459      460      394      393      392      323
PRBNELEM     322     324     325      326
PRBASIN       13
PRBNELEM     464     555     556      557      558      469      468      467      466
PRBNELEM     465     400     401      402
PRBASIN       13
PRBNELEM     269     270     271      336      337      338      273      272      214
PRBNELEM     213     215     216      274
PRBASIN       13
PRBNELEM     204     205     206      207      208      209      158      157      156
PRBNELEM     155     111     112      159
PRBASIN       13
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PRBNELEM    250   251   252   253   200   199   198   197   196
PRBNELEM    195   147   148   149
PRBASIN      13
PRBNELEM    303   304   305   306   307   245   244   243   242
PRBNELEM    302   241   188   189
PRBASIN      13
PRBNELEM    430   517   516   611   610   609   514   515   428
PRBNELEM    429   427   426   513
PRBASIN      13
PRBNELEM    422   423   359   360   295   294   293   358   357
PRBNELEM    421   356   291   292
PRBASIN      13
PRBNELEM    184   185   138   139    96    95    94   137   136
PRBNELEM    183   135    92    93
PRBASIN      13
PRBNELEM    100   101    63    64    65    34    33    62    61
PRBNELEM     60    30    31    32
PRBASIN      13
PRBNELEM     39    72    73    74    75    43    42    41    40
PRBNELEM     38    15    16    17
PRBASIN       6
PRBNELEM    120   121   122   123   167   168
PRBASIN       6
PRBNELEM    408   409   410   474   475   476
PRBASIN       6
PRBNELEM    280   281   282   283   226   225
PRBASIN       5
PRBNELEM   2056  2057  2058  1900  1899
PRBASIN      13
PRBNELEM   1615  1616  1617  1766  1767  1768  1619  1618  1473
PRBNELEM   1472  1474  1475  1620
PRBASIN       6
PRBNELEM    668   669   670   790   791   792
PRBASIN       6
PRBNELEM   1060  1061  1062  1063   927   926
PRBASIN       6
PRBNELEM   1256  1257  1258  1117  1116  1115
GRIDFORM   (3(I6,2F10.2))(2(4I6.F8.2,F8.4))  (5(2I5,F5.2))
     1     4.40     50.80     2     -3.80     48.80     3    -12.00     46.70
     4    28.80     57.20     5     20.50     55.10     6     12.10     52.80
     7     6.00     59.00     8     -2.00     56.70     9    -10.40     54.40
    10   -18.40     52.50    11    -20.30     44.40    12     36.90     59.70
    13    30.50     65.50    14     22.20     63.10    15     14.00     61.00
    16     7.60     67.10    17     -0.50     65.40    18     -8.70     62.90
    19   -16.80     60.90    20    -24.90     58.70    21    -26.90     50.30
    22   -28.50     42.20    23    -37.00     40.10    24    -44.80     37.90
    25    45.30     61.50    26     38.70     67.50    27     32.20     73.60
    28    23.80     71.70    29     15.80     69.30    30      9.50     75.20
    31     1.10     73.10    32     -6.80     71.00    33    -13.20     77.40
    34   -15.20     68.70    35    -23.20     66.80    36    -31.50     64.70
    37   -33.30     56.60    38    -35.20     48.30    39    -43.10     46.10
    40   -52.10     43.80    41    -54.50     35.70    42    -64.00     38.40
    43    53.10     63.70    44     47.00     69.80    45     40.20     76.00
    46    34.20     81.50    47     25.70     79.30    48     17.90     77.50
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49	11.00	83.90	50	2.80	81.40	51	-5.10	79.50
52	-11.50	85.70	53	-19.40	83.50	54	-21.70	75.20
55	-29.80	73.30	56	-37.80	71.40	57	-39.40	62.40
58	-41.30	54.40	59	-50.20	52.30	60	-58.90	49.80
61	-60.90	46.00	62	-69.50	49.10	63	-73.50	41.70
64	61.60	65.90	65	55.00	72.10	66	48.70	77.90
67	42.20	84.00	68	35.70	90.10	69	27.60	87.90
70	19.20	85.70	71	12.90	92.00	72	4.60	89.90
73	-3.20	87.50	74	-9.70	93.50	75	-18.00	91.40
76	-26.20	89.40	77	-28.30	81.10	78	-36.00	79.30
79	-44.90	76.90	80	-46.80	68.50	81	-48.50	60.60
82	-57.30	57.90	83	-66.10	55.80	84	-71.20	54.30
85	-78.40	52.20	86	-82.50	44.60	87	69.90	68.30
88	63.40	73.90	89	56.60	80.00	90	50.70	86.00
91	43.70	92.20	92	37.40	98.00	93	29.30	96.00
94	21.10	93.90	95	14.80	100.00	96	6.60	97.80
97	-1.60	95.50	98	-7.90	101.70	99	-16.20	99.40
100	-24.70	97.70	101	-32.80	95.20	102	-34.40	87.40
103	-43.30	85.00	104	-52.20	82.70	105	-53.90	74.40
106	-55.70	66.30	107	-64.60	64.00	108	-73.10	61.50
109	-80.60	58.00	110	-87.70	55.00	111	-91.80	48.20
112	77.50	70.40	113	71.40	75.70	114	64.80	82.20
115	58.60	88.30	116	52.10	94.00	117	45.90	100.30
118	39.50	105.80	119	30.90	104.20	120	22.80	102.10
121	16.60	108.40	122	8.40	105.80	123	0.10	103.90
124	-6.10	109.50	125	-14.20	107.60	126	-23.10	105.50
127	-31.10	103.20	128	-39.60	101.00	129	-42.10	92.80
130	-50.10	91.00	131	-58.90	88.90	132	-60.70	80.20
133	-62.70	72.00	134	-71.60	69.60	135	-80.10	67.50
136	-82.70	63.50	137	-89.60	65.20	138	-94.30	57.00
139	-99.30	58.60	140	-101.00	51.10	141	85.80	72.30
142	79.60	78.20	143	73.20	84.20	144	66.90	90.40
145	60.50	96.40	146	53.80	102.60	147	47.50	108.50
148	40.70	114.60	149	32.70	112.40	150	24.60	110.40
151	18.30	116.00	152	9.90	114.50	153	1.80	112.00
154	-4.50	118.00	155	-12.60	115.90	156	-20.60	113.60
157	-27.40	119.50	158	-29.20	111.20	159	-37.90	109.50
160	-46.80	107.00	161	-48.60	98.50	162	-57.20	96.30
163	-66.40	94.30	164	-68.10	86.20	165	-69.90	78.00
166	-78.70	75.50	167	-87.10	73.40	168	-95.70	75.10
169	-97.50	67.10	170	-102.90	63.80	171	-108.30	61.10
172	-110.10	54.50	173	94.30	74.40	174	88.40	80.60
175	81.40	86.50	176	75.30	92.60	177	68.80	98.50
178	62.20	104.60	179	55.90	110.50	180	49.40	116.60
181	42.80	122.60	182	34.60	120.50	183	26.30	118.20
184	20.20	124.60	185	11.70	122.30	186	3.50	120.20
187	-2.80	126.50	188	-11.10	123.90	189	-19.30	121.90
190	-25.60	128.20	191	-34.50	125.80	192	-36.40	117.30
193	-45.00	115.30	194	-53.80	112.70	195	-55.90	104.70
196	-64.60	102.40	197	-73.20	100.00	198	-75.00	91.70
199	-76.80	83.90	200	-85.70	81.30	201	-94.20	80.60
202	-103.90	76.70	203	-106.10	69.20	204	-113.60	70.90
205	-115.80	63.90	206	-118.40	57.20	207	102.40	76.80
208	96.30	82.80	209	89.80	88.80	210	83.40	94.60

211	76.90	100.60	212	70.50	106.90	213	64.00	112.90
214	57.50	118.70	215	51.50	124.90	216	44.50	130.90
217	36.40	128.70	218	28.40	126.80	219	21.80	132.60
220	13.40	130.50	221	5.10	128.40	222	-1.00	134.40
223	-9.10	132.30	224	-17.40	130.30	225	-23.90	136.30
226	-32.80	133.80	227	-41.50	131.30	228	-43.50	123.40
229	-52.30	121.10	230	-60.90	118.70	231	-63.00	110.50
232	-71.60	108.40	233	-80.70	106.00	234	-82.40	97.90
235	-83.90	89.70	236	-92.70	87.30	237	-101.60	85.20
238	-111.00	78.30	239	-119.10	71.50	240	-122.20	63.00
241	-130.50	58.60	242	-125.00	54.30	243	-127.50	46.20
244	-130.40	38.10	245	-133.30	29.50	246	-136.60	20.80
247	-138.80	14.40	248	-133.50	8.20	249	-141.10	8.20
250	110.70	81.40	251	106.30	86.60	252	100.70	92.00
253	94.00	98.30	254	87.50	104.50	255	80.40	110.70
256	73.90	116.50	257	67.20	122.00	258	60.50	127.70
259	53.70	133.80	260	47.00	139.40	261	38.40	137.00
262	29.70	134.50	263	23.70	140.70	264	15.30	138.80
265	6.70	136.30	266	0.70	142.40	267	-7.50	140.20
268	-15.30	138.40	269	-22.10	144.70	270	-31.20	142.30
271	-40.20	139.80	272	-48.60	137.60	273	-50.70	129.30
274	-59.40	126.90	275	-68.10	124.60	276	-69.90	116.50
277	-78.80	114.30	278	-87.70	111.90	279	-89.20	103.50
280	-90.80	95.90	281	-99.80	93.40	282	-105.30	94.80
283	-107.90	86.50	284	-113.40	88.20	285	-116.50	79.90
286	-124.70	75.00	287	-127.50	66.90	288	-136.30	63.50
289	-139.60	55.40	290	-133.60	51.10	291	-136.70	42.90
292	-139.60	34.70	293	-142.70	26.00	294	-145.10	19.70
295	-147.00	12.60	296	-148.60	7.70	297	119.50	80.90
298	115.20	88.70	299	110.20	95.90	300	104.40	101.10
301	97.20	107.30	302	90.50	113.40	303	83.20	119.70
304	76.60	125.30	305	69.70	131.00	306	63.10	136.80
307	55.90	142.20	308	49.20	147.60	309	40.20	145.20
310	31.30	142.70	311	25.50	148.90	312	17.00	146.80
313	8.40	144.60	314	2.20	150.80	315	-6.00	148.70
316	-14.10	146.90	317	-20.20	152.60	318	-29.10	150.10
319	-37.80	148.10	320	-47.00	145.50	321	-55.80	143.70
322	-57.30	135.50	323	-66.20	132.90	324	-75.20	130.70
325	-76.70	122.70	326	-85.60	120.00	327	-94.90	117.80
328	-96.50	109.90	329	-98.20	101.60	330	-104.00	98.10
331	-109.10	100.50	332	-110.50	96.60	333	-116.10	97.10
334	-118.70	90.50	335	-121.30	83.30	336	-129.90	79.00
337	-133.10	71.20	338	-142.30	68.10	339	-145.10	60.10
340	-148.20	52.50	341	-142.30	47.70	342	-145.20	39.50
343	-148.60	31.10	344	-151.30	24.40	345	-153.40	16.90
346	-156.30	7.10	347	148.40	1.90	348	146.10	10.40
349	143.80	19.10	350	141.60	27.40	351	139.30	35.60
352	137.30	44.10	353	134.70	52.40	354	132.70	60.90
355	130.60	69.10	356	125.80	76.90	357	130.40	84.20
358	125.40	90.60	359	119.50	98.70	360	114.10	104.90
361	108.40	110.70	362	101.00	116.50	363	94.10	122.40
364	86.70	128.80	365	79.70	134.20	366	72.50	139.90
367	65.40	145.30	368	58.70	151.00	369	51.80	156.30
370	42.70	153.80	371	34.20	151.00	372	27.50	157.30

373	18.50	155.20	374	10.20	153.00	375	4.20	159.20
376	-3.90	157.10	377	-12.40	154.90	378	-18.70	160.70
379	-27.70	158.70	380	-36.30	156.40	381	-45.40	154.00
382	-54.20	151.50	383	-62.90	149.20	384	-64.80	140.90
385	-73.50	138.80	386	-82.30	136.50	387	-84.00	128.80
388	-93.20	126.00	389	-102.00	123.90	390	-103.40	115.60
391	-105.30	107.70	392	-114.50	105.50	393	-123.30	102.70
394	-124.80	93.50	395	-127.40	86.80	396	-136.10	83.00
397	-139.10	75.60	398	-148.00	72.00	399	-151.30	64.60
400	-154.30	56.40	401	-157.70	49.00	402	-151.60	44.30
403	-154.90	35.90	404	-157.50	29.10	405	-159.70	21.30
406	-162.10	14.00	407	-164.30	6.60	408	158.60	1.80
409	156.20	10.50	410	153.70	19.00	411	151.50	28.00
412	149.10	36.40	413	147.00	45.20	414	144.40	53.70
415	142.40	62.50	416	139.80	71.30	417	136.30	78.90
418	135.70	85.50	419	135.30	92.80	420	129.50	100.60
421	123.60	108.30	422	118.00	114.90	423	112.50	119.50
424	104.60	125.60	425	97.70	131.30	426	89.40	137.70
427	82.30	143.10	428	75.30	148.60	429	68.20	154.00
430	61.40	159.50	431	54.10	164.50	432	45.20	162.10
433	36.60	159.50	434	29.70	165.90	435	21.00	163.50
436	12.30	161.40	437	5.90	167.20	438	-2.40	165.10
439	-10.50	163.00	440	-17.10	169.10	441	-26.00	167.00
442	-34.70	164.60	443	-43.60	162.20	444	-52.30	160.00
445	-61.30	157.70	446	-69.70	155.40	447	-72.00	147.10
448	-80.60	144.70	449	-89.30	142.50	450	-91.10	134.10
451	-99.90	131.80	452	-109.10	129.50	453	-110.90	121.20
454	-112.60	113.20	455	-121.50	110.80	456	-130.20	108.70
457	-131.70	99.50	458	-133.10	90.20	459	-142.00	86.90
460	-144.80	79.70	461	-153.80	76.30	462	-156.60	69.00
463	-160.20	61.60	464	-163.20	53.70	465	-172.60	50.60
466	-166.70	45.70	467	-160.90	40.90	468	-163.70	34.20
469	-165.80	26.50	470	-168.20	19.30	471	-170.00	13.20
472	-172.10	6.10	473	168.20	1.90	474	165.70	11.20
475	163.30	19.80	476	161.00	28.70	477	158.60	37.70
478	156.30	46.50	479	154.20	54.90	480	151.70	64.40
481	149.60	73.00	482	146.00	80.80	483	145.30	87.50
484	144.80	94.90	485	139.00	102.70	486	133.50	109.70
487	127.60	117.70	488	122.50	124.10	489	116.20	129.10
490	108.40	134.60	491	101.20	140.20	492	93.10	146.50
493	85.10	152.20	494	78.00	157.40	495	70.70	162.40
496	63.70	167.70	497	56.50	172.80	498	47.20	170.80
499	38.50	168.20	500	32.10	173.90	501	23.10	171.70
502	14.30	169.50	503	8.00	175.50	504	-0.30	173.40
505	-9.00	171.30	506	-15.20	176.20	507	-24.00	174.90
508	-32.80	172.40	509	-41.90	170.30	510	-50.40	168.20
511	-59.90	165.60	512	-68.20	163.20	513	-77.20	160.80
514	-79.00	152.50	515	-87.80	150.40	516	-96.40	148.40
517	-98.20	140.00	518	-107.20	137.80	519	-116.20	135.30
520	-117.90	127.20	521	-119.60	119.00	522	-128.60	116.90
523	-137.30	114.60	524	-139.10	105.50	525	-140.30	96.30
526	-149.00	92.80	527	-150.30	83.90	528	-158.70	80.60
529	-162.20	73.30	530	-165.60	65.90	531	-168.90	58.50
532	-175.90	53.60	533	-178.60	46.60	534	-175.90	44.20

535	-169.70	39.20	536	-172.00	31.50	537	-174.40	24.00
538	-176.80	16.30	539	-178.10	11.60	540	-179.90	5.80
541	178.30	1.30	542	175.50	10.90	543	173.30	20.00
544	170.90	29.40	545	168.50	38.00	546	166.10	47.60
547	163.70	56.20	548	161.40	66.20	549	159.00	74.70
550	156.10	82.60	551	155.30	89.40	552	154.50	97.00
553	148.90	104.40	554	142.90	111.90	555	137.60	119.20
556	131.80	126.40	557	126.30	133.50	558	120.40	137.80
559	112.40	143.70	560	104.60	149.30	561	95.70	155.70
562	88.00	160.80	563	80.90	166.00	564	73.60	171.20
565	66.30	176.20	566	58.90	181.30	567	50.10	178.80
568	40.90	176.70	569	34.30	182.40	570	25.30	180.20
571	16.50	177.90	572	9.80	183.70	573	1.50	181.50
574	-7.00	179.50	575	-13.40	185.70	576	-22.30	183.00
577	-30.80	181.00	578	-40.10	178.60	579	-49.00	176.30
580	-57.80	173.80	581	-66.50	171.40	582	-75.30	169.20
583	-84.20	166.90	584	-86.00	158.40	585	-94.70	156.10
586	-103.20	153.60	587	-105.40	146.10	588	-114.20	142.90
589	-123.20	141.00	590	-124.90	132.80	591	-126.50	124.80
592	-135.30	122.60	593	-144.20	120.50	594	-145.90	110.80
595	-147.20	102.10	596	-155.70	98.90	597	-157.40	89.70
598	-165.70	86.60	599	-166.80	77.40	600	-170.10	69.20
601	-173.00	61.60	602	-180.30	56.80	603	-182.30	49.30
604	-184.30	41.50	605	-178.40	36.50	606	-180.80	28.80
607	-182.90	21.10	608	-185.00	14.10	609	-187.80	5.10
610	188.20	1.30	611	185.90	9.70	612	183.40	19.00
613	181.10	28.20	614	177.90	41.00	615	175.50	50.20
616	173.30	58.80	617	171.10	68.00	618	168.70	76.60
619	166.20	84.40	620	165.00	91.50	621	164.10	99.20
622	158.40	106.70	623	152.70	114.00	624	147.20	121.40
625	141.30	128.70	626	135.70	136.00	627	130.10	143.10
628	124.30	147.10	629	116.10	152.70	630	108.10	158.10
631	98.70	164.40	632	91.00	169.70	633	83.60	174.70
634	76.20	179.60	635	68.90	184.90	636	61.40	189.80
637	52.10	187.30	638	43.20	185.00	639	36.60	190.80
640	27.60	188.50	641	18.70	186.20	642	12.10	192.30
643	3.60	189.90	644	-5.10	187.80	645	-11.60	193.80
646	-20.50	191.40	647	-29.20	189.10	648	-38.30	186.70
649	-47.10	184.60	650	-55.90	182.20	651	-64.90	179.60
652	-73.60	177.40	653	-82.60	175.00	654	-91.30	172.70
655	-93.10	164.60	656	-101.90	162.00	657	-110.60	159.90
658	-112.60	152.10	659	-121.40	149.30	660	-130.20	147.10
661	-131.80	138.90	662	-133.70	130.50	663	-142.60	128.50
664	-151.40	126.20	665	-152.90	116.90	666	-154.40	108.00
667	-162.90	104.80	668	-164.50	95.40	669	-172.80	92.20
670	-174.00	83.00	671	-176.40	74.60	672	-178.50	66.10
673	-186.40	62.10	674	-188.40	54.30	675	-190.80	46.40
676	-192.90	38.80	677	-186.80	33.80	678	-189.20	26.20
679	-191.40	18.60	680	-193.40	12.00	681	-195.80	4.40
682	198.00	1.20	683	196.00	9.80	684	193.50	18.10
685	191.20	27.20	686	189.30	35.30	687	187.20	44.00
688	185.00	52.80	689	183.00	61.40	690	180.80	69.80
691	178.60	78.50	692	176.30	86.30	693	174.80	93.60
694	173.70	101.30	695	168.00	108.90	696	162.50	116.20

697	156.60	123.50	698	150.80	130.90	699	145.10	138.40
700	139.40	145.80	701	134.00	152.60	702	128.30	156.30
703	119.70	161.70	704	111.70	167.00	705	101.80	173.00
706	94.20	178.60	707	86.30	183.40	708	79.00	188.10
709	71.40	193.50	710	63.80	198.20	711	54.20	195.90
712	45.30	193.40	713	38.80	199.20	714	30.00	196.80
715	20.80	194.70	716	14.30	200.70	717	5.70	198.30
718	-3.20	196.00	719	-9.80	202.00	720	-18.70	199.60
721	-27.50	197.20	722	-36.60	194.90	723	-45.20	192.90
724	-54.00	190.40	725	-63.30	187.80	726	-71.90	185.70
727	-80.90	183.20	728	-89.60	180.90	729	-98.30	178.50
730	-100.20	170.70	731	-109.20	168.10	732	-118.00	166.00
733	-119.60	158.10	734	-128.70	155.50	735	-137.30	153.20
736	-138.90	144.80	737	-140.80	136.40	738	-149.80	134.30
739	-158.60	132.00	740	-159.90	122.90	741	-161.70	113.90
742	-170.10	110.50	743	-171.50	101.00	744	-180.00	97.80
745	-181.20	88.70	746	-182.70	80.00	747	-184.10	70.70
748	-192.70	67.30	749	-194.70	59.30	750	-197.10	51.20
751	-199.50	43.70	752	-201.50	36.10	753	-195.20	31.00
754	-197.60	23.50	755	-200.10	15.90	756	-201.80	9.90
757	-203.70	3.80	758	207.80	0.80	759	205.70	10.00
760	203.40	18.80	761	201.20	27.60	762	199.20	36.50
763	196.80	45.30	764	194.70	53.90	765	192.50	62.80
766	190.40	71.70	767	188.20	80.40	768	186.10	87.90
769	184.80	95.90	770	183.00	103.80	771	177.60	110.70
772	171.70	118.40	773	166.00	125.60	774	160.60	133.00
775	154.90	140.00	776	149.00	147.80	777	143.50	154.90
778	138.00	162.30	779	132.20	165.30	780	123.30	170.90
781	114.90	175.70	782	104.80	182.10	783	96.90	187.20
784	89.40	192.10	785	81.60	197.10	786	74.00	201.80
787	66.50	206.80	788	56.40	204.30	789	47.70	201.50
790	41.60	207.80	791	32.10	205.20	792	23.30	202.90
793	16.50	208.80	794	7.80	206.70	795	-1.20	204.20
796	-6.70	212.90	797	-15.50	210.80	798	-24.30	208.40
799	-33.40	206.00	800	-41.90	203.50	801	-51.10	201.70
802	-59.70	199.20	803	-68.80	196.80	804	-77.30	194.50
805	-86.40	192.30	806	-95.00	189.90	807	-104.00	187.50
808	-107.30	175.90	809	-116.10	173.80	810	-124.80	171.60
811	-126.80	163.80	812	-135.70	161.10	813	-145.00	158.70
814	-146.50	150.90	815	-147.80	142.30	816	-156.90	140.10
817	-165.80	137.70	818	-166.90	128.70	819	-168.40	119.70
820	-177.30	116.10	821	-178.40	107.10	822	-186.90	103.60
823	-188.20	94.50	824	-189.80	85.40	825	-190.90	76.10
826	-199.50	73.10	827	-200.80	64.10	828	-203.50	56.10
829	-205.20	48.60	830	-207.70	41.10	831	-210.10	33.10
832	-203.90	28.20	833	-206.00	20.50	834	-208.40	13.30
835	-211.40	3.10	836	217.90	0.80	837	215.30	9.70
838	213.20	18.80	839	211.20	28.10	840	209.00	37.10
841	206.80	46.00	842	204.50	55.30	843	202.30	64.40
844	200.30	73.40	845	198.00	82.40	846	195.90	89.60
847	194.80	97.90	848	192.70	105.70	849	187.10	113.10
850	181.50	120.60	851	175.70	127.80	852	169.90	134.90
853	164.30	142.40	854	158.60	149.70	855	153.10	156.80
856	147.60	164.00	857	141.70	171.40	858	136.30	174.80

859	126.70	179.70	860	118.70	184.80	861	108.00	191.10
862	99.70	195.80	863	91.80	200.90	864	84.00	205.50
865	76.40	210.40	866	68.60	215.20	867	58.70	212.80
868	50.00	210.20	869	43.10	215.70	870	34.50	213.60
871	25.70	211.40	872	18.80	219.70	873	10.30	217.30
874	2.10	215.50	875	-8.30	220.20	876	-17.20	218.50
877	-25.90	216.60	878	-34.70	214.40	879	-43.80	212.00
880	-52.70	210.30	881	-61.50	207.80	882	-68.90	205.40
883	-75.70	204.10	884	-83.30	201.40	885	-90.40	199.70
886	-98.80	196.90	887	-107.30	193.90	888	-112.90	185.50
889	-121.50	182.90	890	-130.00	180.70	891	-133.70	169.60
892	-142.70	166.90	893	-149.00	165.30	894	-153.30	156.50
895	-155.10	148.60	896	-164.20	146.20	897	-172.70	143.80
898	-174.30	134.50	899	-175.70	125.40	900	-184.00	122.20
901	-185.60	113.20	902	-194.20	109.70	903	-195.50	100.40
904	-196.80	91.20	905	-198.20	82.10	906	-207.20	75.90
907	-209.20	67.40	908	-211.30	58.50	909	-213.40	50.70
910	-215.40	42.70	911	-217.60	34.70	912	-212.50	25.80
913	-215.00	18.00	914	-217.70	10.60	915	-219.90	2.80
916	227.30	0.70	917	225.50	9.90	918	222.90	19.10
919	221.30	28.40	920	218.70	37.70	921	216.90	47.20
922	214.50	56.40	923	212.50	65.90	924	210.10	75.10
925	208.10	84.20	926	205.90	91.80	927	204.00	100.00
928	202.20	108.20	929	196.90	114.90	930	190.90	123.00
931	185.60	129.80	932	179.70	136.30	933	173.70	143.70
934	167.70	151.30	935	162.30	158.30	936	156.70	165.40
937	151.20	172.40	938	145.00	179.60	939	139.90	182.80
940	130.90	187.80	941	121.90	193.20	942	112.80	198.60
943	102.80	204.40	944	94.50	209.40	945	86.70	214.00
946	78.80	218.30	947	70.70	223.10	948	61.20	220.80
949	52.30	218.00	950	44.20	226.10	951	35.60	224.00
952	27.60	221.90	953	17.30	227.60	954	8.70	226.10
955	0.20	224.70	956	-9.80	228.30	957	-18.40	226.30
958	-27.30	224.70	959	-36.20	222.70	960	-45.10	220.70
961	-54.10	218.30	962	-63.10	216.80	963	-70.80	214.40
964	-78.50	211.70	965	-85.90	209.60	966	-93.60	207.20
967	-102.20	203.80	968	-110.60	200.10	969	-116.90	193.30
970	-124.90	189.90	971	-133.70	186.70	972	-139.30	178.30
973	-150.90	175.30	974	-157.10	173.80	975	-160.30	162.40
976	-162.20	154.30	977	-171.00	152.20	978	-179.80	149.60
979	-188.40	146.30	980	-181.10	140.50	981	-182.90	131.30
982	-191.10	127.90	983	-192.40	118.80	984	-200.20	111.90
985	-202.50	103.30	986	-204.70	94.00	987	-206.90	85.30
988	-213.70	78.30	989	-216.30	69.30	990	-218.00	60.70
991	-220.40	52.60	992	-222.40	44.20	993	-224.80	35.80
994	-221.70	26.50	995	-223.60	18.70	996	-225.20	10.40
997	-227.20	2.20	998	234.80	0.60	999	233.10	8.90
1000	232.20	18.20	1001	230.80	27.10	1002	229.60	33.60
1003	228.00	40.60	1004	225.70	49.90	1005	222.70	58.80
1006	220.20	67.70	1007	217.60	77.00	1008	215.30	85.50
1009	212.90	93.40	1010	210.30	102.00	1011	208.00	110.10
1012	202.40	117.60	1013	196.80	125.40	1014	191.50	132.60
1015	186.20	140.30	1016	180.70	147.50	1017	175.20	154.90
1018	171.10	159.90	1019	166.00	164.90	1020	160.00	171.70

1021	153.70	178.90	1022	147.70	185.50	1023	143.80	190.10
1024	135.80	195.70	1025	127.40	200.60	1026	117.90	206.40
1027	109.70	211.30	1028	102.00	216.20	1029	93.60	220.90
1030	86.00	225.40	1031	61.00	230.60	1032	53.00	228.40
1033	43.20	232.60	1034	34.20	232.00	1035	25.80	232.40
1036	15.80	235.60	1037	6.80	234.70	1038	-1.60	234.00
1039	-11.10	235.90	1040	-20.20	234.30	1041	-29.10	232.50
1042	-37.70	231.00	1043	-47.20	229.10	1044	-56.10	227.30
1045	-65.20	225.50	1046	-73.30	223.10	1047	-81.30	219.70
1048	-89.30	217.40	1049	-97.10	214.40	1050	-105.30	210.80
1051	-113.80	207.00	1052	-121.00	201.00	1053	-129.20	196.70
1054	-136.90	192.90	1055	-143.50	185.60	1056	-151.50	182.10
1057	-159.40	177.40	1058	-165.60	171.40	1059	-169.10	160.00
1060	-177.70	157.70	1061	-187.00	155.30	1062	-192.90	147.80
1063	-189.80	137.00	1064	-197.40	130.50	1065	-200.50	121.80
1066	-206.70	114.60	1067	-209.90	106.30	1068	-212.70	97.20
1069	-215.40	89.00	1070	-220.50	80.70	1071	-222.90	71.70
1072	-225.40	62.30	1073	-227.50	54.50	1074	-229.70	45.70
1075	-231.80	37.30	1076	-231.00	27.70	1077	-231.70	19.30
1078	-233.20	10.20	1079	-234.40	1.80	1080	242.10	0.30
1081	241.40	8.50	1082	241.40	17.00	1083	240.10	25.80
1084	239.10	34.60	1085	237.50	43.70	1086	235.90	52.40
1087	233.40	61.40	1088	231.40	70.70	1089	228.50	79.00
1090	225.00	87.70	1091	221.60	96.20	1092	218.10	105.10
1093	213.60	112.80	1094	209.60	120.90	1095	204.40	128.90
1096	199.80	136.60	1097	194.20	143.50	1098	188.50	151.40
1099	182.40	158.70	1100	177.00	165.50	1101	170.20	172.40
1102	163.70	178.80	1103	156.60	185.10	1104	149.90	190.50
1105	142.80	196.10	1106	134.70	201.40	1107	128.30	208.00
1108	120.70	212.50	1109	112.80	217.40	1110	105.50	223.90
1111	97.30	228.10	1112	89.20	232.70	1113	78.20	230.50
1114	69.60	233.00	1115	59.40	236.10	1116	51.00	238.00
1117	41.60	240.00	1118	32.80	241.70	1119	23.60	242.50
1120	14.30	243.30	1121	5.40	243.80	1122	-3.50	244.10
1123	-12.70	243.60	1124	-22.00	243.00	1125	-30.70	241.70
1126	-39.90	240.40	1127	-49.00	239.00	1128	-57.80	236.90
1129	-66.90	234.70	1130	-75.60	231.90	1131	-83.90	228.90
1132	-92.60	226.10	1133	-100.70	221.90	1134	-109.00	218.10
1135	-117.20	213.80	1136	-125.10	209.40	1137	-133.10	204.10
1138	-140.30	199.20	1139	-148.20	193.50	1140	-155.00	187.90
1141	-162.00	181.80	1142	-168.80	175.60	1143	-175.30	168.70
1144	-184.00	166.50	1145	-192.50	164.20	1146	-193.60	153.50
1147	-198.80	152.30	1148	-204.10	144.70	1149	-198.00	140.30
1150	-203.20	132.90	1151	-208.00	124.80	1152	-212.80	116.70
1153	-216.80	108.70	1154	-220.70	100.50	1155	-224.40	91.90
1156	-227.70	83.60	1157	-230.60	74.30	1158	-233.40	65.30
1159	-235.50	56.30	1160	-237.40	47.60	1161	-239.10	38.20
1162	-240.40	28.90	1163	-241.20	19.70	1164	-241.80	10.30
1165	-242.00	1.10	1166	252.90	0.00	1167	252.70	9.10
1168	251.70	18.40	1169	251.50	27.30	1170	250.20	36.70
1171	248.50	45.90	1172	246.50	55.50	1173	244.20	64.80
1174	241.70	74.00	1175	238.50	82.90	1176	235.50	91.80
1177	231.50	101.00	1178	227.80	109.50	1179	223.30	118.30
1180	218.60	126.50	1181	214.00	135.00	1182	208.30	142.60

1183	202.80	150.40	1184	197.00	158.70	1185	191.00	165.70
1186	184.60	172.90	1187	178.00	179.90	1188	170.90	186.70
1189	163.50	193.50	1190	156.50	199.10	1191	148.90	204.80
1192	141.30	210.80	1193	133.70	215.90	1194	125.70	220.90
1195	117.20	225.80	1196	109.30	231.90	1197	100.60	235.90
1198	91.60	239.70	1199	81.90	240.40	1200	72.90	243.30
1201	62.60	246.50	1202	52.80	248.80	1203	43.90	250.60
1204	34.30	252.20	1205	24.50	253.10	1206	15.10	254.30
1207	5.50	254.80	1208	-3.80	254.80	1209	-13.20	254.30
1210	-22.60	253.80	1211	-32.20	252.80	1212	-41.60	251.50
1213	-51.00	249.70	1214	-60.50	247.40	1215	-70.00	245.30
1216	-79.00	242.20	1217	-88.20	239.10	1218	-96.60	236.00
1219	-105.50	232.00	1220	-114.00	227.80	1221	-121.90	223.50
1222	-130.80	218.40	1223	-138.90	213.40	1224	-146.80	208.00
1225	-154.70	202.20	1226	-161.80	196.30	1227	-169.30	190.00
1228	-175.90	183.40	1229	-182.90	176.50	1230	-190.70	171.60
1231	-198.50	167.00	1232	-201.80	161.50	1233	-204.60	155.10
1234	-210.10	148.90	1235	-212.30	138.70	1236	-217.10	130.30
1237	-222.10	121.70	1238	-226.50	113.40	1239	-230.50	104.90
1240	-234.30	96.20	1241	-237.70	86.90	1242	-240.90	77.80
1243	-243.60	68.20	1244	-246.10	58.80	1245	-247.70	49.50
1246	-249.60	40.00	1247	-251.00	30.30	1248	-252.00	20.40
1249	-252.50	10.50	1250	-252.60	0.50	1251	263.80	0.00
1252	263.60	9.80	1253	262.80	19.00	1254	262.10	28.20
1255	260.70	38.10	1256	259.10	47.70	1257	257.20	58.00
1258	254.60	67.60	1259	251.90	77.10	1260	248.90	86.70
1261	245.50	96.10	1262	241.40	105.00	1263	237.10	114.30
1264	232.50	123.00	1265	228.00	131.80	1266	223.10	140.60
1267	217.40	149.00	1268	211.50	156.90	1269	205.40	165.30
1270	199.10	172.70	1271	192.50	180.10	1272	185.60	187.60
1273	178.00	194.50	1274	170.50	201.60	1275	162.80	207.70
1276	155.40	213.80	1277	147.30	219.30	1278	138.80	225.00
1279	130.10	230.00	1280	121.70	234.80	1281	112.80	239.40
1282	103.80	243.50	1283	94.70	247.50	1284	85.50	251.00
1285	76.00	253.90	1286	65.20	257.10	1287	55.20	259.20
1288	45.50	261.40	1289	35.80	263.10	1290	25.50	264.40
1291	15.60	265.10	1292	5.50	265.50	1293	-3.80	265.80
1294	-13.70	265.30	1295	-24.10	265.00	1296	-33.50	263.60
1297	-43.40	262.60	1298	-53.00	260.40	1299	-62.50	258.30
1300	-72.70	255.60	1301	-82.30	252.90	1302	-91.90	249.70
1303	-100.70	245.90	1304	-109.90	242.10	1305	-118.50	237.60
1306	-127.40	233.80	1307	-136.10	228.10	1308	-145.00	222.60
1309	-153.10	216.80	1310	-161.00	211.00	1311	-168.60	205.20
1312	-176.50	198.40	1313	-183.70	191.20	1314	-191.10	184.00
1315	-197.30	177.20	1316	-204.10	169.70	1317	-210.30	161.10
1318	-216.10	153.00	1319	-221.70	144.50	1320	-226.80	136.50
1321	-232.00	127.60	1322	-236.80	118.50	1323	-240.80	109.50
1324	-244.50	99.90	1325	-248.40	90.80	1326	-251.30	81.00
1327	-254.40	71.10	1328	-256.60	61.60	1329	-258.90	51.50
1330	-260.30	41.90	1331	-262.10	31.40	1332	-262.90	21.30
1333	-263.40	11.50	1334	-263.80	0.00			

1	1	6	7	11.20	0.0000	2	1	7	8	11.20	0.0000
3	2	1	8	11.20	0.0000	4	2	8	9	11.20	0.0000
5	3	2	9	11.20	0.0000	6	3	9	10	11.20	0.0000

7	11	3	10	11.20	0.0000	8	6	5	15	11.20	0.0000
9	6	15	7	11.20	0.0000	10	7	15	16	14.20	0.0000
11	7	16	17	14.20	0.0000	12	7	17	8	14.20	0.0000
13	8	17	18	14.20	0.0000	14	8	18	9	14.20	0.0000
15	9	18	19	14.20	0.0000	16	9	19	10	14.20	0.0000
17	10	19	20	14.20	0.0000	18	10	20	21	14.20	0.0000
19	21	11	10	11.20	0.0000	20	22	11	21	11.20	0.0000
21	4	12	13	11.20	0.0000	22	4	13	14	11.20	0.0000
23	5	4	14	11.20	0.0000	24	5	14	15	11.20	0.0000
25	12	25	26	11.20	0.0000	26	12	26	13	11.20	0.0000
27	13	26	27	14.20	0.0000	28	13	27	28	14.20	0.0000
29	14	13	28	14.20	0.0000	30	14	28	29	14.20	0.0000
31	15	14	29	14.20	0.0000	32	15	29	16	14.20	0.0000
33	16	29	30	14.20	0.0000	34	16	30	31	14.20	0.0000
35	16	31	17	14.20	0.0000	36	17	31	32	14.20	0.0000
37	17	32	18	14.20	0.0000	38	18	32	34	14.20	0.0000
39	32	33	34	14.20	0.0000	40	19	18	34	14.20	0.0000
41	19	34	35	14.20	0.0000	42	20	19	35	14.20	0.0000
43	20	35	36	14.20	0.0000	44	20	36	37	14.20	0.0000
45	21	20	37	14.20	0.0000	46	21	37	38	14.20	0.0000
47	22	21	38	11.20	0.0000	48	23	22	38	11.20	0.0000
49	23	38	39	11.20	0.0000	50	24	23	39	11.20	0.0000
51	24	39	40	11.20	0.0000	52	41	24	40	11.20	0.0000
53	25	43	44	11.20	0.0000	54	25	44	26	11.20	0.0000
55	26	44	45	14.20	0.0000	56	26	45	27	14.20	0.0000
57	27	45	46	14.20	0.0000	58	27	46	47	14.20	0.0000
59	27	47	28	14.20	0.0000	60	28	47	48	14.20	0.0000
61	28	48	29	14.20	0.0000	62	29	48	30	14.20	0.0000
63	30	48	49	14.20	0.0000	64	30	49	50	14.20	0.0000
65	30	50	31	14.20	0.0000	66	31	50	51	14.20	0.0000
67	31	51	32	14.20	0.0000	68	32	51	33	14.20	0.0000
69	33	51	52	14.20	0.0000	70	33	52	53	14.20	0.0000
71	33	53	54	14.20	0.0000	72	33	54	34	14.20	0.0000
73	34	54	35	14.20	0.0000	74	35	54	55	14.20	0.0000
75	35	55	36	14.20	0.0000	76	36	55	56	14.20	0.0000
77	36	56	57	14.20	0.0000	78	36	57	37	14.20	0.0000
79	37	57	58	14.20	0.0000	80	37	58	38	14.20	0.0000
81	38	58	39	14.20	0.0000	82	39	58	59	14.20	0.0000
83	39	59	40	14.20	0.0000	84	40	59	60	14.20	0.0000
85	40	60	61	14.20	0.0000	86	41	40	61	11.20	0.0000
87	42	41	61	11.20	0.0000	88	42	61	62	11.20	0.0000
89	63	42	62	11.20	0.0000	90	43	64	65	11.20	0.0000
91	43	65	44	11.20	0.0000	92	44	65	66	14.20	0.0000
93	44	66	45	14.20	0.0000	94	45	66	67	14.20	0.0000
95	45	67	46	14.20	0.0000	96	46	67	68	14.20	0.0000
97	46	68	69	14.20	0.0000	98	46	69	47	14.20	0.0000
99	47	69	70	14.20	0.0000	100	47	70	48	14.20	0.0000
101	48	70	49	14.20	0.0000	102	49	70	71	14.20	0.0000
103	49	71	72	14.20	0.0000	104	49	72	50	14.20	0.0000
105	50	72	73	14.20	0.0000	106	51	50	73	14.20	0.0000
107	51	73	52	14.20	0.0000	108	52	73	74	14.20	0.0000
109	52	74	75	15.20	0.0000	110	52	75	53	16.20	0.0000
111	53	75	76	16.20	0.0000	112	53	76	77	16.20	0.0000
113	53	77	54	14.20	0.0000	114	54	77	55	14.20	0.0000

115	55	77	78	14.20	0.0000	116	55	78	56	14.20	0.0000
117	56	78	79	14.20	0.0000	118	56	79	80	14.20	0.0000
119	56	80	57	14.20	0.0000	120	57	80	81	14.20	0.0000
121	57	81	58	14.20	0.0000	122	58	81	59	14.20	0.0000
123	59	81	82	14.20	0.0000	124	59	82	60	14.20	0.0000
125	60	82	83	14.20	0.0000	126	60	83	61	14.20	0.0000
127	61	83	62	14.20	0.0000	128	62	83	84	14.20	0.0000
129	62	84	85	14.20	0.0000	130	62	85	63	11.20	0.0000
131	86	63	85	11.20	0.0000	132	64	87	88	11.20	0.0000
133	64	88	65	11.20	0.0000	134	65	88	89	14.20	0.0000
135	65	89	66	14.20	0.0000	136	66	89	90	14.20	0.0000
137	66	90	67	14.20	0.0000	138	67	90	91	14.20	0.0000
139	67	91	68	14.20	0.0000	140	68	91	92	14.20	0.0000
141	68	92	93	14.20	0.0000	142	68	93	69	14.20	0.0000
143	69	93	94	14.20	0.0000	144	69	94	70	14.20	0.0000
145	70	94	71	14.20	0.0000	146	71	94	95	14.20	0.0000
147	71	95	96	14.20	0.0000	148	71	96	72	14.20	0.0000
149	72	96	97	14.20	0.0000	150	72	97	73	14.20	0.0000
151	73	97	74	14.20	0.0000	152	74	97	98	14.20	0.0000
153	74	98	99	14.20	0.0000	154	74	99	75	15.20	0.0000
155	75	99	100	16.20	0.0000	156	75	100	76	16.20	0.0000
157	76	100	101	16.20	0.0000	158	76	101	102	16.20	0.0000
159	76	102	77	16.20	0.0000	160	77	102	78	16.20	0.0000
161	78	102	103	16.20	0.0000	162	103	79	78	16.20	0.0000
163	79	103	104	16.20	0.0000	164	79	104	105	15.20	0.0000
165	79	105	80	14.20	0.0000	166	80	105	106	14.20	0.0000
167	80	106	81	14.20	0.0000	168	81	106	82	14.20	0.0000
169	82	106	107	14.20	0.0000	170	82	107	83	14.20	0.0000
171	83	107	108	14.20	0.0000	172	83	108	84	14.20	0.0000
173	84	108	85	14.20	0.0000	174	85	108	109	14.20	0.0000
175	85	109	110	14.20	0.0000	176	85	110	86	11.20	0.0000
177	111	86	110	11.20	0.0000	178	87	112	113	11.20	0.0000
179	87	113	88	11.20	0.0000	180	88	113	114	14.20	0.0000
181	88	114	89	14.20	0.0000	182	89	114	115	14.20	0.0000
183	89	115	90	14.20	0.0000	184	90	115	116	14.20	0.0000
185	90	116	91	14.20	0.0000	186	91	116	117	14.20	0.0000
187	91	117	92	14.20	0.0000	188	92	117	118	14.20	0.0000
189	92	118	119	14.20	0.0000	190	92	119	93	14.20	0.0000
191	93	119	120	14.20	0.0000	192	93	120	94	14.20	0.0000
193	94	120	95	14.20	0.0000	194	95	120	121	14.20	0.0000
195	95	121	122	14.20	0.0000	196	95	122	96	14.20	0.0000
197	96	122	123	14.20	0.0000	198	96	123	97	14.20	0.0000
199	97	123	98	14.20	0.0000	200	98	123	124	14.20	0.0000
201	98	124	125	14.20	0.0000	202	98	125	99	14.20	0.0000
203	99	125	126	15.20	0.0000	204	99	126	100	16.20	0.0000
205	100	126	127	16.20	0.0000	206	100	127	101	16.20	0.0000
207	101	127	128	16.20	0.0000	208	101	128	129	16.20	0.0000
209	101	129	102	16.20	0.0000	210	102	129	103	16.20	0.0000
211	103	129	130	16.20	0.0000	212	103	130	104	16.20	0.0000
213	104	130	131	16.20	0.0000	214	104	131	132	15.20	0.0000
215	104	132	105	14.20	0.0000	216	105	132	133	14.20	0.0000
217	105	133	106	14.20	0.0000	218	106	133	107	14.20	0.0000
219	107	133	134	14.20	0.0000	220	107	134	108	14.20	0.0000
221	108	134	135	14.20	0.0000	222	108	135	136	14.20	0.0000

223	108	136	109	14.20	0.0000	224	109	136	110	14.20	0.0000
225	110	136	137	14.20	0.0000	226	110	137	138	14.20	0.0000
227	110	138	111	11.20	0.0000	228	140	111	138	11.20	0.0000
229	140	138	139	11.20	0.0000	230	112	141	142	11.20	0.0000
231	112	142	113	11.20	0.0000	232	113	142	143	14.20	0.0000
233	113	143	114	14.20	0.0000	234	114	143	144	14.20	0.0000
235	114	144	115	14.20	0.0000	236	115	144	145	14.20	0.0000
237	115	145	116	14.20	0.0000	238	116	145	146	14.20	0.0000
239	116	146	117	14.20	0.0000	240	117	146	147	14.20	0.0000
241	117	147	118	14.20	0.0000	242	118	147	148	14.20	0.0000
243	118	148	149	14.20	0.0000	244	118	149	119	14.20	0.0000
245	119	149	150	14.20	0.0000	246	119	150	120	14.20	0.0000
247	120	150	121	14.20	0.0000	248	121	150	151	14.20	0.0000
249	121	151	152	14.20	0.0000	250	121	152	122	14.20	0.0000
251	122	152	153	14.20	0.0000	252	122	153	123	14.20	0.0000
253	123	153	124	14.20	0.0000	254	124	153	154	14.20	0.0000
255	124	154	155	14.20	0.0000	256	124	155	125	14.20	0.0000
257	125	155	156	14.20	0.0000	258	125	156	126	15.20	0.0000
259	126	156	158	16.20	0.0000	260	156	157	158	16.20	0.0000
261	126	158	127	16.20	0.0000	262	127	158	159	16.20	0.0000
263	127	159	128	16.20	0.0000	264	128	159	160	16.20	0.0000
265	128	160	161	16.20	0.0000	266	128	161	129	16.20	0.0000
267	129	161	130	16.20	0.0000	268	130	161	162	16.20	0.0000
269	130	162	131	16.20	0.0000	270	131	162	163	16.20	0.0000
271	131	163	164	14.20	0.0000	272	131	164	132	14.20	0.0000
273	132	164	165	14.20	0.0000	274	132	165	133	14.20	0.0000
275	133	165	134	14.20	0.0000	276	134	165	166	14.20	0.0000
277	134	166	135	14.20	0.0000	278	135	166	167	14.20	0.0000
279	135	167	136	14.20	0.0000	280	136	167	137	14.20	0.0000
281	137	167	168	14.20	0.0000	282	137	168	169	14.20	0.0000
283	137	169	138	14.20	0.0000	284	138	169	139	14.20	0.0000
285	139	169	170	14.20	0.0000	286	139	170	171	14.20	0.0000
287	139	171	140	11.20	0.0000	288	172	140	171	11.20	0.0000
289	141	173	174	11.20	0.0000	290	142	141	174	11.20	0.0000
291	142	174	175	14.20	0.0000	292	143	142	175	14.20	0.0000
293	143	175	176	14.20	0.0000	294	144	143	176	14.20	0.0000
295	144	176	177	14.20	0.0000	296	145	144	177	14.20	0.0000
297	145	177	178	14.20	0.0000	298	146	145	178	14.20	0.0000
299	146	178	179	14.20	0.0000	300	147	146	179	14.20	0.0000
301	147	179	180	14.20	0.0000	302	148	147	180	14.20	0.0000
303	148	180	181	14.20	0.0000	304	148	181	182	14.20	0.0000
305	149	148	182	14.20	0.0000	306	149	182	183	14.20	0.0000
307	150	149	183	14.20	0.0000	308	151	150	183	14.20	0.0000
309	151	183	184	14.20	0.0000	310	151	184	185	14.20	0.0000
311	152	151	185	14.20	0.0000	312	152	185	186	14.20	0.0000
313	153	152	186	14.20	0.0000	314	154	153	186	14.20	0.0000
315	154	186	187	14.20	0.0000	316	154	187	188	14.20	0.0000
317	155	154	188	14.20	0.0000	318	155	188	189	14.20	0.0000
319	156	155	189	14.20	0.0000	320	157	156	189	16.20	0.0000
321	157	189	190	16.20	0.0000	322	157	190	1[illegible]1	16.20	0.0000
323	157	191	192	16.20	0.0000	324	158	157	192	16.20	0.0000
325	159	158	192	16.20	0.0000	326	159	192	193	16.20	0.0000
327	160	159	193	16.20	0.0000	328	160	193	194	16.20	0.0000
329	160	194	195	16.20	0.0000	330	161	160	195	16.20	0.0000

331	162	161	195	16.20	0.0000	332	162	195	196	16.20	0.0000
333	163	162	196	16.20	0.0000	334	163	196	197	15.20	0.0000
335	163	197	198	14.20	0.0000	336	164	163	198	14.20	0.0000
337	164	198	199	14.20	0.0000	338	165	164	199	14.20	0.0000
339	166	165	199	14.20	0.0000	340	166	199	200	14.20	0.0000
341	167	166	200	14.20	0.0000	342	167	200	201	14.20	0.0000
343	168	167	201	14.20	0.0000	344	168	201	202	14.20	0.0000
345	169	168	202	14.20	0.0000	346	169	202	203	14.20	0.0000
347	170	169	203	14.20	0.0000	348	171	170	203	14.20	0.0000
349	171	203	204	11.20	0.0000	350	204	205	171	11.20	0.0000
351	205	206	171	11.20	0.0000	352	206	172	171	11.20	0.0000
353	173	207	208	11.20	0.0000	354	174	173	208	11.20	0.0000
355	174	208	209	14.20	0.0000	356	175	174	209	14.20	0.0000
357	175	209	210	14.20	0.0000	358	176	175	210	14.20	0.0000
359	176	210	211	14.20	0.0000	360	177	176	211	14.20	0.0000
361	177	211	212	14.20	0.0000	362	178	177	212	14.20	0.0000
363	178	212	213	14.20	0.0000	364	179	178	213	14.20	0.0000
365	179	213	214	14.20	0.0000	366	180	179	214	14.20	0.0000
367	180	214	215	14.20	0.0000	368	181	180	215	14.20	0.0000
369	181	215	216	14.20	0.0000	370	181	216	217	14.20	0.0000
371	182	181	217	14.20	0.0000	372	182	217	218	14.20	0.0000
373	183	182	218	14.20	0.0000	374	184	183	218	14.20	0.0000
375	184	218	219	14.20	0.0000	376	184	219	220	14.20	0.0000
377	185	184	220	14.20	0.0000	378	185	220	221	14.20	0.0000
379	186	185	221	14.20	0.0000	380	187	186	221	14.20	0.0000
381	187	221	222	14.20	0.0000	382	187	222	223	14.20	0.0000
383	188	187	223	14.20	0.0000	384	188	223	224	14.20	0.0000
385	189	188	224	14.20	0.0000	386	190	189	224	14.20	0.0000
387	190	224	225	14.20	0.0000	388	190	225	226	16.20	0.0000
389	191	190	226	16.20	0.0000	390	191	226	227	16.20	0.0000
391	191	227	228	16.20	0.0000	392	192	191	228	16.20	0.0000
393	193	192	228	16.20	0.0000	394	193	228	229	16.20	0.0000
395	194	193	229	16.20	0.0000	396	194	229	230	16.20	0.0000
397	194	230	231	16.20	0.0000	398	195	194	231	16.20	0.0000
399	196	195	231	16.20	0.0000	400	196	231	232	16.20	0.0000
401	197	196	232	15.20	0.0000	402	197	232	233	14.20	0.0000
403	197	233	234	14.20	0.0000	404	198	197	234	14.20	0.0000
405	198	234	235	14.20	0.0000	406	199	198	235	14.20	0.0000
407	200	199	235	14.20	0.0000	408	200	235	236	14.20	0.0000
409	201	200	236	14.20	0.0000	410	201	236	237	14.20	0.0000
411	202	201	237	14.20	0.0000	412	202	237	238	11.20	0.0000
413	203	202	238	11.20	0.0000	414	238	204	203	11.20	0.0000
415	242	240	241	7.70	0.0000	416	207	250	251	11.20	0.0000
417	208	207	251	11.20	0.0000	418	208	251	252	14.20	0.0000
419	209	208	252	14.20	0.0000	420	209	252	253	14.20	0.0000
421	210	209	253	14.20	0.0000	422	210	253	254	14.20	0.0000
423	211	210	254	14.20	0.0000	424	211	254	255	14.20	0.0000
425	212	211	255	14.20	0.0000	426	212	255	256	14.20	0.0000
427	213	212	256	14.20	0.0000	428	213	256	257	14.20	0.0000
429	214	213	257	14.20	0.0000	430	214	257	258	14.20	0.0000
431	215	214	258	14.20	0.0000	432	215	258	259	14.20	0.0000
433	216	215	259	14.20	0.0000	434	216	259	260	14.20	0.0000
435	216	260	261	14.20	0.0000	436	217	216	261	14.20	0.0000
437	217	261	262	14.20	0.0000	438	218	217	262	14.20	0.0000

439	219	218	262	14.20	0.0000	440	219	262	263	14.20	0.0000
441	219	263	264	14.20	0.0000	442	220	219	264	14.20	0.0000
443	220	264	265	14.20	0.0000	444	221	220	265	14.20	0.0000
445	222	221	265	14.20	0.0000	446	222	265	266	14.20	0.0000
447	222	266	267	14.20	0.0000	448	223	222	267	14.20	0.0000
449	223	267	268	14.20	0.0000	450	224	223	268	14.20	0.0000
451	225	224	268	14.20	0.0000	452	225	268	269	14.20	0.0000
453	225	269	270	14.20	0.0000	454	226	225	270	16.20	0.0000
455	226	270	271	16.20	0.0000	456	227	226	271	16.20	0.0000
457	227	271	272	16.20	0.0000	458	227	272	273	16.20	0.0000
459	228	227	273	16.20	0.0000	460	229	228	273	16.20	0.0000
461	229	273	274	16.20	0.0000	462	230	229	274	16.20	0.0000
463	230	274	275	17.20	0.0000	464	230	275	276	18.20	0.0000
465	231	230	276	18.20	0.0000	466	232	231	276	18.20	0.0000
467	232	276	277	18.20	0.0000	468	233	232	277	18.20	0.0000
469	233	277	278	18.20	0.0000	470	233	278	279	18.20	0.0000
471	234	233	279	14.20	0.0000	472	234	279	280	14.20	0.0000
473	235	234	280	14.20	0.0000	474	236	235	280	14.20	0.0000
475	236	280	281	14.20	0.0000	476	237	236	281	14.20	0.0000
477	237	281	282	11.20	0.0000	478	282	283	237	11.20	0.0000
479	283	238	237	11.20	0.0000	480	239	285	286	7.70	0.0000
481	239	286	287	7.70	0.0000	482	240	239	287	7.70	0.0000
483	241	240	287	7.70	0.0000	484	241	287	288	7.70	0.0000
485	241	288	289	7.70	0.0000	486	241	289	290	7.70	0.0000
487	242	241	290	7.70	0.0000	488	243	242	290	7.70	0.0000
489	243	290	291	7.70	0.0000	490	244	243	291	7.70	0.0000
491	244	291	292	7.70	0.0000	492	245	244	292	7.70	0.0000
493	245	292	293	7.70	0.0000	494	246	245	293	7.20	0.0000
495	246	293	294	6.20	0.0000	496	247	246	294	6.20	0.0000
497	247	294	295	6.20	0.0000	498	249	247	295	4.20	0.0000
499	248	246	247	5.20	0.0000	500	249	248	247	3.20	0.0000
501	296	249	295	3.20	0.0000	502	250	297	298	11.20	0.0000
503	251	250	298	11.20	0.0000	504	251	298	299	14.20	0.0000
505	252	251	299	14.20	0.0000	506	252	299	300	14.20	0.0000
507	253	252	300	14.20	0.0000	508	253	300	301	14.20	0.0000
509	254	253	301	14.20	0.0000	510	254	301	302	14.20	0.0000
511	255	254	302	14.20	0.0000	512	255	302	303	14.20	0.0000
513	256	255	303	14.20	0.0000	514	256	303	304	14.20	0.0000
515	257	256	304	14.20	0.0000	516	257	304	305	14.20	0.0000
517	258	257	305	14.20	0.0000	518	258	305	306	14.20	0.0000
519	259	258	306	14.20	0.0000	520	259	306	307	14.20	0.0000
521	260	259	307	14.20	0.0000	522	260	307	308	14.20	0.0000
523	260	308	309	14.20	0.0000	524	261	260	309	14.20	0.0000
525	261	309	310	14.20	0.0000	526	262	261	310	14.20	0.0000
527	263	262	310	14.20	0.0000	528	263	310	311	14.20	0.0000
529	263	311	312	14.20	0.0000	530	264	263	312	14.20	0.0000
531	264	312	313	14.20	0.0000	532	265	264	313	14.20	0.0000
533	266	265	313	14.20	0.0000	534	266	313	314	14.20	0.0000
535	266	314	315	14.20	0.0000	536	267	266	315	14.20	0.0000
537	267	315	316	14.20	0.0000	538	268	267	316	14.20	0.0000
539	269	268	316	14.20	0.0000	540	269	316	317	14.20	0.0000
541	269	317	318	15.20	0.0000	542	270	269	318	15.20	0.0000
543	270	318	319	16.20	0.0000	544	271	270	319	16.20	0.0000
545	271	319	320	16.20	0.0000	546	272	271	320	16.20	0.0000

547	272	320	321	16.20	0.0000	548	272	321	322	16.20	0.0000
549	273	272	322	16.20	0.0000	550	274	273	322	16.20	0.0000
551	274	322	323	16.20	0.0000	552	275	274	323	17.20	0.0000
553	275	323	324	18.20	0.0000	554	275	324	325	18.20	0.0000
555	276	275	325	18.20	0 0000	556	277	276	325	18.20	0.0000
557	277	325	326	18.20	0.0000	558	278	277	326	18.20	0.0000
559	278	326	327	18.20	0.0000	560	278	327	328	18.20	0.0000
561	279	278	328	18.20	0.0000	562	279	328	329	16.20	0.0000
563	280	279	329	14.20	0.0000	564	281	280	329	14.20	0.0000
565	281	329	330	12.20	0.0000	566	282	281	330	12.20	0.0000
567	282	330	331	15.20	0.0000	568	332	282	331	13.20	0.0000
569	284	332	333	12.20	0.0000	570	284	333	334	11.20	0.0000
571	284	334	335	8.20	0.0000	572	285	284	335	7.70	0.0000
573	286	285	335	7.70	0.0000	574	286	335	336	7.70	0.0000
575	286	336	337	7.70	0.0000	576	287	286	337	7.70	0.0000
577	288	287	337	7.70	0.0000	578	288	337	338	7.70	0.0000
579	288	338	339	7.70	0.0000	580	289	288	339	7.70	0.0000
581	289	339	340	7.70	0.0000	582	289	340	341	7.70	0.0000
583	290	289	341	7.70	0.0000	584	291	290	341	7.70	0.0000
585	291	341	342	7.70	0.0000	586	292	291	342	7.70	0.0000
587	292	342	343	7.70	0.0000	588	293	292	343	7.70	0.0000
589	293	343	344	7.70	0.0000	590	294	293	344	7.20	0.0000
591	294	344	345	6.20	0.0000	592	295	294	345	6.20	0.0000
593	296	295	345	5.20	0.0000	594	346	296	345	5.20	0.0000
595	297	356	357	7.70	0.0000	596	297	357	358	7.70	0.0000
597	298	297	358	7.70	0.0000	598	298	358	359	7.70	0.0000
599	299	298	359	7.70	0.0000	600	299	359	360	7.70	0.0000
601	300	299	360	7.70	0.0000	602	300	360	361	7.70	0.0000
603	301	300	361	11.20	0.0000	604	301	361	362	11.20	0.0000
605	302	301	362	14.20	0.0000	606	302	362	363	14.20	0.0000
607	303	302	363	14.20	0.0000	608	303	363	364	14.20	0.0000
609	304	303	364	14.20	0.0000	610	304	364	365	14.20	0.0000
611	305	304	365	14.20	0.0000	612	305	365	366	14.20	0.0000
613	306	305	366	14.20	0.0000	614	306	366	367	14.20	0.0000
615	307	306	367	14.20	0.0000	616	307	367	368	14.20	0.0000
617	308	307	368	14.20	0.0000	618	308	368	369	14.20	0.0000
619	308	369	370	14.20	0.0000	620	309	308	370	14.20	0.0000
621	309	370	371	14.20	0.0000	622	310	309	371	14.20	0.0000
623	311	310	371	14.20	0.0000	624	311	371	372	14.20	0.0000
625	311	372	373	14.20	0.0000	626	312	311	373	14.20	0.0000
627	312	373	374	14.20	0.0000	628	313	312	374	14.20	0.0000
629	314	313	374	14.20	0.0000	630	314	374	375	14.20	0.0000
631	314	375	376	15.20	0.0000	632	315	314	376	15.20	0.0000
633	315	376	377	15.20	0.0000	634	316	315	377	15.20	0.0000
635	317	316	377	16.20	0.0000	636	317	377	378	16.20	0.0000
637	317	378	379	16.20	0.0000	638	318	317	379	16.20	0.0000
639	318	379	380	16.20	0.0000	640	319	318	380	16.20	0.0000
641	319	380	381	16.20	0.0000	642	320	319	381	16.20	0.0000
643	320	381	382	16.20	0.0000	644	321	320	382	16.20	0.0000
645	321	382	383	16.20	0.0000	646	321	383	384	16.20	0.0000
647	322	321	384	16.20	0.0000	648	323	322	384	16.20	0.0000
649	323	384	385	18.20	0.0000	650	324	323	385	18.20	0.0000
651	324	385	386	18.20	0.0000	652	324	386	387	18.20	0.0000
653	325	324	387	18.20	0.0000	654	326	325	387	18.20	0.0000

655	326	387	388	18.20	0.0000	656	327	326	388	18.20	0.0000
657	327	388	389	18.20	0.0000	658	327	389	390	18.20	0.0000
659	328	327	390	18.20	0.0000	660	328	390	391	18.20	0.0000
661	329	328	391	18.20	0.0000	662	330	329	391	16.20	0.0000
663	331	330	391	17.20	0.0000	664	331	391	392	19.20	0.0000
665	332	331	392	17.20	0.0000	666	333	332	392	18.20	0.0000
667	333	392	393	20.20	0.0000	668	333	393	394	18.20	0.0000
669	334	333	394	14.20	0.0000	670	334	394	395	12.20	0.0000
671	335	334	395	8.20	0.0000	672	336	335	395	7.70	0.0000
673	336	395	396	7.70	0.0000	674	336	396	397	7.70	0.0000
675	337	336	397	7.70	0.0000	676	338	337	397	7.70	0.0000
677	338	397	398	7.70	0.0000	678	338	398	399	7.70	0.0000
679	339	338	399	7.70	0.0000	680	339	399	400	7.70	0.0000
681	340	339	400	7.70	0.0000	682	340	400	401	7.70	0.0000
683	340	401	402	7.70	0.0000	684	341	340	402	7.70	0.0000
685	342	341	402	7.70	0.0000	686	342	402	403	7.70	0.0000
687	343	342	403	7.70	0.0000	688	343	403	404	7.70	0.0000
689	344	343	404	7.70	0.0000	690	344	404	405	7.70	0.0000
691	345	344	405	7.20	0.0000	692	345	405	406	6.20	0.0000
693	346	345	406	5.20	0.0000	694	407	346	406	3.20	0.0000
695	347	408	409	2.20	0.0000	696	348	347	409	2.20	0.0000
697	348	409	410	3.20	0.0000	698	349	348	410	4.20	0.0000
699	349	410	411	5.20	0.0000	700	350	349	411	5.20	0.0000
701	350	411	412	6.20	0.0000	702	351	350	412	6.20	0.0000
703	351	412	413	7.20	0.0000	704	352	351	413	7.20	0.0000
705	352	413	414	7.70	0.0000	706	353	352	414	7.70	0.0000
707	353	414	415	7.70	0.0000	708	354	353	415	7.70	0.0000
709	354	415	416	7.70	0.0000	710	355	354	416	7.70	0.0000
711	355	416	417	7.70	0.0000	712	356	355	417	7.70	0.0000
713	357	356	417	7.70	0.0000	714	357	417	418	7.70	0.0000
715	357	418	419	7.70	0.0000	716	358	357	419	7.70	0.0000
717	358	419	420	7.70	0.0000	718	359	358	420	7.70	0.0000
719	359	420	421	7.70	0.0000	720	360	359	421	7.70	0.0000
721	360	421	422	7.70	0.0000	722	361	360	422	7.70	0.0000
723	361	422	423	7.70	0.0000	724	362	361	423	7.70	0.0000
725	362	423	424	7.70	0.0000	726	363	362	424	11.20	0.0000
727	363	424	425	11.20	0.0000	728	364	363	425	14.20	0.0000
729	364	425	426	14.20	0.0000	730	365	364	426	14.20	0.0000
731	365	426	427	14.20	0.0000	732	366	365	427	14.20	0.0000
733	366	427	428	14.20	0.0000	734	367	366	428	14.20	0.0000
735	367	428	429	14.20	0.0000	736	368	367	429	14.20	0.0000
737	368	429	430	14.20	0.0000	738	369	368	430	14.20	0.0000
739	369	430	431	14.20	0.0000	740	369	431	432	14.20	0.0000
741	370	369	432	14.20	0.0000	742	370	432	433	14.20	0.0000
743	371	370	433	14.20	0.0000	744	372	371	433	14.20	0.0000
745	372	433	434	14.20	0.0000	746	372	434	435	15.20	0.0000
747	373	372	435	14.20	0.0000	748	373	435	436	15.20	0.0000
749	374	373	436	14.20	0.0000	750	375	374	436	15.20	0.0000
751	375	436	437	16.20	0.0000	752	375	437	438	16.20	0.0000
753	376	375	438	16.20	0.0000	754	376	438	439	16.20	0.0000
755	377	376	439	16.20	0.0000	756	378	377	439	16.20	0.0000
757	378	439	440	16.20	0.0000	758	378	440	441	16.20	0.0000
759	379	378	441	16.20	0.0000	760	379	441	442	16.20	0.0000
761	380	379	442	16.20	0.0000	762	380	442	443	16.20	0.0000

763	381	380	443	16.20	0.0000	764	381	443	444	16.20	0.0000
765	382	381	444	16.20	0.0000	766	382	444	445	16.20	0.0000
767	383	382	445	16.20	0.0000	768	383	445	446	16.20	0.0000
769	383	446	447	16.20	0.0000	770	384	383	447	16.20	0.0000
771	385	384	447	18.20	0.0000	772	385	447	448	18.20	0.0000
773	386	385	448	18.20	0.0000	774	386	448	449	18.20	0.0000
775	386	449	450	18.20	0.0000	776	387	386	450	18.20	0.0000
777	388	387	450	18.20	0.0000	778	388	450	451	18.20	0.0000
779	389	388	451	18.20	0.0000	780	389	451	452	18.20	0.0000
781	389	452	453	18.20	0.0000	782	390	389	453	18.20	0.0000
783	390	453	454	19.20	0.0000	784	391	390	454	19.20	0.0000
785	392	391	454	20.20	0.0000	786	392	454	455	20.20	0.0000
787	393	392	455	21.20	0.0000	788	393	455	456	21.20	0.0000
789	393	456	457	21.20	0.0000	790	394	393	457	21.20	0.0000
791	394	457	458	19.20	0.0000	792	395	394	458	14.20	0.0000
793	396	395	458	11.20	0.0000	794	396	458	459	11.20	0.0000
795	396	459	460	11.20	0.0000	796	397	396	460	7.70	0.0000
797	398	397	460	7.70	0.0000	798	398	460	461	7.70	0.0000
799	398	461	462	7.70	0.0000	800	399	398	462	7.70	0.0000
801	399	462	463	7.70	0.0000	802	400	399	463	7.70	0.0000
803	400	463	464	7.70	0.0000	804	401	400	464	7.70	0.0000
805	401	464	466	7.70	0.0000	806	466	464	465	7.70	0.0000
807	401	466	467	7.70	0.0000	808	402	401	467	7.70	0.0000
809	403	402	467	7.70	0.0000	810	403	467	468	7.70	0.0000
811	404	403	468	7.70	0.0000	812	404	468	469	7.70	0.0000
813	405	404	469	7.70	0.0000	814	405	469	470	7.70	0.0000
815	406	405	470	6.20	0.0000	816	406	470	471	6.20	0.0000
817	407	406	471	4.20	0.0000	818	472	407	471	3.20	0.0000
819	408	473	474	2.20	0.0000	820	409	408	474	2.20	0.0000
821	409	474	475	3.20	0.0000	822	410	409	475	4.20	0.0000
823	410	475	476	5.20	0.0000	824	411	410	476	5.20	0.0000
825	411	476	477	6.20	0.0000	826	412	411	477	6.20	0.0000
827	412	477	478	7.20	0.0000	828	413	412	478	7.70	0.0000
829	413	478	479	7.70	0.0000	830	414	413	479	7.70	0.0000
831	414	479	480	7.70	0.0000	832	415	414	480	7.70	0.0000
833	415	480	481	7.70	0.0000	834	416	415	481	7.70	0.0000
835	416	481	482	7.70	0.0000	836	417	416	482	7.70	0.0000
837	418	417	482	7.70	0.0000	838	418	482	483	7.70	0.0000
839	419	418	483	7.70	0.0000	840	419	483	484	7.70	0.0000
841	419	484	485	7.70	0.0000	842	420	419	485	7.70	0.0000
843	420	485	486	7.70	0.0000	844	421	420	486	7.70	0.0000
845	421	486	487	7.70	0.0000	846	422	421	487	7.70	0.0000
847	422	487	488	7.70	0.0000	848	423	422	488	7.70	0.0000
849	423	488	489	7.70	0.0000	850	424	423	489	7.70	0.0000
851	424	489	490	7.70	0.0000	852	425	424	490	7.70	0.0000
853	425	490	491	7.70	0.0000	854	426	425	491	11.20	0.0000
855	426	491	492	11.20	0.0000	856	427	426	492	14.20	0.0000
857	427	492	493	14.20	0.0000	858	428	427	493	14.20	0.0000
859	428	493	494	14.20	0.0000	860	429	428	494	14.20	0.0000
861	429	494	495	14.20	0.0000	862	430	429	495	14.20	0.0000
863	430	495	496	14.20	0.0000	864	431	430	496	14.20	0.0000
865	431	496	497	15.20	0.0000	866	431	497	498	15.20	0.0000
867	432	431	498	15.20	0.0000	868	432	498	499	15.20	0.0000
869	433	432	499	16.20	0.0000	870	434	433	499	16.20	0.0000

871	434	499	500	16.20	0.0000	872	434	500	501	16.20	0.0000
873	435	434	501	16.20	0.0000	874	435	501	502	16.20	0.0000
875	436	435	502	16.20	0.0000	876	437	436	502	16.20	0.0000
877	437	502	503	16.20	0.0000	878	437	503	504	16.20	0.0000
879	438	437	504	16.20	0.0000	880	438	504	505	16.20	0.0000
881	439	438	505	16.20	0.0000	882	440	439	505	16.20	0.0000
883	440	505	506	16.20	0.0000	884	440	506	507	16.20	0.0000
885	441	440	507	16.20	0.0000	886	441	507	508	16.20	0.0000
887	442	441	508	16.20	0.0000	888	442	508	509	16.20	0.0000
889	443	442	509	16.20	0.0000	890	443	509	510	16.20	0.0000
891	444	443	510	16.20	0.0000	892	444	510	511	16.20	0.0000
893	445	444	511	16.20	0.0000	894	445	511	512	16.20	0.0000
895	446	445	512	16.20	0.0000	896	446	512	513	17.20	0.0000
897	446	513	514	18.20	0.0000	898	447	446	514	18.20	0.0000
899	448	447	514	18.20	0.0000	900	448	514	515	18.20	0.0000
901	449	448	515	18.20	0.0000	902	449	515	516	18.20	0.0000
903	449	516	517	18.20	0.0000	904	450	449	517	18.20	0.0000
905	451	450	517	18.20	0.0000	906	451	517	518	18.20	0.0000
907	452	451	518	18.20	0.0000	908	452	518	519	18.20	0.0000
909	452	519	520	18.20	0.0000	910	453	452	520	18.20	0.0000
911	453	520	521	19.20	0.0000	912	454	453	521	19.20	0.0000
913	455	454	521	20.20	0.0000	914	455	521	522	21.20	0.0000
915	456	455	522	21.20	0.0000	916	456	522	523	21.20	0.0000
917	456	523	524	21.20	0.0000	918	457	456	524	21.20	0.0000
919	457	524	525	21.20	0.0000	920	458	457	525	21.20	0.0000
921	459	458	525	17.20	0.0000	922	459	525	526	17.20	0.0000
923	459	526	527	17.20	0.0000	924	460	459	527	13.20	0.0000
925	461	460	527	8.20	0.0000	926	461	527	528	8.20	0.0000
927	461	528	529	8.20	0.0000	928	462	461	529	7.70	0.0000
929	462	529	530	7.70	0.0000	930	463	462	530	7.70	0.0000
931	463	530	531	7.70	0.0000	932	464	463	531	7.70	0.0000
933	465	464	531	7.70	0.0000	934	465	531	532	7.70	0.0000
935	465	532	533	7.70	0.0000	936	465	533	534	7.70	0.0000
937	466	465	534	7.70	0.0000	938	466	534	535	7.70	0.0000
939	467	466	535	7.70	0.0000	940	468	467	535	7.70	0.0000
941	468	535	536	7.70	0.0000	942	469	468	536	7.70	0.0000
943	469	536	537	7.70	0.0000	944	470	469	537	7.70	0.0000
945	470	537	538	7.20	0.0000	946	471	470	538	6.20	0.0000
947	471	538	539	5.20	0.0000	948	472	471	539	3.20	0.0000
949	540	472	539	2.20	0.0000	950	473	541	542	1.20	0.0000
951	474	473	542	2.20	0.0000	952	474	542	543	4.20	0.0000
953	475	474	543	4.20	0.0000	954	475	543	544	6.20	0.0000
955	476	475	544	6.20	0.0000	956	476	544	545	6.20	0.0000
957	477	476	545	6.20	0.0000	958	477	545	546	7.20	0.0000
959	478	477	546	7.70	0.0000	960	478	546	547	7.70	0.0000
961	479	478	547	7.70	0.0000	962	479	547	548	7.70	0.0000
963	480	479	548	7.70	0.0000	964	480	548	549	7.70	0.0000
965	481	480	549	7.70	0.0000	966	481	549	550	7.70	0.0000
967	482	481	550	7.70	0.0000	968	483	482	550	7.70	0.0000
969	483	550	551	7.70	0.0000	970	484	483	551	7.70	0.0000
971	484	551	552	7.70	0.0000	972	484	552	553	7.70	0.0000
973	485	484	553	7.70	0.0000	974	485	553	554	7.70	0.0000
975	486	485	554	7.70	0.0000	976	486	554	555	7.70	0.0000
977	487	486	555	7.70	0.0000	978	487	555	556	7.70	0.0000

979	488	487	556	7.70	0.0000	980	488	556	557	7.70	0.0000
981	489	488	557	7.70	0.0000	982	489	557	558	7.70	0.0000
983	490	489	558	7.70	0.0000	984	490	558	559	7.70	0.0000
985	491	490	559	7.70	0.0000	986	491	559	560	7.70	0.0000
987	492	491	560	7.70	0.0000	988	492	560	561	7.70	0.0000
989	493	492	561	11.20	0.0000	990	493	561	562	11.20	0.0000
991	494	493	562	14.20	0.0000	992	494	562	563	14.20	0.0000
993	495	494	563	14.20	0.0000	994	495	563	564	14.20	0.0000
995	496	495	564	14.20	0.0000	996	496	564	565	15.20	0.0000
997	497	496	565	16.20	0.0000	998	497	565	566	16.20	0.0000
999	497	566	567	16.20	0.0000	1000	498	497	567	16.20	0.0000
1001	498	567	568	16.20	0.0000	1002	499	498	568	16.20	0.0000
1003	500	499	568	16.20	0.0000	1004	500	568	569	16.20	0.0000
1005	500	569	570	16.20	0.0000	1006	501	500	570	16.20	0.0000
1007	501	570	571	16.20	0.0000	1008	502	501	571	16.20	0.0000
1009	503	502	571	16.20	0.0000	1010	503	571	572	16.20	0.0000
1011	503	572	573	16.20	0.0000	1012	504	503	573	16.20	0.0000
1013	504	573	574	16.20	0.0000	1014	505	504	574	16.20	0.0000
1015	506	505	574	16.20	0.0000	1016	506	574	575	12.20	0.0000
1017	506	575	576	12.20	0.0000	1018	507	506	576	12.20	0.0000
1019	507	576	577	12.20	0.0000	1020	508	507	577	12.20	0.0000
1021	508	577	578	12.20	0.0000	1022	509	508	578	12.20	0.0000
1023	509	578	579	12.20	0.0000	1024	510	509	579	12.20	0.0000
1025	510	579	580	12.20	0.0000	1026	511	510	580	12.20	0.0000
1027	511	580	581	12.20	0.0000	1028	512	511	581	12.20	0.0000
1029	512	581	582	12.20	0.0000	1030	513	512	582	12.20	0.0000
1031	513	582	583	13.20	0.0000	1032	513	583	584	13.20	0.0000
1033	514	513	584	18.20	0.0000	1034	515	514	584	18.20	0.0000
1035	515	584	585	18.20	0.0000	1036	516	515	585	18.20	0.0000
1037	516	585	586	18.20	0.0000	1038	516	586	587	18.20	0.0000
1039	517	516	587	18.20	0.0000	1040	518	517	587	18.20	0.0000
1041	518	587	588	18.20	0.0000	1042	519	518	588	18.20	0.0000
1043	519	588	589	19.20	0.0000	1044	519	589	590	20.20	0.0000
1045	520	519	590	20.20	0.0000	1046	520	590	591	20.20	0.0000
1047	521	520	591	20.20	0.0000	1048	522	521	591	21.20	0.0000
1049	522	591	592	21.20	0.0000	1050	523	522	592	21.20	0.0000
1051	523	592	593	21.20	0.0000	1052	523	593	594	21.20	0.0000
1053	524	523	594	21.20	0.0000	1054	524	594	595	21.20	0.0000
1055	525	524	595	21.20	0.0000	1056	526	525	595	21.20	0.0000
1057	526	595	596	21.20	0.0000	1058	526	596	597	21.20	0.0000
1059	527	526	597	17.20	0.0000	1060	528	527	597	16.20	0.0000
1061	528	597	598	15.20	0.0000	1062	528	598	599	14.20	0.0000
1063	529	528	599	11.20	0.0000	1064	529	599	600	9.20	0.0000
1065	530	529	600	7.70	0.0000	1066	530	600	601	7.70	0.0000
1067	531	530	601	7.70	0.0000	1068	532	531	601	7.70	0.0000
1069	532	601	602	7.70	0.0000	1070	532	602	603	7.70	0.0000
1071	533	532	603	7.70	0.0000	1072	533	603	604	7.70	0.0000
1073	534	533	604	7.70	0.0000	1074	534	604	605	7.70	0.0000
1075	535	534	605	7.70	0.0000	1076	536	535	605	7.70	0.0000
1077	536	605	606	7.70	0.0000	1078	537	536	606	7.70	0.0000
1079	537	606	607	7.70	0.0000	1080	538	537	607	6.20	0.0000
1081	538	607	608	6.20	0.0000	1082	539	538	608	5.20	0.0000
1083	540	539	608	3.20	0.0000	1084	609	540	608	2.20	0.0000
1085	541	610	611	2.20	0.0000	1086	542	541	611	2.20	0.0000

1087	542	611	612	4.20	0.0000	1088	543	542	612	4.20	0.0000
1089	543	612	613	6.20	0.0000	1090	544	543	613	6.20	0.0000
1091	544	613	614	6.20	0.0000	1092	545	544	614	6.20	0.0000
1093	545	614	615	7.20	0.0000	1094	546	545	615	7.70	0.0000
1095	546	615	616	7.70	0.0000	1096	547	546	616	7.70	0.0000
1097	547	616	617	7.70	0.0000	1098	548	547	617	7.70	0.0000
1099	548	617	618	7.70	0.0000	1100	549	548	618	7.70	0.0000
1101	549	618	619	7.70	0.0000	1102	550	549	619	7.70	0.0000
1103	551	550	619	7.70	0.0000	1104	551	619	620	7.70	0.0000
1105	552	551	620	7.70	0.0000	1106	552	620	621	7.70	0.0000
1107	552	621	622	7.70	0.0000	1108	553	552	622	7.70	0.0000
1109	553	622	623	7.70	0.0000	1110	554	553	623	7.70	0.0000
1111	554	623	624	7.70	0.0000	1112	555	554	624	7.70	0.0000
1113	555	624	625	7.70	0.0000	1114	556	555	625	7.70	0.0000
1115	556	625	626	7.70	0.0000	1116	557	556	626	7.70	0.0000
1117	557	626	627	7.70	0.0000	1118	558	557	627	7.70	0.0000
1119	558	627	628	7.70	0.0000	1120	559	558	628	7.70	0.0000
1121	559	628	629	7.70	0.0000	1122	560	559	629	7.70	0.0000
1123	560	629	630	7.70	0.0000	1124	561	560	630	7.70	0.0000
1125	561	630	631	7.70	0.0000	1126	562	561	631	7.70	0.0000
1127	562	631	632	7.70	0.0000	1128	563	562	632	12.20	0.0000
1129	563	632	633	12.20	0.0000	1130	564	563	633	14.20	0.0000
1131	564	633	634	15.20	0.0000	1132	565	564	634	16.20	0.0000
1133	565	634	635	16.20	0.0000	1134	566	565	635	16.20	0.0000
1135	566	635	636	16.20	0.0000	1136	566	636	637	16.20	0.0000
1137	567	566	637	16.20	0.0000	1138	567	637	638	16.20	0.0000
1139	568	567	638	16.20	0.0000	1140	569	568	638	16.20	0.0000
1141	569	638	639	16.20	0.0000	1142	569	639	640	16.20	0.0000
1143	570	569	640	16.20	0.0000	1144	570	640	641	16.20	0.0000
1145	571	570	641	16.20	0.0000	1146	572	571	641	16.20	0.0000
1147	572	641	642	11.20	0.0000	1148	572	642	643	12.20	0.0000
1149	573	572	643	12.20	0.0000	1150	573	643	644	12.20	0.0000
1151	574	573	644	12.20	0.0000	1152	575	574	644	12.20	0.0000
1153	575	644	645	7.70	0.0000	1154	575	645	646	7.70	0.0000
1155	576	575	646	7.70	0.0000	1156	576	646	647	7.70	0.0000
1157	577	576	647	7.70	0.0000	1158	577	647	648	7.70	0.0000
1159	578	577	648	7.70	0.0000	1160	578	648	649	7.70	0.0000
1161	579	578	649	7.70	0.0000	1162	579	649	650	7.70	0.0000
1163	580	579	650	7.70	0.0000	1164	580	650	651	7.70	0.0000
1165	581	580	651	7.70	0.0000	1166	581	651	652	7.70	0.0000
1167	582	581	652	7.70	0.0000	1168	582	652	653	7.70	0.0000
1169	583	582	653	7.70	0.0000	1170	583	653	654	7.70	0.0000
1171	583	654	655	7.70	0.0000	1172	584	583	655	12.20	0.0000
1173	585	584	655	12.20	0.0000	1174	585	655	656	12.20	0.0000
1175	586	585	656	12.20	0.0000	1176	586	656	657	12.20	0.0000
1177	586	657	658	12.20	0.0000	1178	587	586	658	18.20	0.0000
1179	588	587	658	18.20	0.0000	1180	588	658	659	18.20	0.0000
1181	589	588	659	19.20	0.0000	1182	589	659	660	19.20	0.0000
1183	589	660	661	20.20	0.0000	1184	590	589	661	20.20	0.0000
1185	590	661	662	21.20	0.0000	1186	591	590	662	21.20	0.0000
1187	592	591	662	21.20	0.0000	1188	592	662	663	21.20	0.0000
1189	593	592	663	21.20	0.0000	1190	593	663	664	21.20	0.0000
1191	593	664	665	21.20	0.0000	1192	594	593	665	21.20	0.0000
1193	594	665	666	21.20	0.0000	1194	595	594	666	21.20	0.0000

1195	596	595	666	21.20	0.0000	1196	596	666	667	21.20	0.0000
1197	596	667	668	21.20	0.0000	1198	597	596	668	21.20	0.0000
1199	598	597	668	21.20	0.0000	1200	598	668	669	21.20	0.0000
1201	598	669	670	21.20	0.0000	1202	599	598	670	15.20	0.0000
1203	599	670	671	13.20	0.0000	1204	600	599	671	10.20	0.0000
1205	600	671	672	7.70	0.0000	1206	601	600	672	7.70	0.0000
1207	602	601	672	7.70	0.0000	1208	602	672	673	7.70	0.0000
1209	602	673	674	7.70	0.0000	1210	603	602	674	7.70	0.0000
1211	603	674	675	7.70	0.0000	1212	604	603	675	7.70	0.0000
1213	604	675	676	7.70	0.0000	1214	604	676	677	7.70	0.0000
1215	605	604	677	7.70	0.0000	1216	606	605	677	7.70	0.0000
1217	606	677	678	7.70	0.0000	1218	607	606	678	7.20	0.0000
1219	607	678	679	6.20	0.0000	1220	608	607	679	6.20	0.0000
1221	608	679	680	5.20	0.0000	1222	609	608	680	3.20	0.0000
1223	681	609	680	2.20	0.0000	1224	610	682	683	2.20	0.0000
1225	611	610	683	2.20	0.0000	1226	611	683	684	3.20	0.0000
1227	612	611	684	4.20	0.0000	1228	612	684	685	5.20	0.0000
1229	613	612	685	6.20	0.0000	1230	613	685	686	6.20	0.0000
1231	614	613	686	6.20	0.0000	1232	614	686	687	7.20	0.0000
1233	615	614	687	7.70	0.0000	1234	615	687	688	7.70	0.0000
1235	616	615	688	7.70	0.0000	1236	616	688	689	7.70	0.0000
1237	617	616	689	7.70	0.0000	1238	617	689	690	7.70	0.0000
1239	618	617	690	7.70	0.0000	1240	618	690	691	7.70	0.0000
1241	618	691	692	7.70	0.0000	1242	619	618	692	7.70	0.0000
1243	620	619	692	7.70	0.0000	1244	620	692	693	7.70	0.0000
1245	621	620	693	7.70	0.0000	1246	621	693	694	7.70	0.0000
1247	621	694	695	7.70	0.0000	1248	622	621	695	7.70	0.0000
1249	622	695	696	7.70	0.0000	1250	623	622	696	7.70	0.0000
1251	623	696	697	7.70	0.0000	1252	624	623	697	7.70	0.0000
1253	624	697	698	7.70	0.0000	1254	625	624	698	7.70	0.0000
1255	625	698	699	7.70	0.0000	1256	626	625	699	7.70	0.0000
1257	626	699	700	7.70	0.0000	1258	627	626	700	7.70	0.0000
1259	627	700	701	7.70	0.0000	1260	628	627	701	7.70	0.0000
1261	628	701	702	7.70	0.0000	1262	629	628	702	7.70	0.0000
1263	629	702	703	7.70	0.0000	1264	630	629	703	7.70	0.0000
1265	630	703	704	7.70	0.0000	1266	631	630	704	7.70	0.0000
1267	631	704	705	7.70	0.0000	1268	632	631	705	7.70	0.0000
1269	632	705	706	7.70	0.0000	1270	633	632	706	11.20	0.0000
1271	633	706	707	12.20	0.0000	1272	634	633	707	15.20	0.0000
1273	634	707	708	15.20	0.0000	1274	635	634	708	16.20	0.0000
1275	635	708	709	16.20	0.0000	1276	636	635	709	16.20	0.0000
1277	636	709	710	16.20	0.0000	1278	636	710	711	16.20	0.0000
1279	637	636	711	16.20	0.0000	1280	637	711	712	16.20	0.0000
1281	638	637	712	16.20	0.0000	1282	639	638	712	16.20	0.0000
1283	639	712	713	10.20	0.0000	1284	639	713	714	10.20	0.0000
1285	640	639	714	10.20	0.0000	1286	640	714	715	10.20	0.0000
1287	641	640	715	10.20	0.0000	1288	642	641	715	10.20	0.0000
1289	642	715	716	7.70	0.0000	1290	642	716	717	7.70	0.0000
1291	643	642	717	7.70	0.0000	1292	643	717	718	7.70	0.0000
1293	644	643	718	7.70	0.0000	1294	645	644	718	7.70	0.0000
1295	645	718	719	7.70	0.0000	1296	719	720	645	7.70	0.0000
1297	646	645	720	7.70	0.0000	1298	720	721	646	7.70	0.0000
1299	646	721	647	7.70	0.0000	1300	721	722	647	7.70	0.0000
1301	647	722	648	7.70	0.0000	1302	722	723	648	7.70	0.0000

1303	648	723	649	7.70	0.0000	1304	723	724	649	7.70	0.0000
1305	649	724	650	7.70	0.0000	1306	724	725	650	7.70	0.0000
1307	650	725	651	7.70	0.0000	1308	725	726	651	7.70	0.0000
1309	651	726	652	7.70	0.0000	1310	726	727	652	7.70	0.0000
1311	652	727	653	7.70	0.0000	1312	727	728	653	7.70	0.0000
1313	653	728	654	7.70	0.0000	1314	728	729	654	7.70	0.0000
1315	654	729	730	7.70	0.0000	1316	655	654	730	7.70	0.0000
1317	656	655	730	7.70	0.0000	1318	656	730	731	7.70	0.0000
1319	657	656	731	7.70	0.0000	1320	657	731	732	7.70	0.0000
1321	657	732	733	7.70	0.0000	1322	658	657	733	13.20	0.0000
1323	659	658	733	13.20	0.0000	1324	659	733	734	13.20	0.0000
1325	660	659	734	13.20	0.0000	1326	660	734	735	14.20	0.0000
1327	660	735	736	14.20	0.0000	1328	661	660	736	21.20	0.0000
1329	661	736	737	21.20	0.0000	1330	662	661	737	21.20	0.0000
1331	663	662	737	21.20	0.0000	1332	663	737	738	21.20	0.0000
1333	664	663	738	21.20	0.0000	1334	664	738	739	21.20	0.0000
1335	664	739	740	21.20	0.0000	1336	665	664	740	21.20	0.0000
1337	665	740	741	21.20	0.0000	1338	666	665	741	21.20	0.0000
1339	667	666	741	21.20	0.0000	1340	667	741	742	21.20	0.0000
1341	667	742	743	21.20	0.0000	1342	668	667	743	21.20	0.0000
1343	669	668	743	21.20	0.0000	1344	669	743	744	21.20	0.0000
1345	669	744	745	21.20	0.0000	1346	670	669	745	21.20	0.0000
1347	670	745	746	21.20	0.0000	1348	671	670	746	15.20	0.0000
1349	671	746	747	13.20	0.0000	1350	672	671	747	7.70	0.0000
1351	673	672	747	7.70	0.0000	1352	673	747	748	7.70	0.0000
1353	673	748	749	7.70	0.0000	1354	674	673	749	7.70	0.0000
1355	674	749	750	7.70	0.0000	1356	675	674	750	7.70	0.0000
1357	675	750	751	7.70	0.0000	1358	676	675	751	7.70	0.0000
1359	676	751	752	7.70	0.0000	1360	676	752	753	7.70	0.0000
1361	677	676	753	7.70	0.0000	1362	678	677	753	7.70	0.0000
1363	678	753	754	7.20	0.0000	1364	679	678	754	6.20	0.0000
1365	679	754	755	6.20	0.0000	1366	680	679	755	5.20	0.0000
1367	680	755	756	4.20	0.0000	1368	681	680	756	2.20	0.0000
1369	757	681	756	2.20	0.0000	1370	682	758	759	2.20	0.0000
1371	683	682	759	2.20	0.0000	1372	683	759	760	3.20	0.0000
1373	684	683	760	4.20	0.0000	1374	684	760	761	5.20	0.0000
1375	685	684	761	5.20	0.0000	1376	685	761	762	6.20	0.0000
1377	686	685	762	6.20	0.0000	1378	686	762	763	7.20	0.0000
1379	687	686	763	7.70	0.0000	1380	687	763	764	7.70	0.0000
1381	688	687	764	7.70	0.0000	1382	688	764	765	7.70	0.0000
1383	689	688	765	7.70	0.0000	1384	689	765	766	7.70	0.0000
1385	690	689	766	7.70	0.0000	1386	690	766	767	7.70	0.0000
1387	691	690	767	7.70	0.0000	1388	691	767	768	7.70	0.0000
1389	692	691	768	7.70	0.0000	1390	693	692	768	7.70	0.0000
1391	693	768	769	7.70	0.0000	1392	694	693	769	7.70	0.0000
1393	694	769	770	7.70	0.0000	1394	694	770	771	7.70	0.0000
1395	695	694	771	7.70	0.0000	1396	695	771	772	7.70	0.0000
1397	696	695	772	7.70	0.0000	1398	696	772	773	7.70	0.0000
1399	697	696	773	7.70	0.0000	1400	697	773	774	7.70	0.0000
1401	698	697	774	7.70	0.0000	1402	698	774	775	7.70	0.0000
1403	699	698	775	7.70	0.0000	1404	699	775	776	7.70	0.0000
1405	700	699	776	7.70	0.0000	1406	700	776	777	7.70	0.0000
1407	701	700	777	7.70	0.0000	1408	701	777	778	7.70	0.0000
1409	702	701	778	7.70	0.0000	1410	702	778	779	7.70	0.0000

1411	703	702	779	7.70	0.0000	1412	703	779	780	7.70	0.0000
1413	704	703	780	7.70	0.0000	1414	704	780	781	7.70	0.0000
1415	705	704	781	7.70	0.0000	1416	705	781	782	7.70	0.0000
1417	706	705	782	7.70	0.0000	1418	706	782	783	7.70	0.0000
1419	707	706	783	7.70	0.0000	1420	707	783	784	7.70	0.0000
1421	708	707	784	12.20	0.0000	1422	708	784	785	12.20	0.0000
1423	709	708	785	16.20	0.0000	1424	709	785	786	16.20	0.0000
1425	710	709	786	16.20	0.0000	1426	710	786	787	10.20	0.0000
1427	710	787	788	10.20	0.0000	1428	711	710	788	10.20	0.0000
1429	711	788	789	10.20	0.0000	1430	712	711	789	10.20	0.0000
1431	713	712	789	10.20	0.0000	1432	713	789	790	7.70	0.0000
1433	713	790	791	7.70	0.0000	1434	714	713	791	7.70	0.0000
1435	714	791	792	7.70	0.0000	1436	715	714	792	7.70	0.0000
1437	716	715	792	7.70	0.0000	1438	716	792	793	7.70	0.0000
1439	793	794	716	7.70	0.0000	1440	716	794	717	7.70	0.0000
1441	794	795	717	7.70	0.0000	1442	717	795	718	7.70	0.0000
1443	795	719	718	7.70	0.0000	1444	729	808	730	7.70	0.0000
1445	730	808	731	7.70	0.0000	1446	808	809	731	7.70	0.0000
1447	731	809	732	7.70	0.0000	1448	809	810	732	7.70	0.0000
1449	732	810	811	7.70	0.0000	1450	733	732	811	7.70	0.0000
1451	734	733	811	7.70	0.0000	1452	734	811	812	7.70	0.0000
1453	735	734	812	7.70	0.0000	1454	735	812	813	7.70	0.0000
1455	735	813	814	7.70	0.0000	1456	736	735	814	13.20	0.0000
1457	736	814	815	17.20	0.0000	1458	737	736	815	21.20	0.0000
1459	738	737	815	21.20	0.0000	1460	738	815	816	21.20	0.0000
1461	739	738	816	21.20	0.0000	1462	739	816	817	21.20	0.0000
1463	739	817	818	21.20	0.0000	1464	740	739	818	21.20	0.0000
1465	740	818	819	21.20	0.0000	1466	741	740	819	21.20	0.0000
1467	742	741	819	21.20	0.0000	1468	742	819	820	21.20	0.0000
1469	742	820	821	21.20	0.0000	1470	743	742	821	21.20	0.0000
1471	744	743	821	21.20	0.0000	1472	744	821	822	21.20	0.0000
1473	744	822	823	21.20	0.0000	1474	745	744	823	21.20	0.0000
1475	745	823	824	21.20	0.0000	1476	746	745	824	21.20	0.0000
1477	746	824	825	21.20	0.0000	1478	747	746	825	14.20	0.0000
1479	748	747	825	12.20	0.0000	1480	748	825	826	12.20	0.0000
1481	748	826	827	12.20	0.0000	1482	749	748	827	7.70	0.0000
1483	749	827	828	7.70	0.0000	1484	750	749	828	7.70	0.0000
1485	750	828	829	7.70	0.0000	1486	751	750	829	7.70	0.0000
1487	751	829	830	7.70	0.0000	1488	752	751	830	7.70	0.0000
1489	752	830	831	7.70	0.0000	1490	752	831	832	7.70	0.0000
1491	753	752	832	7.70	0.0000	1492	754	753	832	7.20	0.0000
1493	754	832	833	6.20	0.0000	1494	755	754	833	6.20	0.0000
1495	755	833	834	5.20	0.0000	1496	756	755	834	4.20	0.0000
1497	757	756	834	3.20	0.0000	1498	835	757	834	2.20	0.0000
1499	758	836	837	2.20	0.0000	1500	759	758	837	2.20	0.0000
1501	759	837	838	3.20	0.0000	1502	760	759	838	4.20	0.0000
1503	760	838	839	5.20	0.0000	1504	761	760	839	5.20	0.0000
1505	761	839	840	6.20	0.0000	1506	762	761	840	6.20	0.0000
1507	762	840	841	7.20	0.0000	1508	763	762	841	7.70	0.0000
1509	763	841	842	7.70	0.0000	1510	764	763	842	7.70	0.0000
1511	764	842	843	7.70	0.0000	1512	765	764	843	7.70	0.0000
1513	765	843	844	7.70	0.0000	1514	766	765	844	7.70	0.0000
1515	766	844	845	7.70	0.0000	1516	767	766	845	7.70	0.0000
1517	767	845	846	7.70	0.0000	1518	768	767	846	7.70	0.0000

1519	769	768	846	7.70	0.0000	1520	769	846	847	7.70	0.0000
1521	770	769	847	7.70	0.0000	1522	770	847	848	7.70	0.0000
1523	770	848	849	7.70	0.0000	1524	771	770	849	7.70	0.0000
1525	771	849	850	7.70	0.0000	1526	772	771	850	7.70	0.0000
1527	772	850	851	7.70	0.0000	1528	773	772	851	7.70	0.0000
1529	773	851	852	7.70	0.0000	1530	774	773	852	7.70	0.0000
1531	774	852	853	7.70	0.0000	1532	775	774	853	7.70	0.0000
1533	775	853	854	7.70	0.0000	1534	776	775	854	7.70	0.0000
1535	776	854	855	7.70	0.0000	1536	777	776	855	7.70	0.0000
1537	777	855	856	7.70	0.0000	1538	778	777	856	7.70	0.0000
1539	778	856	857	7.70	0.0000	1540	779	778	857	7.70	0.0000
1541	779	857	858	7.70	0.0000	1542	780	779	858	7.70	0.0000
1543	780	858	859	7.70	0.0000	1544	781	780	859	7.70	0.0000
1545	781	859	860	7.70	0.0000	1546	782	781	860	7.70	0.0000
1547	782	860	861	7.70	0.0000	1548	783	782	861	7.70	0.0000
1549	783	861	862	7.70	0.0000	1550	784	783	862	7.70	0.0000
1551	784	862	863	7.70	0.0000	1552	785	784	863	7.70	0.0000
1553	785	863	864	7.70	0.0000	1554	786	785	864	7.70	0.0000
1555	786	864	865	7.70	0.0000	1556	787	786	865	7.70	0.0000
1557	787	865	866	7.70	0.0000	1558	787	866	867	7.70	0.0000
1559	788	787	867	7.70	0.0000	1560	788	867	868	7.70	0.0000
1561	789	788	868	7.70	0.0000	1562	790	789	868	7.70	0.0000
1563	790	868	869	7.70	0.0000	1564	869	870	790	7.70	0.0000
1565	790	870	791	7.70	0.0000	1566	870	871	791	7.70	0.0000
1567	791	871	792	7.70	0.0000	1568	871	793	792	7.70	0.0000
1569	796	874	875	7.70	0.0000	1570	796	875	876	7.70	0.0000
1571	797	796	876	7.70	0.0000	1572	797	876	877	7.70	0.0000
1573	798	797	877	7.70	0.0000	1574	798	877	878	7.70	0.0000
1575	799	798	878	7.70	0.0000	1576	799	878	879	7.70	0.0000
1577	800	799	879	7.70	0.0000	1578	800	879	880	7.70	0.0000
1579	801	800	880	7.70	0.0000	1580	801	880	881	7.70	0.0000
1581	802	801	881	7.70	0.0000	1582	802	881	882	7.70	0.0000
1583	803	802	882	7.70	0.0000	1584	803	882	883	7.70	0.0000
1585	804	803	883	7.70	0.0000	1586	804	883	884	7.70	0.0000
1587	805	804	884	7.70	0.0000	1588	805	884	885	7.70	0.0000
1589	806	805	885	7.70	0.0000	1590	806	885	886	7.70	0.0000
1591	807	806	886	7.70	0.0000	1592	807	886	887	7.70	0.0000
1593	888	807	887	7.70	0.0000	1594	810	891	811	7.70	0.0000
1595	811	891	812	7.70	0.0000	1596	891	892	812	7.70	0.0000
1597	812	892	813	7.70	0.0000	1598	892	893	813	7.70	0.0000
1599	813	893	894	7.70	0.0000	1600	814	813	894	7.70	0.0000
1601	814	894	895	7.70	0.0000	1602	815	814	895	13.20	0.0000
1603	816	815	895	15.20	0.0000	1604	816	895	896	13.20	0.0000
1605	817	816	896	15.20	0.0000	1606	817	896	897	13.20	0.0000
1607	817	897	898	15.20	0.0000	1608	818	817	898	21.20	0.0000
1609	818	898	899	21.20	0.0000	1610	819	818	899	21.20	0.0000
1611	820	819	899	21.20	0.0000	1612	820	899	900	21.20	0.0000
1613	820	900	901	21.20	0.0000	1614	821	820	901	21.20	0.0000
1615	822	821	901	21.20	0.0000	1616	822	901	902	21.20	0.0000
1617	822	902	903	21.20	0.0000	1618	823	822	903	21.20	0.0000
1619	823	903	904	21.20	0.0000	1620	824	823	904	21.20	0.0000
1621	824	904	905	21.20	0.0000	1622	825	824	905	21.20	0.0000
1623	826	825	905	19.20	0.0000	1624	826	905	906	20.20	0.0000
1625	826	906	907	17.20	0.0000	1626	827	826	907	11.20	0.0000

1627	827	907	908	8.20	0.0000	1628	828	827	908	7.70	0.0000
1629	828	908	909	7.70	0.0000	1630	829	828	909	7.70	0.0000
1631	829	909	910	7.70	0.0000	1632	830	829	910	7.70	0.0000
1633	830	910	911	7.70	0.0000	1634	831	830	911	7.70	0.0000
1635	831	911	912	7.70	0.0000	1636	832	831	912	7.20	0.0000
1637	833	832	912	6.20	0.0000	1638	833	912	913	6.20	0.0000
1639	834	833	913	5.20	0.0000	1640	834	913	914	5.20	0.0000
1641	835	834	914	3.20	0.0000	1642	915	835	914	2.20	0.0000
1643	836	916	917	2.20	0.0000	1644	837	836	917	2.20	0.0000
1645	837	917	918	4.20	0.0000	1646	838	837	918	4.20	0.0000
1647	838	918	919	5.20	0.0000	1648	839	838	919	5.20	0.0000
1649	839	919	920	6.20	0.0000	1650	840	839	920	6.20	0.0000
1651	840	920	921	7.70	0.0000	1652	841	840	921	7.70	0.0000
1653	841	921	922	7.70	0.0000	1654	842	841	922	7.70	0.0000
1655	842	922	923	7.70	0.0000	1656	843	842	923	7.70	0.0000
1657	843	923	924	7.70	0.0000	1658	844	843	924	7.70	0.0000
1659	844	924	925	7.70	0.0000	1660	845	844	925	7.70	0.0000
1661	845	925	926	7.70	0.0000	1662	846	845	926	7.70	0.0000
1663	847	846	926	7.70	0.0000	1664	847	926	927	7.70	0.0000
1665	848	847	927	7.70	0.0000	1666	848	927	928	7.70	0.0000
1667	848	928	929	7.70	0.0000	1668	849	848	929	7.70	0.0000
1669	849	929	930	7.70	0.0000	1670	850	849	930	7.70	0.0000
1671	850	930	931	7.70	0.0000	1672	851	850	931	7.70	0.0000
1673	851	931	932	7.70	0.0000	1674	852	851	932	7.70	0.0000
1675	852	932	933	7.70	0.0000	1676	853	852	933	7.70	0.0000
1677	853	933	934	7.70	0.0000	1678	854	853	934	7.70	0.0000
1679	854	934	935	7.70	0.0000	1680	855	854	935	7.70	0.0000
1681	855	935	936	7.70	0.0000	1682	856	855	936	7.70	0.0000
1683	856	936	937	7.70	0.0000	1684	857	856	937	7.70	0.0000
1685	857	937	938	7.70	0.0000	1686	858	857	938	7.70	0.0000
1687	858	938	939	7.70	0.0000	1688	859	858	939	7.70	0.0000
1689	939	940	859	7.70	0.0000	1690	859	940	860	7.70	0.0000
1691	940	941	860	7.70	0.0000	1692	860	941	861	7.70	0.0000
1693	941	942	861	7.70	0.0000	1694	861	942	862	7.70	0.0000
1695	942	943	862	7.70	0.0000	1696	862	943	863	7.70	0.0000
1697	943	944	863	7.70	0.0000	1698	863	944	864	7.70	0.0000
1699	944	945	864	7.70	0.0000	1700	864	945	865	7.70	0.0000
1701	945	946	865	7.70	0.0000	1702	865	946	866	7.70	0.0000
1703	946	947	866	7.70	0.0000	1704	947	948	866	7.70	0.0000
1705	866	948	867	7.70	0.0000	1706	948	949	867	7.70	0.0000
1707	867	949	868	7.70	0.0000	1708	949	869	868	7.70	0.0000
1709	872	952	953	7.70	0.0000	1710	872	953	954	7.70	0.0000
1711	873	872	954	7.70	0.0000	1712	873	954	955	7.70	0.0000
1713	874	873	955	7.70	0.0000	1714	875	874	955	7.70	0.0000
1715	875	955	956	7.70	0.0000	1716	875	956	957	7.70	0.0000
1717	876	875	957	7.70	0.0000	1718	876	957	958	7.70	0.0000
1719	877	876	958	7.70	0.0000	1720	877	958	959	7.70	0.0000
1721	878	877	959	7.70	0.0000	1722	878	959	960	7.70	0.0000
1723	879	878	960	7.70	0.0000	1724	879	960	961	7.70	0.0000
1725	880	879	961	7.70	0.0000	1726	880	961	962	7.70	0.0000
1727	881	880	962	7.70	0.0000	1728	881	962	963	7.70	0.0000
1729	882	881	963	7.70	0.0000	1730	883	882	963	7.70	0.0000
1731	883	963	964	7.70	0.0000	1732	884	883	964	7.70	0.0000
1733	884	964	965	7.70	0.0000	1734	885	884	965	7.70	0.0000

1735	885	965	966	7.70	0.0000	1736	886	885	966	7.70	0.0000
1737	886	966	967	7.70	0.0000	1738	887	886	967	7.70	0.0000
1739	887	967	968	7.70	0.0000	1740	887	968	969	7.70	0.0000
1741	888	887	969	7.70	0.0000	1742	889	888	969	7.70	0.0000
1743	889	969	970	7.70	0.0000	1744	890	889	970	7.70	0.0000
1745	890	970	971	7.70	0.0000	1746	972	890	971	7.70	0.0000
1747	893	975	894	7.70	0.0000	1748	894	975	976	7.70	0.0000
1749	895	894	976	7.70	0.0000	1750	896	895	976	7.70	0.0000
1751	896	976	977	7.70	0.0000	1752	897	896	977	7.70	0.0000
1753	897	977	978	7.70	0.0000	1754	897	978	980	7.70	0.0000
1755	980	978	979	7.70	0.0000	1756	898	897	980	11.20	0.0000
1757	898	980	981	15.20	0.0000	1758	899	898	981	21.20	0.0000
1759	900	899	981	21.20	0.0000	1760	900	981	982	21.20	0.0000
1761	900	982	983	21.20	0.0000	1762	901	900	983	21.20	0.0000
1763	902	901	983	21.20	0.0000	1764	902	983	984	21.20	0.0000
1765	902	984	985	21.20	0.0000	1766	903	902	985	21.20	0.0000
1767	903	985	986	21.20	0.0000	1768	904	903	986	21.20	0.0000
1769	904	986	987	21.20	0.0000	1770	905	904	987	21.20	0.0000
1771	906	905	987	21.20	0.0000	1772	906	987	988	21.20	0.0000
1773	906	988	989	21.20	0.0000	1774	907	906	989	17.20	0.0000
1775	907	989	990	13.20	0.0000	1776	908	907	990	9.20	0.0000
1777	908	990	991	7.70	0.0000	1778	909	908	991	7.70	0.0000
1779	909	991	992	7.70	0.0000	1780	910	909	992	7.70	0.0000
1781	910	992	993	7.70	0.0000	1782	911	910	993	7.70	0.0000
1783	911	993	994	7.70	0.0000	1784	912	911	994	7.70	0.0000
1785	913	912	994	6.20	0.0000	1786	913	994	995	6.20	0.0000
1787	914	913	995	5.20	0.0000	1788	914	995	996	5.20	0.0000
1789	915	914	996	2.20	0.0000	1790	997	915	996	2.20	0.0000
1791	916	998	999	2.20	0.0000	1792	917	916	999	2.20	0.0000
1793	917	999	1000	4.20	0.0000	1794	918	917	1000	4.20	0.0000
1795	918	1000	1001	5.20	0.0000	1796	919	918	1001	5.20	0.0000
1797	919	1001	1002	6.20	0.0000	1798	920	919	1002	6.20	0.0000
1799	920	1002	1003	7.20	0.0000	1800	921	920	1003	7.70	0.0000
1801	921	1003	1004	7.70	0.0000	1802	922	921	1004	7.70	0.0000
1803	922	1004	1005	7.70	0.0000	1804	923	922	1005	7.70	0.0000
1805	923	1005	1006	7.70	0.0000	1806	924	923	1006	7.70	0.0000
1807	924	1006	1007	7.70	0.0000	1808	925	924	1007	7.70	0.0000
1809	925	1007	1008	7.70	0.0000	1810	926	925	1008	7.70	0.0000
1811	926	1008	1009	7.70	0.0000	1812	927	926	1009	7.70	0.0000
1813	927	1009	1010	7.70	0.0000	1814	928	927	1010	7.70	0.0000
1815	928	1010	1011	7.70	0.0000	1816	929	928	1011	7.70	0.0000
1817	929	1011	1012	7.70	0.0000	1818	930	929	1012	7.70	0.0000
1819	930	1012	1013	7.70	0.0000	1820	931	930	1013	7.70	0.0000
1821	931	1013	1014	7.70	0.0000	1822	932	931	1014	7.70	0.0000
1823	932	1014	1015	7.70	0.0000	1824	933	932	1015	7.70	0.0000
1825	933	1015	1016	7.70	0.0000	1826	934	933	1016	7.70	0.0000
1827	934	1016	1017	7.70	0.0000	1828	934	1017	1018	7.70	0.0000
1829	935	934	1018	7.70	0.0000	1830	935	1018	1019	7.70	0.0000
1831	936	935	1019	7.70	0.0000	1832	936	1019	1020	7.70	0.0000
1833	937	936	1020	7.70	0.0000	1834	937	1020	1021	7.70	0.0000
1835	938	937	1021	7.70	0.0000	1836	938	1021	1022	7.70	0.0000
1837	938	1022	1023	7.70	0.0000	1838	1023	939	938	7.70	0.0000
1839	950	1032	1033	7.70	0.0000	1840	950	1033	1034	7.70	0.0000
1841	951	950	1034	7.70	0.0000	1842	951	1034	1035	7.70	0.0000

1843	952	951	1035	7.70	0.0000	1844	953	952	1035	7.70	0.0000
1845	953	1035	1036	7.70	0.0000	1846	953	1036	1037	7.70	0.0000
1847	954	953	1037	7.70	0.0000	1848	954	1037	1038	7.70	0.0000
1849	955	954	1038	7.70	0.0000	1850	956	955	1038	7.70	0.0000
1851	956	1038	1039	7.70	0.0000	1852	956	1039	1040	7.70	0.0000
1853	957	956	1040	7.70	0.0000	1854	957	1040	1041	7.70	0.0000
1855	958	957	1041	7.70	0.0000	1856	958	1041	1042	7.70	0.0000
1857	959	958	1042	7.70	0.0000	1858	959	1042	1043	7.70	0.0000
1859	960	959	1043	7.70	0.0000	1860	960	1043	1044	7.70	0.0000
1861	961	960	1044	7.70	0.0000	1862	961	1044	1045	7.70	0.0000
1863	962	961	1045	7.70	0.0000	1864	962	1045	1046	7.70	0.0000
1865	963	962	1046	7.70	0.0000	1866	964	963	1046	7.70	0.0000
1867	964	1046	1047	7.70	0.0000	1868	965	964	1047	7.70	0.0000
1869	965	1047	1048	7.70	0.0000	1870	966	965	1048	7.70	0.0000
1871	966	1048	1049	7.70	0.0000	1872	967	966	1049	7.70	0.0000
1873	967	1049	1050	7.70	0.0000	1874	968	967	1050	7.70	0.0000
1875	968	1050	1051	7.70	0.0000	1876	968	1051	1052	7.70	0.0000
1877	969	968	1052	7.70	0.0000	1878	970	969	1052	7.70	0.0000
1879	970	1052	1053	7.70	0.0000	1880	971	970	1053	7.70	0.0000
1881	971	1053	1054	7.70	0.0000	1882	971	1054	1055	7.70	0.0000
1883	972	971	1055	7.70	0.0000	1884	972	1055	1056	7.70	0.0000
1885	973	972	1056	7.70	0.0000	1886	973	1056	1057	7.70	0.0000
1887	1058	974	1057	7.70	0.0000	1888	975	1059	976	7.70	0.0000
1889	976	1059	977	7.70	0.0000	1890	1059	1060	977	7.70	0.0000
1891	977	1060	978	7.70	0.0000	1892	1060	1061	978	7.70	0.0000
1893	979	978	1061	7.70	0.0000	1894	979	1061	1062	7.70	0.0000
1895	979	1062	1063	7.70	0.0000	1896	980	979	1063	7.70	0.0000
1897	981	980	1063	13.20	0.0000	1898	982	981	1063	17.20	0.0000
1899	982	1063	1064	17.20	0.0000	1900	982	1064	1065	21.20	0.0000
1901	983	982	1065	21.20	0.0000	1902	984	983	1065	21.20	0.0000
1903	984	1065	1066	21.20	0.0000	1904	984	1066	1067	21.20	0.0000
1905	985	984	1067	21.20	0.0000	1906	985	1067	1068	21.20	0.0000
1907	986	985	1068	21.20	0.0000	1908	986	1068	1069	21.20	0.0000
1909	987	986	1069	21.20	0.0000	1910	988	987	1069	21.20	0.0000
1911	988	1069	1070	21.20	0.0000	1912	988	1070	1071	21.20	0.0000
1913	989	988	1071	21.20	0.0000	1914	989	1071	1072	17.20	0.0000
1915	990	989	1072	13.20	0.0000	1916	990	1072	1073	10.20	0.0000
1917	991	990	1073	7.70	0.0000	1918	991	1073	1074	7.70	0.0000
1919	992	991	1074	7.70	0.0000	1920	992	1074	1075	7.70	0.0000
1921	993	992	1075	7.70	0.0000	1922	993	1075	1076	7.70	0.0000
1923	994	993	1076	7.70	0.0000	1924	995	994	1076	6.20	0.0000
1925	995	1076	1077	6.20	0.0000	1926	996	995	1077	5.20	0.0000
1927	996	1077	1078	5.20	0.0000	1928	997	996	1078	2.20	0.0000
1929	1079	997	1078	2.20	0.0000	1930	998	1080	1081	2.20	0.0000
1931	999	998	1081	2.20	0.0000	1932	999	1081	1082	4.20	0.0000
1933	1000	999	1082	4.20	0.0000	1934	1000	1082	1083	5.20	0.0000
1935	1001	1000	1083	5.20	0.0000	1936	1001	1083	1084	6.20	0.0000
1937	1002	1001	1084	6.20	0.0000	1938	1003	1002	1084	7.20	0.0000
1939	1003	1084	1085	7.20	0.0000	1940	1004	1003	1085	7.70	0.0000
1941	1004	1085	1086	7.70	0.0000	1942	1005	1004	1086	7.70	0.0000
1943	1005	1086	1087	7.70	0.0000	1944	1006	1005	1087	7.70	0.0000
1945	1006	1087	1088	7.70	0.0000	1946	1007	1006	1088	7.70	0.0000
1947	1007	1088	1089	7.70	0.0000	1948	1008	1007	1089	7.70	0.0000
1949	1008	1089	1090	7.70	0.0000	1950	1009	1008	1090	7.70	0.0000

1951	1009	1090	1091	7.70	0.0000	1952	1010	1009	1091	7.70	0.0000
1953	1010	1091	1092	7.70	0.0000	1954	1011	1010	1092	7.70	0.0000
1955	1011	1092	1093	7.70	0.0000	1956	1012	1011	1093	7.70	0.0000
1957	1012	1093	1094	7.70	0.0000	1958	1013	1012	1094	7.70	0.0000
1959	1013	1094	1095	7.70	0.0000	1960	1014	1013	1095	7.70	0.0000
1961	1014	1095	1096	7.70	0.0000	1962	1015	1014	1096	7.70	0.0000
1963	1015	1096	1097	7.70	0.0000	1964	1016	1015	1097	7.70	0.0000
1965	1016	1097	1098	7.70	0.0000	1966	1017	1016	1098	7.70	0.0000
1967	1017	1098	1099	7.70	0.0000	1968	1018	1017	1099	7.70	0.0000
1969	1018	1099	1100	7.70	0.0000	1970	1019	1018	1100	7.70	0.0000
1971	1019	1100	1101	7.70	0.0000	1972	1020	1019	1101	7.70	0.0000
1973	1020	1101	1102	7.70	0.0000	1974	1021	1020	1102	7.70	0.0000
1975	1021	1102	1103	7.70	0.0000	1976	1022	1021	1103	7.70	0.0000
1977	1022	1103	1104	7.70	0.0000	1978	1023	1022	1104	7.70	0.0000
1979	1023	1104	1105	7.70	0.0000	1980	1024	1023	1105	7.70	0.0000
1981	1024	1105	1106	7.70	0.0000	1982	1025	1024	1106	7.70	0.0000
1983	1025	1106	1107	7.70	0.0000	1984	1026	1025	1107	7.70	0.0000
1985	1026	1107	1108	7.70	0.0000	1986	1027	1026	1108	7.70	0.0000
1987	1027	1108	1109	7.70	0.0000	1988	1028	1027	1109	7.70	0.0000
1989	1028	1109	1110	7.70	0.0000	1990	1028	1110	1111	7.70	0.0000
1991	1029	1028	1111	7.70	0.0000	1992	1029	1111	1112	7.70	0.0000
1993	1030	1029	1112	7.70	0.0000	1994	1113	1030	1112	7.70	0.0000
1995	1031	1114	1115	7.70	0.0000	1996	1032	1031	1115	7.70	0.0000
1997	1032	1115	1116	7.70	0.0000	1998	1033	1032	1116	7.70	0.0000
1999	1033	1116	1117	7.70	0.0000	2000	1034	1033	1117	7.70	0.0000
2001	1034	1117	1118	7.70	0.0000	2002	1035	1034	1118	7.70	0.0000
2003	1035	1118	1119	7.70	0.0000	2004	1036	1035	1119	7.70	0.0000
2005	1036	1119	1120	7.70	0.0000	2006	1037	1036	1120	7.70	0.0000
2007	1037	1120	1121	7.70	0.0000	2008	1038	1037	1121	7.70	0.0000
2009	1038	1121	1122	7.70	0.0000	2010	1039	1038	1122	7.70	0.0000
2011	1039	1122	1123	7.70	0.0000	2012	1039	1123	1124	7.70	0.0000
2013	1040	1039	1124	7.70	0.0000	2014	1040	1124	1125	7.70	0.0000
2015	1041	1040	1125	7.70	0.0000	2016	1041	1125	1126	7.70	0.0000
2017	1042	1041	1126	7.70	0.0000	2018	1042	1126	1127	7.70	0.0000
2019	1043	1042	1127	7.70	0.0000	2020	1043	1127	1128	7.70	0.0000
2021	1044	1043	1128	7.70	0.0000	2022	1044	1128	1129	7.70	0.0000
2023	1045	1044	1129	7.70	0.0000	2024	1045	1129	1130	7.70	0.0000
2025	1046	1045	1130	7.70	0.0000	2026	1046	1130	1131	7.70	0.0000
2027	1047	1046	1131	7.70	0.0000	2028	1048	1047	1131	7.70	0.0000
2029	1048	1131	1132	7.70	0.0000	2030	1049	1048	1132	7.70	0.0000
2031	1049	1132	1133	7.70	0.0000	2032	1050	1049	1133	7.70	0.0000
2033	1050	1133	1134	7.70	0.0000	2034	1051	1050	1134	7.70	0.0000
2035	1051	1134	1135	7.70	0.0000	2036	1051	1135	1136	7.70	0.0000
2037	1052	1051	1136	7.70	0.0000	2038	1053	1052	1136	7.70	0.0000
2039	1053	1136	1137	7.70	0.0000	2040	1054	1053	1137	7.70	0.0000
2041	1054	1137	1138	7.70	0.0000	2042	1054	1138	1139	7.70	0.0000
2043	1055	1054	1139	7.70	0.0000	2044	1055	1139	1140	7.70	0.0000
2045	1056	1055	1140	7.70	0.0000	2046	1056	1140	1141	7.70	0.0000
2047	1057	1056	1141	7.70	0.0000	2048	1057	1141	1142	7.70	0.0000
2049	1058	1057	1142	7.70	0.0000	2050	1143	1058	1142	7.70	0.0000
2051	1061	1146	1062	7.70	0.0000	2052	1146	1147	1062	7.70	0.0000
2053	1062	1147	1148	7.70	0.0000	2054	1062	1148	1149	7.70	0.0000
2055	1063	1062	1149	7.70	0.0000	2056	1064	1063	1149	9.20	0.0000
2057	1064	1149	1150	11.20	0.0000	2058	1065	1064	1150	17.20	0.0000

2059	1065	1150	1151	19.20	0.0000	2060	1066	1065	1151	21.20	0.0000
2061	1066	1151	1152	21.20	0.0000	2062	1067	1066	1152	21.20	0.0000
2063	1067	1152	1153	21.20	0.0000	2064	1068	1067	1153	21.20	0.0000
2065	1068	1153	1154	21.20	0.0000	2066	1068	1154	1155	21.20	0.0000
2067	1069	1068	1155	21.20	0.0000	2068	1070	1069	1155	21.20	0.0000
2069	1070	1155	1156	21.20	0.0000	2070	1070	1156	1157	21.20	0.0000
2071	1071	1070	1157	21.20	0.0000	2072	1071	1157	1158	21.20	0.0000
2073	1072	1071	1158	17.20	0.0000	2074	1072	1158	1159	13.20	0.0000
2075	1073	1072	1159	9.20	0.0000	2076	1073	1159	1160	7.70	0.0000
2077	1074	1073	1160	7.70	0.0000	2078	1074	1160	1161	7.70	0.0000
2079	1075	1074	1161	7.70	0.0000	2080	1075	1161	1162	7.70	0.0000
2081	1076	1075	1162	7.70	0.0000	2082	1076	1162	1163	6.20	0.0000
2083	1077	1076	1163	6.20	0.0000	2084	1077	1163	1164	4.20	0.0000
2085	1078	1077	1164	4.20	0.0000	2086	1078	1164	1165	2.20	0.0000
2087	1165	1079	1078	2.20	0.0000	2088	1080	1166	1167	2.20	0.0000
2089	1081	1080	1167	2.20	0.0000	2090	1081	1167	1168	4.20	0.0000
2091	1082	1081	1168	4.20	0.0000	2092	1082	1168	1169	5.20	0.0000
2093	1083	1082	1169	5.20	0.0000	2094	1083	1169	1170	6.20	0.0000
2095	1084	1083	1170	6.20	0.0000	2096	1084	1170	1171	7.20	0.0000
2097	1085	1084	1171	7.70	0.0000	2098	1085	1171	1172	7.70	0.0000
2099	1086	1085	1172	7.70	0.0000	2100	1086	1172	1173	7.70	0.0000
2101	1087	1086	1173	7.70	0.0000	2102	1087	1173	1174	7.70	0.0000
2103	1088	1087	1174	7.70	0.0000	2104	1088	1174	1175	7.70	0.0000
2105	1089	1088	1175	7.70	0.0000	2106	1089	1175	1176	7.70	0.0000
2107	1090	1089	1176	7.70	0.0000	2108	1090	1176	1177	7.70	0.0000
2109	1091	1090	1177	7.70	0.0000	2110	1091	1177	1178	7.70	0.0000
2111	1092	1091	1178	7.70	0.0000	2112	1092	1178	1179	7.70	0.0000
2113	1093	1092	1179	7.70	0.0000	2114	1093	1179	1180	7.70	0.0000
2115	1094	1093	1180	7.70	0.0000	2116	1094	1180	1181	7.70	0.0000
2117	1095	1094	1181	7.70	0.0000	2118	1095	1181	1182	7.70	0.0000
2119	1096	1095	1182	7.70	0.0000	2120	1096	1182	1183	7.70	0.0000
2121	1097	1096	1183	7.70	0.0000	2122	1097	1183	1184	7.70	0.0000
2123	1098	1097	1184	7.70	0.0000	2124	1098	1184	1185	7.70	0.0000
2125	1099	1098	1185	7.70	0.0000	2126	1099	1185	1186	7.70	0.0000
2127	1100	1099	1186	7.70	0.0000	2128	1100	1186	1187	7.70	0.0000
2129	1101	1100	1187	7.70	0.0000	2130	1101	1187	1188	7.70	0.0000
2131	1102	1101	1188	7.70	0.0000	2132	1102	1188	1189	7.70	0.0000
2133	1103	1102	1189	7.70	0.0000	2134	1103	1189	1190	7.70	0.0000
2135	1104	1103	1190	7.70	0.0000	2136	1104	1190	1191	7.70	0.0000
2137	1105	1104	1191	7.70	0.0000	2138	1105	1191	1192	7.70	0.0000
2139	1106	1105	1192	7.70	0.0000	2140	1106	1192	1193	7.70	0.0000
2141	1107	1106	1193	7.70	0.0000	2142	1107	1193	1194	7.70	0.0000
2143	1108	1107	1194	7.70	0.0000	2144	1108	1194	1195	7.70	0.0000
2145	1109	1108	1195	7.70	0.0000	2146	1110	1109	1195	7.70	0.0000
2147	1110	1195	1196	7.70	0.0000	2148	1110	1196	1197	7.70	0.0000
2149	1111	1110	1197	7.70	0.0000	2150	1111	1197	1198	7.70	0.0000
2151	1112	1111	1198	7.70	0.0000	2152	1112	1198	1199	7.70	0.0000
2153	1113	1112	1199	7.70	0.0000	2154	1113	1199	1200	7.70	0.0000
2155	1114	1113	1200	7.70	0.0000	2156	1114	1200	1201	7.70	0.0000
2157	1115	1114	1201	7.70	0.0000	2158	1115	1201	1202	7.70	0.0000
2159	1116	1115	1202	7.70	0.0000	2160	1116	1202	1203	7.70	0.0000
2161	1117	1116	1203	7.70	0.0000	2162	1117	1203	1204	7.70	0.0000
2163	1118	1117	1204	7.70	0.0000	2164	1118	1204	1205	7.70	0.0000
2165	1119	1118	1205	7.70	0.0000	2166	1119	1205	1206	7.70	0.0000

2167	1120	1119	1206	7.70	0.0000	2168	1120	1206	1207	7.70	0.0000
2169	1121	1120	1207	7.70	0.0000	2170	1121	1207	1208	7.70	0.0000
2171	1122	1121	1208	7.70	0.0000	2172	1122	1208	1209	7.70	0.0000
2173	1123	1122	1209	7.70	0.0000	2174	1123	1209	1210	7.70	0.0000
2175	1124	1123	1210	7.70	0.0000	2176	1124	1210	1211	7.70	0.0000
2177	1125	1124	1211	7.70	0.0000	2178	1125	1211	1212	7.70	0.0000
2179	1126	1125	1212	7.70	0.0000	2180	1126	1212	1213	7.70	0.0000
2181	1127	1126	1213	7.70	0.0000	2182	1127	1213	1214	7.70	0.0000
2183	1128	1127	1214	7.70	0.0000	2184	1128	1214	1215	7.70	0.0000
2185	1129	1128	1215	7.70	0.0000	2186	1129	1215	1216	7.70	0.0000
2187	1130	1129	1216	7.70	0.0000	2188	1130	1216	1217	7.70	0.0000
2189	1131	1130	1217	7.70	0.0000	2190	1131	1217	1218	7.70	0.0000
2191	1132	1131	1218	7.70	0.0000	2192	1132	1218	1219	7.70	0.0000
2193	1133	1132	1219	7.70	0.0000	2194	1133	1219	1220	7.70	0.0000
2195	1134	1133	1220	7.70	0.0000	2196	1134	1220	1221	7.70	0.0000
2197	1135	1134	1221	7.70	0.0000	2198	1135	1221	1222	7.70	0.0000
2199	1136	1135	1222	7.70	0.0000	2200	1136	1222	1223	7.70	0.0000
2201	1137	1136	1223	7.70	0.0000	2202	1137	1223	1224	7.70	0.0000
2203	1138	1137	1224	7.70	0.0000	2204	1138	1224	1225	7.70	0.0000
2205	1139	1138	1225	7.70	0.0000	2206	1139	1225	1226	7.70	0.0000
2207	1140	1139	1226	7.70	0.0000	2208	1140	1226	1227	7.70	0.0000
2209	1141	1140	1227	7.70	0.0000	2210	1141	1227	1228	7.70	0.0000
2211	1142	1141	1228	7.70	0.0000	2212	1142	1228	1229	7.70	0.0000
2213	1143	1142	1229	7.70	0.0000	2214	1144	1143	1229	7.70	0.0000
2215	1144	1229	1230	7.70	0.0000	2216	1145	1144	1230	7.70	0.0000
2217	1145	1230	1231	7.70	0.0000	2218	1232	1145	1231	7.70	0.0000
2219	1147	1233	1234	7.70	0.0000	2220	1148	1147	1234	7.70	0.0000
2221	1148	1234	1235	13.20	0.0000	2222	1149	1148	1235	11.20	0.0000
2223	1150	1149	1235	11.20	0.0000	2224	1150	1235	1236	17.20	0.0000
2225	1151	1150	1236	19.20	0.0000	2226	1151	1236	1237	21.20	0.0000
2227	1152	1151	1237	21.20	0.0000	2228	1152	1237	1238	21.20	0.0000
2229	1153	1152	1238	21.20	0.0000	2230	1153	1238	1239	21.20	0.0000
2231	1154	1153	1239	21.20	0.0000	2232	1154	1239	1240	21.20	0.0000
2233	1155	1154	1240	21.20	0.0000	2234	1155	1240	1241	21.20	0.0000
2235	1156	1155	1241	21.20	0.0000	2236	1156	1241	1242	21.20	0.0000
2237	1157	1156	1242	21.20	0.0000	2238	1157	1242	1243	21.20	0.0000
2239	1158	1157	1243	21.20	0.0000	2240	1158	1243	1244	17.20	0.0000
2241	1159	1158	1244	13.20	0.0000	2242	1159	1244	1245	11.20	0.0000
2243	1160	1159	1245	7.70	0.0000	2244	1160	1245	1246	7.70	0.0000
2245	1161	1160	1246	7.70	0.0000	2246	1161	1246	1247	7.70	0.0000
2247	1162	1161	1247	7.20	0.0000	2248	1162	1247	1248	6.20	0.0000
2249	1163	1162	1248	6.20	0.0000	2250	1163	1248	1249	4.20	0.0000
2251	1164	1163	1249	4.20	0.0000	2252	1164	1249	1250	2.20	0.0000
2253	1250	1165	1164	2.20	0.0000	2254	1166	1251	1167	2.20	0.0000
2255	1251	1252	1167	2.20	0.0000	2256	1252	1253	1167	4.20	0.0000
2257	1168	1167	1253	4.20	0.0000	2258	1253	1254	1168	5.20	0.0000
2259	1169	1168	1254	5.20	0.0000	2260	1254	1255	1169	6.20	0.0000
2261	1170	1169	1255	6.20	0.0000	2262	1255	1256	1170	7.70	0.0000
2263	1171	1170	1256	7.70	0.0000	2264	1256	1257	1171	7.70	0.0000
2265	1172	1171	1257	7.70	0.0000	2266	1257	1258	1172	7.70	0.0000
2267	1173	1172	1258	7.70	0.0000	2268	1258	1259	1173	7.70	0.0000
2269	1174	1173	1259	7.70	0.0000	2270	1259	1260	1174	7.70	0.0000
2271	1175	1174	1260	7.70	0.0000	2272	1260	1261	1175	7.70	0.0000
2273	1176	1175	1261	7.70	0.0000	2274	1261	1262	1176	7.70	0.0000

2275	1177	1176	1262	7.70	0.0000	2276	1262	1263	1177	7.70	0.0000
2277	1178	1177	1263	7.70	0.0000	2278	1263	1264	1178	7.70	0.0000
2279	1179	1178	1264	7.70	0.0000	2280	1264	1265	1179	7.70	0.0000
2281	1180	1179	1265	7.70	0.0000	2282	1265	1266	1180	7.70	0.0000
2283	1181	1180	1266	7.70	0.0000	2284	1266	1267	1181	7.70	0.0000
2285	1182	1181	1267	7.70	0.0000	2286	1267	1268	1182	7.70	0.0000
2287	1183	1182	1268	7.70	0.0000	2288	1268	1269	1183	7.70	0.0000
2289	1184	1183	1269	7.70	0.0000	2290	1269	1270	1184	7.70	0.0000
2291	1185	1184	1270	7.70	0.0000	2292	1270	1271	1185	7.70	0.0000
2293	1186	1185	1271	7.70	0.0000	2294	1271	1272	1186	7.70	0.0000
2295	1187	1186	1272	7.70	0.0000	2296	1272	1273	1187	7.70	0.0000
2297	1188	1187	1273	7.70	0.0000	2298	1273	1274	1188	7.70	0.0000
2299	1189	1188	1274	7.70	0.0000	2300	1274	1275	1189	7.70	0.0000
2301	1190	1189	1275	7.70	0.0000	2302	1275	1276	1190	7.70	0.0000
2303	1191	1190	1276	7.70	0.0000	2304	1276	1277	1191	7.70	0.0000
2305	1192	1191	1277	7.70	0.0000	2306	1277	1278	1192	7.70	0.0000
2307	1193	1192	1278	7.70	0.0000	2308	1278	1279	1193	7.70	0.0000
2309	1194	1193	1279	7.70	0.0000	2310	1279	1280	1194	7.70	0.0000
2311	1195	1194	1280	7.70	0.0000	2312	1280	1281	1195	7.70	0.0000
2313	1196	1195	1281	7.70	0.0000	2314	1281	1282	1196	7.70	0.0000
2315	1197	1196	1282	7.70	0.0000	2316	1282	1283	1197	7.70	0.0000
2317	1198	1197	1283	7.70	0.0000	2318	1283	1284	1198	7.70	0.0000
2319	1199	1198	1284	7.70	0.0000	2320	1284	1285	1199	7.70	0.0000
2321	1200	1199	1285	7.70	0.0000	2322	1285	1286	1200	7.70	0.0000
2323	1201	1200	1286	7.70	0.0000	2324	1286	1287	1201	7.70	0.0000
2325	1202	1201	1287	7.70	0.0000	2326	1287	1288	1202	7.70	0.0000
2327	1203	1202	1288	7.70	0.0000	2328	1288	1289	1203	7.70	0.0000
2329	1204	1203	1289	7.70	0.0000	2330	1289	1290	1204	7.70	0.0000
2331	1205	1204	1290	7.70	0.0000	2332	1290	1291	1205	7.70	0.0000
2333	1206	1205	1291	7.70	0.0000	2334	1291	1292	1206	7.70	0.0000
2335	1207	1206	1292	7.70	0.0000	2336	1292	1293	1207	7.70	0.0000
2337	1208	1207	1293	7.70	0.0000	2338	1293	1294	1208	7.70	0.0000
2339	1209	1208	1294	7.70	0.0000	2340	1294	1295	1209	7.70	0.0000
2341	1210	1209	1295	7.70	0.0000	2342	1295	1296	1210	7.70	0.0000
2343	1211	1210	1296	7.70	0.0000	2344	1296	1297	1211	7.70	0.0000
2345	1212	1211	1297	7.70	0.0000	2346	1297	1298	1212	7.70	0.0000
2347	1213	1212	1298	7.70	0.0000	2348	1298	1299	1213	7.70	0.0000
2349	1214	1213	1299	7.70	0.0000	2350	1299	1300	1214	7.70	0.0000
2351	1215	1214	1300	7.70	0.0000	2352	1300	1301	1215	7.70	0.0000
2353	1216	1215	1301	7.70	0.0000	2354	1301	1302	1216	7.70	0.0000
2355	1217	1216	1302	7.70	0.0000	2356	1302	1303	1217	7.70	0.0000
2357	1218	1217	1303	7.70	0.0000	2358	1303	1304	1218	7.70	0.0000
2359	1219	1218	1304	7.70	0.0000	2360	1304	1305	1219	7.70	0.0000
2361	1220	1219	1305	7.70	0.0000	2362	1305	1306	1220	7.70	0.0000
2363	1221	1220	1306	7.70	0.0000	2364	1306	1307	1221	7.70	0.0000
2365	1222	1221	1307	7.70	0.0000	2366	1307	1308	1222	7.70	0.0000
2367	1223	1222	1308	7.70	0.0000	2368	1308	1309	1223	7.70	0.0000
2369	1224	1223	1309	7.70	0.0000	2370	1309	1310	1224	7.70	0.0000
2371	1225	1224	1310	7.70	0.0000	2372	1310	1311	1225	7.70	0.0000
2373	1226	1225	1311	7.70	0.0000	2374	1311	1312	1226	7.70	0.0000
2375	1227	1226	1312	7.70	0.0000	2376	1312	1313	1227	7.70	0.0000
2377	1228	1227	1313	7.70	0.0000	2378	1313	1314	1228	7.70	0.0000
2379	1229	1228	1314	7.70	0.0000	2380	1314	1315	1229	7.70	0.0000
2381	1230	1229	1315	7.70	0.0000	2382	1231	1230	1315	7.70	0.0000

2383	1315	1316	1231	7.70	0.0000	2384	1232	1231	1316	7.70	0.0000
2385	1316	1317	1232	7.70	0.0000	2386	1233	1232	1317	7.70	0.0000
2387	1317	1318	1233	9.20	0.0000	2388	1234	1233	1318	11.20	0.0000
2389	1318	1319	1234	15.20	0.0000	2390	1235	1234	1319	15.20	0.0000
2391	1319	1320	1235	21.20	0.0000	2392	1236	1235	1320	21.20	0.0000
2393	1320	1321	1236	21.20	0.0000	2394	1237	1236	1321	21.20	0.0000
2395	1321	1322	1237	21.20	0.0000	2396	1238	1237	1322	21.20	0.0000
2397	1322	1323	1238	21.20	0.0000	2398	1239	1238	1323	21.20	0.0000
2399	1323	1324	1239	21.20	0.0000	2400	1240	1239	1324	21.20	0.0000
2401	1324	1325	1240	21.20	0.0000	2402	1241	1240	1325	21.20	0.0000
2403	1325	1326	1241	21.20	0.0000	2404	1242	1241	1326	21.20	0.0000
2405	1326	1327	1242	21.20	0.0000	2406	1243	1242	1327	21.20	0.0000
2407	1327	1328	1243	21.20	0.0000	2408	1244	1243	1328	17.20	0.0000
2409	1328	1329	1244	14.20	0.0000	2410	1245	1244	1329	11.20	0.0000
2411	1329	1330	1245	7.70	0.0000	2412	1246	1245	1330	7.70	0.0000
2413	1330	1331	1246	7.20	0.0000	2414	1247	1246	1331	7.20	0.0000
2415	1331	1332	1247	6.20	0.0000	2416	1248	1247	1332	6.20	0.0000
2417	1332	1333	1248	4.20	0.0000	2418	1249	1248	1333	4.20	0.0000
2419	1333	1334	1249	2.20	0.0000	2420	1334	1250	1249	2.20	0.0000
2421	974	973	1057	7.70	0.0000						

1	2420	0.45	2	2253	0.45	3	2087	0.45	4	1929	0.45	5	1790	0.45
6	1642	0.45	7	1498	0.45	8	1369	0.45	9	1223	0.45	10	1084	0.45
11	949	0.45	12	818	0.45	13	694	0.45	14	594	0.45	15	501	0.45
16	500	0.45	17	499	0.45	18	494	0.45	19	492	0.45	20	490	0.45
21	488	0.45	22	415	0.45	23	482	0.45	24	480	0.45	25	572	0.45
26	569	0.45	27	568	0.45	28	478	0.45	29	479	0.45	30	414	0.45
31	350	0.45	32	351	0.45	33	352	0.45	34	288	0.45	35	228	0.45
36	177	0.45	37	131	0.45	38	89	0.45	39	87	0.45	40	52	0.45
41	50	0.45	42	48	0.45	43	20	0.45	44	7	0.45	45	5	0.45
46	3	0.45	47	1	0.45	48	8	0.45	49	23	0.45	50	21	0.45
51	25	0.45	52	53	0.45	53	90	0.45	54	132	0.45	55	178	0.45
56	230	0.45	57	289	0.45	58	353	0.45	59	416	0.45	60	502	0.45
61	595	0.45	62	712	0.45	63	710	0.45	64	708	0.45	65	706	0.45
66	704	0.45	67	702	0.45	68	700	0.45	69	698	0.45	70	696	0.45
71	695	0.45	72	819	0.45	73	950	0.45	74	1085	0.45	75	1224	0.45
76	1370	0.45	77	1499	0.45	78	1643	0.45	79	1791	0.45	80	1930	0.45
81	2088	0.45	82	2254	0.45	83	1598	0.45	84	1596	0.45	85	1594	0.45
86	1448	0.45	87	1446	0.45	88	1444	0.45	89	1314	0.45	90	1312	0.45
91	1310	0.45	92	1308	0.45	93	1306	0.45	94	1304	0.45	95	1302	0.45
96	1300	0.45	97	1298	0.45	98	1296	0.45	99	1443	0.45	100	1441	0.45
101	1439	0.45	102	1568	0.45	103	1566	0.45	104	1564	0.45	105	1708	0.45
106	1706	0.45	107	1704	0.45	108	1703	0.45	109	1701	0.45	110	1699	0.45
111	1697	0.45	112	1695	0.45	113	1693	0.45	114	1691	0.45	115	1689	0.45
116	1838	0.45	117	1980	0.45	118	1982	0.45	119	1984	0.45	120	1986	0.45
121	1988	0.45	122	1991	0.45	123	1993	0.45	124	1994	0.45	125	2155	0.45
126	1995	0.45	127	1996	0.45	128	1839	0.45	129	1841	0.45	130	1843	0.45
131	1709	0.45	132	1711	0.45	133	1713	0.45	134	1569	0.45	135	1571	0.45
136	1573	0.45	137	1575	0.45	138	1577	0.45	139	1579	0.45	140	1581	0.45
141	1583	0.45	142	1585	0.45	143	1587	0.45	144	1589	0.45	145	1591	0.45
146	1593	0.45	147	1742	0.45	148	1744	0.45	149	1746	0.45	150	1885	0.45
151	2421	0.45	152	1887	0.45	153	2050	0.45	154	2214	0.45	155	2216	0.45
156	2218	0.45	157	2386	0.45	158	2219	0.45	159	2052	0.45	160	2051	0.45
161	1892	0.45	162	1890	0.45	163	1888	0.45	164	1747	0.45			

BATHSPEC FEET 0.0 7.70

APPENDIX 9-D: OUTPUT LISTING FOR AGAT HARBOR, GUAM EXAMPLE

---- HARD AGAT HARBOR WES PLAN ----

***** GENSPECS CARD: SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
SUNITS	UNITS SYSTEM USED IN COMPUTATIONS	ENGLISH		*			

***** GRIDSPEC CARD: SPECIFICATION OF THE FINITE-ELEMENT GRID - AGAT.DAT

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
GRTYPE	TYPE OF FINITE-ELEMENT GRID	TRIANG		* GUNITS	SYSTEM OF UNITS USED FOR THE GRID	ENGLISH	
NNOD	NUMBER OF GRID NODES	1334		* NELE	NUMBER OF GRID ELEMENTS	2421	
NODR	NUMBER OF NODES ON SEMICIRCULAR BOUN	84		* NELB	NUMBER OF BOUNDARY ELEMENTS	164	
NBAND	BANDWIDTH OF GRID	88		* RADIUS	RADIUS OF SEMICIRCLE	263.80	

***** PRWINDOW CARD: SPECIFICATION OF THE MODEL OUTPUT

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
WPRNOD	PRINTING OF NODAL SOLUTIONS	SELECT		* MAXNOD	SPECIFIED MAX NUMBER OF OUTPUT NODES	10	
NODOUT	NUMBER OF NODES SELECTED FOR OUTPUT	10		* WPRBSN	NUMBER OF SPECIFIED BASINS	32	
MAXBSN	SPECIFIED MAXIMUM NUMBER OF BASINS	32		* MAXELE	SPECIFIED MAX ELEMENTS IN ANY BASIN	13	
WPRCOF	PRINTING OF COEFFICIENT SOLUTIONS	YES		* WPRGRD	PRINTING OF FINITE ELEMENT GRID	NO	

BASIN	* NUMBER OF ELEMENTS	* BASIN	* NUMBER OF ELEMENTS
1	6	2	13
3	13	4	13
5	6	6	6
7	6	8	6
9	6	10	6
11	13	12	13
13	13	14	13
15	13	16	13
17	13	18	13
19	13	20	13
21	13	22	13
23	13	24	13
25	6	26	6
27	6	28	5
29	13	30	6
31	6	32	6

***** WAVCOND CARD: NUMBER OF WAVE CONDITIONS: 2

WAVE CONDITION NUMBER: 1

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
HDEEP	DEEPWATER WAVE HEIGHT	0.00		* TDEEP	WAVE PERIOD	8.00	
ZDEEP	DEEPWATER WAVE ANGLE	329.70		*			

WAVE CONDITION NUMBER: 2

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
HDEEP	DEEPWATER WAVE HEIGHT	0.00		* TDEEP	WAVE PERIOD	11.00	
ZDEEP	DEEPWATER WAVE ANGLE	329.70		*			

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
DUNITS	SYSTEM OF UNITS FOR DEPTH DATA	FEET		* WDATUM	DATUM FOR WATER DEPTHS	0.00	
FARD	WATER DEPTH OF FAR REGION	7.700					

NUMBER OF ELEVATION CHANGES = 0

***** CONVERGENCE CRITERIA ARE AS FOLLOWS:

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
REFLEC	REFL. COEFF. ALONG OPEN COAST BNDRY	0.00000					

****
*** INPUT PROCESSING COMPLETED:
FATAL ERRORS= 0 WARNINGS= 0
****

W A V E   C O N D I T I O N   1

THE DEEP WATER WAVE PARAMETERS FOR CASE 1 ARE: HEIGHT= 0.000 PERIOD= 8.000 ANGLE= 329.700

SOLUTION OF THE SYSTEM

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1	0.26	1.67	2	0.28	1.49	3	0.28	1.32	4	0.18	2.49
5	0.21	2.12	6	0.24	1.86	7	0.25	1.63	8	0.27	1.45
9	0.27	1.28	10	0.27	1.11	11	0.26	1.14	12	0.17	2.98
13	0.17	2.57	14	0.20	2.14	15	0.23	1.84	16	0.24	1.61
17	0.26	1.41	18	0.26	1.24	19	0.26	1.08	20	0.25	0.90
21	0.25	0.91	22	0.25	0.95	23	0.23	0.72	24	0.22	0.50
25	0.19	-2.79	26	0.17	3.09	27	0.16	2.66	28	0.18	2.18
29	0.21	1.85	30	0.22	1.59	31	0.24	1.38	32	0.25	1.21
33	0.24	0.98	34	0.25	1.04	35	0.24	0.86	36	0.21	0.65
37	0.23	0.68	38	0.23	0.70	39	0.22	0.47	40	0.21	0.21
41	0.21	0.28	42	0.21	-0.05	43	0.24	-2.43	44	0.21	-2.74
45	0.18	-3.13	46	0.16	2.74	47	0.17	2.23	48	0.19	1.87
49	0.21	1.56	50	0.23	1.34	51	0.24	1.15	52	0.23	0.90
53	0.21	0.73	54	0.22	0.80	55	0.20	0.59	56	0.18	0.34
57	0.19	0.42	58	0.21	0.45	59	0.19	0.15	60	0.19	-0.14
61	0.20	-0.13	62	0.21	-0.52	63	0.22	-0.44	64	0.30	-2.17
65	0.26	-2.43	66	0.22	-2.71	67	0.18	-3.09	68	0.16	2.73
69	0.16	2.26	70	0.18	1.86	71	0.20	1.53	72	0.22	1.29
73	0.23	1.10	74	0.22	0.84	75	0.21	0.64	76	0.19	0.42
77	0.19	0.50	78	0.16	0.25	79	0.14	-0.14	80	0.16	-0.02
81	0.18	0.07	82	0.18	-0.27	83	0.19	-0.58	84	0.20	-0.72
85	0.23	-0.86	86	0.24	-0.75	87	0.35	-2.01	88	0.31	-2.21
89	0.26	-2.44	90	0.22	-2.71	91	0.18	-3.12	92	0.16	2.71
93	0.16	2.26	94	0.18	1.85	95	0.19	1.51	96	0.21	1.25
97	0.23	1.03	98	0.23	0.76	99	0.21	0.55	100	0.19	0.31
101	0.16	0.04	102	0.16	0.14	103	0.13	-0.28	104	0.13	-0.82
105	0.14	-0.61	106	0.16	-0.43	107	0.17	-0.78	108	0.20	-1.00
109	0.23	-1.07	110	0.26	-1.10	111	0.27	-0.98	112	0.40	-1.89
113	0.36	-2.06	114	0.32	-2.25	115	0.26	-2.47	116	0.22	-2.77
117	0.18	3.11	118	0.17	2.67	119	0.17	2.24	120	0.18	1.84
121	0.19	1.49	122	0.21	1.21	123	0.22	0.96	124	0.23	0.70
125	0.23	0.48	126	0.21	0.22	127	0.18	-0.05	128	0.15	-0.47
129	0.13	-0.44	130	0.13	-0.97	131	0.15	-1.48	132	0.15	-1.25
133	0.16	-1.00	134	0.19	-1.26	135	0.22	-1.38	136	0.24	-1.28
137	0.26	-1.41	138	0.28	-1.20	139	0.29	-1.24	140	0.30	-1.08
141	0.43	-1.81	142	0.41	-1.96	143	0.36	-2.10	144	0.31	-2.28
145	0.25	-2.53	146	0.21	-2.88	147	0.18	3.00	148	0.18	2.56
149	0.17	2.22	150	0.18	1.84	151	0.20	1.50	152	0.21	1.17
153	0.23	0.91	154	0.25	0.64	155	0.25	0.41	156	0.23	0.18
157	0.24	-0.12	158	0.20	-0.10	159	0.17	-0.51	160	0.16	-1.07
161	0.14	-1.07	162	0.17	-1.59	163	0.21	-1.98	164	0.20	-1.82
165	0.19	-1.56	166	0.22	-1.69	167	0.25	-1.72	168	0.27	-1.83
169	0.28	-1.49	170	0.29	-1.35	171	0.31	-1.22	172	0.31	-1.09
173	0.45	-1.76	174	0.43	-1.89	175	0.39	-2.00	176	0.34	-2.14
177	0.28	-2.33	178	0.23	-2.62	179	0.20	-3.00	180	0.19	2.87
181	0.20	2.52	182	0.19	2.22	183	0.19	1.85	184	0.20	1.53
185	0.22	1.17	186	0.24	0.88	187	0.26	0.61	188	0.27	0.37
189	0.26	0.13	190	0.28	-0.11	191	0.25	-0.43	192	0.21	-0.50
193	0.19	-0.99	194	0.20	-1.55	195	0.19	-1.64	196	0.24	-2.04
197	0.29	-2.31	198	0.26	-2.20	199	0.23	-2.00	200	0.26	-2.07
201	0.27	-2.12	202	0.27	-1.84	203	0.29	-1.48	204	0.29	-1.37
205	0.31	-1.14	206	0.32	-0.98	207	0.45	-1.78	208	0.44	-1.86
209	0.41	-1.93	210	0.36	-2.03	211	0.30	-2.17	212	0.24	-2.42
213	0.20	-2.77	214	0.19	3.10	215	0.20	2.76	216	0.22	2.49
217	0.20	2.23	218	0.20	1.90	219	0.20	1.58	220	0.22	1.19
221	0.24	0.86	222	0.27	0.61	223	0.29	0.37	224	0.30	0.14
225	0.32	-0.07	226	0.30	-0.36	227	0.27	-0.73	228	0.23	-0.88
229	0.23	-1.42	230	0.27	-1.90	231	0.26	-2.02	232	0.32	-2.34
233	0.38	-2.60	234	0.34	-2.55	235	0.29	-2.37	236	0.31	-2.45
237	0.30	-2.38	238	0.28	-1.74	239	1.21	2.60	240	1.18	2.60
241	1.06	2.48	242	1.03	2.62	243	0.80	2.65	244	0.58	2.71
245	0.17	3.02	246	0.20	-0.86	247	0.33	-0.63	248	0.43	-0.31
249	0.42	-0.53	250	0.42	-1.93	251	0.42	-1.93	252	0.40	-1.91
253	0.35	-1.92	254	0.29	-1.99	255	0.22	-2.18	256	0.18	-2.52
257	0.16	-2.98	258	0.19	2.92	259	0.22	2.67	260	0.24	2.52
261	0.22	2.30	262	0.21	1.96	263	0.20	1.69	264	0.22	1.25
265	0.25	0.87	266	0.28	0.63	267	0.31	0.38	268	0.33	0.17
269	0.37	-0.01	270	0.35	-0.28	271	0.32	-0.60	272	0.30	-1.01
273	0.26	-1.23	274	0.29	-1.74	275	0.34	-2.14	276	0.33	-2.27
277	0.40	-2.56	278	0.46	-2.81	279	0.43	-2.82	280	0.37	-2.73
281	0.39	-2.89	282	0.45	-3.10	283	0.29	-2.35	284	0.91	2.63
285	1.11	2.60	286	1.18	2.48	287	1.18	2.48	288	1.04	2.32
289	0.85	2.33	290	0.86	2.49	291	0.57	2.54	292	0.25	2.71
293	0.12	-1.34	294	0.31	-0.91	295	0.46	-0.78	296	0.55	-0.70
297	0.41	-2.29	298	0.39	-2.09	299	0.36	-1.95	300	0.33	-1.86
301	0.27	-1.81	302	0.20	-1.85	303	0.13	-2.14	304	0.11	-2.75
305	0.14	2.98	306	0.19	2.74	307	0.24	2.64	308	0.26	2.59
309	0.24	2.39	310	0.22	2.07	311	0.21	1.86	312	0.21	1.36
313	0.24	0.92	314	0.28	0.66	315	0.33	0.41	316	0.36	0.20
317	0.41	0.07	318	0.40	-0.17	319	0.38	-0.44	320	0.35	-0.82
321	0.34	-1.26	322	0.31	-1.49	323	0.35	-1.96	324	0.42	-2.31
325	0.41	-2.45	326	0.47	-2.72	327	0.54	-2.99	328	0.52	-3.06
329	0.48	-3.07	330	0.50	3.08	331	0.62	2.83	332	0.66	2.77
333	0.75	2.60	334	0.89	2.52	335	1.06	2.49	336	1.10	2.34
337	1.12	2.33	338	0.98	2.14	339	0.83	2.14	340	0.61	2.13
341	0.60	2.36	342	0.29	2.47	343	0.08	-1.71	344	0.31	-1.08
345	0.52	-0.96	346	0.69	-0.80	347	0.94	-1.59	348	0.78	-1.90
349	0.66	-2.20	350	0.60	-2.49	351	0.60	-2.72	352	0.62	-2.88
353	0.65	-2.96	354	0.64	-2.99	355	0.59	-2.95	356	0.47	-2.72
357	0.43	-2.85	358	0.35	-2.55	359	0.28	-2.13	360	0.24	-1.76
361	0.22	-1.48	362	0.18	-1.35	363	0.11	-1.26	364	0.04	-1.54
365	0.06	2.79	366	0.14	2.63	367	0.21	2.45	368	0.26	2.68
369	0.29	2.71	370	0.27	2.56	371	0.23	2.28	372	0.21	2.11
373	0.20	1.51	374	0.23	1.00	375	0.27	0.74	376	0.33	0.47
377	0.39	0.25	378	0.44	0.14	379	0.45	-0.07	380	0.44	-0.31

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
381	0.40	-0.63	382	0.38	-1.04	383	0.39	-1.49	384	0.37	-1.76
385	0.42	-2.13	386	0.49	-2.44	387	0.48	-2.60	388	0.55	-2.87
389	0.60	-3.13	390	0.59	3.04	391	0.59	2.95	392	0.68	2.67
393	0.76	2.44	394	0.86	2.38	395	0.97	2.34	396	0.97	2.15
397	1.02	2.15	398	0.89	1.92	399	0.78	1.89	400	0.57	1.86
401	0.32	1.76	402	0.30	2.15	403	0.05	-1.59	404	0.31	-1.15
405	0.55	-1.10	406	0.75	-1.04	407	0.90	-0.92	408	0.78	-1.82
409	0.70	-2.10	410	0.59	-2.38	411	0.53	-2.69	412	0.53	-2.93
413	0.56	-3.10	414	0.60	3.11	415	0.62	3.07	416	0.59	3.09
417	0.52	-3.09	418	0.44	-3.07	419	0.34	-3.04	420	0.20	-2.60
421	0.13	-1.54	422	0.19	-0.75	423	0.22	-0.52	424	0.20	-0.34
425	0.15	-0.10	426	0.08	0.56	427	0.08	1.78	428	0.15	2.39
429	0.22	2.63	430	0.29	2.77	431	0.33	2.86	432	0.30	2.74
433	0.26	2.52	434	0.22	2.42	435	0.18	1.83	436	0.21	1.16
437	0.25	0.85	438	0.33	0.54	439	0.40	0.33	440	0.46	0.24
441	0.50	0.04	442	0.49	-0.17	443	0.46	-0.45	444	0.43	-0.79
445	0.42	-1.23	446	0.45	-1.66	447	0.43	-1.93	448	0.50	-2.26
449	0.56	-2.54	450	0.55	-2.72	451	0.60	-2.97	452	0.64	3.05
453	0.64	2.89	454	0.65	2.77	455	0.70	2.53	456	0.72	2.29
457	0.79	2.22	458	0.89	2.19	459	0.86	1.96	460	0.90	1.94
461	0.80	1.66	462	0.74	1.62	463	0.59	1.53	464	0.37	1.38
465	0.27	0.59	466	0.14	0.60	467	0.04	0.32	468	0.27	-1.12
469	0.54	-1.20	470	0.76	-1.20	471	0.93	-1.17	472	1.08	-1.03
473	0.54	-2.17	474	0.44	-2.48	475	0.37	-2.77	476	0.34	-3.09
477	0.37	2.91	478	0.43	2.78	479	0.49	2.73	480	0.54	2.75
481	0.55	2.77	482	0.52	2.87	483	0.46	2.86	484	0.37	2.84
485	0.19	3.01	486	0.03	-1.74	487	0.21	-0.20	488	0.35	-0.07
489	0.41	0.01	490	0.39	0.11	491	0.31	0.28	492	0.19	0.67
493	0.13	1.50	494	0.17	2.30	495	0.24	2.70	496	0.32	2.91
497	0.37	3.02	498	0.34	2.93	499	0.29	2.75	500	0.26	2.73
501	0.19	2.21	502	0.18	1.41	503	0.22	1.04	504	0.31	0.66
505	0.40	0.42	506	0.47	0.34	507	0.53	0.17	508	0.54	-0.03
509	0.52	-0.28	510	0.49	-0.57	511	0.46	-0.99	512	0.47	-1.42
513	0.52	-1.83	514	0.50	-2.06	515	0.57	-2.37	516	0.63	-2.63
517	0.61	-2.81	518	0.64	-3.06	519	0.65	2.95	520	0.65	2.79
521	0.67	2.64	522	0.68	2.39	523	0.66	2.12	524	0.72	2.03
525	0.79	1.99	526	0.75	1.71	527	0.80	1.71	528	0.74	1.39
529	0.71	1.31	530	0.62	1.23	531	0.46	1.06	532	0.35	0.56
533	0.24	-0.16	534	0.22	-0.42	535	0.22	-0.89	536	0.48	-1.25
537	0.73	-1.34	538	0.97	-1.35	539	1.10	-1.32	540	1.26	-1.22
541	0.40	-3.12	542	0.29	2.91	543	0.23	2.46	544	0.24	2.07
545	0.29	1.90	546	0.35	1.93	547	0.40	2.07	548	0.46	2.23
549	0.49	2.38	550	0.50	2.51	551	0.47	2.54	552	0.40	2.54
553	0.26	2.58	554	0.07	1.91	555	0.20	0.13	556	0.41	0.06
557	0.57	0.10	558	0.62	0.15	559	0.60	0.25	560	0.49	0.40
561	0.29	0.72	562	0.17	1.45	563	0.18	2.34	564	0.27	2.84
565	0.35	3.06	566	0.42	-3.09	567	0.40	3.12	568	0.34	2.99
569	0.32	3.01	570	0.21	2.63	571	0.16	1.82	572	0.18	1.32
573	0.28	0.80	574	0.39	0.54	575	0.48	0.49	576	0.56	0.30
577	0.60	0.13	578	0.59	-0.09	579	0.56	-0.36	580	0.52	-0.72
581	0.51	-1.13	582	0.54	-1.55	583	0.60	-1.91	584	0.58	-2.16
585	0.64	-2.45	586	0.68	-2.70	587	0.66	-2.88	588	0.67	3.13
589	0.65	2.86	590	0.64	2.68	591	0.65	2.53	592	0.63	2.25
593	0.60	1.91	594	0.65	1.81	595	0.70	1.76	596	0.69	1.44
597	0.72	1.41	598	0.71	1.08	599	0.71	1.08	600	0.66	1.00
601	0.53	0.87	602	0.44	0.49	603	0.29	0.03	604	0.28	-0.98
605	0.39	-1.22	606	0.64	-1.46	607	0.89	-1.54	608	1.12	-1.56
609	1.40	-1.46	610	0.47	2.80	611	0.37	2.29	612	0.34	1.64
613	0.40	1.23	614	0.50	1.04	615	0.50	1.12	616	0.48	1.29
617	0.45	1.56	618	0.45	1.89	619	0.46	2.15	620	0.46	2.29
621	0.43	2.39	622	0.32	2.45	623	0.15	2.14	624	0.16	0.41
625	0.40	0.10	626	0.61	0.10	627	0.76	0.15	628	0.80	0.21
629	0.76	0.32	630	0.63	0.46	631	0.39	0.74	632	0.19	1.44
633	0.19	2.50	634	0.30	3.00	635	0.40	-3.05	636	0.48	-2.92
637	0.46	-2.99	638	0.41	-3.09	639	0.39	-3.05	640	0.27	2.98
641	0.17	2.36	642	0.15	1.86	643	0.24	1.03	644	0.37	0.69
645	0.47	0.67	646	0.58	0.49	647	0.64	0.32	648	0.66	0.12
649	0.63	-0.11	650	0.59	-0.42	651	0.56	-0.82	652	0.57	-1.23
653	0.63	-1.63	654	0.70	-1.95	655	0.67	-2.22	656	0.72	-2.49
657	0.75	-2.74	658	0.70	-2.95	659	0.68	3.06	660	0.64	2.77
661	0.61	2.58	662	0.61	2.39	663	0.58	2.05	664	0.56	1.64
665	0.60	1.53	666	0.64	1.47	667	0.66	1.12	668	0.69	1.09
669	0.72	0.79	670	0.73	0.78	671	0.72	0.72	672	0.63	0.66
673	0.58	0.41	674	0.40	0.22	675	0.23	-0.42	676	0.29	-1.53
677	0.48	-1.54	678	0.73	-1.74	679	1.01	-1.82	680	1.24	-1.84
681	1.50	-1.74	682	0.58	2.95	683	0.44	2.28	684	0.43	1.47
685	0.57	0.96	686	0.71	0.75	687	0.77	0.68	688	0.75	0.69
689	0.67	0.78	690	0.54	0.99	691	0.44	1.36	692	0.41	1.81
693	0.42	2.13	694	0.43	2.37	695	0.38	2.50	696	0.22	2.45
697	0.08	0.96	698	0.31	0.08	699	0.56	0.04	700	0.75	0.09
701	0.86	0.16	702	0.89	0.24	703	0.84	0.38	704	0.71	0.52
705	0.43	0.79	706	0.21	1.44	707	0.21	2.71	708	0.33	-3.10
709	0.45	-2.88	710	0.54	-2.77	711	0.54	-2.82	712	0.48	-2.91
713	0.49	-2.82	714	0.37	-2.99	715	0.22	2.91	716	0.16	2.65
717	0.19	1.42	718	0.34	0.90	719	0.43	0.89	720	0.56	0.69
721	0.64	0.52	722	0.68	0.33	723	0.67	0.13	724	0.63	-0.14
725	0.59	-0.52	726	0.58	-0.92	727	0.62	-1.33	728	0.69	-1.68
729	0.76	-1.98	730	0.77	-2.22	731	0.80	-2.49	732	0.80	-2.74
733	0.74	-2.99	734	0.69	3.00	735	0.63	2.69	736	0.58	2.43
737	0.57	2.22	738	0.54	1.80	739	0.55	1.32	740	0.58	1.21
741	0.62	1.13	742	0.67	0.78	743	0.70	0.78	744	0.75	0.50
745	0.76	0.53	746	0.75	0.51	747	0.71	0.49	748	0.69	0.31
749	0.53	0.26	750	0.30	0.08	751	0.11	-1.06	752	0.32	-2.30
753	0.54	-1.97	754	0.83	-2.12	755	1.14	-2.19	756	1.39	-2.18
757	1.61	-2.11	758	0.85	-2.96	759	0.52	2.70	760	0.39	1.48
761	0.64	0.77	762	0.89	0.53	763	1.00	0.44	764	1.00	0.42
765	0.88	0.45	766	0.68	0.56	767	0.45	0.86	768	0.33	1.44
769	0.34	2.11	770	0.43	2.51	771	0.44	2.64	772	0.32	2.73
773	0.11	2.71	774	0.15	-0.15	775	0.41	-0.12	776	0.64	-0.05
777	0.78	0.04	778	0.85	0.16	779	0.88	0.27	780	0.85	0.44
781	0.72	0.60	782	0.44	0.89	783	0.21	1.53	784	0.22	2.91
785	0.38	-2.90	786	0.51	-2.72	787	0.64	-2.57	788	0.64	-2.63
789	0.59	-2.71	790	0.61	-2.59	791	0.47	-2.72	792	0.31	-2.95

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
797	0.84	-0.58	798	0.84	-0.70	799	0.76	-0.84	800	0.63	-1.02
801	0.48	-1.36	802	0.40	-1.90	803	0.45	-2.45	804	0.55	-2.75
805	0.65	-2.93	806	0.71	-3.03	807	0.72	-3.11	808	0.81	-2.25
809	0.82	-2.50	810	0.80	-2.75	811	0.76	-3.00	812	0.69	2.97
813	0.60	2.56	814	0.56	2.26	815	0.54	2.02	816	0.53	1.50
817	0.59	1.00	818	0.61	0.89	819	0.64	0.82	820	0.73	0.47
821	0.74	0.49	822	0.81	0.25	823	0.80	0.29	824	0.79	0.32
825	0.76	0.33	826	0.74	0.20	827	0.63	0.23	828	0.42	0.25
829	0.16	0.33	830	0.14	3.12	831	0.48	-3.02	832	0.63	-2.50
833	0.99	-2.54	834	1.34	-2.58	835	1.77	-2.47	836	1.36	-2.78
837	0.84	3.11	838	0.31	2.09	839	0.57	0.64	840	0.96	0.35
841	1.16	0.25	842	1.20	0.19	843	1.08	0.18	844	0.81	0.21
845	0.47	0.37	846	0.23	0.95	847	0.25	2.34	848	0.44	2.74
849	0.52	2.83	850	0.46	2.93	851	0.28	3.12	852	0.09	-2.04
853	0.27	-0.56	854	0.49	-0.32	855	0.64	-0.17	856	0.72	-0.03
857	0.72	0.16	858	0.75	0.32	859	0.80	0.55	860	0.70	0.73
861	0.41	1.04	862	0.19	1.78	863	0.25	-3.07	864	0.44	-2.67
865	0.60	-2.49	866	0.72	-2.37	867	0.73	-2.43	868	0.69	-2.50
869	0.67	-2.41	870	0.55	-2.51	871	0.40	-2.66	872	0.50	0.66
873	0.53	0.16	874	0.64	-0.20	875	0.75	-0.57	876	0.82	-0.73
877	0.82	-0.85	878	0.74	-0.98	879	0.60	-1.17	880	0.46	-1.51
881	0.38	-2.05	882	0.41	-2.53	883	0.48	-2.84	884	0.58	-3.02
885	0.64	-3.13	886	0.69	3.08	887	0.69	3.02	888	0.68	3.07
889	0.63	2.94	890	0.57	2.71	891	0.74	-3.02	892	0.64	2.90
893	0.59	2.58	894	0.54	2.08	895	0.53	1.76	896	0.58	1.20
897	0.68	0.75	898	0.69	0.59	899	0.71	0.50	900	0.82	0.21
901	0.82	0.21	902	0.88	-0.01	903	0.85	0.05	904	0.82	0.12
905	0.78	0.17	906	0.72	0.08	907	0.63	0.15	908	0.45	0.32
909	0.24	0.84	910	0.26	2.23	911	0.56	2.73	912	0.83	-3.00
913	1.23	-2.97	914	1.61	-2.95	915	1.97	-2.79	916	1.90	-2.78
917	1.28	-3.10	918	0.49	2.76	919	0.40	0.61	920	0.94	0.19
921	1.25	0.07	922	1.35	0.00	923	1.24	-0.06	924	0.94	-0.09
925	0.53	-0.12	926	0.14	-0.05	927	0.23	2.94	928	0.52	2.98
929	0.64	2.96	930	0.62	3.03	931	0.48	-3.11	932	0.29	-2.72
933	0.21	-1.53	934	0.38	-0.79	935	0.52	-0.53	936	0.58	-0.33
937	0.56	-0.14	938	0.50	0.15	939	0.56	0.38	940	0.75	0.69
941	0.66	0.89	942	0.43	1.16	943	0.17	2.19	944	0.29	-2.77
945	0.49	-2.45	946	0.65	-2.31	947	0.73	-2.21	948	0.76	-2.27
949	0.74	-2.34	950	0.80	1.47	951	0.71	1.34	952	0.59	1.11
953	0.47	0.55	954	0.49	0.00	955	0.60	-0.39	956	0.68	-0.77
957	0.75	-0.90	958	0.75	-1.02	959	0.67	-1.15	960	0.54	-1.33
961	0.39	-1.67	962	0.31	-2.31	963	0.35	-2.84	964	0.44	-3.14
965	0.53	2.99	966	0.58	2.91	967	0.61	2.89	968	0.61	2.87
969	0.63	2.89	970	0.58	2.77	971	0.53	2.53	972	0.54	2.33
973	0.61	1.81	974	0.69	1.56	975	0.55	1.87	976	0.56	1.50
977	0.67	0.97	978	0.83	0.52	979	1.02	0.13	980	0.83	0.35
981	0.83	0.24	982	0.94	-0.03	983	0.91	-0.03	984	0.94	-0.18
985	0.89	-0.14	986	0.83	-0.08	987	0.77	-0.01	988	0.68	-0.01
989	0.59	0.11	990	0.47	0.33	991	0.33	0.95	992	0.40	1.89
993	0.68	2.35	994	0.96	2.80	995	1.35	2.91	996	1.75	3.01
997	2.12	-3.07	998	2.35	-2.85	999	1.72	-3.11	1000	0.87	2.92
1001	0.20	1.45	1002	0.57	0.22	1003	0.99	0.02	1004	1.34	-0.10
1005	1.44	-0.17	1006	1.31	-0.24	1007	0.98	-0.32	1008	0.57	-0.45
1009	0.18	-1.04	1010	0.33	-3.02	1011	0.62	3.07	1012	0.75	3.01
1013	0.72	3.06	1014	0.58	-3.08	1015	0.39	-2.68	1016	0.31	-1.88
1017	0.40	-1.21	1018	0.48	-0.96	1019	0.52	-0.75	1020	0.50	-0.54
1021	0.39	-0.31	1022	0.21	-0.01	1023	0.02	1.78	1024	0.44	-3.09
1025	0.59	-3.00	1026	0.60	-2.90	1027	0.51	-2.81	1028	0.37	-2.76
1029	0.19	-2.90	1030	0.11	2.23	1031	0.74	1.50	1032	0.82	1.51
1033	0.78	1.37	1034	0.68	1.23	1035	0.55	0.99	1036	0.37	0.43
1037	0.40	-0.25	1038	0.51	-0.67	1039	0.60	-1.01	1040	0.67	-1.14
1041	0.66	-1.24	1042	0.57	-1.36	1043	0.42	-1.57	1044	0.28	-2.02
1045	0.24	-2.88	1046	0.32	2.88	1047	0.41	2.71	1048	0.48	2.60
1049	0.50	2.59	1050	0.50	2.63	1051	0.48	2.66	1052	0.50	2.71
1053	0.47	2.61	1054	0.44	2.38	1055	0.50	2.10	1056	0.57	1.73
1057	0.71	1.45	1058	0.84	1.29	1059	0.62	1.29	1060	0.77	0.81
1061	0.97	0.37	1062	1.13	-0.02	1063	0.98	0.01	1064	1.05	-0.23
1065	1.01	-0.27	1066	0.99	-0.37	1067	0.92	-0.35	1068	0.83	-0.29
1069	0.74	-0.20	1070	0.63	-0.12	1071	0.54	0.06	1072	0.45	0.37
1073	0.40	0.94	1074	0.53	1.67	1075	0.78	2.03	1076	1.09	2.37
1077	1.44	2.57	1078	1.85	2.71	1079	2.11	2.93	1080	2.72	-2.95
1081	2.09	3.06	1082	1.30	2.85	1083	0.42	2.34	1084	0.52	0.20
1085	1.07	-0.13	1086	1.40	-0.27	1087	1.51	-0.37	1088	1.37	-0.49
1089	1.06	-0.62	1090	0.63	-0.88	1091	0.31	-1.81	1092	0.52	-2.93
1093	0.76	3.09	1094	0.89	3.02	1095	0.84	3.05	1096	0.68	-3.10
1097	0.48	-2.76	1098	0.39	-2.04	1099	0.46	-1.45	1100	0.54	-1.18
1101	0.53	-1.00	1102	0.42	-0.87	1103	0.23	-0.74	1104	0.03	-1.65
1105	0.28	3.07	1106	0.52	-3.14	1107	0.61	-3.11	1108	0.58	-3.01
1109	0.48	-2.91	1110	0.33	-2.85	1111	0.17	-2.94	1112	0.09	1.85
1113	0.31	1.49	1114	0.56	1.44	1115	0.75	1.40	1116	0.78	1.36
1117	0.72	1.28	1118	0.58	1.16	1119	0.40	0.89	1120	0.24	0.20
1121	0.28	-0.74	1122	0.42	-1.17	1123	0.53	-1.35	1124	0.58	-1.48
1125	0.55	-1.57	1126	0.44	-1.73	1127	0.30	-2.05	1128	0.20	-2.78
1129	0.26	2.62	1130	0.37	2.28	1131	0.45	2.15	1132	0.47	2.06
1133	0.44	2.11	1134	0.38	2.18	1135	0.32	2.32	1136	0.29	2.45
1137	0.28	2.43	1138	0.30	2.21	1139	0.39	1.83	1140	0.53	1.55
1141	0.70	1.32	1142	0.86	1.15	1143	0.98	1.00	1144	1.07	0.73
1145	1.14	0.40	1146	1.11	0.07	1147	1.26	-0.20	1148	1.31	-0.46
1149	1.18	-0.28	1150	1.16	-0.42	1151	1.11	-0.49	1152	1.03	-0.54
1153	0.93	-0.54	1154	0.81	-0.52	1155	0.68	-0.43	1156	0.56	-0.29
1157	0.46	-0.01	1158	0.41	0.36	1159	0.43	0.91	1160	0.61	1.46
1161	0.88	1.77	1162	1.16	1.97	1163	1.47	2.14	1164	1.85	2.33
1165	2.13	2.62	1166	2.83	3.12	1167	2.36	2.82	1168	1.44	2.60
1169	0.59	2.07	1170	0.55	0.25	1171	1.07	-0.22	1172	1.44	-0.41
1173	1.54	-0.56	1174	1.39	-0.72	1175	1.06	-0.93	1176	0.68	-1.39
1177	0.54	-2.34	1178	0.76	-2.99	1179	0.99	3.03	1180	1.04	2.94
1181	0.93	2.94	1182	0.68	3.09	1183	0.45	-2.73	1184	0.43	-1.88
1185	0.57	-1.48	1186	0.64	-1.32	1187	0.58	-1.28	1188	0.41	-1.36
1189	0.20	-1.93	1190	0.24	-3.10	1191	0.44	2.91	1192	0.59	2.91
1193	0.62	2.98	1194	0.55	3.09	1195	0.42	-3.02	1196	0.25	-2.78
1197	0.10	-2.51	1198	0.07	0.79	1199	0.27	1.14	1200	0.47	1.20
1201	0.63	1.23	1202	0.67	1.23	1203	0.61	1.21	1204	0.46	1.17
1205	0.24	1.02	1206	0.06	-0.56	1207	0.25	-1.69	1208	0.42	-1.81
1209	0.52	-1.87	1210	0.54	-1.96	1211	0.48	-2.09	1212	0.37	-2.33

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1213	0.27	-2.87	1214	0.28	2.57	1215	0.42	2.05	1216	0.53	1.82
1217	0.59	1.65	1218	0.58	1.52	1219	0.48	1.37	1220	0.34	1.20
1221	0.21	0.98	1222	0.09	0.51	1223	0.04	-0.03	1224	0.05	1.11
1225	0.19	1.28	1226	0.39	1.19	1227	0.62	1.05	1228	0.84	0.91
1229	1.01	0.72	1230	1.09	0.46	1231	1.17	0.10	1232	1.27	-0.14
1233	1.37	-0.40	1234	1.42	-0.62	1235	1.33	-0.67	1236	1.23	-0.74
1237	1.11	-0.81	1238	0.96	-0.85	1239	0.79	-0.85	1240	0.61	-0.79
1241	0.44	-0.60	1242	0.33	-0.19	1243	0.32	0.42	1244	0.42	0.92
1245	0.64	1.23	1246	0.92	1.41	1247	1.17	1.51	1248	1.39	1.61
1249	1.64	1.77	1250	1.81	2.07	1251	2.89	2.79	1252	2.25	2.47
1253	1.56	2.27	1254	0.79	1.77	1255	0.63	0.35	1256	1.07	-0.25
1257	1.43	-0.52	1258	1.52	-0.72	1259	1.37	-0.93	1260	1.05	-1.26
1261	0.78	-1.84	1262	0.77	-2.60	1263	0.99	-3.13	1264	1.16	2.91
1265	1.14	2.78	1266	0.94	2.73	1267	0.58	2.84	1268	0.27	-2.72
1269	0.42	-1.53	1270	0.64	-1.33	1271	0.73	-1.32	1272	0.64	-1.40
1273	0.42	-1.65	1274	0.26	-2.56	1275	0.40	2.88	1276	0.58	2.68
1277	0.66	2.67	1278	0.60	2.74	1279	0.46	2.90	1280	0.29	-3.06
1281	0.17	-2.37	1282	0.14	-1.40	1283	0.15	-0.41	1284	0.23	0.38
1285	0.37	0.82	1286	0.50	1.01	1287	0.52	1.09	1288	0.44	1.13
1289	0.28	1.20	1290	0.07	1.78	1291	0.18	-2.38	1292	0.39	-2.28
1293	0.52	-2.28	1294	0.58	-2.30	1295	0.57	-2.40	1296	0.50	-2.55
1297	0.40	-2.90	1298	0.35	2.83	1299	0.42	2.23	1300	0.57	1.83
1301	0.70	1.58	1302	0.76	1.37	1303	0.73	1.17	1304	0.65	0.88
1305	0.53	0.51	1306	0.47	0.02	1307	0.41	-0.47	1308	0.39	-0.86
1309	0.31	-1.05	1310	0.16	-0.85	1311	0.17	0.56	1312	0.43	0.84
1313	0.70	0.74	1314	0.91	0.53	1315	1.06	0.28	1316	1.20	-0.10
1317	1.40	-0.51	1318	1.49	-0.75	1319	1.43	-0.88	1320	1.34	-0.98
1321	1.19	-1.08	1322	1.01	-1.19	1323	0.81	-1.26	1324	0.57	-1.28
1325	0.35	-1.23	1326	0.17	-0.66	1327	0.20	0.60	1328	0.36	0.96
1329	0.59	1.05	1330	0.88	1.07	1331	1.13	1.03	1332	1.30	0.97
1333	1.45	0.90	1334	1.43	1.03	0	0.00	0.00	0	0.00	0.00

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FOR THE BASIN =  1
                           THE TOTAL AREA =  0.2121E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.6996

FOR THE BASIN =  2
                           THE TOTAL AREA =  0.4759E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.6299

FOR THE BASIN =  3
                           THE TOTAL AREA =  0.4349E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.6532

FOR THE BASIN =  4
                           THE TOTAL AREA =  0.4497E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.5648

FOR THE BASIN =  5
                           THE TOTAL AREA =  0.2069E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3943

FOR THE BASIN =  6
                           THE TOTAL AREA =  0.2091E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.4343

FOR THE BASIN =  7
                           THE TOTAL AREA =  0.1908E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3956

FOR THE BASIN =  8
                           THE TOTAL AREA =  0.1987E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1952

FOR THE BASIN =  9
                           THE TOTAL AREA =  0.2057E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3397

FOR THE BASIN = 10
                           THE TOTAL AREA =  0.2317E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3951

FOR THE BASIN = 11
                           THE TOTAL AREA =  0.4823E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2287

FOR THE BASIN = 12
                           THE TOTAL AREA =  0.4129E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2123

FOR THE BASIN = 13
                           THE TOTAL AREA =  0.4010E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2766

FOR THE BASIN = 14
                           THE TOTAL AREA =  0.4440E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2359

FOR THE BASIN = 15
                           THE TOTAL AREA =  0.4463E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3523

FOR THE BASIN = 16
                           THE TOTAL AREA =  0.4409E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1761

FOR THE BASIN = 17
                           THE TOTAL AREA =  0.4175E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1832

FOR THE BASIN = 18
                           THE TOTAL AREA =  0.4083E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2160

FOR THE BASIN = 19
                           THE TOTAL AREA =  0.4142E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1782

FOR THE BASIN = 20
                           THE TOTAL AREA =  0.5045E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1615

FOR THE BASIN = 21
                           THE TOTAL AREA =  0.4521E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3575

FOR THE BASIN = 22
                           THE TOTAL AREA =  0.4066E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2096
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FOR THE BASIN = 23
THE TOTAL AREA = 0.4150E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.2104

FOR THE BASIN = 24
THE TOTAL AREA = 0.4190E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.2451

FOR THE BASIN = 25
THE TOTAL AREA = 0.2066E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.1804

FOR THE BASIN = 26
THE TOTAL AREA = 0.1975E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.3167

FOR THE BASIN = 27
THE TOTAL AREA = 0.2033E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.2616

FOR THE BASIN = 28
THE TOTAL AREA = 0.1576E+03
THE MEAN SORT VALUE OVER THE BASIN = 1.0545

FOR THE BASIN = 29
THE TOTAL AREA = 0.4784E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.8160

FOR THE BASIN = 30
THE TOTAL AREA = 0.1817E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.8430

FOR THE BASIN = 31
THE TOTAL AREA = 0.1828E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.7439

FOR THE BASIN = 32
THE TOTAL AREA = 0.2450E+03
THE MEAN SORT VALUE OVER THE BASIN = 0.5979

NODAL POINTS SELECTED

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1	0.26	1.67	100	0.19	0.31	200	0.26	-2.07	300	0.33	-1.86
400	0.57	1.86	500	0.26	2.73	600	0.66	1.00	700	0.75	0.09
800	0.63	-1.02	900	0.82	0.21	0	0.00	0.00	0	0.00	0.00

COEFFICIENTS

NO.	ABSOL	PHASE	NO.	ABSOL	PHASE	NO.	ABSOL	PHASE	NO.	ABSOL	PHASE
1	0.14	3.14	2	0.43	-2.91	3	0.08	-2.84	4	0.05	-0.25
5	0.28	1.26	6	0.27	0.87	7	0.43	1.45	8	0.27	2.14

WAVE CONDITION 2

THE DEEP WATER WAVE PARAMETERS FOR CASE 2 ARE: HEIGHT= 0.000 PERIOD- 11.000 ANGLE= 329.700

SOLUTION OF THE SYSTEM

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1	0.29	1.62	2	0.31	1.62	3	0.32	1.62	4	0.15	1.62
5	0.20	1.62	6	0.25	1.62	7	0.27	1.53	8	0.30	1.53
9	0.32	1.54	10	0.32	1.54	11	0.32	1.63	12	0.08	1.64
13	0.12	1.54	14	0.18	1.53	15	0.23	1.53	16	0.25	1.46
17	0.28	1.45	18	0.30	1.46	19	0.31	1.46	20	0.31	1.46
21	0.32	1.55	22	0.32	1.64	23	0.30	1.65	24	0.28	1.66
25	0.01	2.86	26	0.05	1.60	27	0.09	1.48	28	0.15	1.46
29	0.21	1.46	30	0.23	1.38	31	0.27	1.38	32	0.29	1.38
33	0.29	1.29	34	0.30	1.38	35	0.30	1.38	36	0.29	1.39
37	0.30	1.47	38	0.30	1.55	39	0.29	1.57	40	0.26	1.59
41	0.26	1.68	42	0.23	1.65	43	0.07	-1.64	44	0.03	-1.80
45	0.02	1.63	46	0.06	1.42	47	0.13	1.39	48	0.18	1.39
49	0.21	1.31	50	0.25	1.30	51	0.28	1.30	52	0.28	1.21
53	0.28	1.20	54	0.29	1.29	55	0.28	1.29	56	0.27	1.28
57	0.28	1.40	58	0.28	1.48	59	0.26	1.50	60	0.23	1.52
61	0.23	1.56	62	0.19	1.51	63	0.18	1.60	64	0.15	-1.61
65	0.11	-1.70	66	0.06	-1.78	67	0.01	-2.13	68	0.04	1.37
69	0.11	1.33	70	0.17	1.32	71	0.20	1.24	72	0.24	1.23
73	0.26	1.22	74	0.27	1.13	75	0.27	1.11	76	0.26	1.09
77	0.27	1.19	78	0.25	1.17	79	0.23	1.17	80	0.24	1.30
81	0.25	1.40	82	0.22	1.42	83	0.19	1.43	84	0.17	1.44
85	0.14	1.45	86	0.14	1.55	87	0.23	-1.62	88	0.19	-1.69
89	0.13	-1.75	90	0.09	-1.82	91	0.03	-1.96	92	0.02	1.42
93	0.09	1.28	94	0.15	1.26	95	0.18	1.19	96	0.22	1.17
97	0.25	1.15	98	0.26	1.06	99	0.27	1.03	100	0.26	0.99
101	0.24	0.96	102	0.25	1.07	103	0.22	1.04	104	0.18	1.01
105	0.19	1.17	106	0.21	1.30	107	0.17	1.31	108	0.14	1.33
109	0.11	1.36	110	0.09	1.36	111	0.09	1.45	112	0.30	-1.63
113	0.26	-1.69	114	0.21	-1.75	115	0.16	-1.81	116	0.10	-1.87
117	0.05	-1.99	118	0.01	2.07	119	0.07	1.27	120	0.13	1.21
121	0.17	1.15	122	0.21	1.12	123	0.24	1.09	124	0.25	1.01
125	0.26	0.97	126	0.26	0.91	127	0.24	0.86	128	0.21	0.79
129	0.21	0.91	130	0.18	0.84	131	0.14	0.72	132	0.14	0.97
133	0.16	1.17	134	0.12	1.16	135	0.09	1.14	136	0.09	1.23
137	0.05	1.06	138	0.06	1.25	139	0.04	1.11	140	0.05	1.27
141	0.37	-1.64	142	0.33	-1.71	143	0.28	-1.76	144	0.23	-1.81
145	0.18	-1.87	146	0.12	-1.94	147	0.06	-2.09	148	0.01	2.74
149	0.06	1.32	150	0.12	1.20	151	0.16	1.14	152	0.20	1.09
153	0.24	1.05	154	0.25	0.97	155	0.26	0.91	156	0.26	0.85
157	0.25	0.71	158	0.24	0.78	159	0.22	0.67	160	0.18	0.52
161	0.17	0.68	162	0.13	0.51	163	0.10	0.16	164	0.09	0.54
165	0.10	0.90	166	0.06	0.78	167	0.04	0.50	168	0.03	-0.75
169	0.03	0.59	170	0.03	0.69	171	0.02	0.73	172	0.03	0.97
173	0.42	-1.66	174	0.39	-1.73	175	0.35	-1.78	176	0.30	-1.82
177	0.25	-1.87	178	0.19	-1.93	179	0.13	-2.01	180	0.07	-2.20
181	0.02	3.14	182	0.05	1.46	183	0.11	1.23	184	0.15	1.17
185	0.20	1.08	186	0.23	1.02	187	0.25	0.95	188	0.26	0.88
189	0.26	0.80	190	0.25	0.67	191	0.23	0.53	192	0.22	0.58
193	0.19	0.41	194	0.16	0.14	195	0.14	0.27	196	0.11	-0.13
197	0.10	-0.68	198	0.07	-0.41	199	0.06	0.13	200	0.04	-0.61
201	0.06	-1.21	202	0.05	-1.18	203	0.02	-0.28	204	0.02	-0.44
205	0.02	0.53	206	0.02	0.84	207	0.46	-1.70	208	0.44	-1.76
209	0.40	-1.80	210	0.36	-1.84	211	0.31	-1.88	212	0.25	-1.93
213	0.19	-2.00	214	0.13	-2.10	215	0.08	-2.33	216	0.04	3.07
217	0.05	1.68	218	0.10	1.31	219	0.15	1.22	220	0.19	1.11
221	0.23	1.02	222	0.25	0.96	223	0.26	0.87	224	0.26	0.78
225	0.26	0.66	226	0.25	0.51	227	0.22	0.31	228	0.21	0.33
229	0.18	0.05	230	0.16	-0.35	231	0.14	-0.31	232	0.14	-0.79
233	0.17	-1.24	234	0.13	-1.22	235	0.08	-1.08	236	0.10	-1.43
237	0.11	-1.52	238	0.05	-1.19	239	0.32	-2.56	240	0.27	-3.09
241	0.27	2.60	242	0.30	2.50	243	0.42	2.09	244	0.57	1.87
245	0.74	1.75	246	0.89	1.72	247	0.96	1.76	248	1.03	1.99
249	1.00	1.81	250	0.49	-1.79	251	0.48	-1.83	252	0.46	-1.84
253	0.42	-1.87	254	0.37	-1.90	255	0.31	-1.94	256	0.26	-1.99
257	0.20	-2.07	258	0.14	-2.21	259	0.09	-2.50	260	0.05	3.07
261	0.06	1.94	262	0.10	1.41	263	0.14	1.31	264	0.19	1.16
265	0.22	1.05	266	0.24	0.99	267	0.26	0.89	268	0.27	0.79
269	0.27	0.68	270	0.26	0.51	271	0.24	0.31	272	0.22	0.05
273	0.20	0.02	274	0.18	-0.35	275	0.19	-0.75	276	0.17	-0.79
277	0.19	-1.18	278	0.24	-1.48	279	0.21	-1.52	280	0.16	-1.52
281	0.19	-1.70	282	0.25	-1.80	283	0.11	-1.53	284	0.41	-2.12
285	0.39	-2.29	286	0.34	-2.57	287	0.27	-3.01	288	0.25	2.80
289	0.31	2.13	290	0.37	2.10	291	0.52	1.80	292	0.68	1.66
293	0.83	1.58	294	0.92	1.56	295	0.98	1.58	296	1.01	1.61
297	0.52	-1.90	298	0.50	-1.90	299	0.48	-1.90	300	0.45	-1.91
301	0.41	-1.92	302	0.36	-1.95	303	0.30	-2.00	304	0.25	-2.06
305	0.19	-2.16	306	0.14	-2.33	307	0.10	-2.66	308	0.07	3.01
309	0.07	2.14	310	0.10	1.55	311	0.14	1.43	312	0.18	1.23
313	0.22	1.09	314	0.24	1.04	315	0.26	0.93	316	0.27	0.81
317	0.28	0.73	318	0.27	0.56	319	0.26	0.37	320	0.24	0.10
321	0.23	-0.22	322	0.21	-0.29	323	0.21	-0.68	324	0.24	-1.02
325	0.22	-1.10	326	0.26	-1.39	327	0.32	-1.62	328	0.29	-1.69
329	0.26	-1.73	330	0.28	-1.84	331	0.36	-1.95	332	0.37	-1.99
333	0.41	-2.09	334	0.42	-2.18	335	0.40	-2.31	336	0.36	-2.54
337	0.29	-2.89	338	0.24	3.05	339	0.24	2.29	340	0.34	1.74
341	0.44	1.77	342	0.60	1.56	343	0.75	1.44	344	0.86	1.38
345	0.96	1.37	346	1.02	1.43	347	0.48	-1.10	348	0.45	-1.35
349	0.43	-1.56	350	0.43	-1.73	351	0.45	-1.87	352	0.46	-1.98
353	0.48	-2.03	354	0.50	-2.07	355	0.51	-2.08	356	0.52	-2.01
357	0.51	-2.11	358	0.51	-2.05	359	0.49	-2.01	360	0.47	-1.98
361	0.43	-1.97	362	0.39	-1.97	363	0.34	-1.99	364	0.29	-2.05
365	0.24	-2.12	366	0.19	-2.25	367	0.14	-2.46	368	0.11	-2.80
369	0.09	2.98	370	0.08	2.33	371	0.10	1.77	372	0.14	1.58
373	0.18	1.33	374	0.22	1.17	375	0.24	1.12	376	0.26	0.99
377	0.28	0.86	378	0.28	0.79	379	0.28	0.63	380	0.27	0.43

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
381	0.25	0.18	382	0.24	-0.13	383	0.25	-0.48	384	0.23	-0.60
385	0.26	-0.93	386	0.30	-1.21	387	0.28	-1.30	388	0.33	-1.54
389	0.39	-1.72	390	0.37	-1.80	391	0.35	-1.87	392	0.41	-2.02
393	0.45	-2.16	394	0.44	-2.24	395	0.42	-2.34	396	0.39	-2.51
397	0.32	-2.76	398	0.25	-3.02	399	0.19	2.57	400	0.26	1.72
401	0.40	1.31	402	0.50	1.44	403	0.67	1.27	404	0.79	1.19
405	0.91	1.16	406	1.00	1.14	407	1.07	1.19	408	0.42	-1.22
409	0.41	-1.47	410	0.40	-1.67	411	0.40	-1.86	412	0.42	-2.00
413	0.43	-2.12	414	0.46	-2.18	415	0.47	-2.23	416	0.49	-2.24
417	0.49	-2.20	418	0.48	-2.21	419	0.47	-2.22	420	0.46	-2.14
421	0.44	-2.07	422	0.41	-2.03	423	0.39	-2.00	424	0.35	-2.00
425	0.31	-2.03	426	0.26	-2.10	427	0.22	-2.20	428	0.18	-2.36
429	0.14	-2.59	430	0.12	-2.91	431	0.11	2.96	432	0.10	2.47
433	0.11	1.97	434	0.14	1.75	435	0.18	1.47	436	0.21	1.27
437	0.24	1.22	438	0.26	1.07	439	0.28	0.94	440	0.29	0.88
441	0.29	0.71	442	0.28	0.52	443	0.27	0.28	444	0.26	0.00
445	0.26	-0.34	446	0.28	-0.67	447	0.27	-0.82	448	0.31	-1.09
449	0.36	-1.33	450	0.35	-1.43	451	0.40	-1.62	452	0.45	-1.79
453	0.44	-1.88	454	0.42	-1.95	455	0.46	-2.09	456	0.49	-2.20
457	0.46	-2.28	458	0.44	-2.37	459	0.42	-2.50	460	0.35	-2.66
461	0.29	-2.83	462	0.19	2.99	463	0.16	1.95	464	0.28	1.21
465	0.35	0.69	466	0.47	0.91	467	0.57	1.10	468	0.71	0.99
469	0.86	0.94	470	0.97	0.90	471	1.06	0.90	472	1.14	0.96
473	0.30	-1.27	474	0.29	-1.57	475	0.30	-1.81	476	0.31	-2.02
477	0.34	-2.20	478	0.37	-2.32	479	0.40	-2.40	480	0.42	-2.45
481	0.43	-2.46	482	0.44	-2.41	483	0.43	-2.43	484	0.40	-2.43
485	0.39	-2.31	486	0.38	-2.20	487	0.35	-2.10	488	0.32	-2.04
489	0.31	-2.00	490	0.29	-2.00	491	0.26	-2.04	492	0.22	-2.15
493	0.19	-2.30	494	0.16	-2.48	495	0.14	-2.72	496	0.13	-3.01
497	0.13	2.97	498	0.12	2.57	499	0.12	2.13	500	0.15	1.92
501	0.18	1.61	502	0.21	1.39	503	0.24	1.33	504	0.26	1.17
505	0.28	1.02	506	0.30	0.97	507	0.30	0.81	508	0.30	0.62
509	0.29	0.39	510	0.28	0.14	511	0.28	-0.21	512	0.29	-0.53
513	0.32	-0.84	514	0.32	-0.98	515	0.37	-1.22	516	0.42	-1.41
517	0.41	-1.52	518	0.47	-1.69	519	0.51	-1.84	520	0.50	-1.93
521	0.48	-2.01	522	0.51	-2.13	523	0.52	-2.24	524	0.49	-2.32
525	0.46	-2.40	526	0.44	-2.52	527	0.38	-2.61	528	0.33	-2.73
529	0.23	-2.95	530	0.11	2.58	531	0.17	1.12	532	0.29	0.55
533	0.48	0.42	534	0.53	0.54	535	0.62	0.77	536	0.80	0.71
537	0.95	0.66	538	1.09	0.64	539	1.17	0.65	540	1.27	0.70
541	0.08	-0.83	542	0.13	-1.59	543	0.16	-1.99	544	0.19	-2.30
545	0.24	-2.52	546	0.29	-2.66	547	0.33	-2.73	548	0.36	-2.78
549	0.37	-2.78	550	0.37	-2.74	551	0.36	-2.75	552	0.33	-2.76
553	0.31	-2.58	554	0.30	-2.39	555	0.27	-2.23	556	0.25	-2.08
557	0.22	-1.96	558	0.21	-1.91	559	0.20	-1.93	560	0.19	-2.02
561	0.18	-2.21	562	0.16	-2.41	563	0.15	-2.61	564	0.15	-2.83
565	0.14	-3.05	566	0.14	3.01	567	0.13	2.71	568	0.13	2.31
569	0.15	2.10	570	0.18	1.78	571	0.21	1.52	572	0.24	1.45
573	0.26	1.28	574	0.28	1.13	575	0.30	1.10	576	0.31	0.93
577	0.31	0.76	578	0.30	0.54	579	0.29	0.28	580	0.29	-0.02
581	0.30	-0.35	582	0.33	-0.66	583	0.37	-0.93	584	0.37	-1.09
585	0.42	-1.30	586	0.48	-1.48	587	0.48	-1.59	588	0.52	-1.75
589	0.56	-1.88	590	0.54	-1.97	591	0.52	-2.05	592	0.54	-2.17
593	0.54	-2.29	594	0.51	-2.37	595	0.48	-2.44	596	0.45	-2.55
597	0.40	-2.62	598	0.36	-2.72	599	0.27	-2.82	600	0.13	-3.12
601	0.09	1.10	602	0.21	0.31	603	0.42	0.26	604	0.64	0.22
605	0.73	0.46	606	0.91	0.42	607	1.09	0.40	608	1.24	0.39
609	1.45	0.45	610	0.12	0.85	611	0.05	0.61	612	0.02	2.96
613	0.08	-3.14	614	0.18	3.04	615	0.24	3.03	616	0.29	3.02
617	0.32	3.02	618	0.34	3.04	619	0.33	3.09	620	0.32	3.08
621	0.28	3.05	622	0.25	-3.00	623	0.21	-2.75	624	0.18	-2.49
625	0.15	-2.18	626	0.12	-1.85	627	0.10	-1.51	628	0.11	-1.51
629	0.11	-1.66	630	0.11	-1.93	631	0.13	-2.28	632	0.14	-2.54
633	0.15	-2.73	634	0.15	-2.89	635	0.15	-3.05	636	0.16	3.08
637	0.15	2.81	638	0.14	2.48	639	0.16	2.30	640	0.18	1.96
641	0.20	1.67	642	0.23	1.62	643	0.26	1.42	644	0.29	1.26
645	0.31	1.26	646	0.32	1.10	647	0.32	0.92	648	0.32	0.71
649	0.31	0.48	650	0.30	0.19	651	0.31	-0.14	652	0.34	-0.45
653	0.38	-0.74	654	0.43	-0.98	655	0.43	-1.16	656	0.49	-1.35
657	0.54	-1.51	658	0.54	-1.64	659	0.57	-1.78	660	0.60	-1.91
661	0.58	-2.00	662	0.56	-2.09	663	0.57	-2.22	664	0.56	-2.35
665	0.53	-2.43	666	0.49	-2.49	667	0.47	-2.62	668	0.42	-2.67
669	0.38	-2.77	670	0.31	-2.79	671	0.21	-2.83	672	0.03	-3.07
673	0.10	-0.32	674	0.32	-0.06	675	0.56	-0.04	676	0.79	-0.05
677	0.86	0.19	678	1.06	0.16	679	1.26	0.16	680	1.43	0.16
681	1.63	0.26	682	0.26	0.93	683	0.20	0.87	684	0.14	1.11
685	0.13	1.69	686	0.17	2.09	687	0.22	2.30	688	0.28	2.42
689	0.33	2.47	690	0.35	2.51	691	0.36	2.54	692	0.35	2.58
693	0.33	2.58	694	0.30	2.54	695	0.23	2.71	696	0.17	2.88
697	0.11	3.13	698	0.05	-2.69	699	0.03	-0.81	700	0.08	-0.16
701	0.11	0.02	702	0.10	-0.10	703	0.06	-0.48	704	0.05	-1.42
705	0.08	-2.37	706	0.12	-2.65	707	0.15	-2.80	708	0.16	-2.91
709	0.17	-3.01	710	0.17	-3.12	711	0.16	2.93	712	0.16	2.64
713	0.17	2.50	714	0.18	2.17	715	0.21	1.87	716	0.23	1.83
717	0.26	1.61	718	0.29	1.43	719	0.31	1.43	720	0.32	1.26
721	0.33	1.09	722	0.33	0.89	723	0.32	0.68	724	0.31	0.41
725	0.31	0.09	726	0.33	-0.22	727	0.37	-0.53	728	0.42	-0.78
729	0.48	-1.00	730	0.49	-1.17	731	0.56	-1.35	732	0.61	-1.50
733	0.59	-1.65	734	0.63	-1.80	735	0.64	-1.93	736	0.61	-2.04
737	0.59	-2.13	738	0.59	-2.27	739	0.57	-2.42	740	0.54	-2.50
741	0.51	-2.57	742	0.47	-2.71	743	0.43	-2.75	744	0.39	-2.86
745	0.33	-2.85	746	0.26	-2.82	747	0.13	-2.67	748	0.10	-1.91
749	0.22	-0.52	750	0.46	-0.33	751	0.70	-0.30	752	0.94	-0.28
753	1.02	-0.05	754	1.24	-0.06	755	1.46	-0.06	756	1.64	-0.03
757	1.79	0.05	758	0.38	0.73	759	0.32	0.68	760	0.25	0.88
761	0.22	1.26	762	0.25	1.65	763	0.29	1.89	764	0.35	2.02
765	0.40	2.11	766	0.43	2.15	767	0.44	2.19	768	0.42	2.21
769	0.40	2.19	770	0.35	2.17	771	0.28	2.25	772	0.19	2.29
773	0.12	2.20	774	0.07	1.60	775	0.09	0.74	776	0.15	0.46
777	0.21	0.42	778	0.25	0.44	779	0.21	0.41	780	0.13	0.36
781	0.04	0.16	782	0.05	-2.56	783	0.11	-2.73	784	0.15	-2.81
785	0.17	-2.89	786	0.18	-2.95	787	0.19	-3.01	788	0.18	3.07
789	0.17	2.82	790	0.18	2.75	791	0.19	2.40	792	0.21	2.10
793	0.22	2.04	794	0.25	1.81	795	0.28	1.60	796	0.97	2.08

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
797	1.03	1.89	798	1.07	1.73	799	1.08	1.57	800	1.07	1.41
801	1.02	1.21	802	0.97	0.98	803	0.94	0.69	804	0.95	0.39
805	1.01	0.07	806	1.11	-0.21	807	1.22	-0.46	808	0.54	-1.19
809	0.60	-1.34	810	0.65	-1.48	811	0.65	-1.64	812	0.67	-1.78
813	0.68	-1.92	814	0.65	-2.07	815	0.61	-2.18	816	0.60	-2.33
817	0.58	-2.51	818	0.55	-2.59	819	0.51	-2.66	820	0.48	-2.85
821	0.44	-2.86	822	0.40	-3.00	823	0.35	-2.96	824	0.28	-2.88
825	0.20	-2.73	826	0.17	-2.47	827	0.15	-1.30	828	0.36	-0.69
829	0.60	-0.54	830	0.85	-0.50	831	1.10	-0.49	832	1.18	-0.28
833	1.43	-0.26	834	1.67	-0.26	835	1.93	-0.14	836	0.48	0.38
837	0.40	0.35	838	0.31	0.55	839	0.26	0.97	840	0.29	1.39
841	0.35	1.64	842	0.42	1.80	843	0.48	1.88	844	0.52	1.92
845	0.53	1.95	846	0.51	1.97	847	0.47	1.95	848	0.41	1.93
849	0.33	1.97	850	0.24	1.94	851	0.17	1.78	852	0.14	1.36
853	0.16	0.86	854	0.22	0.62	855	0.29	0.54	856	0.36	0.52
857	0.40	0.54	858	0.35	0.55	859	0.20	0.57	860	0.08	0.60
861	0.04	-2.79	862	0.10	-2.73	863	0.15	-2.76	864	0.18	-2.80
865	0.19	-2.84	866	0.20	-2.87	867	0.19	-3.04	868	0.19	3.02
869	0.19	2.95	870	0.19	2.65	871	0.20	2.34	872	0.87	2.84
873	0.87	2.56	874	0.90	2.30	875	0.95	1.98	876	1.01	1.79
877	1.05	1.63	878	1.06	1.47	879	1.05	1.30	880	1.01	1.11
881	0.96	0.88	882	0.93	0.65	883	0.92	0.41	884	0.96	0.14
885	1.01	-0.10	886	1.12	-0.36	887	1.23	-0.59	888	1.33	-0.68
889	1.40	-0.88	890	1.43	-1.07	891	0.68	-1.61	892	0.69	-1.75
893	0.70	-1.86	894	0.68	-2.06	895	0.64	-2.22	896	0.62	-2.40
897	0.59	-2.60	898	0.55	-2.72	899	0.52	-2.80	900	0.49	-3.01
901	0.45	-3.02	902	0.42	3.09	903	0.37	-3.13	904	0.31	-3.02
905	0.24	-2.84	906	0.19	-2.54	907	0.18	-1.86	908	0.33	-1.06
909	0.58	-0.82	910	0.85	-0.73	911	1.11	-0.70	912	1.34	-0.48
913	1.61	-0.47	914	1.83	-0.44	915	2.03	-0.32	916	0.58	-0.01
917	0.48	-0.08	918	0.35	0.13	919	0.26	0.59	920	0.29	1.18
921	0.37	1.49	922	0.47	1.65	923	0.55	1.73	924	0.59	1.77
925	0.60	1.79	926	0.58	1.80	927	0.52	1.79	928	0.45	1.77
929	0.36	1.78	930	0.27	1.74	931	0.20	1.60	932	0.17	1.31
933	0.19	0.90	934	0.26	0.66	935	0.34	0.58	936	0.42	0.55
937	0.50	0.55	938	0.55	0.57	939	0.49	0.62	940	0.24	0.68
941	0.09	0.76	942	0.03	-2.90	943	0.11	-2.65	944	0.16	-2.66
945	0.18	-2.69	946	0.20	-2.73	947	0.20	-2.74	948	0.20	-2.87
949	0.19	-3.07	950	1.13	-2.74	951	1.02	-2.94	952	0.93	3.12
953	0.85	2.74	954	0.84	2.44	955	0.87	2.18	956	0.89	1.85
957	0.95	1.68	958	0.99	1.52	959	1.00	1.37	960	0.99	1.21
961	0.95	1.03	962	0.90	0.80	963	0.87	0.56	964	0.87	0.30
965	0.90	0.02	966	0.97	-0.24	967	1.09	-0.50	968	1.22	-0.72
969	1.33	-0.84	970	1.40	-1.01	971	1.42	-1.20	972	1.42	-1.29
973	1.32	-1.61	974	1.26	-1.82	975	0.68	-2.06	976	0.66	-2.23
977	0.63	-2.45	978	0.60	-2.74	979	0.60	-3.12	980	0.56	-2.88
981	0.52	-2.97	982	0.51	3.06	983	0.47	3.06	984	0.43	2.92
985	0.37	2.99	986	0.31	3.13	987	0.25	-2.94	988	0.21	-2.61
989	0.21	-2.03	990	0.31	-1.43	991	0.55	-1.08	992	0.83	-0.95
993	1.11	-0.90	994	1.38	-0.72	995	1.64	-0.68	996	1.88	-0.63
997	2.08	-0.49	998	0.72	-0.34	999	0.59	-0.42	1000	0.43	-0.36
1001	0.27	-0.03	1002	0.22	0.51	1003	0.26	1.07	1004	0.37	1.44
1005	0.49	1.59	1006	0.58	1.66	1007	0.63	1.69	1008	0.64	1.70
1009	0.61	1.71	1010	0.54	1.70	1011	0.45	1.68	1012	0.35	1.69
1013	0.26	1.64	1014	0.19	1.47	1015	0.17	1.12	1016	0.19	0.79
1017	0.27	0.62	1018	0.33	0.58	1019	0.41	0.56	1020	0.51	0.55
1021	0.62	0.56	1022	0.72	0.56	1023	0.82	0.57	1024	0.99	0.49
1025	0.98	0.35	1026	0.86	0.08	1027	0.75	-0.30	1028	0.72	-0.81
1029	0.80	-1.33	1030	0.94	-1.70	1031	1.26	-2.45	1032	1.22	-2.58
1033	1.11	-2.82	1034	1.00	-3.03	1035	0.90	3.00	1036	0.78	2.62
1037	0.76	2.29	1038	0.79	2.01	1039	0.81	1.71	1040	0.86	1.53
1041	0.90	1.39	1042	0.91	1.26	1043	0.89	1.11	1044	0.84	0.94
1045	0.79	0.72	1046	0.76	0.47	1047	0.76	0.18	1048	0.81	-0.12
1049	0.90	-0.40	1050	1.03	-0.64	1051	1.16	-0.85	1052	1.29	-0.99
1053	1.37	-1.16	1054	1.39	-1.32	1055	1.39	-1.45	1056	1.33	-1.67
1057	1.26	-1.92	1058	1.20	-2.15	1059	0.65	-2.26	1060	0.62	-2.52
1061	0.60	-2.91	1062	0.63	2.96	1063	0.55	3.09	1064	0.53	2.84
1065	0.49	2.81	1066	0.45	2.73	1067	0.39	2.80	1068	0.32	2.94
1069	0.26	-3.11	1070	0.22	-2.72	1071	0.23	-2.19	1072	0.32	-1.69
1073	0.51	-1.37	1074	0.80	-1.18	1075	1.07	-1.11	1076	1.37	-0.98
1077	1.63	-0.90	1078	1.90	-0.83	1079	2.06	-0.68	1080	0.90	-0.60
1081	0.76	-0.74	1082	0.58	-0.79	1083	0.36	-0.65	1084	0.19	-0.09
1085	0.21	1.02	1086	0.35	1.42	1087	0.49	1.55	1088	0.60	1.59
1089	0.66	1.61	1090	0.66	1.62	1091	0.62	1.61	1092	0.53	1.60
1093	0.43	1.60	1094	0.32	1.57	1095	0.22	1.49	1096	0.14	1.27
1097	0.13	0.90	1098	0.16	0.58	1099	0.24	0.51	1100	0.34	0.52
1101	0.47	0.55	1102	0.60	0.56	1103	0.72	0.55	1104	0.82	0.54
1105	0.94	0.49	1106	1.00	0.38	1107	0.95	0.21	1108	0.85	-0.03
1109	0.74	-0.41	1110	0.71	-0.96	1111	0.81	-1.45	1112	0.97	-1.82
1113	1.13	-2.03	1114	1.25	-2.29	1115	1.26	-2.54	1116	1.20	-2.71
1117	1.07	-2.92	1118	0.92	3.12	1119	0.78	2.83	1120	0.68	2.45
1121	0.64	2.07	1122	0.66	1.74	1123	0.71	1.50	1124	0.75	1.32
1125	0.77	1.20	1126	0.76	1.09	1127	0.73	0.97	1128	0.69	0.84
1129	0.63	0.64	1130	0.60	0.38	1131	0.61	0.06	1132	0.66	-0.29
1133	0.79	-0.56	1134	0.94	-0.79	1135	1.09	-0.98	1136	1.22	-1.14
1137	1.31	-1.29	1138	1.34	-1.44	1139	1.34	-1.62	1140	1.30	-1.81
1141	1.24	-2.03	1142	1.19	-2.29	1143	1.17	-2.56	1144	1.21	-2.93
1145	1.27	2.99	1146	0.64	3.02	1147	0.76	2.68	1148	0.74	2.47
1149	0.63	2.71	1150	0.58	2.60	1151	0.53	2.56	1152	0.47	2.56
1153	0.40	2.62	1154	0.33	2.74	1155	0.26	3.00	1156	0.23	-2.87
1157	0.25	-2.34	1158	0.33	-1.97	1159	0.49	-1.68	1160	0.76	-1.45
1161	1.05	-1.34	1162	1.33	-1.27	1163	1.60	-1.20	1164	1.89	-1.10
1165	2.08	-0.91	1166	1.17	-0.93	1167	1.03	-1.11	1168	0.76	-1.15
1169	0.49	-1.16	1170	0.20	-0.96	1171	0.10	0.90	1172	0.30	1.49
1173	0.48	1.56	1174	0.60	1.57	1175	0.66	1.55	1176	0.66	1.53
1177	0.59	1.50	1178	0.49	1.47	1179	0.35	1.42	1180	0.22	1.33
1181	0.10	1.02	1182	0.06	0.15	1183	0.08	-0.41	1184	0.11	-0.24
1185	0.18	0.16	1186	0.29	0.42	1187	0.44	0.53	1188	0.61	0.57
1189	0.78	0.56	1190	0.90	0.52	1191	0.99	0.45	1192	1.02	0.33
1193	0.96	0.16	1194	0.84	-0.10	1195	0.73	-0.52	1196	0.71	-1.08
1197	0.82	-1.57	1198	1.01	-1.93	1199	1.15	-2.16	1200	1.26	-2.38
1201	1.26	-2.60	1202	1.17	-2.79	1203	1.02	-2.99	1204	0.82	3.04
1205	0.64	2.69	1206	0.52	2.21	1207	0.51	1.70	1208	0.55	1.33
1209	0.60	1.10	1210	0.41	0.95	1211	0.60	0.85	1212	0.56	0.79

NODAL POINTS

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1213	0.51	0.75	1214	0.46	0.67	1215	0.39	0.51	1216	0.36	0.23
1217	0.38	-0.18	1218	0.46	-0.55	1219	0.61	-0.82	1220	0.78	-1.02
1221	0.94	-1.17	1222	1.10	-1.32	1223	1.20	-1.47	1224	1.24	-1.64
1225	1.25	-1.84	1226	1.23	-2.05	1227	1.20	-2.32	1228	1.19	-2.59
1229	1.21	-2.90	1230	1.25	3.05	1231	1.30	2.73	1232	1.24	2.58
1233	0.99	2.42	1234	0.90	2.27	1235	0.73	2.29	1236	0.63	2.28
1237	0.54	2.30	1238	0.45	2.35	1239	0.36	2.47	1240	0.28	2.73
1241	0.23	-3.08	1242	0.26	-2.56	1243	0.36	-2.21	1244	0.50	-1.99
1245	0.71	-1.81	1246	1.01	-1.69	1247	1.28	-1.63	1248	1.55	-1.58
1249	1.82	-1.50	1250	2.00	-1.29	1251	1.56	-1.25	1252	1.29	-1.41
1253	0.99	-1.44	1254	0.65	-1.48	1255	0.29	-1.52	1256	0.01	-2.73
1257	0.26	1.67	1258	0.45	1.61	1259	0.59	1.56	1260	0.65	1.51
1261	0.63	1.45	1262	0.55	1.39	1263	0.42	1.29	1264	0.26	1.12
1265	0.11	0.55	1266	0.11	-0.90	1267	0.19	-1.35	1268	0.21	-1.44
1269	0.19	-1.37	1270	0.13	-0.90	1271	0.17	0.18	1272	0.34	0.56
1273	0.55	0.63	1274	0.74	0.62	1275	0.90	0.56	1276	1.00	0.47
1277	1.02	0.34	1278	0.95	0.15	1279	0.82	-0.15	1280	0.70	-0.60
1281	0.70	-1.18	1282	0.84	-1.67	1283	1.03	-2.02	1284	1.18	-2.27
1285	1.27	-2.48	1286	1.25	-2.69	1287	1.12	-2.89	1288	0.92	-3.13
1289	0.69	2.85	1290	0.50	2.35	1291	0.43	1.68	1292	0.49	1.08
1293	0.57	0.74	1294	0.60	0.54	1295	0.59	0.37	1296	0.52	0.29
1297	0.41	0.20	1298	0.30	0.21	1299	0.20	0.25	1300	0.12	0.20
1301	0.08	-0.32	1302	0.13	-0.99	1303	0.24	-1.13	1304	0.40	-1.23
1305	0.58	-1.29	1306	0.75	-1.40	1307	0.92	-1.49	1308	1.04	-1.65
1309	1.11	-1.82	1310	1.13	-2.03	1311	1.13	-2.28	1312	1.15	-2.58
1313	1.19	-2.90	1314	1.28	3.05	1315	1.38	2.80	1316	1.40	2.53
1317	1.23	2.28	1318	1.02	2.13	1319	0.86	2.08	1320	0.75	2.05
1321	0.63	2.05	1322	0.51	2.08	1323	0.39	2.19	1324	0.29	2.46
1325	0.23	2.94	1326	0.26	-2.75	1327	0.37	-2.40	1328	0.50	-2.25
1329	0.71	-2.15	1330	0.99	-2.05	1331	1.27	-2.01	1332	1.51	-2.01
1333	1.74	-2.01	1334	1.87	-1.87	0	0.00	0.00	0	0.00	0.00

```
FOR THE BASIN =  1
                      THE TOTAL AREA =  0.2121E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.5880

FOR THE BASIN =  2
                      THE TOTAL AREA =  0.4759E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.5080

FOR THE BASIN =  3
                      THE TOTAL AREA =  0.4349E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.4980

FOR THE BASIN =  4
                      THE TOTAL AREA =  0.4497E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3645

FOR THE BASIN =  5
                      THE TOTAL AREA =  0.2069E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2536

FOR THE BASIN =  6
                      THE TOTAL AREA =  0.2091E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2692

FOR THE BASIN =  7
                      THE TOTAL AREA =  0.1908E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2767

FOR THE BASIN =  8
                      THE TOTAL AREA =  0.1987E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2094

FOR THE BASIN =  9
                      THE TOTAL AREA =  0.2057E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1348

FOR THE BASIN = 10
                      THE TOTAL AREA =  0.2317E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1536

FOR THE BASIN = 11
                      THE TOTAL AREA =  0.4823E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1341

FOR THE BASIN = 12
                      THE TOTAL AREA =  0.4129E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1208

FOR THE BASIN = 13
                      THE TOTAL AREA =  0.4010E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2499

FOR THE BASIN = 14
                      THE TOTAL AREA =  0.4440E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2222

FOR THE BASIN = 15
                      THE TOTAL AREA =  0.4463E+03

  THE MEAN SORT VALUE OVER THE BASIN =  0.1760

FOR THE BASIN = 16
                      THE TOTAL AREA =  0.4409E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.1325

FOR THE BASIN = 17
                      THE TOTAL AREA =  0.4175E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2525

FOR THE BASIN = 18
                      THE TOTAL AREA =  0.4083E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2249

FOR THE BASIN = 19
                      THE TOTAL AREA =  0.4142E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.0578

FOR THE BASIN = 20
                      THE TOTAL AREA =  0.5045E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.2371

FOR THE BASIN = 21
                      THE TOTAL AREA =  0.4521E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.3407

FOR THE BASIN = 22
                      THE TOTAL AREA =  0.4066E+03
  THE MEAN SORT VALUE OVER THE BASIN =  0.0764
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FOR THE BASIN = 23
                              THE TOTAL AREA =  0.4150E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.2108

FOR THE BASIN = 24
                              THE TOTAL AREA =  0.4190E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.3033

FOR THE BASIN = 25
                              THE TOTAL AREA =  0.2066E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.2505

FOR THE BASIN = 26
                              THE TOTAL AREA =  0.1975E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.1153

FOR THE BASIN = 27
                              THE TOTAL AREA =  0.2033E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.0588

FOR THE BASIN = 28
                              THE TOTAL AREA =  0.1576E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.5461

FOR THE BASIN = 29
                              THE TOTAL AREA =  0.4784E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.3737

FOR THE BASIN = 30
                              THE TOTAL AREA =  0.1817E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.4378

FOR THE BASIN = 31
                              THE TOTAL AREA =  0.1828E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.3355

FOR THE BASIN = 32
                              THE TOTAL AREA =  0.2450E+03
   THE MEAN SORT VALUE OVER THE BASIN =  0.1441
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NODAL POINTS SELECTED

NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE	NOD	ABSOL	PHASE
1	0.29	1.62	100	0.26	0.99	200	0.04	-0.61	300	0.45	-1.91
400	0.26	1.72	500	0.15	1.92	600	0.13	-3.12	700	0.08	-0.16
800	1.07	1.41	900	0.49	-3.01	0	0.00	0.00	0	0.00	0.00

COEFFICIENTS

NO.	ABSOL	PHASE	NO.	ABSOL	PHASE	NO.	ABSOL	PHASE	NO.	ABSOL	PHASE
1	0.17	-0.83	2	0.37	-0.23	3	0.14	-0.36	4	0.05	2.51
5	0.33	-2.51	6	0.38	-2.38	7	0.58	-1.57	8	0.43	-0.37

APPENDIX 9-E: INPUT DATA SET FOR
MAALAEA HARBOR, MAUI, HAWAII EXAMPLE

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GENSPECS ENGLISH   HARBD MAALAEA HARBOR, MAUI, HI - EXISTING CONFIGURATION
GRIDSPEC  TRIANG ENGLISH    3752    7146     105     252     107    MAALAEA.INP
CONVERG      0.1
WAVCOND     0.00    20.0   265.0
PRWINDOW      NO    NONE      NO      16
PRBASIN        7
PRBNELEM    2978    2987    2976    3063    3018    3011    2969
PRBASIN        6
PRBNELEM    2250    2235    2230    2116    2097    2115
PRBASIN        6
PRBNELEM    1249    1277    1231    1142    1113    1167
PRBASIN        6
PRBNELEM    2653    2617    2533    2570    2584    2691
PRBASIN        6
PRBNELEM    1750    1817    1657    1661    1720    1818
PRBASIN        6
PRBNELEM      85      93     125     138     130     102
PRBASIN        7
PRBNELEM     154     169     159     216     235     210     163
PRBASIN        6
PRBNELEM     200     206     270     248     242     182
PRBASIN        6
PRBNELEM     359     337     355     387     428     402
PRBASIN        7
PRBNELEM     488     509     565     603     574     510     488
PRBASIN        7
PRBNELEM     911     939    1009    1045    1012     931     900
PRBASIN        7
PRBNELEM    1431    1304    1271    1302    1392    1440    1467
PRBASIN        6
PRBNELEM    2611    2627    2621    2484    2460    2476
PRBASIN        6
PRBNELEM    2733    2727    2622    2600    2618    2720
PRBASIN        6
PRBNELEM    2803    2793    2677    2654    2673    2790
PRBASIN        6
PRBNELEM    2765    2782    2766    2685    2656    2693
GRIDFORM  (3(I6,2F10.2))(2(4I6,F8.2,F8.4))   (5(2I5,F5.2))
     1   1082.90   -309.69     2   1070.74   -317.02     3   1082.32   -328.53
     4   1063.82   -306.45     5   1053.89   -315.08     6   1062.70   -327.94
     7   1046.16   -304.22     8   1034.33   -313.79     9   1044.01   -326.80
    10   1026.43   -301.99    11   1015.36   -310.66    12   1021.45   -325.43
    13   1004.71   -297.53    14   1002.43   -309.59    15   1002.98   -324.27
    16    997.76   -339.47    17    991.39   -357.09    18   1022.64   -113.44
    19   1019.04   -145.87    20   1016.84   -168.01    21   1014.43   -192.20
    22   1011.82   -218.45    23   1009.22   -244.60    24   1006.91   -267.83
    25   1004.87   -288.29    26    990.89   -294.67    27    988.89   -306.04
    28    986.79   -320.25    29    981.97   -335.10    30    974.62   -355.36
    31   1005.27   -112.07    32   1002.98   -142.54    33    999.89   -165.48
    34    996.79   -189.33    35    992.86   -213.77    36    989.20   -237.92
    37    985.54   -261.46    38    982.17   -281.39    39    974.29   -306.14
    40    967.13   -330.68    41    958.38   -353.44    42    991.48   -110.98
    43    987.51   -143.14    44    984.14   -166.69    45    980.20   -190.53
    46    975.14   -213.47    47    970.07   -237.32    48    965.29   -261.16
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49	960.23	-282.90	50	954.12	-307.49	51	946.47	-330.29
52	939.27	-352.84	53	974.30	-109.63	54	970.63	-142.84
55	966.70	-167.29	56	961.91	-191.14	57	957.13	-214.08
58	951.79	-237.32	59	946.44	-260.56	60	940.80	-284.20
61	933.57	-307.11	62	925.78	-329.84	63	920.74	-351.01
64	901.63	-349.19	65	955.85	-108.18	66	957.32	-125.15
67	952.37	-143.61	68	948.50	-167.24	69	944.04	-190.83
70	938.98	-214.31	71	933.35	-237.65	72	927.14	-260.85
73	920.34	-283.88	74	912.98	-306.74	75	905.05	-329.40
76	888.55	-350.90	77	937.17	-106.71	78	935.75	-124.22
79	932.51	-143.22	80	928.56	-167.12	81	924.00	-190.69
82	918.85	-214.13	83	913.11	-237.43	84	906.78	-260.58
85	899.86	-283.56	86	892.35	-306.35	87	884.27	-328.95
88	875.92	-353.93	89	916.37	-105.08	90	915.97	-123.35
91	912.64	-142.83	92	908.61	-166.96	93	903.97	-190.50
94	898.72	-213.90	95	892.86	-237.16	96	886.40	-260.26
97	879.35	-283.18	98	871.70	-305.92	99	863.46	-328.44
100	855.20	-345.34	101	856.34	-358.63	102	833.74	-364.06
103	898.73	-103.69	104	896.17	-122.49	105	892.76	-142.44
106	888.64	-166.84	107	883.90	-190.33	108	878.55	-213.70
109	872.57	-236.91	110	865.99	-259.96	111	858.79	-282.82
112	850.99	-305.49	113	842.60	-327.94	114	833.61	-350.16
115	817.70	-367.90	116	877.93	-102.06	117	876.36	-121.63
118	872.87	-142.05	119	868.66	-166.67	120	863.83	-190.13
121	858.37	-213.45	122	852.27	-236.62	123	845.55	-259.61
124	838.21	-282.41	125	830.26	-305.01	126	821.69	-327.38
127	812.53	-349.51	128	802.77	-371.49	129	861.09	-101.24
130	856.55	-120.77	131	852.97	-141.66	132	848.67	-166.51
133	843.74	-189.94	134	838.16	-213.21	135	831.94	-236.33
136	825.08	-259.26	137	817.59	-282.00	138	809.47	-304.52
139	800.73	-326.80	140	791.38	-348.84	141	782.51	-376.35
142	763.03	-381.84	143	840.66	-99.13	144	836.73	-119.90

*Printing of the input grid nodes is discontinued here to reserve space

1	299	328	327	1.33	0.0500	2	322	299	326	1.00	0.0500
3	299	327	326	1.00	0.0500	4	324	323	357	1.00	0.0500
5	328	363	327	1.67	0.0500	6	328	329	363	2.00	0.0500
7	329	364	363	2.00	0.0500	8	329	365	364	2.00	0.0500
9	365	404	364	2.00	0.0500	10	364	404	403	2.00	0.0500
11	323	322	355	1.00	0.0500	12	365	405	404	2.00	0.0500
13	325	324	356	1.00	0.0500	14	323	355	357	1.00	0.0500
15	322	326	355	1.00	0.0500	16	327	362	326	1.00	0.0500
17	364	403	402	2.00	0.0500	18	324	357	356	1.00	0.0500
19	327	363	362	1.33	0.0500	20	364	402	363	2.00	0.0500
21	405	450	404	2.00	0.0500	22	357	395	356	1.00	0.0500
23	326	361	355	1.00	0.0500	24	360	325	358	1.00	0.0500
25	326	362	361	1.00	0.0500	26	405	451	450	2.00	0.0500
27	325	356	358	1.00	0.0500	28	363	401	362	1.67	0.0500
29	357	355	395	1.00	0.0500	30	363	402	401	2.00	0.0500
31	403	404	449	2.00	0.0500	32	403	449	402	2.00	0.0500
33	404	450	449	2.00	0.0500	34	356	394	358	1.00	0.0500
35	355	393	395	1.00	0.0500	36	356	395	394	1.00	0.0500
37	355	361	393	1.00	0.0500	38	362	400	361	1.00	0.0500
39	451	496	450	2.00	0.0500	40	362	401	400	1.33	0.0500
41	360	358	359	1.00	0.0500	42	402	448	401	2.06	0.0500
43	451	497	496	2.00	0.0500	44	398	360	359	1.00	0.0500
45	402	449	448	2.06	0.0500	46	450	495	449	2.17	0.0500
47	358	396	359	1.00	0.0500	48	395	441	394	1.00	0.0500
49	361	399	393	1.00	0.0500	50	395	393	441	1.00	0.0500
51	450	496	495	2.17	0.0500	52	358	394	396	1.00	0.0500
53	361	400	399	1.00	0.0500	54	497	544	496	2.53	0.0500
55	401	447	400	1.70	0.0500	56	497	498	545	5.63	0.0500
57	401	448	447	2.09	0.0500	58	497	545	544	3.98	0.0500
59	449	494	448	2.43	0.0500	60	498	546	545	8.29	0.0500
61	449	495	494	2.54	0.0500	62	359	397	398	1.00	0.0500
63	394	440	396	1.00	0.0500	64	393	439	441	1.00	0.0500
65	359	396	397	1.00	0.0500	66	496	543	495	2.71	0.0500
67	394	441	440	1.00	0.0500	68	546	547	595	10.97	0.0500
69	400	446	399	1.22	0.0500	70	393	399	439	1.00	0.0500
71	546	594	545	9.17	0.0500	72	400	447	446	1.58	0.0500
73	496	544	543	3.07	0.0500	74	448	493	447	2.46	0.0500
75	546	595	594	11.06	0.0500	76	547	596	595	11.56	0.0500
77	448	494	493	2.80	0.0500	78	444	398	397	1.00	0.0500
79	495	542	494	3.16	0.0500	80	545	593	544	5.66	0.0500
81	495	543	542	3.33	0.0500	82	441	487	440	1.00	0.0500
83	596	597	648	12.44	0.0500	84	396	442	397	1.00	0.0500
85	596	647	595	12.14	0.0500	86	399	445	439	1.03	0.0500
87	441	439	487	1.00	0.0500	88	396	440	442	1.00	0.0500
89	545	594	593	8.19	0.0500	90	399	446	445	1.24	0.0500
91	447	492	446	2.17	0.0500	92	544	592	543	4.20	0.0500
93	596	648	647	12.46	0.0500	94	447	493	492	2.65	0.0500
95	397	443	444	1.00	0.0500	96	397	442	443	1.00	0.0500
97	544	593	592	5.34	0.0500	98	595	646	594	11.73	0.0500
99	494	541	493	3.39	0.0500	100	597	650	648	12.86	0.0500
101	494	542	541	3.64	0.0500	102	595	647	646	12.22	0.0500
103	437	436	483	5.16	0.0500	104	482	437	483	5.27	0.0500
105	543	591	542	4.20	0.0500	106	594	645	593	9.48	0.0500
107	439	485	487	1.05	0.0500	108	440	486	442	1.00	0.0500

109	650	649	703	12.82	0.0500	110	650	702	648	13.08	0.0500
111	446	491	445	1.72	0.0500	112	543	592	591	4.71	0.0500
113	436	438	483	5.16	0.0500	114	439	445	485	1.08	0.0500
115	440	487	486	1.00	0.0500	116	438	484	483	5.48	0.0500
117	594	646	645	11.12	0.0500	118	649	631	684	12.25	0.0500
119	446	492	491	2.28	0.0500	120	493	540	492	3.29	0.0500
121	489	444	443	1.00	0.0500	122	631	683	684	11.84	0.0500
123	650	703	702	13.08	0.0500	124	649	684	703	12.64	0.0500
125	648	701	647	12.96	0.0500	126	493	541	540	3.68	0.0500
127	593	644	592	6.74	0.0500	128	542	590	541	4.11	0.0500
129	593	645	644	8.34	0.0500	130	647	700	646	12.44	0.0500
131	648	702	701	13.15	0.0500	132	542	591	590	4.50	0.0500
133	438	435	481	5.45	0.0500	134	438	481	484	5.77	0.0500
135	445	490	485	1.40	0.0500	136	487	533	486	1.15	0.0500
137	592	643	591	5.59	0.0500	138	647	701	700	12.86	0.0500
139	442	488	443	1.00	0.0500	140	487	485	533	1.20	0.0500
141	492	539	491	3.03	0.0500	142	445	491	490	1.83	0.0500
143	646	699	645	11.27	0.0500	144	442	486	488	1.00	0.0500
145	483	529	482	6.42	0.0500	146	592	644	643	6.48	0.0500
147	492	540	539	3.55	0.0500	148	528	482	529	6.95	0.0500
149	683	735	684	12.21	0.0500	150	443	488	489	1.00	0.0500
151	541	589	540	4.08	0.0500	152	684	736	703	12.91	0.0500
153	646	700	699	12.10	0.0500	154	683	682	734	11.55	0.0500
155	435	434	480	5.63	0.0500	156	435	480	481	6.07	0.0500
157	541	590	589	4.26	0.0500	158	703	755	702	13.23	0.0500
159	682	679	731	11.20	0.0500	160	483	484	529	6.63	0.0500
161	484	530	529	7.79	0.0500	162	645	698	644	9.20	0.0500
163	683	734	735	12.30	0.0500	164	591	642	590	4.98	0.0500
165	702	754	701	13.36	0.0500	166	486	532	488	1.27	0.0500
167	486	533	532	1.42	0.0500	168	684	735	736	12.90	0.0500
169	682	731	734	11.96	0.0500	170	679	630	681	10.99	0.0500
171	645	699	698	10.49	0.0500	172	591	643	642	5.56	0.0500

*Printing of the input grid elements is discontinued here to reserve space

1	1	0.35	2	6	0.35	3	8	0.35	4	12	0.35	5	26	0.35
6	43	0.35	7	56	1.00	8	60	1.00	9	68	1.00	10	76	1.00
11	83	1.00	12	100	1.00	13	109	1.00	14	118	1.00	15	122	1.00
16	154	1.00	17	159	1.00	18	170	1.00	19	191	1.00	20	201	1.00
21	213	1.00	22	197	1.00	23	148	1.00	24	104	0.50	25	103	0.50
26	113	0.50	27	133	0.50	28	155	0.50	29	181	0.50	30	200	0.50
31	196	0.50	32	217	0.50	33	258	0.50	34	257	0.50	35	283	0.50
36	332	0.50	37	337	0.50	38	355	0.50	39	376	0.50	40	412	0.50
41	430	0.50	42	458	0.50	43	488	0.50	44	489	0.50	45	508	0.50
46	554	0.50	47	580	0.50	48	631	0.50	49	684	0.50	50	772	0.50
51	811	0.50	52	812	0.50	53	849	0.50	54	904	0.50	55	900	0.50
56	911	0.50	57	939	0.50	58	1001	0.50	59	1004	0.50	60	1033	0.50
61	1032	0.50	62	1061	0.50	63	1123	0.50	64	1148	0.50	65	1136	0.50
66	1124	0.50	67	1118	0.50	68	1112	0.50	69	1085	0.50	70	1093	0.50
71	1202	0.50	72	1243	0.35	73	1222	0.35	74	1215	0.35	75	1204	0.35
76	1251	0.35	77	1331	0.35	78	1340	0.35	79	1362	0.35	80	1386	0.35
81	1415	0.50	82	1559	0.50	83	1700	0.50	84	1852	0.50	85	2016	0.50
86	2168	0.50	87	2294	0.50	88	2494	0.50	89	2495	0.50	90	2514	0.50
91	2527	0.50	92	2551	0.50	93	2553	0.50	94	2564	0.50	95	2565	0.50
96	2573	0.50	97	2586	0.50	98	2576	0.50	99	2596	0.50	100	2613	0.50
101	2619	0.50	102	2627	0.50	103	2645	0.50	104	2655	0.50	105	2667	0.50
106	2676	0.50	107	2683	0.50	108	2698	0.50	109	2706	0.50	110	2711	0.50
111	2717	0.50	112	2722	0.50	113	2733	0.50	114	2735	0.50	115	2743	0.50
116	2749	0.50	117	2759	0.50	118	2764	0.50	119	2774	0.50	120	2783	0.50
121	2791	0.50	122	2798	0.50	123	2803	0.50	124	2815	0.50	125	2823	0.50
126	2834	0.50	127	2832	0.50	128	2780	0.50	129	2773	0.50	130	2781	0.50
131	2782	0.50	132	2789	0.50	133	2797	0.50	134	2802	0.50	135	2851	0.50
136	2887	0.50	137	2907	0.50	138	2915	0.50	139	2950	0.50	140	2998	0.50
141	3058	0.50	142	3144	0.50	143	3247	0.50	144	3253	0.50	145	3370	0.50
146	3383	0.50	147	3397	0.50	148	3329	0.50	149	3279	0.50	150	3302	0.50
151	3306	0.50	152	3303	0.50	153	3298	0.50	154	3286	0.50	155	3270	0.50
156	3262	0.50	157	3269	0.50	158	3271	0.50	159	3207	0.50	160	3201	0.50
161	3194	0.50	162	3186	0.50	163	3178	0.50	164	3174	0.50	165	3171	0.50
166	3168	0.50	167	3163	0.50	168	3164	0.50	169	3112	0.50	170	3090	0.50
171	3080	0.50	172	3074	0.50	173	3071	0.50	174	3065	0.50	175	3064	0.50
176	3060	0.50	177	2995	0.50	178	2994	0.50	179	2993	0.50	180	2992	0.50
181	2991	0.50	182	2990	0.50	183	2988	0.50	184	2986	0.50	185	2985	0.50
186	3006	0.50	187	3004	0.50	188	2984	0.50	189	2996	0.50	190	3022	0.50
191	3077	0.50	192	3130	0.45	193	3205	0.45	194	3254	0.45	195	3358	0.50
196	3375	0.45	197	3398	0.45	198	3576	0.45	199	3692	0.45	200	3738	0.45
201	3788	0.45	202	3854	0.45	203	3845	0.45	204	3697	0.45	205	3540	0.45
206	3404	0.45	207	3268	0.45	208	3242	0.45	209	3165	0.45	210	3131	0.45
211	3116	0.45	212	3051	0.45	213	3003	0.45	214	2972	0.45	215	2953	0.45
216	2932	0.45	217	2910	0.45	218	2893	0.45	219	2862	0.45	220	2835	0.45
221	2777	0.45	222	2705	0.45	223	2582	0.45	224	2511	0.45	225	2400	0.45
226	2270	0.45	227	2206	0.45	228	2127	0.45	229	2004	0.45	230	1826	0.45
231	1614	0.45	232	1405	0.45	233	1187	0.45	234	1026	0.45	235	869	0.45
236	750	0.45	237	656	0.45	238	559	0.45	239	447	0.45	240	334	0.45
241	247	0.45	242	174	0.45	243	121	0.35	244	78	0.35	245	44	0.35
246	24	0.35	247	13	0.35	248	4	0.35	249	11	0.35	250	2	0.35
251	3024	0.00	252	3056	0.50									

BATHSPEC **FEET** 0.0 25.00

APPENDIX 9-F: OUTPUT LISTING FOR
MAALAEA HARBOR, MAUI, HAWAII EXAMPLE

COASTAL MODELING SYSTEM (CMS): HARBD , VERSION 1.0

---- HARBD MAALAEA HARBOR, MAUI, HI - EXISTING CONFIGURATION ---

***** GENSPECS CARD: SPECIFICATION OF TITLE AND GENERAL SYSTEM OF UNITS

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
SUNITS	UNITS SYSTEM USED IN COMPUTATIONS	ENGLISH		*			

***** GRIDSPEC CARD: SPECIFICATION OF THE FINITE-ELEMENT GRID - MAALAEA.INP

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
GRTYPE	TYPE OF FINITE-ELEMENT GRID	TRIANG		* GUNITS	SYSTEM OF UNITS USED FOR THE GRID	ENGLISH	
NNOD	NUMBER OF GRID NODES	3752		* NELE	NUMBER OF GRID ELEMENTS	7146	
NODR	NUMBER OF NODES ON SEMICIRCULAR BOUN	105		* NELB	NUMBER OF BOUNDARY ELEMENTS	252	
NBAND	BANDWIDTH OF GRID	107		* RADIUS	RADIUS OF SEMICIRCLE	786.03	

***** PRWINDOW CARD: SPECIFICATION OF THE MODEL OUTPUT

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
WPRNOD	PRINTING OF NODAL SOLUTIONS	NONE		* MAXNOD	SPECIFIED MAX NUMBER OF OUTPUT NODES	1	
NODOUT	NUMBER OF NODES SELECTED FOR OUTPUT	0		* WPRBSN	NUMBER OF SPECIFIED BASINS	16	
MAXBSN	SPECIFIED MAXIMUM NUMBER OF BASINS	16		* MAXELE	SPECIFIED MAX ELEMENTS IN ANY BASIN	7	
WPRCOF	PRINTING OF COEFFICIENT SOLUTIONS	NO		* WPRGRD	PRINTING OF FINITE ELEMENT GRID	NO	

BASIN	* NUMBER OF ELEMENTS	* BASIN	* NUMBER OF ELEMENTS
1	7	2	6
3	6	4	6
5	6	6	6
7	7	8	6
9	6	10	7
11	7	12	7
13	6	14	[illegible]
15	6	16	

***** WAVCOND CARD: NUMBER OF WAVE CONDITIONS: 1

WAVE CONDITION NUMBER: 1

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
HDEEP	DEEPWATER WAVE HEIGHT	0.00		* TDEEP	WAVE PERIOD	20.00	
ZDEEP	DEEPWATER WAVE ANGLE	265.00		*			

COASTAL MODELING SYSTEM (CMS): HARBD , VERSION 1.0

***** BATHSPEC CARD: SPECIFICATION OF BATHYMETRY/TOPOGRAPHY -

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
BUNITS	SYSTEM OF UNITS FOR DEPTH DATA	FEET		* WDATUM	DATUM FOR WATER DEPTHS	0.00	
FARD	WATER DEPTH OF FAR REGION	25.000					

NUMBER OF ELEVATION CHANGES = 0

***** CONVERGENCE CRITERIA ARE AS FOLLOWS:

VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:	* VARIABLE	DESCRIPTION OF USAGE:	VALUE:	NOTES:
REFLEC	REFL. COEFF. ALONG OPEN COAST BNDRY	0.10000					

```
****************************************
*** INPUT PROCESSING COMPLETED:
    FATAL ERRORS=  0      WARNINGS=  0
****************************************
```

WAVE CONDITION 1

THE DEEP WATER WAVE PARAMETERS FOR CASE 1 ARE: HEIGHT= 0.000 PERIOD= 20.000 ANGLE= 265.000

- -

FOR THE BASIN = 1
THE TOTAL AREA = 0.9115E+03
THE MEAN SORT VALUE OVER THE BASIN = 1.7314

FOR THE BASIN = 2
THE TOTAL AREA = 0.1259E+04
THE MEAN SORT VALUE OVER THE BASIN = 1.1693

FOR THE BASIN = 3
THE TOTAL AREA = 0.1345E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.7846

FOR THE BASIN = 4
THE TOTAL AREA = 0.1327E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.7501

FOR THE BASIN = 5
THE TOTAL AREA = 0.1339E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.6534

FOR THE BASIN = 6
THE TOTAL AREA = 0.1492E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.8328

FOR THE BASIN = 7
THE TOTAL AREA = 0.1854E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.8117

FOR THE BASIN = 8
THE TOTAL AREA = 0.1693E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.6091

FOR THE BASIN = 9
THE TOTAL AREA = 0.1568E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.7361

FOR THE BASIN = 10
THE TOTAL AREA = 0.1842E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.3222

FOR THE BASIN = 11
THE TOTAL AREA = 0.1347E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.0531

FOR THE BASIN = 12
THE TOTAL AREA = 0.1303E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.0866

FOR THE BASIN = 13
THE TOTAL AREA = 0.1378E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.2862

FOR THE BASIN = 14
THE TOTAL AREA = 0.1236E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.4057

FOR THE BASIN = 15
THE TOTAL AREA = 0.1608E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.5103

FOR THE BASIN = 16
THE TOTAL AREA = 0.1320E+04
THE MEAN SORT VALUE OVER THE BASIN = 0.6114

- -

APPENDIX A: CMSGRID

Introduction

1. Numerical models consist of one or more mathematical equations that define or describe the physical processes of a system. The equations often contain partial derivatives that define how flow field variables change with respect to time and/or space. The models use mathematical (finite difference or finite element) approximations to represent these continuous equations at discrete locations. The continuum is, therefore, represented by discrete points in time and space. Hence, a computational grid is employed by the model to define the flow field at discrete points.

2. A grid is composed of a lattice network of cells, and each cell has certain flow field parameters associated with it. In the case of the WES Implicit Flooding Model (WIFM), these parameters include water depths, water and wind velocities, and water surface elevations. A model is expected to accurately predict flow parameters in the domain of interest, and model accuracy is dependent, in part, on how well the specified grid resolution represents the spatial domain and the flow field. The methodology used to create computational grids for models residing in the Coastal Modeling System (CMS) is presented here.

3. At the present time this package has the capability to generate grids in a stretched rectangular coordinate system. Uniformly spaced grids, which are a subset of this group, can also be generated. The programs contained in this package are listed in Table A-1.

Table A-1

CMSGRID Components

Program	Description
MAPIT	Stretch rectangular coordinate grid generator.
DRAWIT	Graphical program to plot grids generated by MAPIT.
LISTIT	Program to print grid coordinate points.

Computational Technique of Program MAPIT

4. Program MAPIT is designed to calculate the mapping function that relates a variably spaced grid in prototype space to a uniformly spaced grid in computational space. The function defining the mapping from prototype space (x) to computational space (α) is:

$$x = a + b\alpha^{c} \tag{A1}$$

where

- x - actual mapping distance from the origin
- α - distance from the origin in computational space (which can also be thought of as the cell index number assuming a constant computational grid cell size of 1.0)
- a, b, c - coefficients calculated by the program (Figure A-1)

The entire prototype space to be mapped can be separated into user-specified regions of arbitrary length defined by end points $x_1, x_2 \ldots x_n$ (for n-1 regions), and the mapping function is applied to each region. Values of the three coefficients are thus derived for each of the n-1 regions. The values of a, b, and c are determined by requiring continuity of both the function, x, and its first derivative from region to region. This constraint provides a smoothly varying grid.

5. For any region the following relationships must be satisfied:

$$x_i = a + b\alpha_i^{c} \tag{A2}$$

$$x_i' = \left(\frac{dx}{d\alpha}\right)_i = bc\alpha_i^{c-1} \tag{A3}$$

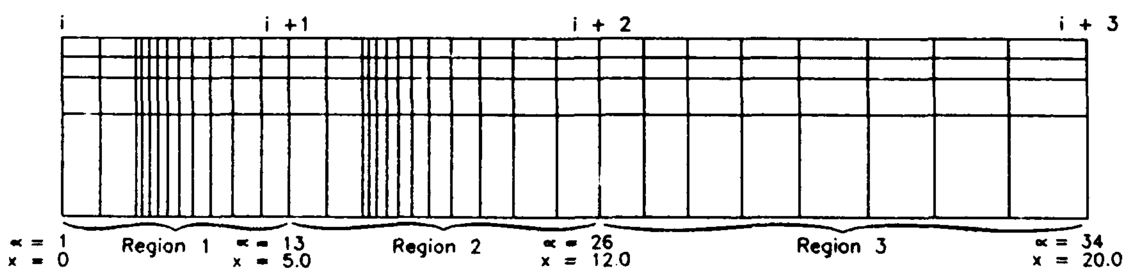

Figure A-1. Variably-spaced grid

$$x_{i+1} = a + b\alpha_{i+1}^{c} \tag{A4}$$

$$x'_{i+1} = \left(\frac{dx}{d\alpha}\right)_{i+1} = bc\alpha_{i+1}^{c-1} \tag{A5}$$

where the subscripts i and $i+1$ refer to the beginning and ending points of the region. The three coefficients (a, b, c) for each region are derived from four nonlinear equations, over-constrained by the known values of x_i , x_{i+1} , x'_i , x'_{i+1} , α_i , and α_{i+1} .

6. In practice, the solution procedure of MAPIT operates somewhat differently. The algorithm assumes that regions are mapped in a sequential order from 1 to $(n-1)$, and that the α's are always positive integers. For any given region, the values of x_i , x'_i , and α_i are known from the computations for the previous region. (The user specifies these values for the first region.) The user specifies the distance to the far end of the region (x_{i+1}) and the cell size at the far end of the region (x'_{i+1}), while the number of cells (α_{i+1}) is computed by the program in a preliminary computation. It should be noted that the value $(\alpha_{i+1} - \alpha_i)$ gives the number of grid cells that lie between the endpoints of a region.

7. Providing that a , b , and c have been determined, an optimal value of α_{i+1} can be chosen, such that the difference between the desired value of x_{i+1} and that calculated from Equation A4 can be minimized. The three coefficients, derived from Equations A2 through A5, are presented below:

$$c = 1 + \frac{\log\ (x'_i/x'_{i+1})}{\log\ (\alpha_i/\alpha_{i+1})} \tag{A6}$$

$$a = x_i - b\alpha_i^{c} = x_i - \frac{\alpha_i x'_i}{c} \tag{A7}$$

$$b = (x_i - a)/\alpha_i^{c} \tag{A8}$$

8. This preliminary calculation in MAPIT starts by assuming an α_{i+1} value greater than α_i . The values of a , b , and c are then determined from Equations A6 through A8, and a calculated value of x_{i+1} is obtained from Equation A4. This computed value is compared with the desired value of x_{i+1} ; the value of α_{i+1} is incremented or decremented; and the procedure is repeated until the calculated x_{i+1} value becomes approximately equal to the

desired value. The program warns the user if the region is too small to fit a single cell, or if more than 500 cells appear in any one region. The non-linear system of equations are solved iteratively to assure that a convergent value of the exponent c is generated. Two procedures are used in MAPIT, and they are expressed mathematically below:

$$\text{Procedure I} \qquad c_{k+1} = \frac{\log\left[\dfrac{(x_{i+1} - x_i)\, c_k}{\alpha_i x'_i} + 1\right]}{\log\,(\alpha_{i+1}/\alpha_i)} \tag{A9}$$

$$\text{Procedure II} \qquad c_{k+1} = \frac{\alpha_i x'_i}{(x_{i+1} - x_i)} \left[\left(\frac{\alpha_{i+1}}{\alpha_i}\right)^{c_k} - 1\right] \tag{A10}$$

where k is the iteration counter. These two relationships are derived from Equations A2 through A5. Both equations contain one zero root, as well as the root of interest. The roots of interest are then averaged, and the average value of c is used for computing a and b. Procedure I also has an asymptote:

$$c_k = \frac{-\alpha_i x'_i}{x_{i+1} - x_i} \tag{A11}$$

9. Both procedures are solved using the Newton-Raphson method and are compared with each other. All four roots of the two equations are found and checked in order to find problems with pathological solutions for c and poor convergence in iteration. Following the solution for c, the values of a and b are found from Equations A7 and A8. It should be noted that x'_{i+1} is never used in the calculations of the three coefficients computed from Equations A7 through A10. The three coefficients are computed using previously known values of c and the given x_{i+1}. The values of the coefficients satisfy the relationships of Equations A2 through A4, but not Equation A5. MAPIT recalculates x'_{i+1} from Equation A5 to complete the problem, and it displays the results for the region to the user. The user then has the option to continue to the next region, try the same region again with different inputs, or back up to a previous region. If the user does not want the value of x'_{i+1} recalculated by the program, but requires specific

values of both x_{i+1} and x'_{i+1} , then the code can calculate coefficients for two regions at once. The values of x , the derivative, and alpha of the partition point between the two regions are all calculated by the code. The equations for two adjacent regions are:

$$x_i = a_1 + b_1 \alpha_i^{c_1} \tag{A12}$$

$$x_{i+1} = a_1 + b_1 \alpha_{i+1}^{c_1} \tag{A13}$$

$$x_{i+1} = a_2 + b_2 \alpha_{i+1}^{c_1} \tag{A14}$$

$$x_{i+2} = a_2 + b_2 \alpha_{i+2}^{c_2} \tag{A15}$$

$$x'_i = b_1 c_1 \alpha_i^{c_1 - 1} \tag{A16}$$

$$x'_{i+1} = b_1 c_1 \alpha_{i+1}^{c_1 - 1} \tag{A17}$$

$$x'_{i+1} = b_2 c_2 \alpha_{i+1}^{c_2 - 1} \tag{A18}$$

$$x'_{i+2} = b_1 c_2 \alpha_{i+2}^{c_2 - 1} \tag{A19}$$

10. If a value for α_{i+1} is assumed, then this system of equations becomes eight equations with six unknown coefficients, x_i , x_{i+1} , x_{i+2} , x'_i , x'_{i+1} , x'_{i+2} . Equations A12 through A19 can be algebraically reduced to two equations in the unknowns of c_1 and c_2 :

$$x_i + \frac{\alpha_i x'_i}{c_1}\left[\left(\frac{\alpha_{i+1}}{\alpha_i}\right)^{c_1} - 1\right] = x_{i+2} + \frac{\alpha_{i+2} x'_{i+2}}{c_2}\left[\left(\frac{\alpha_{i+1}}{\alpha_{i+2}}\right)^{c_2} - 1\right] \tag{A20}$$

$$x'_i \left(\frac{\alpha_{i+1}}{\alpha_i}\right)^{c_1 - 1} = x'_{i+2}\left(\frac{\alpha_{i+2}}{\alpha_{i+2}}\right)^{c_2 - 1} \tag{A21}$$

These two equations can be manipulated to yield two pairs of equations in c_1 and c_2 :

$$c_1 = 1 + \frac{\log\left[\frac{x_{i+2}^i}{x_i^i}\left(\frac{\alpha_{i+1}}{\alpha_{i+2}}\right)^{c_2 - 1}\right]}{\log(\alpha_{i+1}/\alpha_i)} \tag{A22}$$

$$c_2^{k+1} = \frac{\log\left[1 + \frac{c_2^k}{\alpha_{i+2}x_{i+2}^i}\left(x_i - x_{i+2} + \frac{\alpha_i x_i^i}{c_1}\left[\left(\frac{\alpha_{i+1}}{\alpha_i}\right)^{c_1} - 1\right]\right)\right]}{\log(\alpha_{i+1}/\alpha_{i+2})} \tag{A23}$$

$$c_2 = 1 + \frac{\log\left[\frac{x_i^i}{x_{i+2}^i}\left(\frac{\alpha_{i+1}}{\alpha_i}\right)^{c_1 - 1}\right]}{\log(\alpha_{i+1}/\alpha_{i+2})} \tag{A24}$$

$$c_1^{k+1} = \frac{\log\left[1 + \frac{c_1^k}{\alpha_i x_i^i}\left(x_{i+2} - x_i + \frac{\alpha_{i+2}x_{i+2}^i}{c_2}\left[\left(\frac{\alpha_{i+1}}{\alpha_{i+2}}\right)^{c_2} - 1\right]\right)\right]}{\log(\alpha_{i+1}/\alpha_i)} \tag{A25}$$

where the k superscript is an iteration counter. The coefficients c_1 and c_2 can be calculated from either of the above pairs of equations, and the remaining unknowns can be found by substitution.

11. The actual algorithm for the double region routine is rather complicated due to the nature of Equations A22 through A24. Equation A21 represents a straight line with a negative slope in $c_1 - c_2$ space, whereas Equations A23 through A25 each have one asymptote for their dependent variable. These asymptotes are given by:

$$c_1^{k+1} = \frac{\log\left[1 + \frac{c_1^k}{\alpha_i x_i^i}(x_{i+2} - x_i)\right]}{\log(\alpha_{i+1}/\alpha_i)} \tag{A26}$$

for Equation A23, and

$$c_2^{k+1} = \frac{\log\left[1 + \frac{c_2^k}{\alpha_{i+2}x_{i+2}^i}(x_i - x_{i+2})\right]}{\log(\alpha_{i+1}/\alpha_{i+2})} \tag{A27}$$

for Equation A25.

12. The plot of Equations A21 through A27 is shown in Figure A-2 together with the two possible solution paths suggested by the equation pairs of Equations A22 and A23, and A24 and A25. The major difficulties in the solution algorithm are choosing the appropriate starting values of c_1 and

c_2 and determining which of the two equation pairs yield a convergent solution. Since the asymptotic values of c_1 and c_2 can be determined from Equations A26 and A27, starting values are arbitrarily chosen as a specified percentage of these asymptotic values.

13. In attempting to find a convergent solution, a first estimate is obtained from Equations A22 and A23. If the value of c_2 becomes zero, Equations A24 and A25 are used with the starting values. Should the value of c_1 also become zero, then the starting point lies too close to the asymptotes. A new starting point closer to the origin is then defined, and the whole calculation cycle is repeated. Any time both equation sets are satisfied by a zero solution or fail to converge within a set number of iterations, the starting point is redefined, and the iteration procedure is repeated. Calculations cease after 10 different starting points have been tried, and the user is warned about nonconvergence of the input values.

14. It must be pointed out that not every possible set of inputs for the double region routine will yield a solution. The algorithm is coded to make a reasonable attempt to find a solution; however, the user is warned about nonconvergent cases or pathological functions. The procedure also attempts to resolve other problems, such as attempts to take the logarithm of negative numbers.

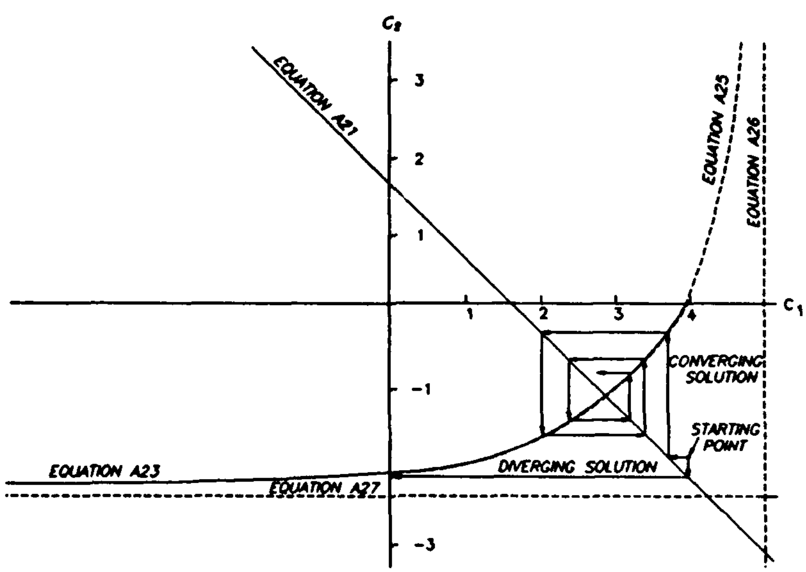

Figure A-2. Graphic solution of double region procedure

Generating Stretch Rectilinear Grids

15. Three basic steps are required to generate stretched rectilinear grids:

- a. Defining the grid orientation and limits.
- b. Determining the grid cell resolution in the seaward direction.
- c. Determining the grid cell resolution in the longshore direction.

16. The following discussion presents guidelines for the above topics; however, due to the complexity of coastal regions, these guidelines will not be applicable to every situation encountered. Hence, knowledge of the capabilities and limitations of the model intended to be used is needed in developing computational grids.

Grid orientation and limits

17. The user should select a detailed chart or map of the study area with sufficient resolution of the coastline and hydraulic features to resolve such features as sharp depth gradients or reefs. Maps constructed from a Mercator projection should be used, especially if multiple maps are needed to define the study area. Mercator projection preserves the angle relationship, allowing the grid to be transferred from one scale to another without distortion.

18. The user should overlay the map with a sheet of Mylar or tracing paper and draw a line on the Mylar that best describes the coastline orientation along the reach that is of primary interest. A line perpendicular to any inlet or channel of interest should be drawn. These lines provide guidance concerning orientation of grid axes.

19. The x and y axes can be oriented arbitrarily as long as a right-handed coordinate system is used. However, the choice of alignment for the grid axes is extremely important, especially when the geometric features of the area to be modeled are complex. Because the modeled area must be represented with rectangular cells, the user should keep in mind that minimizing any stair-stepped representation of shorelines, structures, and/or major channels will produce the most suitable grid.

20. For WIFM simulations, the user should estimate the maximum flood height resulting from extreme tidal- or storm-induced water levels that will be simulated by the model. This estimate can usually be supplied from

historical records; if not, approximate values can be computed by the procedures presented in EM 1110-2-1412. Next, a freeboard of at least 3 ft should be added to the maximum flood height. The user then locates points or line segments delineating the extent of flooding and uses these points to define the boundaries of the grid. Topographic features that prevent flooding should also be considered when defining the model domain.

21. For a storm surge simulation, the seaward boundary should extend to the seaward edge of the Continental Shelf. Therefore, the user should draw another line on the Mylar parallel to the reference line, at the Continental Shelf. The adjacent, or lateral, boundaries must be placed far enough from the area of interest so that inaccuracies caused by uncertainties in the boundary values specified in the model are minimized. As a rule of thumb, the grid should extend laterally from the area of interest in each direction, a distance of at least 1.5 to 2.0 times the distance from the coastline to the shelf.

22. For a tidal circulation investigation, the grid limits are dependent on the size and shape of the area of interest and where data are available for establishing a proper boundary condition. For example, back-bay areas in the model may be influenced by river/channel systems. The model grid should extend into such systems to a point where the water level, flow rate, or velocity have been measured and can be used to establish a boundary condition. In the open coast area, the seaward and lateral open boundaries should extend far enough from the area of interest so that computations in the area of interest are not significantly affected by inaccuracies in boundary specification. Again, data (usually water level measurements or tidal constituents) should be available in the open coastal area to be used as boundary conditions.

23. Many WIFM applications involve consideration of tidal hydrodynamics at structured inlets. A general rule of thumb is to locate open water boundaries a distance from the inlet equivalent to 5 times the length of the inlet structure.

24. In storm or tidal investigations, a grid sensitivity study can be performed. This type of test is usually performed to minimize the size of the open ocean portion of a grid. The test is done by first developing a grid with limits exceeding the specifications mentioned in earlier paragraphs. Having made good engineering estimates for other model input parameters

(depth, friction, etc.), a test is run with the large grid. The test is then repeated after reducing the grid size in both seaward and lateral directions. The results in the area of interest are checked to determine the impact of the new boundary location.

Seaward grid cell resolution

25. A profile of the seabed is drawn on a separate sheet of Mylar, running from the onshore boundary to the seaward boundary. The bottom profile is simplified by drawing straight lines that represent regions having approximately the same slope. (Normally four to eight regions are sufficient.) A separate stretching function (Equation A2) should be applied to each region in order to generate grid cells that adequately define the area. As a first attempt at creating a grid, a constant value of the ratio, $\Delta x/L$, (where Δx is the grid cell size and L is the wavelength) should be maintained.

26. Cell dimensions are first chosen for the area of interest. In this region the cells should be square, or nearly square, and have a greater resolution (i.e., more cells per unit area) than in the remaining regions. Cell sizes must be small enough so that the hydraulic features are resolved. However, computer costs for executing the model will be prohibitive if the grid has too many cells or if the minimum cell size forces the choice of a very small time-step according to the Courant stability constraint.

27. Seaward of the area of interest, cell dimensions can usually be increased. This is performed by smoothly increasing cell dimension sizes over the distance defined by the slope region. The first cell in a region should not increase by more than 25 percent of the size of the last cell in the previous region. The largest cell in the grid, normally located at the seaward boundary, should not be greater than 20 times the size of the smallest cell in the grid.

28. Grid sizes may increase in the inland direction away from the area of interest. However, care should be taken to sufficiently resolve the inland water/land system. Proper resolution will ensure the flooding and drying algorithm in model WIFM can be accurately applied to this area.

Longshore grid cell resolution

29. Longshore grid cell resolution is determined from the variability of the coastline as opposed to bed slope in the seaward direction. However, the concepts of increasing the resolution in areas of rapid change are the

same. Greater resolution is needed in areas where the landforms or other hydraulic features have significant influence on hydrodynamics in the region of interest. Grid lines should be placed to match the orientation of these features, where possible.

30. As a practical guideline, there are two basic methods for ensuring good grid resolution of small hydraulic features such as inlets. The first method is to put a partition in the middle of the inlet. If a suitably small cell width is chosen for this partition, with larger cell sizes at the two nearest endpoints, then the inlet will be modeled with a cell group smallest in the center of the inlet and largest at its edges. If a relatively constant cell size is desired across an inlet, then it is best to place a partition point at each edge of the inlet, so that the inlet becomes one region. Equal cell widths can be defined at the end points, resulting in nearly constant cell widths across the inlet. This method has the advantages of placing partition lines at the land-water boundaries of the inlet and ensuring a specific grid resolution; however, this often generates a larger number of cells over the entire grid because the fine resolution in the inlet will be "carried" into the open ocean area.

31. For featureless terrain bounded by high-resolution regions, two partitioning methods can be used to minimize the number of required grid cells. One method divides the area into two regions, containing partitions with small cells in the required areas. The second method divides the area into three regions, with small cells at the outer partitions and large cells at the two inner partitions. This method creates large cells in the middle region and rapid changes in cell size in the two outer regions of the area. The method that produces the minimum number of cells is preferable.

Additional considerations for grid generation

32. As a practical guideline, channels should be oriented approximately parallel to the grid axes to avoid stair-stepping. Orientation at a 45-degree angle for square grid cells would maximize stair-stepping and should be avoided. Another method of avoiding stair-stepping is to alter the orientation of water bodies in nonsensitive areas while preserving storage capacity, as shown in Figure A-3.

33. The ratio of the cell size in the longshore direction to the cell size in the on-offshore direction, or aspect ratio, should also be examined and considered when generating a grid. For example, model RCPWAVE requires

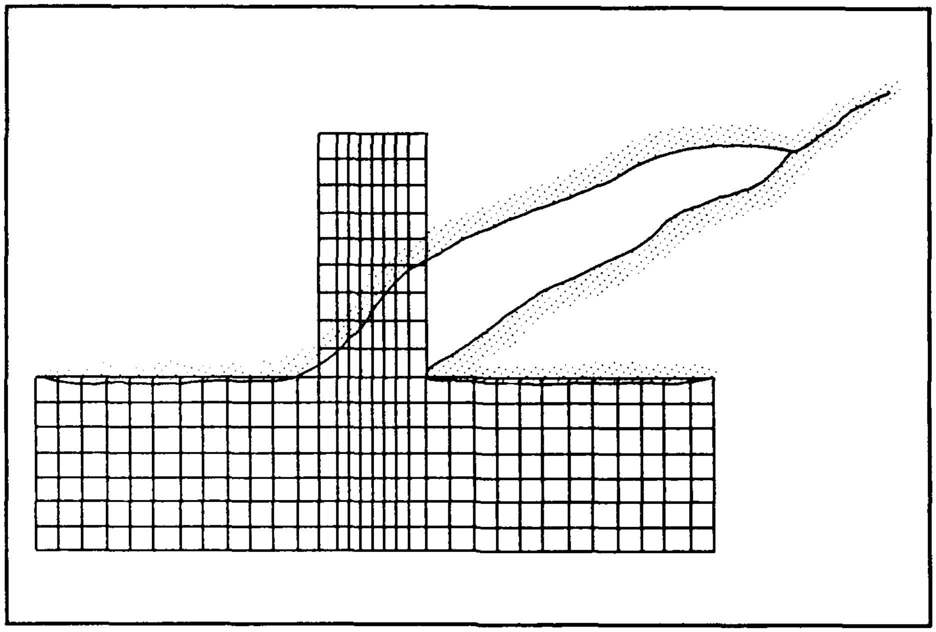

Figure A-3. Altered representation of a water body

large aspect ratios to resolve large input wave angles. An aspect ratio of two is typically used for RCPWAVE applications. On the other hand, hydrodynamic models, such as WIFM and CLHYD, produce most accurate results with an aspect ratio of 1, indicating "square" grid cells. An aspect ratio within the range 0.2 and 5 produces adequate results in the area of interest and the aspect ratio can be as much as 20 away from the area of interest.

34. Lastly, the user should be aware of the implications of two stability criteria on grid generation, the Courant condition and the diffusion number. The Courant condition

$$C_r = \frac{\sqrt{gH}}{\Delta x/\Delta t}$$

defines the maximum permissible time-step size for a given value of C_r , where g is the gravitational acceleration, Δx is the dimension of the smallest grid cell within the computational domain, H is the depth at that cell, and Δt is the time-step size. Therefore, a fine-resolution grid will require a small time-step size and a large number of time-steps for a given simulation length, which can become computation prohibitive. The Courant number, C_r , is ideally less than 0.5, but results can be obtained for C_r

less than 7.0. It is recommended that a Courant number on the order of 1.0 to 7.0 be used for WIFM and CLHYD applications.

35. The second stability criterion, the advection limit, is the maximum allowable time-step, Δt , based on the time for a particle to travel through the smallest grid cell:

$$\Delta t \leq \frac{\Delta x}{U} \; or \; \frac{\Delta y}{V}$$

where Δx and Δy are the smallest grid cells in the x- and y- directions, respectively and U and V are the particle velocities in the x- and y-directions, respectively. Experienced modelers usually select a time-step somewhat "less than" this limit, rather than "equal to" the limiting value.

Program MAPIT

36. Program MAPIT generates computational grids for the models residing in CMS. Presently, this program will generate only grids having stretched or uniform rectilinear coordinate systems (i.e., models WIFM, SPH, RCPWAVE, CLHYD, and SHALWV). Guidelines for developing a stretched rectilinear grid have been discussed previously in this Appendix.

37. Computer costs incurred in executing the models can be reduced by selecting the x-direction axis so that it contains more grid cells than the y-axis. Cost reduction is related to the manner in which two-dimensional arrays are stored. The x- and y-direction grid axes can be computed, or mapped, in either order; however, the following requirements must be met:

- a. Each region must be mapped in sequence, starting at the axis origin.
- b. Distances are measured from the axis origin. A common choice for distance units is map inches so a map overlay can be created.
- c. Grid cells are numbered sequentially, with the first cell at the axis origin.

Program input data

38. Program MAPIT is executed interactively. Hence, the program will prompt the user for the input data. *MAPIT responses require capital letters.* An instruction menu, listing the valid user commands and corresponding variables, is presented in Table A-2.

Table A-2

Instruction Menu for Program MAPIT

Command	Input Data	Defaults	Description
?			Invokes the HELP utility that lists valid user responses.
SINGLE	X2 X2P	none	SINGLE region mapping. X2 - distance from origin to far end of region. X2P - cell width at last cell in region.
DOUBLE	X3 X3P L3 L2	none	DOUBLE region mapping. X3 - distance to far end of region partition. X3P - cell width of last cell in region. L3 - cell number of last cell in region. L2 - cell number of cell at center of region.
BACKUP	IREG	none	Recompute region mapping IREG - region number to be remapped.
SUMMARY		none	Produces a summary of all mapping previously performed.
ENDDIR		none	Ends mapping direction.
DEBUG	"ON" "OFF"	"OFF"	Prints diagnostics and intermediate computations.

39. A SINGLE command specifies a region composed of one stretching function. Variable X2 defines the distance from the axis origin to the far edge, or partition, of the region. Variable X2P defines the grid cell width at the far edge.

40. A DOUBLE command specifies a region composed of two stretching functions. Variable X3 defines the distance from the axis origin to the far edge, or partition of the region, and variable X3P is the width of the last cell in that region. The user must also specify the cell number at the far edge of the region (variable L3) and the cell number at the center of the region (variable L2).

41. The solution algorithm in program MAPIT will diverge if improper values are entered for a region. If the solution does diverge, convergence can normally be achieved by adjusting the values for variables X3P and/or L2. Additional information concerning the divergence/convergence of the computational algorithm is discussed in the section titled "Computational Technique of Program MAPIT."

42. An option is included in program MAPIT to allow the user to recompute regions (option BACKUP). However, all regions mapped subsequent to the initial attempt of a remapped region will be deleted.

43. Mapping is terminated by entering the ENDDIR command. The user is then prompted to map the remaining direction or terminate the mapping session.

<u>Program execution</u>

44. The program will prompt the user for:

- a. A mapping direction (either x- or y-axis).
- b. The initial distance to the grid origin (x) which is usually set to 0.0.
- c. The initial grid cell index number (ALPHA), which is usually set to 1.
- d. Initial cell width.

45. The interactive session begins by entering the command:

```
h2crplc1:larry$/u3/h2crplc0/cms
```

on the CRAY Y-YMP supercomputer located at WES (see Chapter 2). It should be noted that user entries are shown as shaded and the CMS response "screens" are shaded boxes.

The CMS responds:

```
        W E L C O M E   T O . . .

   XXXXX         X     X        XXXXX
  X     X        XX   XX       X     X
  X              X X X X       X
  X              X  X  X        XXXXX
  X              X     X             X
  X     X        X     X       X     X
   XXXXX         X     X        XXXXX


            Return for more...
```

```
**********************************************************************
*                         C M S   COMPONENTS                         *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------>  1   *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                  numerical models)  ------------------------>  2   *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  ------------------>  3   *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  ------------------>  4   *
*                                                                    *
*  CMSSAMP (Sample input and output files for each model)  ---->  5  *
*                                                                    *
*  Exit CMS  ------------------------------------------------->  q   *
**********************************************************************
```

Enter option number ------------------------->

The CMS responds:

```
   CCCC      M     M    SSSS      GGGG     RRRRR    I    DDDDD
  C    C     MM   MM   S    S    G    G    R    R   I    D    D
 C           M M M M   S        G          R    R   I    D     D
 C           M  M  M    SSSS    G          RRRRR    I    D     D
 C           M     M        S   G   GGG    R  R     I    D     D
  C    C     M     M   S    S    G    G    R   R    I    D    D
   CCCC      M     M    SSSS      GGGG     R    R   I    DDDDD


                       Return for more...
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ------------------------------------------> 1     *
*                                                                   *
*    Enter CMSGRID Module ----------------------------------> 2     *
*                                                                   *
*    Return to Main Menu -----------------------------------> 3     *
*                                                                   *
*********************************************************************
```

```
Enter option number ------------------> 2
```

```
*************************************************************
*                    CMSGRID COMPONENTS                     *
*************************************************************
*   MAPIT: (Stretched/constant rectangular                  *
*            coordinate grid generator) -------------->  1 *
*                                                           *
*   DRAWIT:    (Graphical program to plot grids             *
*            generated by MAPIT) -------------------->  2 *
*                                                           *
*   LISTIT:    (Program to print grid coordinate            *
*            points) ------------------------------->  3 *
*                                                           *
*   EXIT:  (Terminate computer session) ------------>  4  *
*************************************************************
```

The user is prompted to select a CMSGRID component:

```
Enter option number  -------------------->  1
```

The CMS responds:

```
     X       X          X       XXXXXX      XXXXXXX   XXXXXXX
     XX     XX         X X      X     X        X         X
     X X   X X        X   X     X     X        X         X
     X  X X  X       XXXXXXX    XXXXXX         X         X
     X   X   X       X     X    X              X         X
     X       X       X     X    X              X         X
     X       X       X     X    X           XXXXXXX      X

                        Return for more...
```

The user is prompted to provide a name for the output file which will contain the grid stretching coefficients:

```
Enter output file name  2area2.map
```

The user is prompted to select a mapping direction:

```
SPECIFY MAPPING DIRECTION (X OR Y):
NOTE:  REGIONS MUST BE MAPPED IN SEQUENCE...
X
```

The user is prompted for an initial distance for the grid origin (x) and an initial grid cell index number (ALPHA):

```
SPECIFY INITIAL X DISTANCE AND ALPHA
(CARRIAGE RETURN EMPLOYS DEFAULTS: X=0.0 AND ALPHA=1)
*** USE ONLY INTEGERS FOR ALL ALPHAS INPUT!!!
0.0 1
```

The user is prompted for an initial cell size (x'):

```
SPECIFY ASSOCIATED DERIVATIVE X-PRIME:
1.
```

The user may now chose to display a menu of valid commands:

```
CHOOSE AN INSTRUCTION FROM THE MENU:
   ...MAY BE ABBREV TO FIRST 3 CHAR...
   ...ENTER "MENU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...
?
```

The program responds:

```
                 INSTRUCTION MENU FOR PROGRAM MAPIT:

KEYWORD:  INPUT DATA:      DEFAULTS:    KEYWORD FUNCTION:

MENU                                    PRINTS THIS MENU
SINGLE    X2 X2P           NONE         SINGLE REGION MAPPING
DOUBLE    X3 X3P AL3 AL2   NONE         DOUBLE REGION MAPPING
BACKUP    REG              CURRENT REG  BACK UP/REDO REGION (REG=0
                                        RESTARTS DIR)
SUMMARY                                 SUMMARIZES MAPPING WORK DONE
SO                                          FAR
ENDDIR                                  ENDS THIS MAPPING DIRECTION
AND                                          SAVES DATA
DEBUG     "ON" OR "OFF"    "OFF"        PRINTING SWITCH FOR PROGRAM
                                        DEBUGGING
AN EXPLANATION OF THE INPUT DATA:
X2  - DISTANCE AT RIGHT SIDE OF A SINGLE REGION
X2P - SLOPE (X-PRIME) AT RIGHT SIDE OF A SINGLE REGION
X3  - DISTANCE AT FAR END OF THE SECOND REGION
X3P - SLOPE (X-PRIME) AT FAR END OF THE SECOND REGION
AL3 - ALPHA AT FAR END OF THE SECOND REGION
AL2 - ALPHA AT THE MIDDLE REGION LINE OF A DOUBLE REGION
REG - THE REGION NUMBER YOU WISH TO REMAP
      (NOTE ALL MAPPING COMPUTATIONS AFTER THIS REGION ARE
      WRITTEN OVER AND WIPED OUT)
```

The user selects a single region 15 units long with an ending cell size of 1 unit:

```
CHOOSE AN INSTRUCTION FROM THE MENU:
   ...MAY BE ABBREV TO FIRST 3 CHAR...
   ...ENTER "MENU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...
SINGLE 15. 1.
```

Since the initial cell size (x') was 1 unit, then the cells for this region are a constant value of 1 unit. The program responds:

```
          FOR REGION     1
     X1 -   0.00000      ALPHA1 -  1       X1 PRIME -  1.00000000
     X2 -  15.00000      ALPHA2 -  16      GIVEN X2 PRIME -  1.00000000
 X2CALC -  15.00000                         CALC X2 PRIME -  1.00000000

         A - -.100000000000000000E+01
         B - 0.100000000000000000E+01
         C - 0.100000000000000000E+01
```

The user selects a single region ending 25 units from the origin with an ending cell size of 0.5 units:

```
CHOOSE AN INSTRUCTION FROM THE MENU:
   ...MAY BE ABBREV TO FIRST 3 CHAR...
   ...ENTER "MENU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...
SINGLE 25. .5
```

The program responds:

```
          FOR REGION     1
     X1 -  15.00000      ALPHA1 -  16            X1 PRIME -  1.000000000
     X2 -  25.00000      ALPHA2 -  30      GIVEN X2 PRIME -  1.000000000
 X2CALC -  24.74005                         CALC X2 PRIME -  0.52722165


         A - 0.887645621036801458E+03
         B - -.918153961332387552E+03
          C - -.183350487463515010E-01
```

The user has completed mapping the x-direction:

```
CHOOSE AN INSTRUC.ION FROM THE MENU:
   ...MAY BE ABR..EV TO FIRST 3 CHAR...
   ...ENTER '..NU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...
END
```

The program responds:

```
X-DIRECTION MAPPING COMPLETE:    2 REGIONS
```

REG	X-SPACE		ALPHA		X-PRIME		A	B	C
	FROM	TO	FROM	TO	FROM	TO			
1	0.0000	15.0000	1	16	1.000	1.000	-1.000	1.000	1.000
2	15.0000	25.0000	16	30	1.000	0.527	887.6	-918.2	-.1834E-01

The user selects to map another direction:

```
MAPPING IN THE X DIRECTION IS COMPLETED
DO YOU WISH TO MAP IN ANOTHER DIRECTION (Y/N)?
Y
```

The user specifies which direction to map:

```
SPECIFY MAPPING DIRECTION (X OR Y):
Y
```

The user is prompted for an initial distance from the grid origin (Y) and an initial cell size (ALPHA):

```
SPECIFY INITIAL Y DISTANCE AND ALPHA
(CARRIAGE RETURN EMPLOYS DEFAULTS: Y=0.0 AND ALPHA=1)
*** USE ONLY INTEGERS FOR ALL ALPHAS INPUT!!!

0,0 1
```

The user is prompted for an initial cell size (Y'):

```
SPECIFY ASSOCIATED DERIVATIVE Y-PRIME:
1.
```

The user selects a single region 15 inches in length with a cell size of 1 inch:

```
CHOOSE AN INSTRUCTION FORM THE MENU:
   ...MAY BE ABBREV TO FIRST 3 CHAR...
   ...ENTER "MENU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...
SINGLE 15. 1.
```

Since the initial cell size (Y') was 1 inch, then the cells for this region are a constant value of 1 inch. The program responds:

```
          FOR REGION    1
     Y1 -   0.00000     ALPHA1 -   1          Y1 PRIME -  1.00000000
     Y2 -  15.00000     ALPHA2 -  16    GIVEN Y2 PRIME -  1.00000000
Y2CALC -  15.00000                       CALC Y2 PRIME -  1.00000000

          A - -.100000000000000000E+01
          B - 0.100000000000000000E+01
          C - 0.100000000000000000E+01
```

The user has completed mapping the y-direction:

```
CHOOSE AN INSTRUCTION FROM THE MENU:
   ...MAY BE ABBREV TO FIRST 3 CHAR...
   ...ENTER "MENU" OR "?" TO SEE MENU...
   ...PLEASE USE UPPERCASE...


END
```

The program responds:

```
Y-DIRECTION MAPPING COMPLETE:    1 REGIONS

 REG      Y-SPACE         ALPHA       Y-PRIME         A          B          C
      FROM       TO     FROM   TO   FROM    TO
   1  0.0000  15.0000     1    16   1.000  1.000 -1.000     1.000      1.000


 MAPPING IN THE Y DIRECTION IS COMPLETED
 DO YOU WISH TO MAP IN ANOTHER DIRECTION (Y/N)?
 N
```

The system responds:

```
STOP
CP:  0.010s,   Wallclock:  70.114s


*** END OF CMSGRID PROCEDURE ***
```

Program output

46. Output of program MAPIT consists of a file containing the XSTRETCH and YSTRETCH records used by models WIFM and SPH. These records can be directly added to those models' input data files. Furthermore, this file can be processed using programs LISTIT and DRAWIT, which are discussed in the following sections.

Program DRAWIT

47. Program DRAWIT is an interactive program for graphically displaying and/or plotting the computational grid produced by program MAPIT. Hence, program MAPIT must be executed first to develop the grid stretching coefficients. In addition, bathymetric data can be plotted directly on the computational grid, if such data are available in a computer file in the format shown below:

```
BATHSPEC      FEET     0.0     0.0      -10.0     XY     (9F8.2)
-10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00
-10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00
-10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00  -10.00
. . .
```

48. Program DRAWIT presently can generate graphical output for the following devices:

a. Tektronix 4014 terminals, DEC VT series terminals, or compatible devices.

b. Hewlett Packard DraftMaster II drum plotters or compatible devices.

49. A drum plotter is typically used for producing map overlays. These overlays are very helpful when developing input bathymetry/topography data set for models such as WIFM. Presently, the map overlays can be plotted at the Waterways Experiment Station (WES) Coastal Engineering Research Center (CERC) or Information Technology Laboratory (ITL). The user may wish to contact their ADP coordinator to determine whether a plot file can be plotted on in-house devices.

Program execution

50. The interactive session begins by entering the command:

```
h2crplc1:larry$/u3/h2crplc0/cms
```

The CMS responds:

```
 W E L C O M E   T O . . .

  XXXXX          X     X          XXXXX
 X     X         XX   XX         X     X
 X               X X X X         X
 X               X  X  X          XXXXX
 X               X     X               X
 X     X         X     X         X     X
  XXXXX          X     X          XXXXX

             Return for more...
```

```
**********************************************************************
*                         C M S   COMPONENTS                         *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------>  1   *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                 numerical models)  ----------------------->  2     *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  ----------------->  3    *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  ----------------->  4    *
*                                                                    *
*  CMSSAMP (Sample input and output files for each model)  --->  5   *
*                                                                    *
*  Exit CMS  ---------------------------------------------->  q      *
**********************************************************************
```

Enter option number ------------------------> 1

The CMS responds:

```
   CCCC      M     M    SSSS     GGGG    RRRRR    I   DDDDD
  C    C     MM   MM   S    S   G    G   R    R   I   D    D
 C           M M M M   S       G         R    R   I   D     D
 C           M  M  M    SSSS   G         RRRRR    I   D     D
 C           M     M        S  G   GGG   R  R     I   D     D
  C    C     M     M   S    S   G    G   R   R    I   D    D
   CCCC      M     M    SSSS     GGGG    R    R   I   DDDDD


                        Return for more...
```

```
*********************************************************************
*                                                                   *
*                 USING THE COASTAL MODELING SYSTEM                 *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ---------------------------------------->  1     *
*                                                                   *
*    Enter CMSGRID Module -------------------------------->  2     *
*                                                                   *
*    Return to Main Menu --------------------------------->  3     *
*                                                                   *
*********************************************************************
```

```
Enter option number ------------------> 2
```

```
*************************************************************
*                  CMSGRID COMPONENTS                       *
*************************************************************
*  MAPIT: (Stretched/constant rectangular                  *
*          coordinate grid generator) -------------> 1 *
*                                                           *
*  DRAWIT:    (Graphical program to plot grids
           *
*          generated by MAPIT) ------------------> 2 *
*                                                           *
*  LISTIT:    (Program to print grid coordinate
*
*          points) ------------------------------> 3 *
*                                                           *
```

The user is prompted to select a CMSGRID component:

Enter option number ------------------> 2

The CMS responds:

```
DDDDDD        RRRRR         A        W     W    IIIIIII   TTTTTTT
D    D        R    R       A A       W     W       I         T
D     D       R    R      A   A      W     W       I         T
D     D       RRRRR      AAAAAAA     W  W  W       I         T
D     D       R R        A     A     W W W W       I         T
D    D        R  R       A     A     WW   WW       I         T
DDDDDD        R   R      A     A     W     W    IIIIIII      T


                        Return for more...
```

The user is prompted for the file name generated by MAPIT containing grid stretching coefficients:

Enter name of the input data set 2area2.map

The user is prompted for bathymetric data if they exist:

```
Do you want to plot bathymetric data on the grid
N
```

The program responds:

```
     CURRENT PLOT FEATURE SUMMARY:
   INDEX DIRECTION:  ----X-----   ----Y-----
 NO. OF GRID CELLS:     1 TO  29    1 TO  15
    CURRENT WINDOW:     1 TO  29    1 TO  15
    CURRENT LENGTH:   26.69(IN)   16.01(IN)
        CURRENT SCALE:    1.00
        PLOT CELL INDICES:  YES
        PLOT BATHYMETRY:  NO         BATHYMETRY FILE:   N/A
        FTITLE:
 PRESS RETURN TO CONTINUE . . .

AVAILABLE MENU ITEMS:
CHOICE:                    FUNCTION

MENU                       PRINTS THIS LIST OF INSTRUCTIONS
STOP                       ENDS PROCEDURE
FTITLE PLTITL              DECLARES PLOT TITLE...64 CHAR OR LESS
WINDOW IX1, IX2, IY1, IY2  SELECTS PLOT WINDOW
WHOLE                      SELECTS WHOLE GRID FOR PLOTTING
SCALE PLSCAL               SELECTS DESIRED PLOTTING SCALE
INDICES                    CELL INDICES TO BE LABELLED
NOINDICES                  NO LABELLING OF CELL INDICES
BATH BATHFIL               BATHYMETRY VALUES TO BE INDICATED
                           ... BATHYMETRY DATA TO BE READ FROM FILE:
 NOBATH                     BATHYMETRY VALUES WILL NOT BE INDICATED
 SUMMARY                    PRINT CURRENT PLOT FEATURES
 HARDCOPY                   GENERATE THE PLOT (ON THE LOCAL
                            PLOTFILE)
```

```
   CHOOSE AN INSTRUCTION FROM THE MENU:
...MAY BE ABBREV TO FIRST 3 CHAR...
...PLEASE USE UPPERCASE...
```

A selection is made from the available menu items given in Table A-3.

Table A-3

DRAWIT Instructions

Instruction	Data	Description
MENU		Displays instruction commands.
STOP		Terminates program execution.
TITLE	title	Writes a title of up to 64 characters on plot.
WINDOW	IX1,IX2,IY1,IX2 (integers)	Defines a subgrid area to be plotted. IX1 = minimum x-axis cell index IX2 = maximum x-axis cell index IY1 = minimum y-axis cell index IY2 = maximum y-axis cell index
WHOLE		Entire grid will be plotted.
SCALE		Plotting scale to enlarge or shrink grid size on output medium.
INDICES		Cell indices will be printed on plot.
NOINDICES		Cell indices will not be printed on plot.
BATH	file name	Bathymetry values, supplied from file listed in instruction, will be printed on plot.
NOBATH		Bathymetry values will not be printed.
SUMMARY		Displays current plotting parameters.
HARDCOPY		Produces plot.

The user selects not to plot cell indices:

```
NOI
            PLOT CELL INDICES:  NO


CHOOSE AN INSTRUCTION FROM THE MENU:
     ...MAY BE ABBREV TO FIRST 3 CHAR...
     ...PLEASE USE UPPERCASE...
```

The user selects the plot generation option:

```
HAR

  END OF DISSPLA 10.0 -- 1375 VECTORS IN 1 PLOTS.
  RUN ON 10/25/90 USING SERIAL NUMBER 60 AT USA VICKSBURG CORPS OF
  ENGINEERS
  PROPRIETARY SOFTWARE PRODUCT OF ISSCO, SAN DIEGO, CALIF.
  139 VIRTUAL STORAGE REFERENCES; 4 READS; 0 WRITES.


  CHOOSE AN INSTRUCTION FROM THE MENU:
     ...MAY BE ABBREV TO FIRST 3 CHAR...
     ...PLEASE USE UPPERCASE...
```

The user selects to end the DRAWIT procedure:

```
STO

*** PROGRAM ENDING:   0 PLOTS GENERATED
 STOP
CP: 0.080S, Wallclock:  111.689s

*** END OF CMSPOST PROCEDURE
```

51. To display the grid on a terminal screen, the user sets the terminal to TEK 4014 using the set up key and enters the command:

```
h2crplcl:larry$ /u3/h2crplc0/cmsplot
```

The system responds:

```
ENTER POST-PROCESSOR DIRECTIVES

PLOT FILE GENERATED BY PID18433
              AT ISSCO
              ON OCT 25, 1990  14:27
```

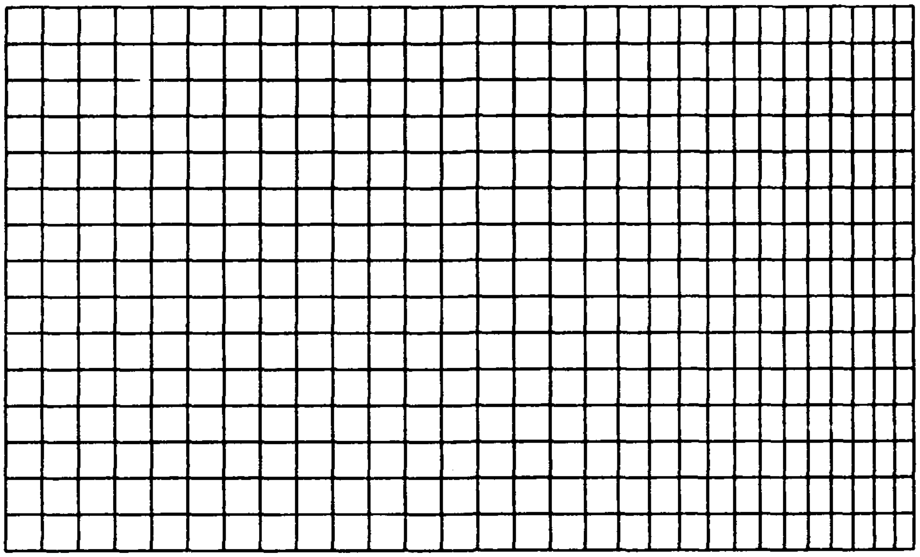

Figure A-4. Sample grid from program DRAWIT

The plotting file can be displayed on the VAX 8800 by following the procedure outlined below. The metafile created by the CRAY Y-MP DRAWIT program (metfil) is converted to a hexafile (metafile.hex) using the CRAY Y-MP system utility meta2hex as follows:

```
h2crplcl:larry$  meta2hex

****************
*  CA-DISSPLA  *
*   META2HEX   *
****************

Enter name of DISSPLA metafile to be converted [popfil]:
metfil

Enter name of output hex metafile [metafile.hex]:  <ret>

* Conversion complete - output file is metafile.hex *
STOP
```

The user then transfers the hexafile to the VAX 8800 as follows:

```
h2crplcl:larry$  ftp wesim3
Connected to wesim3.
220 wesim3.army.mil Wollongong FTP Server  (Version 5.1)  at Wed
Oct 10 10:56T
Name (wesim3:h2crplcl):  h2crplc0
331 Password required for h2crplc0.
Password: __________
230  User logged in, default directory $DISK2:[H2CRPLC0]
Remote system type is VMS
```

```
ftp> put metafile.hex
200 PORT Command OK.
125 File transfer started correctly
226 File transfer completed ok
119481 bytes sent 1.2 seconds (97Kbytes/s)
ftp> quit
221 Goodbye.
h2crplcl:larry$
Connection closed to larry.wes.army.mil
```

The hexafile is then converted to a metafile on the VAX 8800 using the system utility HEX2META as follows:

```
$ HEX2META

****************
*  CA-DISSPLA  *
*   HEX2META   *
****************

Enter name for output binary DISSPLA metafile [popfil.dat]:  <ret>

Enter name of input DISSPLA hex metafile [metafile.hex]:  <ret>

* Starting translation of DISSPLA hex metafile created on 10/10/90 at
  10:56:40
* CRAY filename was metfil
* Metafile conversion is complete output file is POPFIL.DAT *
```

The output file can then be transferred to the CERC VAX 3300 for plotting on the drum plotter by invoking the command:

```
COPY WESIM3"username password"::$DISK3:[VAX8800 acct]popfil.dat pictur.dat
```

52. To plot on the drum plotter located in the CERC terminal room, the user logs onto the terminal adjacent to the drum plotter by typing:

```
C> C Surf (Inlet, or Aeolus)
```

The system will prompt the user for a VAX 3300 user name and password. Once logged onto the VAX 3300, the user must create a file called DRUMPLT.FOR as given below:

```
CALL HP75
CALL METNAM('PICTUR',6)
CALL DISPOP(1)
STOP
END
```

To compile and link the DRUMPLT file, the user types:

```
$ DISS DRUMPLT
```

To produce an actual size plot, type:

```
$ Run Drumplt
```

Program LISTIT

53. Program LISTIT produces a file containing a listing of the stretched rectilinear coordinates computed from the stretching coefficients generated by program MAPIT. Therefore, program MAPIT must be executed first, and its output file stored as an indirect access file before attempting to use program LISTIT.

Program execution

54. Program LISTIT is executed interactively by the commands:

```
h2crplc1:larry$/u3/h2crplc0/cms
```

The CMS responds:

```
           W E L C O M E   T O . . .

       XXXXX         X     X        XXXXX
      X     X        XX   XX       X     X
      X              X X X X       X
      X              X  X  X        XXXXX
      X              X     X             X
      X     X        X     X       X     X
       XXXXX         X     X        XXXXX


               Return for more...
```

```
**********************************************************************
*                          C M S   COMPONENTS                        *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------>  1  *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                 numerical models)  ----------------------->  2  *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  ----------------->  3  *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  ----------------->  4  *
*                                                                    *
*  CMSSAMP (Sample input and output files for each model  ---->  5  *
*                                                                    *
*  Exit CMS  ----------------------------------------------->  q  *
**********************************************************************
```

```
Enter option number  ------------------------>  1
```

The CMS responds:

```
   CCCC      M     M    SSSS      GGGG     RRRRR     I    DDDDD
  C    C     MM   MM   S    S    G    G    R    R    I    D    D
 C           M M M M   S        G          R    R    I    D     D
 C           M  M  M    SSSS    G          RRRRR     I    D     D
 C           M     M        S   G   GGG    R  R      I    D     D
  C    C     M     M   S    S    G    G    R   R     I    D    D
   CCCC      M     M    SSSS      GGGG     R    R    I    DDDDD


                     Return for more...
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ------------------------------------------> 1   *
*                                                                   *
*    Enter CMSGRID Module  ----------------------------------> 2   *
*                                                                   *
*    Return to Main Menu  -----------------------------------> 3   *
*                                                                   *
*********************************************************************
```

Enter option number ------------------> 2

```
***************************************************************
*                    CMSGRID COMPONENTS                       *
***************************************************************
*   MAPIT: (Stretched/constant rectangular                    *
*           coordinate grid generator) --------------> 1     *
*                                                             *
*   DRAWIT:    (Graphical program to plot grids               *
*              generated by MAPIT) ------------------> 2     *
*                                                             *
*   LISTIT:    (Program to print grid coordinate              *
*              points) ----------------------------> 3       *
*                                                             *
*   EXIT:  (Terminate computer session) -------------> 4     *
***************************************************************
```

The user is prompted to select a CMSGRID component:

Enter option number -----------------> 3

The CMS responds:

```
X             X       XXXXX     XXXXXXX     X       XXXXXXX
X             X      X     X       X        X          X
X             X      X             X        X          X
X             X       XXXXX        X        X          X
X             X            X       X        X          X
X             X      X     X       X        X          X
XXXXXXXX      X       XXXXX        X        X          X

                    Return for more...
```

Enter name of the input data set **mock.map**

Enter name of the output file **mock.lst**

The system responds:

```
...NORMAL TERMINATION...PROCESSING FINISHED
  STOP
CP: 0.019S, Wallclock: 0.028s,  10.9% of 6-CPU Machine

*** END OF CMSPOST PROCEDURE
```

Program LISTIT produces an output file containing the grid coordinates. "FACE" indicates the location of the edge of a grid cell and "CENTER" indicates the location of the grid cell center. Output file mock.lst is displayed as follows:

```
h2crplcl:larry$ pg mock.lst

** SUMMARY OF MAPPED REGIONS:

 REGION  NO.      CELL       ALPHA            A            B             C
               FROM  TO   FROM  TO
XREGION   1      1   30     1.  31.      -1.00000     1.00000       1.00000
YREGION   1      1   15     1.  16.      -1.00000     1.00000       1.00000


 *** SUMMARY OF X-COORDINATES:

     CELL
     INDEX  ALPHA  FEATURE    X              X'             X"

     -----   1.0     FACE:  0.0000000000   1.0000000000   0.0000000000
       1     1.5   CENTER:  0.5000000000   1.0000000000   0.0000000000
     -----   2.0     FACE:  1.0000000000   1.0000000000   0.0000000000
       2     2.5   CENTER:  1.5000000000   1.0000000000   0.0000000000
     -----   3.0     FACE:  2.0000000000   1.0000000000   0.0000000000
       3     3.5   CENTER:  2.5000000000   1.0000000000   0.0000000000
     -----   4.0     FACE:  3.0000000000   1.0000000000   0.0000000000
       4     4.5   CENTER:  3.5000000000   1.0000000000   0.0000000000
     -----   5.0     FACE:  4.0000000000   1.0000000000   0.0000000000
       5     5.5   CENTER:  4.5000000000   1.0000000000   0.0000000000
     -----   6.0     FACE:  5.0000000000   1.0000000000   0.0000000000
       6     6.5   CENTER:  5.5000000000   1.0000000000   0.0000000000
     -----   7.0     FACE:  6.0000000000   1.0000000000   0.0000000000
       7     7.5   CENTER:  6.5000000000   1.0000000000   0.0000000000
     -----   8.0     FACE:  7.0000000000   1.0000000000   0.0000000000
       8     8.5   CENTER:  7.5000000000   1.0000000000   0.0000000000
     -----   9.0     FACE:  8.0000000000   1.0000000000   0.0000000000
       9     9.5   CENTER:  8.5000000000   1.0000000000   0.0000000000
```

REFERENCE

EM 1110-2-1412. 1986. "Engineering and Design Storm Surge Analysis," Department of the Army Corps of Engineers, Office of the Chief of Engineers.

APPENDIX B: CMSUTIL

Introduction

1. CMSUTIL is the software package in the Coastal Model System (CMS) that provides the user access to programs that supplement the CMS models. Presently, the following programs reside in this package:

TIDEGEN	Generates tidal elevation time-history data at select locations from tidal harmonic constituents.
TIDECON	Synthesizes tidal harmonic constituents from a time series of hourly tidal elevations.

2. Descriptions of each program, including data requirements and execution procedures, are provided in the following sections.

Program TIDEGEN

3. Program TIDEGEN generates a time series of tidal elevations from tidal harmonic constituents. The mathematical procedures used to produce the data are described in Schureman*. This program can simultaneously process records for a maximum of 60 gage locations. The following data are required for each gage:

a. Longitude of the gage.

b. Constituents that are applicable to that gage location.

c. Amplitudes and epochs corresponding to each constituent selected in item b.

d. Starting date and local time at the specified longitude.

4. The National Ocean Service (NOS) provides amplitude and epoch data for different tidal constituents at US coastal locations. To facilitate the use of NOS information, program TIDEGEN uses the same constituent names as NOS. Table B-1 presents a list of those constituents available for use in this program.

5. The output of TIDEGEN consists of a file containing the computed water surface elevations and an optional printout of the constituents. Model WIFM contains TIDEGEN as a component to compute the tide data internally

* P. Schureman, 1958, "Manual of Harmonic Analysis and Prediction of Tides," Special Publication No. 98, US Coast and Geodetic Survey, Department of Commerce, Washington, DC.

during the course of a simulation. However, it is suggested that the user reproduce the data with TIDEGEN before running WIFM to check the accuracy of the program output. Tide elevations may be plotted using program HYDPLT in package CMSPOST (Appendix C).

6. The first tidal elevation in the output file corresponds to the starting date and time. Time intervals between subsequent tidal elevations are constant; however, the time interval depends on the total length of time for which output data are generated. Table B-2 presents the time intervals at which the output data are generated.

Data requirements

7. An instruction file containing certain input data records must be created before executing the TIDEGEN program (see Table B-3). Each instruction or data record in the file must begin with a record identifier starting in column 1, which identifies the type of data. For example, record identifier EPCH1 is for the epoch of each constituent associated with gage 1, AMPL1 is for the amplitude of each constituent associated with gage 1, and so forth. Table B-3 presents the instruction file records applicable to this program. Data to the right of the record identifiers are read format-free. These data must be separated by at least one blank column (commas cannot be used). Note the "Type" designations [R] and [O] in column 1 of Table B-3 indicate required and optional records, respectively.

8. The TITLE record gives the simulation a general title that can be used by the plotting program, HYDPLT. The TIMES record specifies the starting time for computing tidal elevation data. Parameters contained on this record include the year, month, day, and hour for beginning the simulation and the length of the simulation, in hours. The GNAM_ record is used to give a reference name to a particular time series, or gage. (The _ is explained in the following paragraph.)

9. Each gage requires one set of GNAM_, LONG_, CNST_, AMPL_, and EPCH_ commands, entered in the order specified in Table B-3. The record identifiers describing the gage, constituent, amplitude, epoch, and longitude data require a qualifier or number that corresponds to the gage number. This qualifier must be immediately adjacent to the record identifier. The first gage has the qualifier "1," the second gage has the qualifier "2," and so forth.

10. The LONG_ provides the longitude (in degrees) west of the Greenwich meridian for the specific gage. If the command LONG1 is omitted, the time

Table B-1

List of Available Constituents

Reference Number	NOS Name	Description
1	M2	Semidiurnal
2	S2	Semidiurnal
3	N2	Semidiurnal
4	K1	Diurnal
5	M4	Shallow-water quarter diurnal
6	O1	Diurnal
7	M6	Shallow-water sixth diurnal
8	MK3	Shallow-water terdiurnal
9	S4	Shallow-water quarter diurnal
10	MN4	Shallow-water quarter diurnal
11	NU2	Semidiurnal
12	S6	Shallow-water sixth diurnal
13	MU2	Semidiurnal
14	2N2	Semidiurnal
15	OO1	Diurnal
16	LAMBDA2	Semidiurnal
17	S1	Diurnal
18	M1	Diurnal
19	J1	Diurnal
20	MM	Long-period
21	SSA	Long-period
22	SA	Long-period
23	MSF	Long-period
24	MS	Long-period
25	RHO1	Diurnal
26	Q1	Diurnal
27	T2	Semidiurnal
28	R2	Diurnal
29	2Q1	Diurnal
30	P1	Diurnal
31	2SM2	Shallow-water semidiurnal
32	M3	Terdiurnal
33	L2	Semidiurnal
34	2MK3	Shallow-water terdiurnal
35	K2	Semidiurnal
36	M8	Shallow-water eight diurnal
37	MS4	Shallow-water quarter diurnal

Table B-2

TIDEGEN Output Data Time Intervals

Simulation Length hr			Time Interval min
	<	1.5	0.5
1.5	-	3.0	1.0
3.0	-	7.0	2.0
7.0	-	15.0	5.0
15.0	-	25.0	10.0
25.0	-	45.0	15.0
45.0	-	90.0	30.0
90.0	-		60.0

specified in command TIMES would default to Greenwich time. For each selected constituent for a particular gage, the user must specify a corresponding amplitude using record AMPL_. For example, if GNAM1 has constituents M2 and S2, then record AMPL1 would contain two amplitudes, one corresponding to constituent M2 and the other corresponding to S2. Similarly, the epoch is provided for each constituent selected for a particular gage using record EPCH_.

11. Constituents are designated on the CNST_ record by their reference number, or index (see Table B-1) rather than by their names. However, if all 37 constituents are desired, the user may enter "ALL" instead of listing all of the reference numbers. Also, if some of the reference numbers are consecutive, the user can list the first number, immediately followed by a hyphen, then the last reference number (e.g., 5-9 would include constituents 5 through 9 from Table B-1).

Table B-3

Instruction File Records for Program TIDEGEN

Type	CARDID	Data	Default	Description
[R]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[R]	TIMES	YR MNTH DAY SHR RHR	none	Time at beginning of computation. YR = calendar year (e.g., 1981). Integer. MNTH = calendar month (e.g., February = 2). Integer. DAY = calendar date. Integer. SHR = starting hour, local time (e.g. 13.) Real. RHR = record length of computed time-histories, hours (e.g. 720.) Real.
[R]	GNAM_	gage name	none	Gage name, up to 45 characters. Qualifier _ referenced to gage number.
[R]	LONG_	longitude	none	Longitude (in deg) west of the Greenwich meridian.
[R]	CNST_	constituent index	none	Constituent index value. Up to 37 constituents can be selected for processing. Qualifier _ referenced to gage number.
[R]	AMPL_	constituent amplitude	none	Amplitude(s) for constituents in command CNST_. (Ft) Command must include one amplitude for each constituent, and amplitudes must be entered in identical order to their respective constituent. Qualifier _ referenced to gage number.
[R]	EPCH_	constituent epoch		Epoch(s) for constituents in command CNST_. (Deg.) Command must include one epoch for each constituent, and epochs must be entered in identical order to their respective constituent. Qualifier _ referenced to gage number.
[O]	GLIST	none	N/A	Prints summary of tidal constituent data.
[O]	DEBUG	none	N/A	Generates output to locate errors in processing.

12. The following example illustrates the structure of the instruction file:

```
TITLE          EXAMPLE INSTRUCTION FILE
TIMES          1987  2  14  12  36
GAGE1          GAGE NO. 1
LONG1          135.0
CNST1          1  3
AMPL1          2.0  0.5
EPCH1       35.0   90.0
GAGE2          GAGE NO. 2
LONG2       135.2
CNST2       3-5
AMPL2       0.25  0.10  0.05
EPCH2      15.0  5.0  45.0
```

13. For this example, two tidal elevation time-histories will be generated. The starting date and time for each gage is 12 noon on 14 February 1987 (local time), and data will be produced, at 10-min intervals, for the 36-hr record length.

14. Gage no. 1 is located 135.0 deg west of the Greenwich meridian (i.e., command LONG1). Constituents M2 and N2, selected with command CNST1 (see Table B-1) are used to generate the tidal elevation time-history. Constituent M2 has an amplitude of 2.0 ft and an epoch of 35.0 deg. Constituent N2 has an amplitude and epoch of 0.5 ft and 90.0 deg, respectively.

15. Three constituents are used to generate the tidal elevation time-history for the second gage. These constituents are N2, K1, and M4. Amplitudes and epochs are assigned to their respective constituents in the same fashion as for gage no. 1.

<u>Program execution</u>

16. After creating and saving the instruction file, the user enters the following interactive command at the system prompt:

```
h2crplc1:larry$/u3/h2crplc0/cms
system prompt     user entry
```

It should be noted that user entries are shown as shaded, and CMS response "screens" are shaded boxes.

The CMS responds:

```
 W E L C O M E   T O . . .

  XXXXX          X    X      XXXXX
 X     X         XX  XX     X     X
 X               X X X X    X
 X               X  X  X     XXXXX
 X               X     X          X
 X     X         X     X    X     X
  XXXXX          X     X     XXXXX

            Return for more...
```

```
**********************************************************************
*                          C M S   COMPONENTS                        *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------> 1    *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                numerical models)  -------------------------> 2     *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  -----------------> 3     *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  -----------------> 4     *
*                                                                    *
*  CMSSAMP (Sample input and output files for each model  ----> 5    *
*                                                                    *
*  Exit CMS  -----------------------------------------------> q      *
**********************************************************************
```

To enter CMSUTIL, the user enters a value of 4:

Enter option number ------------------------> 4

The CMS responds:

```
  CCCC        M     M     SSSS     U    U    TTTTTTT    I    L
 C    C       MM   MM    S    S    U    U       T       I    L
C             M M M M    S         U    U       T       I    L
C             M  M  M     SSSS     U    U       T       I    L
C             M     M         S    U    U       T       I    L
 C    C       M     M    S    S    U    U       T       I    L
  CCCC        M     M     SSSS      UUUU        T       I    LLLLLL

                          Return for more...
```

```
*********************************************************************
*                                                                   *
*                  USING THE COASTAL MODELING SYSTEM                *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ------------------------------------------> 1     *
*                                                                   *
*    Enter CMSUTIL Module ----------------------------------> 2     *
*                                                                   *
*    Return to Main Menu -----------------------------------> 3     *
*                                                                   *
*********************************************************************
```

```
Enter option number -------------->
```

```
*******************************************************************
*                        C M S U T I L   M E N U                  *
*******************************************************************
*                                                                 *
*   TIDEGEN  Generates a time series of tidal elevations          *
*            from harmonic and tidal constituents. -----> 1       *
*                                                                 *
*   TIDECON  Synthesizes harmonic constituents from time          *
*            series of hourly tidal elevation data. ----> 2       *
*                                                                 *
*   EXIT  ------------------------------------------------> 3     *
*                                                                 *
*******************************************************************
```

To execute program TIDEGEN, the user enters a value of 1:

Enter option number ----------------------> 1

The CMS responds:

```
TTTTTTT    I    DDDDD     EEEEEE     GGGG       EEEEEE    N      N
   T       I    D    D    E         G    G      E         NN     N
   T       I    D     D   E        G            E         N N    N
   T       I    D     D   EEEE     G            EEEE      N  N   N
   T       I    D     D   E        G   GGG      E         N   N  N
   T       I    D    D    E         G    G      E         N    NN
   T       I    DDDDD     EEEEEE     GGGG       EEEEEE    N      N


                         Return for more...
```

Enter the name ofthe instruction file: tidegen.ins

The user can choose any meaningful naming convention when selecting filenames. For example, the user may choose a project name with different extensions for each file.

Enter the name of the output file containing water surface elevations:

tidegen.hyd

Constituent print-out desired? y

Enter the name of the constituent output file: tidegen.con

The CMS submits a batch job to the CRAY Y-MP and the system responds:

Request 1234.larry submitted to queue prime.

The user enters a 3 to terminate the CMSUTIL session and return to the main menu.

Program output

17. Program TIDEGEN's output file containing the time series of tidal elevations for each gage can be printed for inspection of the values, or it can be used as direct input to models WIFM and CLHYD or the plotting program HYDPLT in package CMSPOST.

```
*******************************************************************
*                     C M S U T I L   M E N U                     *
*******************************************************************
*                                                                 *
*   TIDEGEN  Generates a time series of tidal elevations          *
*            from harmonic and tidal constituents. -----> 1       *
*                                                                 *
*   TIDECON  Synthesizes harmonic constituents from time          *
*            series of hourly tidal elevation data. ----> 2       *
*                                                                 *
*   EXIT --------------------------------------------> 3          *
*                                                                 *
*******************************************************************
```

Program TIDECON

18. Program TIDECON synthesizes harmonic constituents from a time series of hourly tidal elevation data. This program requires the following data:

   a. Time series of tidal elevation data in the format used by the National Ocean Service (NOS) (see Table B-4).

   b. Longitude of the gage.

   c. Constituent(s) that are desired.

   d. Starting date of the tide data. Starting time of data must be at midnight (HR 0).

19. Tide data must be free of gaps, spikes, and other errors in order to compute accurate constituents. No error correction or data reconstruction features exist in this program. Furthermore, the tidal elevation time-history data set length required varies from constituent to constituent. A minimum of 30 days of continuous hourly data are needed to resolve lunar constituents (for example, M2). However, some longer period constituents (which usually have a relatively small effect on the total tidal elevation) may require as many as 19 years of continuous hourly data to obtain accurate results. Hence, the user should plot the time-history data generated using the computed constituents to check the accuracy of program TIDECON output. (See program HYDPLT in package CMSPOST (Appendix C) to plot time-history data.)

20. Output consists of four files containing: (1) original gage data, (2) constituent data, (3) synthesized gage data, and (4) residual difference between original and synthesized gage data. Items (1), (3), and (4) are

Table B-4

NOS Tidal Elevation Record Format

Record Columns	Data Type	Data Field Description
1 - 19	Character	Tide Station Name or seven-digit station ID number.
20 - 25	Integer	Date (YYMMDD).
26	Integer	Card number, either 1 or 2, of 2 per day. Card number 1 corresponds to tidal elevation data starting at hour 0.
27 - 31	Integer	Gage longitude in decimal degrees times 100 (e.g. 124.18 deg = 12418)
32	Character	Longitude direction from Greenwich, England (E or W).
33 - 36	Integer	Tidal elevation at hour 0 or 12.
37 - 40	Integer	Tidal elevation at hour 1 or 13.
41 - 44	Integer	Tidal elevation at hour 2 or 14.
45 - 48	Integer	Tidal elevation at hour 3 or 15.
49 - 52	Integer	Tidal elevation at hour 4 or 16.
53 - 56	Integer	Tidal elevation at hour 5 or 17.
57 - 60	Integer	Tidal elevation at hour 6 or 18.
63 - 64	Integer	Tidal elevation at hour 7 or 19.
65 - 68	Integer	Tidal elevation at hour 8 or 20.
69 - 72	Integer	Tidal elevation at hour 9 or 21.
73 - 76	Integer	Tidal elevation at hour 10 or 22.
77 - 80	Integer	Tidal elevation at hour 11 or 23.

Table B-5

Instruction File Commands for Program TIDECON

Type	CARDID	Data	Default	Description
[R]	FILES	file name	none	Name of file to be containing gage data in NOS format. Must be first record listed in instruction file.
[R]	TIMES	YR MNTH DAY	none	Time at beginning of computation. YR = calendar year (e.g., 1981). Integer. MNTH = calendar month (e.g., February =2). Integer. DAY = calendar date. Integer.
[R]	CNST	constituent index	none	Constituent index value. Up to 37 constituents can be selected for processing.
[R]	LONG	GLONG	none	West longitude of gage, in degrees. Omit record if time on command TIMES is Greenwich time.
[O]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[O]	DEBUG	none	N/A	Generates output to locate errors in processing.

25. Time series input data must be in the format used by the NOS Tidal Evaluation Group (Table B-4). The following requirements must also be met:

<u>a</u>. The first tide record must begin at midnight (HR 0) of the date specified in the instruction file. If the user's data begin at a time other than midnight, then the time series should be truncated to begin at midnight of the following day.

<u>b</u>. Each record must contain 12 hourly values, with the first record starting at hour 0, the second record starting at hour 13, the third record starting at hour 0 of the second day, etc.

<u>c</u>. Tidal heights are entered as integers and measured in hundredths of a foot. (For example, the value "1247" translates to 12.47 ft.)

26. This program processes only the elevation data listed in columns 33 through 80 of the time series data file. Columns 1 through 32 are for optional documenting of the data set, and data in these columns are not used by the program.

27. The following example illustrates the structure of an instruction file:

```
FILES     MYDAT
TIMES     1987  2  15
LONG      135.0
CNST      1  3  6-8
TITLE     EXAMPLE INSTRUCTION FILE
```

28. In this example, tidal elevation time-history data have a starting date of 15 February 1987. The starting time, specified in the NOS data set, must be at midnight (0 hr). The time-history data will be analyzed to derive the amplitudes and epochs for the five constituents listed in command CNST. These constituents are M2, N2, 01, M6, and MK3 (see Table B-1).

<u>Program execution</u>

29. After creating and saving the instruction file, enter the following interactive commands to execute the program:

```
h2crplc1:larry$/u3/h2crplc0/cms
```

The CMS responds:

```
          W E L C O M E   T O . . .


     XXXXX          X     X          XXXXX
    X     X         XX   XX         X     X
    X               X X X X         X
    X               X  X  X          XXXXX
    X               X     X               X
    X     X         X     X         X     X
     XXXXX          X     X          XXXXX


              Return for more...
```

```
*********************************************************************
*                        C M S   COMPONENTS                         *
*-------------------------------------------------------------------*
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid)  ------> 1  *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                 numerical models)  -----------------------> 2  *
*                                                                   *
*  CMSPOST (Plots and lists model outputs)  -----------------> 3  *
*                                                                   *
*  CMSUTIL (Additional "utility" programs)  -----------------> 4  *
*                                                                   *
*  CMSSAMP (Sample input and output files for each model)  ---> 5  *
*                                                                   *
*  Exit CMS  -------------------------------------------------> q  *
*********************************************************************
```

To enter CMSUTIL, the user enters a value of 4:

```
Enter option number  -----------------------> 4
```

The CMS responds:

```
  CCCC      M     M     SSSS    U    U   TTTTTTT   I    L
 C    C     MM   MM    S    S   U    U      T      I    L
C           M M M M    S        U    U      T      I    L
C           M  M  M     SSSS    U    U      T      I    L
C           M     M         S   U    U      T      I    L
 C    C     M     M    S    S   U    U      T      I    L
  CCCC      M     M     SSSS     UUUU       T      I    LLLLLL


                     Return for more...
```

```
**********************************************************************
*                                                                    *
*                  USING THE COASTAL MODELING SYSTEM                 *
*                                                                    *
**********************************************************************
*                                                                    *
*  Options:                                                          *
*                                                                    *
*    On-Line Help  -------------------------------------------->  1  *
*                                                                    *
*    Enter CMSUTIL Module  ------------------------------------>  2  *
*                                                                    *
*    Return to Main Menu  ------------------------------------->  3  *
*                                                                    *
**********************************************************************
```

```
Enter option number  -------------->
```

```
*******************************************************************
*                      C M S U T I L   M E N U                    *
*******************************************************************
*                                                                 *
*   TIDEGEN  Generates a time series of tidal elevations         *
*            from harmonic and tidal constituents.  ---->  1      *
*                                                                 *
*   TIDECON  Synthesizes harmonic constituents from time         *
*            series of hourly tidal elevation data. ---->  2      *
*                                                                 *
*   EXIT  ---------------------------------------------->  3      *
*                                                                 *
*******************************************************************
```

To execute program TIDECON, the user enters a value of 2:

Enter option number ---------------------> 2

The CMS responds:

```
TTTTTTT   I   DDDDD     EEEEEE    CCCC      OO      N     N
   T      I   D    D    E        C    C    O  O     NN    N
   T      I   D     D   E       C         O    O    N N   N
   T      I   D     D   EEEE    C         O    O    N  N  N
   T      I   D     D   E       C         O    O    N   N N
   T      I   D    D    E        C    C    O  O     N    NN
   T      I   DDDDD     EEEEEE    CCCC      OO      N     N

                    Return for more...
```

Enter the name of the instruction file tidecon.ins

Again, the user can choose any meaningful naming convention when selecting filenames.

Enter the name of the input file containing time series data tidecon.inp

Enter the name of the time-history and constituent output file tidecon.out

The CMS submits a batch job to the CRAY Y-MP and the system responds:

```
Request 5678.larry submitted to queue prime.
```

```
*******************************************************************
*                      C M S U T I L   M E N U                     *
*******************************************************************
*                                                                 *
*   TIDEGEN  Generates a time series of tidal elevations          *
*            from harmonic and shallow water tidal                *
*            constituents. ---------------------------> 1         *
*                                                                 *
*   TIDECON  Synthesizes harmonic constituents from time          *
*            series of hourly tidal elevation data. ----> 2       *
*                                                                 *
*   EXIT  ----------------------------------------------> 3       *
*                                                                 *
*******************************************************************
```

The user enters 3 to terminate the CMSUTIL session and return to the main menu.

Program output

30. Program TIDECON's output file may be printed for inspection of values. Output files containing time-histories of tide elevations can be used as direct input to the plotting program HYDPLT in package CMSPOST. The actual tidal constituents are output in the same file.

APPENDIX C: CMSPOST

Introduction

1. CMSPOST is the post-processing package in the Coastal Modeling System (CMS) for displaying output generated by models. CMSPOST's graphical and tabular output will help the user in analyzing model results. Model output is directly read into this package; however, in most cases an instruction file containing information to generate the plots must be created by the user. CMSPOST can also process data not generated by the models; but data must be in the format required by the programs. The types of graphics that can be produced are:

- a. Time-histories of water surface elevations, water and wind velocities, and pressure at discrete locations.
- b. Vector maps, or "snapshots," of water or wind velocities at a specified time in the simulation.
- c. Profile plots showing the spatial distribution of a variable.
- d. Wave ray plots for displaying RCPWAVE output only.

In addition, models SHALWV and STWAVE have their own graphics options (see Chapters 7 and 8).

2. All programs are written in FORTRAN 77, and graphics are produced using DISSPLA™ software. Graphic output structure requires use of Tektronix 4014 or compatible terminals.

3. The programs contained in CMSPOST are described in Table C-1. Refer to records RECGAGE, RECSNAPS, PLOTREC, XRECRANG, and YRECRANG in the model documentation for creating and saving data used in CMSPOST.

Data Requirements

Instruction file for time-history programs

4. The instruction file contains commands describing how the data set(s) are to be processed. Each line in the file must begin with a record identifier that signifies an operation. The record identifier must begin in column 1 of the line; the program will not right-justify these variables. The data entered after the record identifier, unless otherwise noted, are read free format and must be separated by at least one blank column (commas can not be used). All instruction file commands for the time-history programs are listed in Table C-2.

Table C-1

Post-Processing Programs

Program	Description	Applicable to
HYDPLT	Produces time-series plots of water surface fluctuations, wind and water velocities, pressure head and discharge.	SPH, WIFM, CLHYD
HYDLST	Prints time-series of water surface fluctuations water velocities, wind velocities, and angles, pressure head, and water discharge.	SPH, WIFM, CLHYD
HYDADD	Concatenates time-history records from successive runs of a model for processing by HYDLST or HYDPLT.	SPH, WIFM, CLHYD
SNAPVEC	Produces vector plots of water and wind velocity fields.	SPH, WIFM, CLHYD
SNAPLST	Prints field arrays described in SNAPVEC. Vectors may be printed as either x-y components or as magnitude and direction.	SPH, WIFM, CLHYD
PROFPLT	Profile plot of specified field variable.	SPH, WIFM, CLHYD, RCPWAVE
RAYPLT	Wave ray plots from model RCPWAVE.	RCPWAVE

5. Programs that create time-history plots and tables can process a maximum of four separate data sets simultaneously. Furthermore, data from one file can be plotted with data from another on the same graph.

6. All commands, categorized as format [F] or select [S] commands, may appear in any order. Format commands refer to operations that modify the default parameters controlling the format of the plots or tables. For example, the type of modifications that can be made include changing axes titles, or the minimum, maximum, and increment values used to plot the independent variable.

7. Select commands are used to select the data set, type of data, and the time-history to be plotted or tabularized. The first letter in the record identifier for select commands represents the type of data (e.g., T = water surface level data) that is to be processed. Immediately adjacent to the record identifier is a qualifier that identifies which file is to be used.

Table C-2

Instruction File Commands for Time-History Plots

Type	CARDID	Data	Default	Description
[F]	DEBUG	none	N/A	Generates output to locate errors in processing.
[F]	REPRT	none		Produces plots in report format.
[F]	PFORM	N	4	Number of graphs plotted per page. Maximum of 4.
[F]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[F]	TIMES	TMIN TMAX TINC		Specify time plotting limits and increment. Default values are calculated from the data set.
[F]	TAXIS	EMIN EMAX EINC	-10. 10. 2.	Elevation axis plotting limits and increment.
[F]	VAXIS	VELMAX VELINC	10. 1.	Velocity axis plotting limit and increment.
[F]	WAXIS	WMAX WINC PMAX PINC	120. 20. 5. 1.	Wind and pressure plotting limits. Pressure is ignored if not saved.
[F]	RAXIS	RMAX RINC RNORM	10. 1. 5.	Range discharge plotting limits and normalization factor.
[F]	TTITL	title	ELEVATION (unit)	Elevation axis title. Title size is 17 characters.
[F]	WTITL	title	WIND MAGNITUDE (unit)	Wind velocity axis title. Title size is 20 characters. Units supplied from gage file.
[F]	PTITL	title	PRESSURE HEAD (unit)	Pressure head axis title. Title size is 19 characters. Units supplied from gage file.

(Continued)

(Sheet 1 of 3)

Table C-2 (Continued)

Type	CARDID	Data	Default	Description
[F]	RTITL	title	FLOW (unit)	Range discharge axis title. Title size is 18 characters. Units supplied from gage file.
[F]	PENUP	X	none	Value that will interrupt plotting when encountered in data set. Used to replace missing or bad data when no lines through bad data are wanted.
[F]	XAXIS	title	TIME (unit)	Time axis title. Title size is 17 characters. Units supplied from gage file.
[F]	NHCPY	none		Overrides program code to produce hard copies of plots.
[S]	TGAG_	gage numbers	none	Select command to process elevations. Qualifier _ referenced to gage file number.
[S]	WGAG_	gage numbers	none	Select command to process wind velocities and pressures. Qualifier _ referenced to gage file number.
[S]	VGAG_	gage numbers	none	Select command to process water velocities. Qualifier _ referenced to gage file number.
[S]	TADJ_	adjustment values	0.0	Values added to water surface elevations. Procedure applied to gages selected according to position in matrix. Qualifier _ referenced to gage file number.

(Continued)

(Sheet 2 of 3)

Table C-2 (Concluded)

Type	CARDID	Data	Default	Description
[S]	TSPL_	index increment	1	Integers for specifying the plotting/printing frequency of elevation gage points. A value of 1 for every point to be plotted, 2 for every second point in array, etc. Procedure applied to gages selected by position in matrix. Qualifier _ referenced to gage file number.
[S]	VSPL_	index increment	1	Integers for specifying the plotting/printing frequency of water velocity gage points. A value of 1 for every point to be plotted, 2 for every second point in array, etc. Procedure applied to gages selected by position in matrix. Qualifier _ referenced to gage file number.
[S]	WSPL_	index increment	1	Integers for specifying the plotting/printing frequency of wind velocity gage points. A value of 1 for every point to be plotted, 2 for every second point in array, etc. Procedure applied to gages selected by position in matrix. Qualifier _ referenced to gage file number.
[S]	RSPL_	index increment	1	Integers for specifying the plotting/printing frequency of range gage points. A value of 1 for every point to be plotted, 2 for every second point in array, etc. Procedure applied to gages selected by position in matrix. Qualifier _ referenced to gage file number.

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This qualifier is either the number corresponding to the order in which the file names are entered, or the character string "ALL." If the string "ALL" is used, then all processing procedures selected with this command will be performed on all files.

8. Gage numbers are listed after the record identifier for those gages that the user wishes to process. If the gages are consecutive in value, the user can list the first and last gage numbers, separated by a hyphen.

9. When processing more than one file simultaneously, the select commands form a "plotting matrix" that determines the contents of each plot. One plot will be produced for each column in the matrix. The number of non-zero entries in each column of the matrix determine the number of lines drawn on each plot. The nonzero entries are the gage numbers whose time-histories are to be plotted. The command qualifiers, which define the matrix rows, designate the file containing the gage data. The following example illustrates this matrix structure for files AFILE, BFILE, CFILE, and DFILE:

TGAG1	3	0	1-5
TGAG2	0	4	1-5
TGAG3	0	2	1-5
TGAG4	0	0	1-5
	Plot 1	Plot 2	Plots 3-7

10. A total of seven water surface elevation plots (or tables) will be generated from the four files. Command qualifier 1 (in command TGAG1) corresponds to file AFILE, qualifier 2 corresponds to BFILE, etc. The first plot will contain the time-history of gage 3 stored in file AFILE. (Zeros must be entered for null gages.) The second plot will contain two time-histories, one of gage 4 in file BFILE and the other gage 2 in CFILE. The third column will produce five plots. The third plot will contain the time-histories of gage 1 from each of the four files. The fourth plot will contain time-histories of gage 2, also from all four files, and so forth, with the seventh plot being time-histories of gage 5 from all four files.

<u>Instruction file for snapshot programs</u>

11. Instruction file requirements for the snapshot programs are similar to those required by the time-history programs:

<u>a</u>. Each command in the file must begin with a record identifier starting in column 1.

<u>b</u>. Format and select commands may appear in any order.

c. Data entered after the record identifier are read free-format.

12. In contrast to the time-history programs, the snapshot programs can process only one file at a time. All snapshot instruction file commands are described in Table C-3. Those applicable to each program are listed in the program descriptions.

Table C-3

Instruction File Commands for Snapshot Plots

Type	CARDID	Data	Default	Description
[F]	DEBUG	none		Generates output to locate errors in processing.
[F]	GAGLOC	none		Plots numerical gage locations on snapshots.
[F]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[F]	TIMES	TIME	ALL	Time(s), in TUNITS, of snapshot(s) to be plotted. TIME = "ALL" results in all snapshots to be plotted. TIME = "LAST" results in the last snapshot to be plotted.
[S]	VPOLAR_		none	Water velocities printed as magnitude and direction.
[S]	WPOLAR_		none	Wind velocities printed as magnitude and direction.
[S]	TFORMT_	format	(15F8.2)	Print format for elevations. Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	VFORMT_	format	(15F8.2)	Print format for water velocities. Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	WFORMT_	format	(15F8.2)	Print format for wind velocities. Qualifier _ referenced to order of snapshot specified in TIMES.

(Continued)

(Sheet 1 of 4)

Table C-3 (Continued)

Type	CARDID	Data	Default	Description
[S]	PFORMT_	format	(15F8.2)	Print format for atmospheric pressures. Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	TSAMPL_	ISMPL JSMPL	1 1	Cell index printing interval for elevations. ISMPL - Print every "ISMPL" cell x-direction JSMPL - Print every "JSMPL" cell y-direction Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	VSAMPL_	ISMPL JSMPL	1 1	Cell index printing interval for water velocities. ISMPL - Print every "ISMPL" cell in x-direction JSMPL - Print every "JSMPL" cell in y-direction Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	WSAMPL_	ISMPL JSMPL	1 1	Cell index printing interval for wind velocities. ISMPL - Print every "ISMPL" cell in x-direction JSMPL - Print every "JSMPL" cell in y-direction Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	PSAMPL_	ISMPL JSMPL	1 1	Cell index printing interval for pressures. ISMPL - Print every "ISMPL" cell in x-direction JSMPL - Print every "JSMPL" cell in y-direction Qualifier _ referenced to order of snapshot specified in TIMES.

(Continued)

(Sheet 2 of 4)

Table C-3 (Continued)

Type	CARDID	Data	Default	Description
[S]	TWINDO_	I1 I2 J1 J2	none	Select command to process elevation snapshots. I1 = minimum x-direction cell index to plot I2 = maximum x-direction cell index to plot J1 = minimum y-direction cell index to plot J2 = maximum y-direction cell index to plot Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	VWINDO_	I1 I2 J1 J2	none	Select command to process water velocity snapshots. I1 = minimum x-direction cell index to plot I2 = maximum x-direction cell index to plot J1 = minimum y-direction cell index to plot J2 = maximum y-direction cell index to plot Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	WWINDO_	I1 I2 J1 J2	none	Select command to process wind velocity snapshots. I1 = minimum x-direction cell index to plot I2 = maximum x-direction cell index to plot J1 = minimum y-direction cell index to plot J2 = maximum y-direction cell index to plot Qualifier _ referenced to order of snapshot specified in TIMES.

(Continued)

(Sheet 3 of 4)

Table C-3 (Concluded)

Type	CARDID	Data	Default	Description
[S]	PWINDO_	I1 I2 J1 J2	none	Select command to process atmospheric pressure snapshots. I1 = minimum x-direction cell index to plot I2 = maximum x-direction cell index to plot J1 = minimum y-direction cell index to plot J2 = maximum y-direction cell index to plot Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	VSCALE_	SFAC THRS	10.0 0.05	Select command to specify water velocity vector length. SFAC = vector scale factor (velocity units per inch) THRS = minimum velocity value to plot (velocity units per inch) Qualifier _ referenced to order of snapshot specified in TIMES.
[S]	WSCALE_	SFAC THRS	10.0 0.05	Select command to specify wind velocity vector length. SFAC = vector scale factor (velocity units per inch) THRS = minimum velocity value to plot (velocity units per inch) Qualifier _ referenced to order of snapshot specified in TIMES.

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<u>Program HYDPLT</u>

13. Program HYDPLT is a general purpose program for plotting time-history records generated and stored by the models contained in CMS. The CMS models save the following information for each gage specified by a RECGAGE record: water surface fluctuation, x and/or y water velocity components, and x and y wind velocity components. Atmospheric pressures are saved if SPH is used to generate the wind fields. Discharges, saved using a XRECRANG or YRECRANG record when running the models, are also stored in this file.

14. A maximum of four time-series data files, where each data file can contain up to 120 gages, may be processed simultaneously. No gage can contain more than 1,000 sampling points.

15. An instruction file must be created and stored before execution can begin. Options to change the default plotting formats are included in this file. The following instruction commands, which were described in Table C-2 are valid for this program:

DEBUG	TGAG_	VGAG_	WGAG_	RGAG_
REPRT	TSPL_	VSPL_	WSPL_	RSPL_
PFORM	TAXIS	VAXIS	WAXIS	RAXIS
TITLE	TTITL	VTITL	WTITL	RTITL
TIMES	TADJ_			
PENUP				
XAXIS				
NHCPY				

A sample instruction file for program HYDPLT is given below:

```
PFORM 4
TITLE CLHYD SIMULATION NO 1.  TIDE WITHOUT    FEATHERING
TAXIS -5. 5. 2.5
TGAG1 1-2
DEBUG
```

This file is used in the following example.

To invoke program HYDPLT, the user enters the command:

h2crplc1:larry$ /u3/h2crplc0/cms

(It should be noted that user entries are shown as shaded, and CMS response "screens" are shaded boxes.) The CMS responds:

```
           W E L C O M E   T O . . .

         XXXXX          X     X         XXXXX
        X     X         XX   XX        X     X
        X               X X X X        X
        X               X  X  X         XXXXX
        X               X     X              X
        X     X         X     X        X     X
         XXXXX          X     X         XXXXX

              Return for more...
```

```
*********************************************************************
*                         C M S   COMPONENTS                        *
*-------------------------------------------------------------------*
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1 *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                 numerical models)  -------------------------> 2 *
*                                                                   *
*  CMSPOST (Plots and lists model outputs)  ------------------> 3 *
*                                                                   *
*  CMSUTIL (Additional "utility" programs)  ------------------> 4 *
*                                                                   *
*  CMSSAMP (Sample input and output files for each model ------> 5 *
*                                                                   *
*  Exit CMS  -------------------------------------------------> q *
*********************************************************************
```

To use the CMSPOST programs, the user responds to the CMS prompt with a value of 3:

Enter option number -------------------------> 3

The CMS responds:

```
  CCCC      M     M     SSSS     PPPPP      OO      SSSS    TTTTTTT
 C    C     MM   MM    S    S    P    P    O  O    S    S      T
C           M M M M    S         P    P   O    O   S           T
C           M  M  M     SSSS     PPPPP    O    O    SSSS       T
C           M     M         S    P        O    O        S      T
 C    C     M     M    S    S    P         O  O    S    S      T
  CCCC      M     M     SSSS     P          OO      SSSS       T


                        Return for more...
```

```
**********************************************************************
*                                                                    *
*                  USING THE COASTAL MODELING SYSTEM                 *
*                                                                    *
**********************************************************************
*                                                                    *
*  Options:                                                          *
*                                                                    *
*    On-Line Help ------------------------------------------->  1    *
*                                                                    *
*    Enter CMSPOST Module ----------------------------------->  2    *
*                                                                    *
*    Return to Main Menu ------------------------------------>  3    *
*                                                                    *
**********************************************************************
```

Enter option number -------------> 2

The CMS responds:

```
                    CMSPOST

   HYDPLT:  Generates plots of time series output
   HYDLST:  Generates lists of time series output
   HYDADD:  Concatenates two successive time series
  SNAPVEC:  Generates vector plots of model output
 SNAPLST:  Generates lists of field arrays described
           in SNAPVEC
   RAYPLT:  Generates wave ray plots of RCPWAVE output
 PROFPLT:  Generate profile plots of model output
     EXIT:  Terminates this CMSPOST session
```

The user enters: hydplt

The CMS responds:

```
H     H   Y     Y   DDDDD     PPPPP    L          TTTTTTT
H     H    Y   Y    D    D    P    P   L             T
H     H     Y Y     D     D   P    P   L             T
HHHHHHH      Y      D     D   PPPPP    L             T
H     H      Y      D     D   P        L             T
H     H      Y      D    D    P        L             T
H     H      Y      DDDDD     P        LLLLLLL       T

               Return for more. . .
```

Enter the name of the instruction file: hydplt.ins

Valid user responses are:

TEK40 or tek40 - (hydrograph file will be plotted on TEKTRONIX 4014 or VT240 terminal)

LASER or laser - (hydrograph file plotted on laser printer)

Enter device name TEK40

How many input data files will be processed? 5
***the number of files must be between 1 and 4

Do you want to reenter the number of files to be processed?
Enter yes or no to continue yes

Enter the number of files to be processed 1

Enter the name of the first data set: hydplt.1

Enter the name of the output file: hydplt.out

The user can choose any meaningful naming convention when selecting filenames. For example, the user may choose a project name with different extensions for each simulation.

The CMS submits a batch job to the CRAY Y-MP and the system responds:

Request 4359.larry submitted to queue:prime

CMSPOST

HYDPLT:	Generates plots of time series output
HYDLST:	Generates lists of time series output
HYDADD:	Concantenates two successive time series
SNAPVEC:	Generates vector plots of model output
SNAPLST:	Generates lists of field arrays described in SNAPVEC
RAYPLT:	Generates wave ray plots of RCPWAVE output
PROFPLT:	Generate profile plots of model output
EXIT:	Terminates this CMSPOST session

The user types 'exit' or 'EXIT' to terminate the CMSPOST component. A DISSPLA™ metfil is thus produced. To plot the HYDPLT metfil on a Tektronix or Tektronix emulator, the user types:

/u3/h2crp1c0/cmsplot

and the plot is displayed, as shown below:

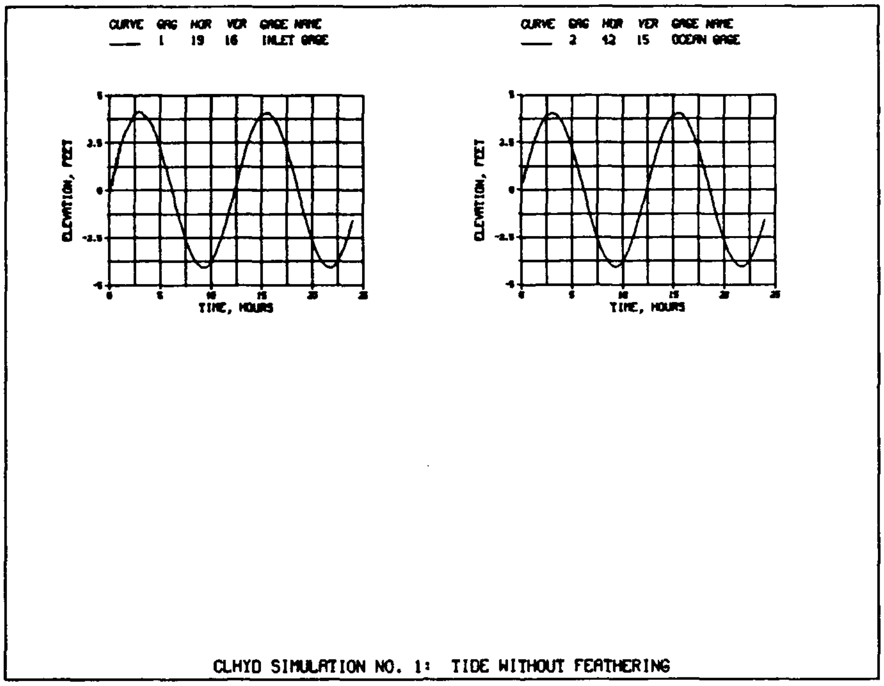

Figure C-1. Sample water surface elevation HYDPLT

Similarly, a time-history of velocity data can be generated using the instruction file below:

```
PFORM 4
TITLE CLHYD SIMULATION NO. 1:  TIDE WITHOUT FEATHERING
VAXIS 6.0 2.0
VGAG1 1-2
```

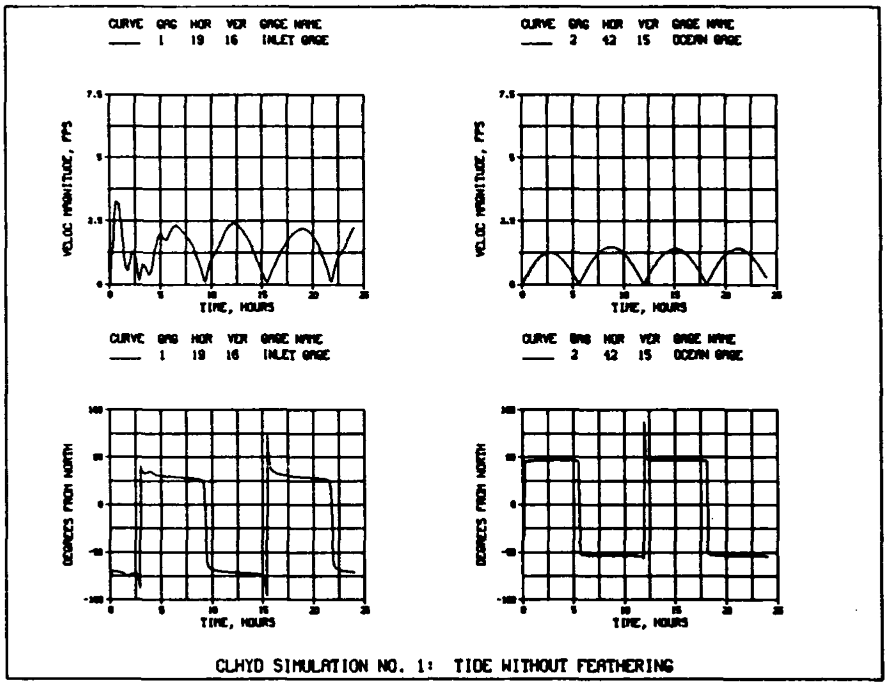

Figure C-2. Sample velocity HYDPLT

In the following example, time-histories of wind and pressure for an SPH simulation are displayed. The instruction file for this plot was simply:

```
WGAG1
WAXIS 120 20 2.1
```

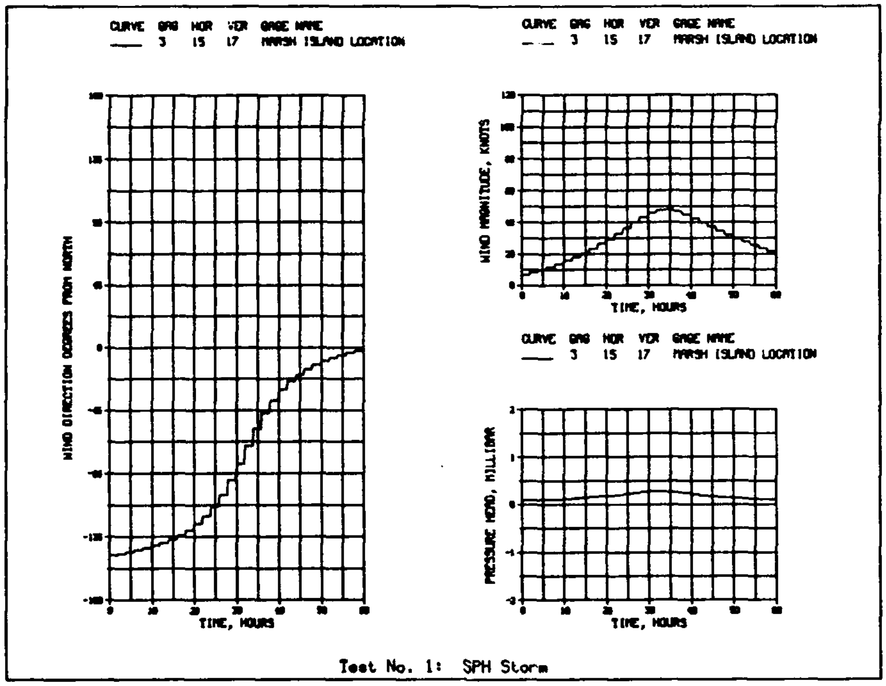

Figure C-3. Sample wind and pressure HYDPLT

Program HYDLST

16. Program HYDLST is a general purpose program for printing gage time-history records generated and stored by the models contained in CMS. The CMS models save the following information for each gage specified by a RECGAGE record: water surface elevations, x and/or y water velocity components, and x and y wind velocity components. Atmospheric pressures are saved if SPH is used to generate the wind fields. Discharges, saved using an XRECRANG or YRECRANG record when running the models, are also stored in this file.

17. A maximum of four time-history data files may be processed simultaneously by program HYDLST, with each data file containing up to 120 gages. No gage can contain more than 1,000 sampling points.

18. An instruction file must be created before execution can begin. Options to change the default formats are included in this file. The following instruction commands, which were described in Table C-2 are valid for this program:

```
TIMES
TGAG_
TADJ_
VGAG_
WGAG_
RGAG_
```

A sample instruction file for program HYDLST is given below:

```
TGAG1 1-2
```

19. To invoke program HYDLST, the user enters the command:

```
h2crplc1:larry$ /u3/h2crplc0/cms
```

The CMS responds:

```
        W E L C O M E   T O . . .

   XXXXX        X     X        XXXXX
  X     X       XX   XX       X     X
  X             X X X X       X
  X             X  X  X        XXXXX
  X             X     X             X
  X     X       X     X       X     X
   XXXXX        X     X        XXXXX

           Return for more...
```

```
**********************************************************************
*                       C M S   COMPONENTS                           *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
   CMSGRID (Maps, plots, and lists the numerical grid) ------->  1 *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                    *
*                 numerical models) -------------------------->  2 *
*                                                                    *
*  CMSPOST (Plots and lists model outputs) ------------------->  3 *
*                                                                    *
*  CMSUTIL (Additional "utility" programs) ------------------->  4 *
*                                                                    *
*  Exit CMS ------------------------------------------------->  e *
**********************************************************************
```

Enter option number -----------------------> 3

The CMS responds:

```
  CCCC     M     M     SSSS    PPPPP     OO     SSSS   TTTTTTT
 C    C    MM   MM    S    S   P    P   O  O   S    S     T
C          M M M M    S        P    P  O    O  S          T
C          M  M  M     SSSS    PPPPP   O    O   SSSS      T
C          M     M         S   P       O    O       S     T
 C    C    M     M    S    S   P        O  O   S    S     T
  CCCC     M     M     SSSS    P         OO     SSSS      T



                         Return for more...
```

```
*********************************************************************
*                                                                   *
*                  USING THE COASTAL MODELING SYSTEM                *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ------------------------------------------->  1  *
*                                                                   *
*    Enter CMSPOST Module  ----------------------------------->  2  *
*                                                                   *
*    Return to Main Menu  ------------------------------------>  3  *
*                                                                   *
*********************************************************************
```

```
Enter option number  ----------------> 2
```

The CMS responds:

```
                         CMSPOST

 HYDPLT:   Generates plots of time series output
 HYDLST:   Generates lists of time series output
 HYDADD:   Concantenates two successive time series data
SNAPVEC:   Generates vector plots of model output
SNAPLST:   Generates lists of field arrays described
           in SNAPVEC
 RAYPLT:   Generates wave ray plots of RCPWAVE output
PROFPLT:   Generate profile plots of model output
   EXIT:   Terminates this CMSPOST session
```

The user enters: **hydlst**

The CMS responds:

```
H    H   Y     Y   DDDDD     L         SSSSS    TTTTTTT
H    H    Y   Y    D     D   L        S            T
H    H     Y Y     D      D  L        S            T
HHHHHH      Y      D      D  L         SSSS        T
H    H      Y      D      D  L             S       T
H    H      Y      D     D   L             S       T
H    H      Y      DDDDD     LLLLLLL  SSSSS        T


                   Return for more. . .
```

Enter the name of the instruction file: **hydlst.ins**

How many input data files will be processed? **5**
the number of files must be between number 1 and 4

Do you want to reenter the number of files to be processed?
Enter yes or no to continue **yes**

Enter the number of files to be processed **1**

Enter the name of the first data set: **hydlst.1**

Enter name of output file **hydlst.out**

The user can choose any meaningful naming convention when selecting filenames.

For example, the user may choose a project name with different extensions for each simulation.

The CMS submits a batch job to the CRAY Y-MP and the system responds:

```
Request 4343.larry submitted to queue:prime
```

```
                         CMSPOST

 HYDPLT:  Generates plots of time series output
 HYDLST:  Generates lists of time series output
 HYDADD:  Concantenates two successive time series
SNAPVEC:  Generates vector plots of model output
SNAPLST:  Generates lists of field arrays described
          in SNAPVEC
 RAYPLT:  Generates wave ray plots of RCPWAVE output
PROFPLT:  Generate profile plots of model output
   EXIT:  Terminates this CMSPOST session
```

The user types 'exit' or 'EXIT' to terminate the CMSPOST component. To list the HYDLST results, the user types:

```
pg hydlst.out
```

The system responds:

FILE 1
FILE TITLE
MOCK-UP TEST
PROVISIONAL STARTING TIME: 0.00
PROVISIONAL ENDING TIME: 0.86E+05
DATA INTERVAL: 360.000
TIME UNIT: SECONDS

ELEVATION LISTING

FILE 1 TITLE: MOCK-UP TEST

FILE 1	GAGE 1	GAGE 2
	X Y	X Y
LOCATION	3 13	11 13
TIME SECONDS	ELEVATION FEET	ELEVATION FEET
0.00	0.500	0.570
360.00	0.500	0.570
720.00	0.500	0.570
	.	
	.	
	.	
10440.00	0.500	0.570
10800.00	0.613	0.570
11160.00	0.900	0.570
11520.00	1.11	0.570
11880.00	1.35	0.629
12240.00	1.49	0.687
12600.00	1.62	0.685
12960.00	1.80	0.724
13320.00	2.02	0.771
13680.00	2.20	0.799
14040.00	2.30	1.03
14400.00	2.42	1.26
14760.00	2.58	1.48
15120.00	2.67	1.72
15480.00	2.86	1.97
15840.00	3.09	2.22
16200.00	3.16	2.47
16560.00	3.17	2.74

Program HYDADD

20. Program HYDADD concatenates two time-history data files from successive simulations of the long-wave models. Program HYDADD is typically applied to a WIFM "cold start" hydrofile and a WIFM "hot start" hydrofile to make one combined hydrofile. No instruction file is required. However, the following requirements must be met:

a. The two files must be sequential in time.

b. All gages and ranges must be identical, in number and sequence, in the two files.

c. Grid rotation must be identical in the two files.

The program will check the above requirements and will terminate with an appropriate error message if any violations are detected.

21. To invoke program HYDADD, the user enters the command:

```
h2crplcl:larry$ /u3/h2crplc0/cms
```

The CMS responds:

```
        W E L C O M E   T O . . .

   XXXXX         X     X        XXXXX
  X     X        XX   XX       X     X
  X              X X X X       X
  X              X  X  X        XXXXX
  X              X     X             X
  X     X        X     X       X     X
   XXXXX         X     X        XXXXX

            Return for more...
```

```
*******************************************************************
*                          C M S    COMPONENTS                    *
*-----------------------------------------------------------------*
*  Options:                                                       *
*                                                                 *
*  CMSGRID (Maps, plots, and lists the numerical grid) -------> 1 *
*                                                                 *
*  CMSMODEL (Compiles, links, loads, and executes                 *
*                  numerical models) ------------------------> 2 *
*                                                                 *
*  CMSPOST (Plots and lists model outputs) ------------------> 3 *
*                                                                 *
*  CMSUTIL (Additional "utility" programs) ------------------> 4 *
*                                                                 *
*  CMSSAMP (Sample input and output files for each model -----> 5 *
*                                                                 *
*  Exit CMS ------------------------------------------------> q *
*******************************************************************
```

Enter option number ------------------------> 3

The CMS responds:

```
   CCCC     M     M     SSSS     PPPPP      OO      SSSS    TTTTTTT
  C    C    MM   MM    S    S    P    P    O  O    S    S      T
 C          M M M M    S         P    P   O    O   S           T
 C          M  M  M     SSSS     PPPPP    O    O    SSSS       T
 C          M     M         S    P        O    O        S      T
  C    C    M     M    S    S    P         O  O    S    S      T
   CCCC     M     M     SSSS     P          OO      SSSS       T


                      Return for more...
```

```
*********************************************************************
*                                                                   *
*                 USING THE COASTAL MODELING SYSTEM                 *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help -------------------------------------------> 1   *
*                                                                   *
*    Enter CMSPOST Module ----------------------------------> 2   *
*                                                                   *
*    Return to Main Menu -----------------------------------> 3   *
*                                                                   *
*********************************************************************
```

Enter option number --------------------> 2

```
                         CMSPOST

     HYDPLT:  Generates plots of time series output
     HYDLST:  Generates lists of time series output
     HYDADD:  Concatenates two successive time series
    SNAPVEC:  Generates vector plots of model output
    SNAPLST:  Generates lists of field arrays described
              in SNAPVEC
     RAYPLT:  Generates wave ray plots of RCPWAVE output
    PROFPLT:  Generate profile plots of model output
       EXIT:  Terminates this CMSPOST session
```

The user enters: hydadd

The CMS responds:

```
H     H   Y     Y   DDDDD       AA      DDDDD     DDDDD
H     H    Y   Y    D    D     A  A     D    D    D    D
H     H     Y Y     D     D   A    A    D     D   D     D
HHHHHH       Y      D     D   AAAAAA    D     D   D     D
H     H      Y      D     D   A    A    D     D   D     D
H     H      Y      D    D    A    A    D    D    D    D
H     H      Y      DDDDD     A    A    DDDDD     DDDDD

                    Return for more. . .
```

Enter the name of the first data set: file1.hyd

Enter the name of the second data set: file2.hyd

Enter the name of combined data set: filecom.hyd

The user can choose any meaningful naming convention when selecting filenames. For example, the user may choose a project name with different extensions for each file.

The CMS submits a batch job to the CRAY Y-MP and the system responds:

Request 4243.larry submitted to queue:prime

The user types 'exit' or 'EXIT' to terminate the CMSPOST component.

The individual files and combined files are as follows:

```
                    MOCK-UP TEST
        11 0.000E+00    1     1     1     0     0
                   SECONDS FEET    FPS      FPS      FEETH20 CFS
      0.00     360.00     720.00   1080.00   1440.00   1800.00   2160.00   2520.00
   2880.00    3240.00    3600.00
TGAGE     1     3    13GAGE 1        2 13$
     0.500      0.500      0.500     0.500     0.500     0.500     0.500     0.500
     0.500      0.500      0.500
VGAGE     1     3    13GAGE 1        2 13$
    -0.120     -0.454     -0.218    -0.237    -0.277    -0.276    -0.230    -0.113
    -0.131     -0.184     -0.098
```

```
                    MOCK-UP TEST
       8 0.000E+00    1    1    1    0    0
                 SECONDS FEET    FPS     FPS     FEETH20 CFS
   3600.00   3960.00   4320.00   4680.00   5040.00   5400.00   5760.00   6120.00
TGAGE    1    3   13GAGE 1       2 13$
    01.500     01.500     01.500     01.500     01.500     01.500     01.500
01.500
VGAGE    1    3   13GAGE 1       2 13$
    -1.120    -1.454    -1.218    -1.237    -1.277    -1.276    -1.230    -1.113
```

```
                    MOCK-UP TEST
      18 0.000        1    1    1    0    0
                 SECONDS FEET    FPS     F
      0.00    360.00    720.00   1080.00   1440.00   1800.00   2160.00   2520.00
   2880.00   3240.00   3600.00   3960.00   4320.00   4680.00   5040.00   5400.00
   5760.00   6120.00
TGAGE    1    3   13GAGE 1       2 13$
     0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500
     0.500     0.500     1.500     1.500     1.500     1.500     1.500     1.500
     1.500     1.500
VGAGE    1    3   13GAGE 1       2 13$
```

Program SNAPVEC

22. Program SNAPVEC produces vector plots of water and wind velocities. A maximum of 100 snapshots can be stored in the data file. An instruction file must be created before execution can begin. Options to change the default plotting formats are included in this file. The following instruction commands, which are described in Table C-3, are valid for this program:

DEBUG	VWINDO_	WWINDO_
NOAVE	VSCALE_	WSCALE_
TIMES	TWINDO_	PWINDO_
TITLE		
GAGLOC		

A sample instruction file for program SNAPVEC is given below:

```
TIMES LAST
WWINDO1  1 26 1 24
WSCALE1 60.0 0.5
```

23. To invoke program SNAPVEC, the user enters the command:

```
h2crplc1:larry$ /u3/h2crplc0/cms
```

The CMS responds:

```
W E L C O M E   T O . . .

  XXXXX        X     X       XXXXX
 X     X       XX   XX      X     X
 X             X X X X      X
 X             X  X  X       XXXXX
 X             X     X            X
 X     X       X     X      X     X
  XXXXX        X     X       XXXXX

          Return for more...
```

```
**********************************************************************
*                        C M S   COMPONENTS                          *
*--------------------------------------------------------------------*
*  Options:                                                          *
*                                                                    *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1 *
*                                                                    *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                 numerical models) -------------------------> 2 *
*                                                                    *
*  CMSPOST (Plots and lists model outputs)  ------------------> 3 *
*                                                                    *
*  CMSUTIL (Additional "utility" programs)  ------------------> 4 *
*                                                                    *
*  CMSSAMP (Sample input and output files for each model  -----> 5 *
*                                                                    *
*  Exit CMS  -----------------------------------------------------> q *
**********************************************************************
```

Enter option number ------------------------> 3

The CMS responds:

```
  CCCC      M     M      SSSS     PPPPP       OO       SSSS    TTTTTTT
 C    C     MM   MM     S    S    P    P     O  O     S    S      T
C           M M M M     S         P    P    O    O    S           T
C           M  M  M      SSSS     PPPPP     O    O     SSSS       T
C           M     M          S    P         O    O         S      T
 C    C     M     M     S    S    P          O  O     S    S      T
  CCCC      M     M      SSSS     P           OO       SSSS       T


                        Return for more...
```

```
*********************************************************************
*                                                                   *
*                USING THE COASTAL MODELING SYSTEM                  *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help ---------------------------------------------> 1  *
*                                                                   *
*    Enter CMSPOST Module ------------------------------------> 2  *
*                                                                   *
*    Return to Main Menu -------------------------------------> 3  *
*                                                                   *
*********************************************************************
```

```
Enter option number --------------------> 2
```

The CMS responds:

```
                    CMSPOST

  HYDPLT:  Generates plots of time series output
  HYDLST:  Generates lists of time series output
  HYDADD:  Concantenates two successive time series
 SNAPVEC:  Generates vector plots of model output
SNAPLST:  Generates lists of field arrays described
           in SNAPVEC
  RAYPLT:  Generates wave ray plots of RCPWAVE output
 PROFPLT:  Generate profile plots of model output
    EXIT:  Terminates this CMSPOST session
```

The user enters: **snapvec**

The system responds:

```
 SSSSS   N     N     AA     PPPPP   V     V  EEEEEE   CCCC
S        NN    N    A  A    P    P  V     V  E       C
S        N N   N   A    A   P    P  V     V  E      C
 SSSS    N  N  N   AAAAAAAA PPPPP   V     V  EEEE   C
     S   N   N N   A      A P        V   V   E      C
     S   N    NN   A      A P         V V    E       C
SSSSS    N     N   A      A P          V     EEEEEE   CCCC

                    Return for more. . .
```

Enter the name of the instruction file: **snapvec.ins**

Valid user responses are:

TEK40 or tek40 - hydrograph file will be plotted on TEKTRONIX 4014 or VT240 terminal

LASER or laser - if you want laser output here at CERC

Enter device name **laser**

Enter name of input file containing snapshots data that were generated by WIFM, CLHYD, SPH, or other model **wifm.snp**

Enter name of output data set **snapshot.out**

The system responds:

```
STOP
CP:0.002s, Wallclock:0.038s, 0.8% of 6-CPU Machine
Request 4362.larry submitted to queue:prime
```

The CMS responds:

```
                    CMSPOST

 HYDPLT:  Generates plots of time series output
 HYDLST:  Generates lists of time series output
 HYDADD:  Concatenates two successive time series
SNAPVEC:  Generates vector plots of model output
SNAPLST:  Generates lists of field arrays described
          in SNAPVEC
 RAYPLT:  Generates wave ray plots of RCPWAVE output
PROFPLT:  Generate profile plots of model output
   EXIT:  Terminates this CMSPOST session
```

The user types 'exit' or 'EXIT' to terminate the CMSPOST component.

To plot the SNAPVEC file on the laser printer, the user transfers the file to the VAX 3300 using the ftp command (see Chapter 2) and types:

laser std00001.dat

A typical SNAPVEC plot is shown below:

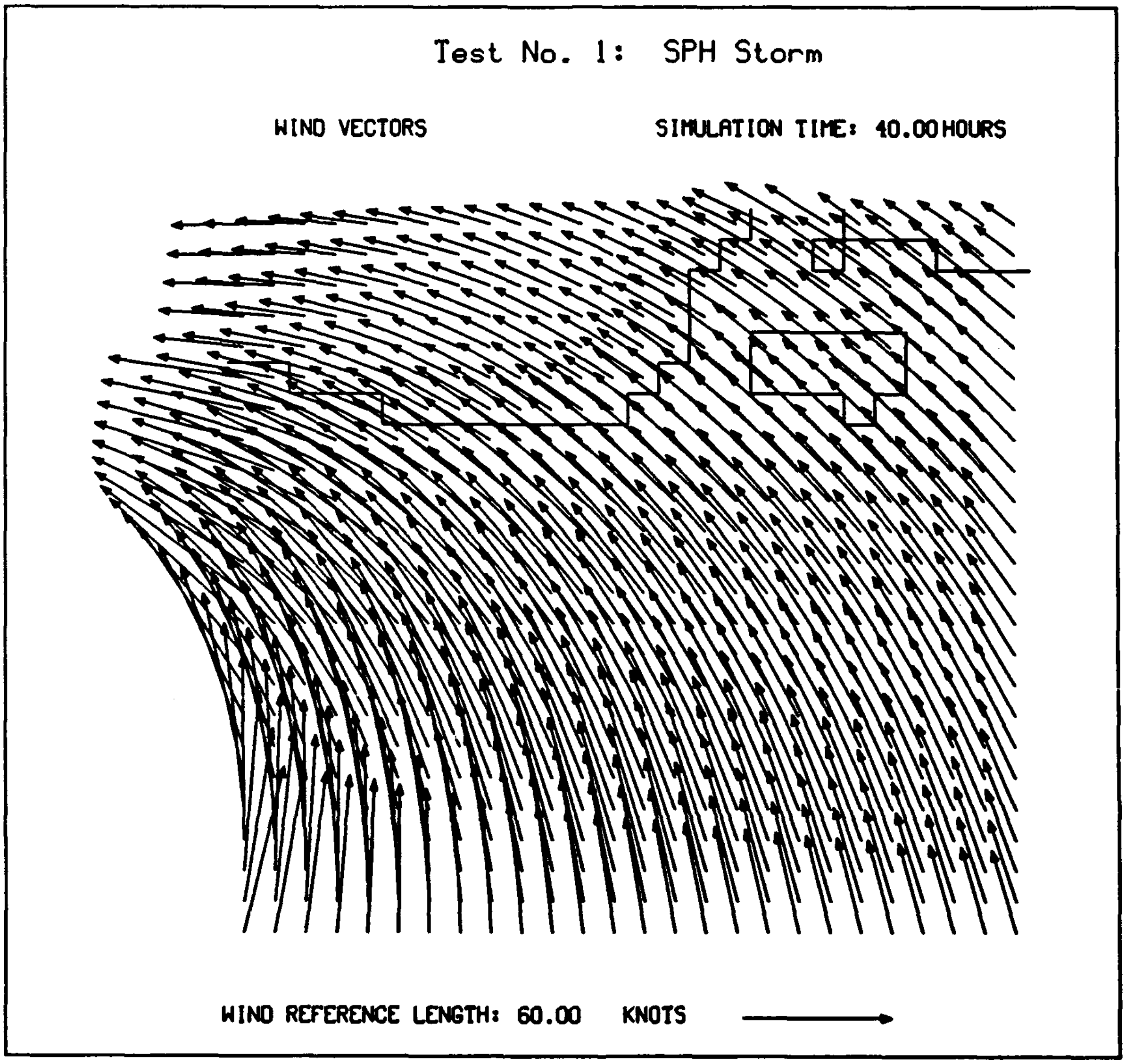

Figure C-4. Sample wind velocity (SNAPVEC) plot

Program SNAPLST

24. Program SNAPLST produces printouts of field array variables. These variables are total water depth, water surface elevation, water velocities, wind velocities, and atmospheric pressure. Water and wind velocities may be printed as x and y components, or as magnitude and direction. Atmospheric pressures are printed if SPH is used, either as a stand-alone model or as a component of WIFM, to generate the wind fields. A maximum of 100 snapshots can be stored in the data file.

25. An instruction file must be created before execution can begin. Options to change the default printing formats are included in this file. The following instructions commands, which are described in Table C-3, are valid for this program:

```
DEBUG      TSAMPL_       VSAMPL_       WSAMPL_       PSAMPL_
TIMES      TFORMT_       VFORMT_       WFORMT_       PFORMT_
                   VPOLAR_       WPOLAR_
```

A sample instruction file for program SNAPLST is given below:

```
TIMES    1
TFORMT1 1 5 1 4
TSAMPL1 1 1
```

26. To invoke program SNAPLST, the user enters the command:

h2crplc1:larry$ **/u3/h2crplc0/cms**

The CMS responds:

```
W E L C O M E   T O . . .

 XXXXX          X     X          XXXXX
X     X         XX   XX         X     X
X               X X X X         X
X               X  X  X          XXXXX
X               X     X               X
X     X         X     X         X     X
 XXXXX          X     X          XXXXX

        Return for more...
```

```
*********************************************************************
*                         C M S   COMPONENTS                        *
*-------------------------------------------------------------------*
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1 *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*                numerical models)  -----------------------> 2 *
*                                                                   *
*  CMSPOST (Plots and lists model outputs)  -----------------> 3 *
*                                                                   *
*  CMSUTIL (Additional "utility" programs)  -----------------> 4 *
*                                                                   *
*  CMSSAMP (Sample input and output files for each model  -----> 5 *
*                                                                   *
*  Exit CMS  -------------------------------------------------> q *
*********************************************************************
```

```
Enter option number  ------------------------>  3
```

The CMS responds:

The user enters: snaplst

The system responds:

```
 SSSSS   N     N     AA      PPPPP    L         SSSSS   TTTTTTT
S        NN    N    A  A     P    P   L        S           T
S        N N   N   A    A    P    P   L        S           T
 SSSS    N  N  N   AAAAAAAA  PPPPP    L         SSSS       T
     S   N   N N   A      A  P        L             S      T
     S   N    NN   A      A  P        L             S      T
SSSSS    N     N   A      A  P        LLLLLLL  SSSSS       T

                      Return for more. . .
```

Enter the name of the instruction file: snaplst.ins

Enter the name of the input data set: snaplst.1

Enter the name of the output data set snaplst.out

The system responds:

```
  STOP
 CP:002s, Wallclock:0:105s, 0.3% of 6-CPU Machine

Request 4343.larry submitted to queue:prime
```

```
                         CMSPOST

   HYDPLT:  Generates plots of time series output
   HYDLST:  Generates lists of time series output
   HYDADD:  Concatenates two successive time series
  SNAPVEC:  Generates vector plots of model output
  SNAPLST:  Generates lists of field arrays described
            in SNAPVEC
  RAYPLT:   Generates wave ray plots of RCPWAVE output
  PROFPLT:  Generate profile plots of model output
     EXIT:  Terminates this CMSPOST session
```

The user types 'exit' or 'EXIT' to terminate the CMSPOST component. To display the output file, the user enters:

```
pg snaplst.out
```

and the system responds:

```
1      MOCK_UP TEST
       SURFACE ELEVATIONS                      (FEET      )
       SNAPSHOT TIME =      1hrs     0MIN     0SEC

       X=       1        2        3        4        5
     Y=
       4      7.13     7.25     7.22     7.29     7.44
       3      7.13     7.21     7.20     7.29     7.48
       2      7.13     7.16     7.09     7.13     7.24
       1      7.13     7.13     7.13     7.13     7.13
```

Program RAYPLT

27. Program RAYPLT is a wave ray plotting program specific to model RCPWAVE output only. RCPWAVE saves wave angle data for each grid cell if a PLOTREC record is contained in the RCPWAVE input file. The wave angle information is used to generate a wave ray plot for each wave condition simulated by RCPWAVE.

28. An instruction file must be created and stored before execution can begin. Options to change the default plotting formats are included in this file. The following instruction commands, which are described in Table C-4, are valid for this program:

```
TITLE      RATIO
ROTAN      DEBUG
COAST
DUNIT
XYINC
```

A sample instruction file for program RAYPLT is given below:

```
TITLE DUCK, NC
ROTAN 0
COAST E
DUNIT m
XYINC 12 24
RATIO 1 4
DEBUG
```

29. To invoke program RAYPLT, the user enters the command:

```
h2crplcl:larry$ /u3/h2crplc0/cms
```

Table C-4

Instruction File Commands for Wave Ray Plots

Type	CARDID	Data	Default	Description
[F]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[F]	ROTAN		0.0	Rotation angle for north arrow.
[F]	COAST	E, W, or G	none	Selection of east, west, or gulf coast.
[F]	DUNIT	ft or m	ft	Distance units for shoreline data.
[F]	RATIO		none	X and Y increment for calculating wave rays.
[F]	XYING		1 4	Cell spacing in the x and y directions.
[F]	DEBUG		none	Generates output to locate errors in processing.

The CMS responds:

```
            W E L C O M E   T O . . .


        XXXXX          X     X          XXXXX
       X     X         XX   XX         X     X
       X               X X X X         X
       X               X  X  X          XXXXX
       X               X     X               X
       X     X         X     X         X     X
        XXXXX          X     X          XXXXX


                 Return for more...
```

```
*********************************************************************
*                          C M S   COMPONENTS                       *
*-------------------------------------------------------------------*
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1 *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                  *
*                numerical models)  -------------------------> 2 *
*                                                                   *
*  CMSPOST (Plots and lists model outputs)  ------------------> 3 *
*                                                                   *
*  CMSUTIL (Additional "utility" programs)  ------------------> 4 *
*                                                                   *
*  CMSSAMP (Sample input and output files for each model  -----> 5 *
*                                                                   *
*  Exit CMS  ---------------------------------------------- > q *
*********************************************************************
```

Enter option number ------------------------> 3

The CMS responds:

```
  CCCC     M     M     SSSS     PPPPP       OO       SSSS    TTTTTTT
 C    C    MM   MM    S    S    P    P     O  O     S    S      T
C          M M M M    S         P    P    O    O    S           T
C          M  M  M     SSSS     PPPPP     O    O     SSSS       T
C          M     M         S    P         O    O         S      T
 C    C    M     M    S    S    P          O  O     S    S      T
  CCCC     M     M     SSSS     P           OO       SSSS       T


                        Return for more...
```

```
*********************************************************************
*                                                                   *
*                  USING THE COASTAL MODELING SYSTEM                *
*                                                                   *
*********************************************************************
*                                                                   *
*  Options:                                                         *
*                                                                   *
*    On-Line Help  ---------------------------------------->  1     *
*                                                                   *
*    Enter CMSPOST Module  -------------------------------->  2     *
*                                                                   *
*    Return to Main Menu  --------------------------------->  3     *
*                                                                   *
*********************************************************************
```

Enter option number ------------------> 2

The CMS responds:

```
                 CMSPOST

  HYDPLT:  Generates lists of time sereis output
  HYDLST:  Generates lists of time series output
  HYDADD:  Concatenates two successive time series
 SNAPVEC:  Generates vector plots of model output
 SNAPLST:  Generates lists of field arrays described
           in SNAPVEC
  RAYPLT:  Generates wave ray plots of RCPWAVE output
 PROFPLT:  Generate profile plots of model output
    EXIT:  Terminates this CMSPOST session
```

The user enters: rayplt

The system responds:

```
RRRRR      AA      Y     Y   PPPPP    L        TTTTTTT
R    R    A  A      Y   Y    P    P   L           T
R    R   A    A      Y Y     P    P   L           T
RRRRR    AAAAAAAA     Y      PPPPP    L           T
R R      A      A     Y      P        L           T
R  R     A      A     Y      P        L           T
R    R   A      A     Y      P        LLLLLL      T

                   Return for more. . .
```

Enter the name of the instruction file: rayplt.ins

Enter the name of the shoreline file: rayplt.shl

Enter the name of the wave angle file: rayplt.ang

Valid user responses are:

TEK40 or tek40 - (hydrograph file will be plotted on TEKTRONIX 4014 or VT240 terminal)

LASER or laser - (hydrograph file plotted on laser printer)

Enter device name TEK40

Enter name of output data file: rayplt.out

The CMS submits a batch job to the CRAY Y-MP and the system responds:

```
   STOP
 CP:002s, Wallclock:0:105s, 0.3% of 6-CPU Machine

Request 4343.larry submitted to queue:prime
```

```
                          CMSPOST

  HYDPLT:  Generates plots of time series output
  HYDLST:  Generates lists of time series output
  HYDADD:  Concatenates two successive time series
 SNAPVEC:  Generates vector plots of model output
 SNAPLST:  Generates lists of field arrays described
           in SNAPVEC
  RAYPLT:  Generates wave ray plots of RCPWAVE output
 PROFPLT:  Generate profile plots of model output
    EXIT:  Terminates this CMSPOST session
```

The user types 'exit' or 'EXIT' to terminate the CMSPOST component. To plot the RAYPLT metfil on a Tektronix or Tektronix emulator, the user types:

/u3/h2crplc0/cmsplot

and the plots are displayed, as shown below:

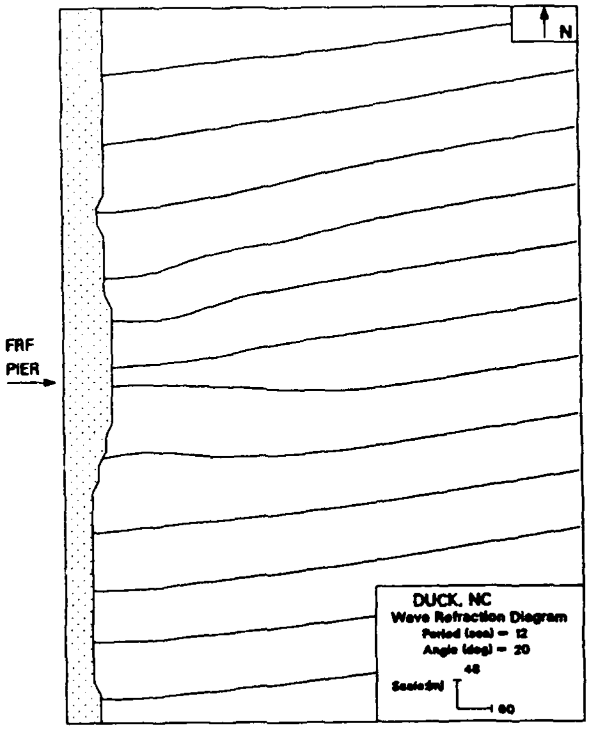

Figure C-5. RAYPLT for Duck, North Carolina, Case 1

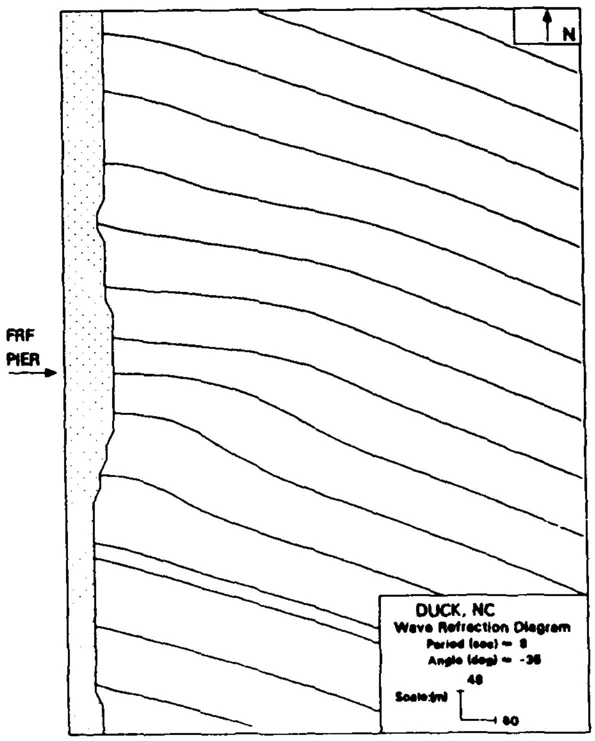

Figure C-6. RAYPLT for Duck, North Carolina, Case 2

Program PROFPLT

30. Program PROFPLT is a general purpose program for generating profile plots of data produced by the models in CMS. Field arrays, such as bathymetry, water surface level, wave height, magnitude of water velocity, and magnitude of wind velocity, can be: (a) saved by the models (using RECSNAPS), or (b) read directly from the model input file (i.e., BATHSPEC) for use by PROFPLT. A one-dimensional "line" from the array is plotted in profile form to show the distribution of the variable along the selected "transect." For example, if a mound exists in a given study area, one could select a transect through the mound, and plot the bathymetry and wave height over the mound.

31. A maximum of 100 profiles can be processed during one PROFPLT session. An instruction file must be created before execution can begin. Options to change the default plotting formats are included in this file. The following instruction commands, which are decribed in Table C-5, are valid for this program:

```
DEBUG
TITLE
YAXIS
TRANS
LINE_
BATHY
CURV2
TIMES
```

A sample instruction file for program PROFPLT is given below:

```
TRANS 1
LINE1 1 20 27 27
BATHY
YAXIS DEPTH, meters
DEBUG
TITLE PROFPLT EXAMPLE
```

Table C-4

Instruction File Commands for Wave Ray Plots

Type	CARDID	Data	Default	Description
[F]	TITLE	title	TITLE1	General plot title. Title size is 64 characters.
[S]	TRANS	integer		Number of transects to be plotted.
[S]	LINE_	X1 X2 Y1 Y2	none	Select command to process transects. Qualifier _ referenced to transect number. The number of LINE records corresponds to the number specified on TRANS. X1 = minimum x-direction cell number to plot X2 = maximum x-direction cell number to plot Y1 = minimum y-direction cell number to plot Y2 = maximum y-direction cell number to plot Note that X1 must equal X2 for a Y transect and Y1 must equal Y2 for a X transect.
[S]	BATHY			Plot bathymetry for all transects.
[S]	CURV2			Secondary variable plotted for all transects.
[F]	TIMES	TMIN TMAX TINC		Specify time plotting limits and increment. Default values are calculated from the data set.

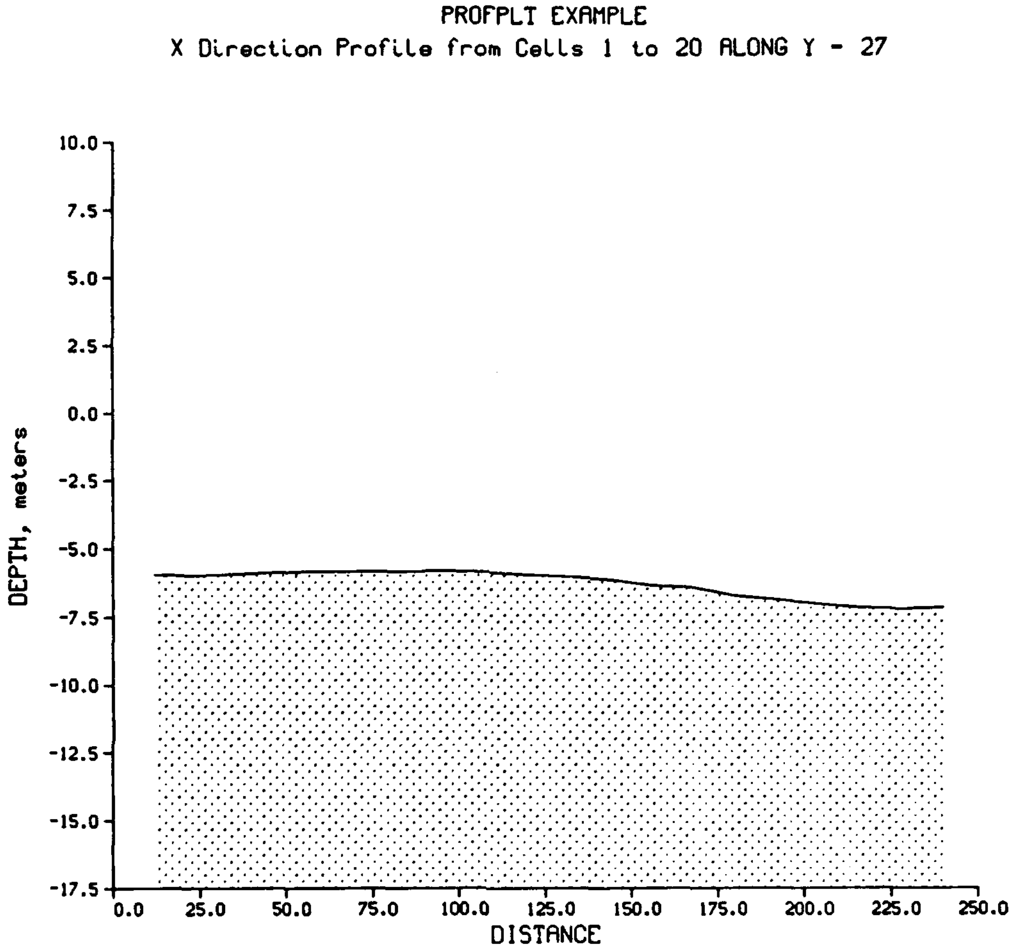

Figure C-7. Sample PROFPLT bathymetric plot

APPENDIX D: CMSSAMP

<u>Introduction</u>

1. CMSSAMP is a component of the Coastal Modeling System (CMS) that contains sample input and output files for each of the models in the CMS for users to view or copy to their own computer accounts. This feature allows the user to examine the general input requirements and data formats or actually run a model to get a "feel" for typical input/output data set structures, model responses, and model execution times. Table D-1 contains the names and a brief description of the sample input and output files contained in CMSSAMP for each of the CMS models. These files are also used for the examples documented in the individual model chapters.

2. For illustrative purposes, the input and output files for model WIFM will be displayed with the CMS menus in the following paragraphs. To invoke the CMS, the user enters the command:

```
h2crplcl:larry$ /u3/h2crplc0/cms
```

(It should be noted that user entries are shown as shaded, and CMS response "screens" are shaded boxes.) The CMS responds:

```
         W E L C O M E   T O . . .


      XXXXX           X     X          XXXXX
     X     X          XX   XX         X     X
     X                X X X X         X
     X                X  X  X          XXXXX
     X                X     X               X
     X     X          X     X         X     X
      XXXXX           X     X          XXXXX


              Return for more...
```

Table D-1

CMSSAMP Input and Output Files

Model	Input File Name	Description	Output File Name	Description
SPH	SPH_EX1.INP	SPH Storm	SPH_EX1.OUT	General output
			SPH_EX1.SNP	Snapshot data
			SPH_EX1.HYD	Hydrograph data
	SPH_EX2.INP	Hindcast Storm	SPH_EX2.OUT	General output
			SPH_EX2.SNP	Snapshot data
			SPH_EX2.HYD	Hydrograph data
WIFM	WIFM_EX1.INP	Tide without feathering	WIFM_EX1.OUT	General output
			WIFM_EX1.HYD	Hydrograph data
	WIFM_EX2.INP	Tide + nonlinear terms	WIFM_EX2.OUT	General output
			WIFM_EX2.HYD	Hydrograph data
	WIFM_EX3.INP	Tide with wind	WIFM_EX3.OUT	General output
			WIFM_EX3.HYD	Hydrograph data
	WIFM_EX4.INP	Tide + river discharge	WIFM_EX4.OUT	General output
			WIFM_EX4.HYD	Hydrograph data
	WIFM_EX5.INP	Storm surge example	WIFM_EX5.OUT	General output
			WIFM_EX5.HYD	Hydrograph data
RCPWAVE	RCP_EX1.INP	Duck, NC example	RCP_EX1.OUT	General output
			RCP_EX1.SHL	Shoreline data
			RCP_EX1.ANG	Wave angle data
	RCP_EX2.INP	Homer Spit, AK example	RCP_EX2.OUT	General output
			RCP_EX2.SHL	Shoreline data
			RCP_EX2.ANG	Wave angle data
CLHYD	CLHYD_EX1.INP	Tide without feathering	CLHYD_EX1.OUT	General output
			CLHYD_EX1.HYD	Hydrograph data
	CLHYD_EX2.INP	Tide + nonlinear terms	CLHYD_EX2.OUT	General output
			CLHYD_EX2.HYD	Hydrograph data
	CLHYD_EX3.INP	Tide with wind	CLHYD_EX3.OUT	General output
			CLHYD_EX3.HYD	Hydrograph data
	CLHYD_EX4.INP	Tide + river discharge	CLHYD_EX4.OUT	General output
			CLHYD_EX4.HYD	Hydrograph data
	CLHYD_EX5.INP	Storm surge example	CLHYD_EX5.OUT	General output
			CLHYD_EX5.HYD	Hydrograph data
SHALWV	FILE1M.SWV	Parameter file	MOUND.MTX	Wave field
or	DEPMOUND.SWV	Bathymetry file	MOUND.SPE	Wave spectra
STWAVE	BOUNDIN.SWV	Boundary condition file	MOUND.SEA	Wave characteristics
	STWAVEIN.SWV	General input file	FILENMM.SWV	Post-processing
	FILENMIM.SWV	Main file name file	BOUNDOTM.SWV	Binary boundary conditions
HARBD	AGAT.INP	Agat Harbor, Guam	AGAT.OUT	General output
	MAAL.INP	Maaleaa Habor, Hawaii	MAAL.OUT	General output

```
*********************************************************************
*                           C M S   COMPONENTS                      *
*-------------------------------------------------------------------*
*  Options:                                                         *
*                                                                   *
*  CMSGRID (Maps, plots, and lists the numerical grid)  -------> 1 *
*                                                                   *
*  CMSMODEL (Compiles, links, loads, and executes                   *
*            numerical models  -------------------------------> 2 *
*                                                                   *
*  CMSPOST (Plots and lists model outputs)  ------------------> 3 *
*                                                                   *
*  CMSUTIL (Additional "utility" programs)  ------------------> 4 *
*                                                                   *
*  CMSSAMP (Sample input and output files for each model ------> 5 *
*                                                                   *
*  Exit CMS  -------------------------------------------------> q *
*********************************************************************
```

To display the CMSSAMP menu, the user responds to the CMS prompt with a value of 5:

```
Enter option number  ----------------------->  5
```

The CMS responds:

```
   CCCC    M     M     SSSS     SSSS       AA      MM   MM   PPPPPP
  C    C   MM    MM   S    S   S    S     A  A     M M M M   P     P
 C         M M M M    S        S         A    A    M  M  M   P     P
 C         M  M  M     SSSS     SSSS     AAAAAA    M  M  M   PPPPPP
 C         M     M                  S    A    A    M     M   P
  C    C   M     M    S     S  S     S   A    A    M     M   P
   CCCC    M     M     SSSSS    SSSSS    A    A    M     M   P


                        Return for more...
```

```
**********************************************************************
*                                                                    *
*         Sample Input and Output Files Available for Models:        *
*                                                                    *
**********************************************************************
*                                                                    *
*    SPH ---------------------------------------------------> 1     *
*                                                                    *
*    WIFM --------------------------------------------------> 2     *
*                                                                    *
*    RCPWAVE -----------------------------------------------> 3     *
*                                                                    *
*    CLHYD -------------------------------------------------> 4     *
*                                                                    *
*    SHALWV ------------------------------------------------> 5     *
*                                                                    *
*    STWAVE ------------------------------------------------> 6     *
*                                                                    *
*    HARBD -------------------------------------------------> 7     *
*                                                                    *
**********************************************************************
```

To view the sample input and output files for model WIFM, the user responds to the CMS prompt with a value of 2:

```
Enter option number -------------------------> 2
```

The CMS responds:

```
                W     W     I     FFFFFF    M     M
                W     W     I     F         M M M M
                W WWW W     I     FFFF      M  M  M
                WW   WW     I     F         M     M
                W     W     I     F         M     M


SSSSS   AA    M    M PPPP   L     EEEEE      FFFFF I L    EEEEE SSSSS
S      A  A   MM  MM P    P L     E          F     I L    E     S
 SSSS  AAAAAA M  M M PPPP   L     EEE        FFF   I L    EEE    SSSS
     S A    A M    M P      L     E          F     I L    E          S
SSSSS  A    A M    M P      LLLLL EEEEE      F     I LLLLL EEEEE SSSSS

                       Return for more...
```

```
*******************************************************************
*                                                                 *
*        Sample Input and Output Files Available for WIFM:        *
*                                                                 *
*******************************************************************
*                                                                 *
*    Input Files:                                                 *
*                                                                 *
*                WIFM_EX1.INP                                     *
*                WIFM_EX2.INP                                     *
*                WIFM_EX3.INP                                     *
*                WIFM_EX4.INP                                     *
*                WIFM_EX5.INP                                     *
*                                                                 *
*                                                                 *
*    Output Files:                                                *
*                                                                 *
*                WIFM_EX1.OUT     WIFM_EX1.HYD                    *
*                WIFM_EX2.OUT     WIFM_EX2.HYD                    *
*                WIFM_EX3.OUT     WIFM_EX3.HYD                    *
*                WIFM_EX4.OUT     WIFM_EX4.HYD                    *
*                WIFM_EX5.OUT     WIFM_EX5.HYD                    *
*                                                                 *
*******************************************************************
```

To select a sample input or output file from the list above, the user types the file name at the CMS prompt:

Enter file name (or 'exit' to return to previous menu) ------> wifm_ex1.inp

To display a portion of the contents of the selected file, the user types 'y' at the CMS prompt:

Display file? ((y)es or (n)o) -------> y

The CMS responds:

*** NOTE ***

To terminate the screen display type 'q' at the prompt

Press 'RETURN' to display the selected file

```
GENSPECS    WIFM SIMULATION NO. 1:  TIDE WITHOUT FEATHERING      ENGLISH
TIMESPEC      30. SECONDS       0.  86400.     360.
GRIDSPEC          ENGLISH      75       30    500.    1000.       0.       0.
PRWINDOW                                      3600.                       EV
RECGAGE        19       16          INLET GAGE
RECGAGE        42       15          OCEAN GAGE
XBOUNDRYCONSTELV        75        1      30        1          BRDYX
YBOUNDRYINTRPELV         1       17      75        2       1  BRDY1
YBOUNDRYINTRPELV        30       17      75        2       1  BRDY2
FUNCTION        1HARNCNST
CNRECORD      0.0     1981        6       1      2.5
CONSTIT        M2     3.97   199.02
FUNCTION        2HARNCNST
CNRECORD      0.0     1981        6       1   2.6667
CONSTIT        M2     3.97   199.02
XBARRIER       17       14       14     2.5            XB1
XBARRIER       19       15       15     2.5            XB2
XBARRIER       21       16       16     2.5            XB3
XBARRIER       18       17       17     2.5            XB4
```

:q terminates the screen display of the selected file. To copy the selected file to the user's account, the user types 'y' at the CMS prompt:

Copy the file to your account? ((y)es or (n)o) ------> y

Enter the destination file name (the file name on your account, including the path) ------> /u3/h2crplcl/myfiles/ex1.inp

Any of the sample files can be displayed or copied to the user's account in this manner. As additional models are added to the CMS, sample input and output files for those models will be added to CMSSAMP.